Understanding Freight-Built Environment Interrelationships

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16. Abstract The main aim of this study is to advance the understanding of interactions among land use, transportation infrastructure, and movement of freight. There are three research thrusts for the study. The first thrust examines the effects of transportation infrastructure on the trucking sector output, employment, and productivity at both state and urban area levels. The second thrust looks at how built environment factors such as intersection and road densities affect consumption of retail goods while accounting for the effects economic and demographic conditions. The third thrust examines the perceptions and knowledge of the stakeholders involved in urban freight movement and commercial real estate development regarding the relationship between land use and freight. While these thrusts do not comprise a complete list of critically important topics in understanding the land use – freight relationships, collecting information and advancing our understanding of these issues will establish a foundation for further studies to build on.		
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Executive Summary

This study, funded by the Research and Innovative Technology Administration (RITA) through the National Center for Freight and Infrastructure Re*s*earch and Education (CFIRE), addresses some of the knowledge gaps concerning the relationship between land use and freight. Land use pattern in any community can be considered as a manifestation of its history and policy decisions concerning land development and transportation infrastructure. As such, the main aim of this study is to advance the understanding of interactions among land use, transportation infrastructure, and movement of freight.

There are three research thrusts for the study. The first thrust examines the effects of transportation infrastructure on the trucking sector output, employment, and productivity at both state and urban area levels. The second thrust looks at how built environment factors such as intersection and road densities affect consumption of retail goods while accounting for the effects economic and demographic conditions. The third thrust examines the perceptions and knowledge of the stakeholders involved in urban freight movement and commercial real estate development regarding the relationship between land use and freight. While these thrusts do not comprise a complete list of critically important topics in understanding the land use – freight relationships, collecting information and advancing our understanding of these issues will establish a foundation for further studies to build on.

1. Effects of transportation infrastructure on the freight sector output, employment, and productivity

Many policy makers fear that not making adequate investment on freight infrastructure negatively affects freight productivity, and, in turn, economic growth at the regional and also national levels. Then, it is reasonable to ask whether it is worthwhile to invest in the development and maintenance of infrastructure systems to ensure that movements of freight can occur efficiently, and also the level and type of investment that are most effective in achieving that goal. We used statistical models to identify the links between the indicators of transportation infrastructure (road or lane miles and road density) and congestion (vehicle miles traveled divided by road or lane miles) and the economic activity of the trucking sector (employment, Gross Domestic Product, and productivity). Among those three indicators of economic activity, productivity is most important for the aim of this study since more efficient trucking sector should, at least in theory, give advantage to a city or a state to grow the economic sectors that are dependent on freight, e.g. manufacturing. Analyses were conducted at both state and metropolitan area levels. However, due to the limited availability of data, the analysis at the metropolitan level is not as rich as that for the state level.

For the state level analysis, we used annual data from 2001 to 2007. In addition to the indicators of transportation infrastructure, congestion and trucking sector activities, various socioeconomic factors were included to control for the effect of the overall size of state economy, population, educational attainment, etc.

We found that congestion has a negative effect on trucking sector employment but not on the trucking sector productivity. Meanwhile, road density, measured in lane miles per square mile, had no effect on employment but had a positive, albeit weak, effect on productivity. Therefore, we did not find conclusive evidence that building roads increases trucking employment or productivity. The most consistent factor related to infrastructure seems to be the air cargo volume. Both employment and productivity are positively and significantly affected by the landing tons of air cargo within each state. We also found that the percent of population without high school is positively associated with trucking employment, suggesting that for people who do not complete high school, trucking is a viable form of employment (presumably because obtaining commercial driver's license does not require high school diploma).

Simply adding lane miles, as far as the analysis results are concerned, does not seem to contribute to the increase in the trucking sector productivity nor employment. One policy implication of this analysis is that investing in traffic operations and management, in combination with targeted infrastructure improvements to relieve bottlenecks, may be fruitful in jointly leading to overall increases in trucking industry productivity. A second implication is that increases in private trucking innovative technology approaches may lead to large gains in trucking industry productivity. Finally, workforce development initiatives in states with higher levels of population with low skills could generally be fruitful towards increased trucking sector jobs and for the attraction of trucking businesses there.

For the analysis at the metropolitan area level, we used trucking sector GDP growths between 2002 and 2007 as economic indicators. We used congestion, measured in terms of VMT per road mile) and road density for 2002 as two transportation infrastructure indicators. We did not find any evidence that suggested there is a correlation between congestion and road density and the growth in trucking sector GDP. This is mostly consistent with the findings from the analysis using the state-level data for the entire nation. It should be stressed, however, that these results should be interpreted as preliminary due to the limitations in data and resources. If anything, our findings confirm a need for further research on this important topic.

2. Built Environment and Retail goods consumption

We used a truck owner survey data from Texas to conduct an analysis of how land use and socioeconomic factors influence the demand for retail freight deliveries. The underlying hypothesis for the analysis is that with everything else being equal, built environment has measurable effects on consumption of retail goods. Policy implication of such hypothesis is that so called Smart Growth policies that aim to affect travel behavior through built environment, including job-housing balance, pedestrian friendly design, increased population and employment densities, etc. may also influence the demand for goods from the residents. We examined the relationship between variables such as intersection density, road density, employment and population densities, block size, median number of rooms per housing unit, percentages of houses built before 1969 or after 1990, percentages of housing units that are single detached homes, and household density, all measured at Census tract level, and tons of retail goods delivered per person. The statistical analysis accounted for the influences of socioeconomic factors such as income, ethnicity, percentages of population who are foreign born, and percentages of recent immigrants within each tract.

In general, stronger associations between the built environment variables and the response variable are observed when the consumption of retail goods is measured using buffers, drawn around each census tract to account for the fact that people often travel across Census tract boundaries to shop. Also, we found that the statistical method used had a profound influence on the findings. Nevertheless, the analysis generally indicates that consumption of retail goods seems to decrease with household density, which may suggest that living in a compact dwelling unit has an effect of reducing goods consumption. This effect is statistically significant, but the magnitude is very small. At the same time, poor fit of the model indicates that there are other factors that our analysis was not able to capture.

3. Stakeholder Analysis of the Effects of Built Environment on Freight Transportation

We examined the perceptions and knowledge of the stakeholders involved in urban freight movement and commercial real estate development regarding the relationship between built environment and freight. Our hypothesis was that differences in perspectives and knowledge levels among stakeholders, especially between private and public sectors, often resulted in mismatches between public policies and private investment decisions. If the hypothesis is true, many of the issues related to the movement of freight can be addressed by better communication and education.

We interviewed a total of 24 stakeholders in the Chicago region. The interviewees were drawn from industrial real-estate development industry, governments, non-profit economic development organizations, trucking industry, and third-party logistics (3PL) industry. The interview questions covered following four issues:

1) Effect of built environment on the "last mile" part of the freight movement (e.g. congestion, competition for loading spaces, delivery time restrictions, turning radius and height restrictions, etc.).

2) Effect of the performance of transportation infrastructure on the supply chain management decisions (e.g., does congestion affects the location of the distribution centers?)
3) Effect of the cost of freight transportation on the location choices of businesses in different industries, and
4) Necessary conditions for the development of a large-scale development of supply chain-oriented industry centers

We found that stakeholder groups as a whole revealed a surprisingly high consistency in the knowledge levels about freight industry but also pointed out some institutional issues. Following is a summary of findings for each of the critical issues.

In terms of the physical aspects of built environment, all the stakeholders pointed out the viaducts as a serious problem that contributes to inefficient routing and increased level of congestion. Within the city of Chicago, there is a web-based database/map of vertical clearances, provided by the city, truckers found it unreliable and outdated. When it comes to inadequate turning radii often seen in some parts of the region, trucking industry sees it as no more than an inconvenience that skilled drivers should be able to navigate, while municipal staffs see it as a serious problem for their residents and road maintenance. This can be characterized as a problem that is caused by the difference in the interests of stakeholders. For truckers, their main concern is whether or not they can deliver the load to the customers, while cities are concerned about the inconvenience to other drivers while the trucks negotiate the turns. We also found similar difference in perceptions regarding the congestion at loading areas and curb-side loading.

There is a high level of agreement on the negative impacts of congestion on freight operations. All the stakeholders understand that trucks have little choice over the selection of delivery times, and that the shippers give little consideration for the added cost and also negative externalities when deciding on the delivery time windows for shipments. However, the stakeholders from the public sector tend to believe that trucking firms are able to pass on the added cost of congestion to the customers while it is often not an option according to the truckers. Nearly everyone interviewed, except for some from the municipalities, view off-peak delivery (i.e. nighttime) as a promising option to improve the efficiency of trucking operations and reduce congestion. However, some stakeholders pointed out that the real problem is the complexity of the delivery time restrictions that are inconsistent among the cities or, in some cases, within a city. In many cases, night-time delivery restrictions are implemented on site-by-site bases in response to complaints from the neighbors. There is little documentation and often the drivers who regularly deliver to the restricted site are the only ones who are actually aware of the restriction. For municipalities, enforcing delivery time restriction is highly problematic and expensive.

The stakeholders were unanimous in stating that access is only one of the factors that are involved in the site selection for freight-intensive businesses. While not being close to expressway ramps excludes most of the sites from consideration, it is not a sufficient condition for the site to be ultimately selected. It is important to point out that there are some differences among the stakeholder groups about the reasons that make the proximity to expressways such a critical factor in site selection. While municipal staffs commonly attributed it to the cost of transportation, truck operators' views were more nuanced. Truck operators felt that being close to expressways enabled them to reduce the number of uncertainties such as construction projects, truck routes changes, weight restrictions, and congestion, which ultimately result in an increased reliability in delivery times and cost. Managing uncertainty is especially important when they need to make a commitment to a long-term contract with a customer. Having to cross many jurisdictional boundaries (and neighborhoods) to make a delivery brings increased level of uncertainty in their operation. One truck operator commented that it takes only one person complaining to the city to make their operation very difficult. Real Estate professionals also pointed out that the freight-intensive businesses are sensitive about the attitude of the local government toward freight traffic and also other potential source of conflicts. Therefore, having to go through a quiet residential neighborhood to reach an Expressway interchange would make the site less attractive for those businesses.

The view on the access to rail is also consistent in that it is important for some businesses that deal with bulk freight, but for others it is not relevant. Tax incentives are listed by many as critical. However, there are considerable differences in how the stakeholders view other factors such as labor supply and site characteristics. Some view labor supply as an afterthought due to the abundant supply of willing work force due to the economic downturn, while others argued that it is critical.

We have been able to identify some institutional issues. The first observation is that overwhelmingly, local governments place priority on the management of negative externalities instead of proactive and strategic actions to address issues related to freight transport. Many recognize the need for integrated planning of land use and transportation infrastructure for freight, but none of the communities have taken a credible step toward actually developing one. While many recognize that such effort will be immensely beneficial, our interviews revealed that political reality is complex and there is no clear solution on the horizon. As such, the state of the practice is to treat individual problems, e.g. noise, turning radius, etc., as they emerge without coordination across political boundaries and long-term vision.

Another finding is that the municipalities do not have an effective channel of communication to collect accurate and up-to-date information on the various issues related to trucking. From the truck operators' point of view, voicing their concerns to the local government is not an effective way to address an on-going problem since they are not a member of the community. The customer, e.g. shipper or consignee, would have a greater credibility with the local government. However, our interviews found that trucking firms rarely communicate their concerns to the customers out of a concern that they will be seen as incompetent or too demanding. This culture of silent suffering creates a gap in the feedback system that the public sectors rely on to identify problems when the transportation infrastructure is not providing adequate performance.

4. Conclusion

The aim of this study was not to produce a comprehensive knowledge on all the issues related to the interrelationships between freight and land use. Instead, this effort strived to address some of the critical knowledge gaps that currently exist. We found that in each of the research thrusts, information collected from the field painted a picture of nuanced and complex relationships between land use, which include transportation infrastructure, and freight . Often, statistical analysis did not produce the results that we expected from the conventional wisdom, which is often the basis for making policy decisions regarding freight. As such, there is a need for in-depth research in each of the thrusts to confirm our findings and extract more concrete policy implications. That being said, there were some valuable insights that our analysis were able to produce.

The findings suggest that the supply of roads, measured in terms of lane miles or centerline miles, does not stimulate the growth of freight sectors nor improve their productivity. Rather, improvements in the management of traffic operations or bottlenecks may be more fruitful. A micro-level analysis of the effects of bottlenecks on the growth of freight industry, perhaps at the site level, should be conducted to confirm this.

We found that the growth in trucking sector seems to become a zero-sum game in which the growth for one urban area translates to a decline in another, often right next to each other. Urban areas that engaged in aggressive economic development initiatives often emerged as winners.

We did find solid evidences that increasing air cargo activity is correlated with both trucking sector employment and productivity. In general, increasing the value of goods being transported seems to be the key to increasing the output of the freight sector since the freight rates tend to reflect the value of goods that are being transported. As a future study, it will be beneficial to examine the causal relationship between the growth in the manufacturing of high-value goods and the productivity of the freight sector (and possibly congestion) to investigate whether or not the efficiency of freight transportation affect specific economic sectors that are highly dependent on the sophisticated supply chain.

We found that compact urban development pattern seems to reduce consumption of retail goods, measured in weight. The effect, however, is very small. A direct survey of households or an analysis of data obtained from moving companies should be considered for further research.

The information gathered from the interviews of freight experts underscores the importance of involving a broad spectrum of stakeholders in the discussion of freight issues. Especially, the participation and cooperation of shippers are critical in implementing nighttime deliveries that are seen by all the stakeholders as a promising strategy to address congestion and inefficiency. It is also our recommendation that a regional coordination committee to be set up and operated by the MPO or state department of transportation for each urban area to facilitate open exchange of information since our analysis indicated that currently there is no mechanism for the stakeholders to communicate.

Chapter1. Introduction

In recent years, the relationship between land use and transport of freight has not attracted the same level of attention as that for the transport of people. Although there is a wide recognition that freight transportation has profound impacts on the economical well-being of the nation and regions, and many communities envision logistics facilities replacing factories as the "anchor" for the next generation of industrial centers, the interaction between land use and various aspects of freight transportation (e.g. demand for good movement, employment generation, supply chain operation, etc.) have not been studied extensively.

There have been only a few efforts that tried to study the integration of land use and freight transportation planning in a rigorous manner. Although regional freight plans for the San Francisco Bay area[1] and also the Greater Atlanta area[2] actually include chapters on land use and provide wide-ranging practical strategies, justifications for the recommendations in those documents are based primarily on anecdotal information or rationale not linked to credible empirical observations. The state of the practice seems to suggest that the link between land use and freight planning is an important issue that needs to be studied. However, there are significant gaps in both conceptual understanding and data that are needed to rigorously study it.

The relationship between land use and freight is multi-faceted. Many transportation infrastructure projects, especially the ones that are important for the movement of freight, are pursued based on an underlying assumption that a transportation system that facilitates efficient movement of freight will stimulate economic growth, which is often accompanied by change in land use. There have been a number of studies that examined the relationship between the growth in overall economy, e.g. GDP, and transportation infrastructure. Most of the studies suggest that there is a positive correlation between the provision of transportation infrastructure and the economy at a macro scale. However, the role that freight transportation plays is not clearly understood. Therefore, decision makers must rely on anecdotal evidences or simply hope that efficient transportation system will indeed make their city or state more productive and economically competitive.

Meanwhile, land use decisions, implemented through plans, regulations and local ordinances, affect the design and management of supply chains, including the placement of facilities. In the current land use decision process, each municipality tends to consider pros (jobs and economic benefits) and cons (negative externality such as congestion and noise) of having a freight facility in their community in a parochial manner. Not surprisingly, many

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[1]HausrathEconmic Group and Cambridge Systematics. MTC Good Movement Study - Phase 2: Task 11 Working Paper (A Land Use Strategy to Support Goods Movement in the Bay Area). September 2004.
[2]Atlanta Regional Commission.Atlanta Freight Mobility Plan - Final Report. February 2008.

municipalities do not welcome a proposal for a major freight facility even if that may force the facility to locate in a sub-optimal location from a regional standpoint[3]. Also, it should not be overlooked that land use affects the characteristics of transportation infrastructure. For example, wide streets designed to accommodate large trucks do not fit well in residential neighborhoods. Also, density of land use determines the location and intensity of demand for freight movements. Thus, it is clear that any study of the interaction between land use and freight must examine the relationships from both directions.

In this study, we often use the term “built environment” to represent land use, urban design elements and also transportation infrastructure. Built environment has profound impacts on the efficiency of freight movements for the "last mile" segment of the journey[4,5,6]. Areas with narrow streets and small storefronts and scarce off-street loading spaces make it more challenging to deliver goods. Even if built environment does not physically impede the transportation of freight, highly diversified land use can increase the risk of friction between local residents and freight businesses. Land use may also affect the demand for freight. While many cities strive to increase the density of core areas with densification and transit-oriented development (TOD), very little attention is paid to the fact that such land use pattern may lead to an increase or decrease in the intensity of goods consumption per a unit of land area.

While movement of freight is certainly affected by built environment and infrastructure performance as described above, there is a relationship in the opposite direction as well. Classic Urban Economics theories postulate that locational advantage for the movement of freight is one of the main determinants of business locations[7,8,9], and consequently, land use. It is widely accepted that freight transportation plays a significant role in the growth of regional and local economies, both by giving industries the necessary means to obtain inputs and transport their products but also by creating jobs. The most convincing evidence supporting such claim is the fact that many of the world's largest cities can trace their roots to being an important freight hub. Certainly, in the past, efficient movement of freight and its potential for economic benefits have provided a powerful rationale for transportation

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[3] For example, it is well known that Union Pacific's Global III terminal had to locate some 80 miles from Chicago due to the lack of takers.

[4] Gary Pivo et al., “Learning From Truckers: Moving Goods in Compact, Livable Urban Areas,” (Olympia, WS: WSDOT, 1997)

[5] Anne G. Morris and Alain L. Kornhauser, "Relationship of Freight Facilities in Central Business District Office Buildings to Truck Traffic,”Transportation Research Record 1707 (January 2000): 56-63.

[6] R. O'Laughlin. Chicago Downtown Freight Study.Presented at TRB AT025 Committee meeting. January 2008

[7] Alfred Weber, Theory of the Location of Industries. The University of Chicago Press. 1929

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infrastructure projects. In today's service-oriented economy, however, it is less convincing of an argument. In fact, recent empirical studies of disaggregate-level data are not clear about the importance of freight transportation as the determinant of business location[10,11]. Aggregate-level studies[12,13,14], while they have identified favorable rates of return for highway investments, relied on the highway stock and did not specifically examine the role of freight transportation. Thus, there is a need to examine whether the efficiency of freight transportation still plays an important role in business location decisions and thus influence the overall economic competitiveness of the region.

Further making understanding the land use - freight interrelationship difficult is the feedback among those effects. Figure 1 below shows an example of how public sector decisions and private sector interests interact for a supply chain. The figure represents idealized interactions that were derived based on the understanding of supply chain and public sector behaviors. Feedback loops, shown in the striped arrows, inform both private and public stakeholders in the form of formal performance measures and other signals. As shown in the figure, complex relationships exist among public sector decisions, private sector decisions, and exogenous factors. What the figure underscores is the fact that each stakeholders tend to make decisions based on assumptions which may or may not be correct. For example, as discussed previously, the decisions by the public sector are made based on the assumption that the quality of the infrastructure affects the performance of the freight industry. It should be noted that in most cases, the public sector has no means to verify its assumption because there is no direct feedback system to monitor the effect of infrastructure improvements on the performance of freight industry in terms of metrics that truly count, e.g. cost, productivity, employment, etc. The figure also illustrates that private and public sectors rely on different sets of indicators to obtain feedback on the performance of the transportation infrastructure.

In order to truly understand the connection between built environment and freight transportation and translate the knowledge to effective public sector policies, it is critical to grasp those actions and reactions shown in the figure. It means that the study must include an examination of the decision-making process employed by the businesses and the factors that influence them. Also, it is important to understand how the public and private sector decisions affect performance and outcomes. For example, a public agency, such as

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[10]Scott Leitham, R.W. McQuaid, and J.D. Nelson. The Influence of Transport on Industrial Location Choice: a Stated Preference Experiment. Transportation Research Part A. 34, 2000, pp. 515 – 535.

[11] Kazuya Kawamura. "Empirical Examination of the Relationship between Firm Location and Transportation Facilities", Transportation Research Record 1747, Transportation Research Board, Washington, D.C., 2001

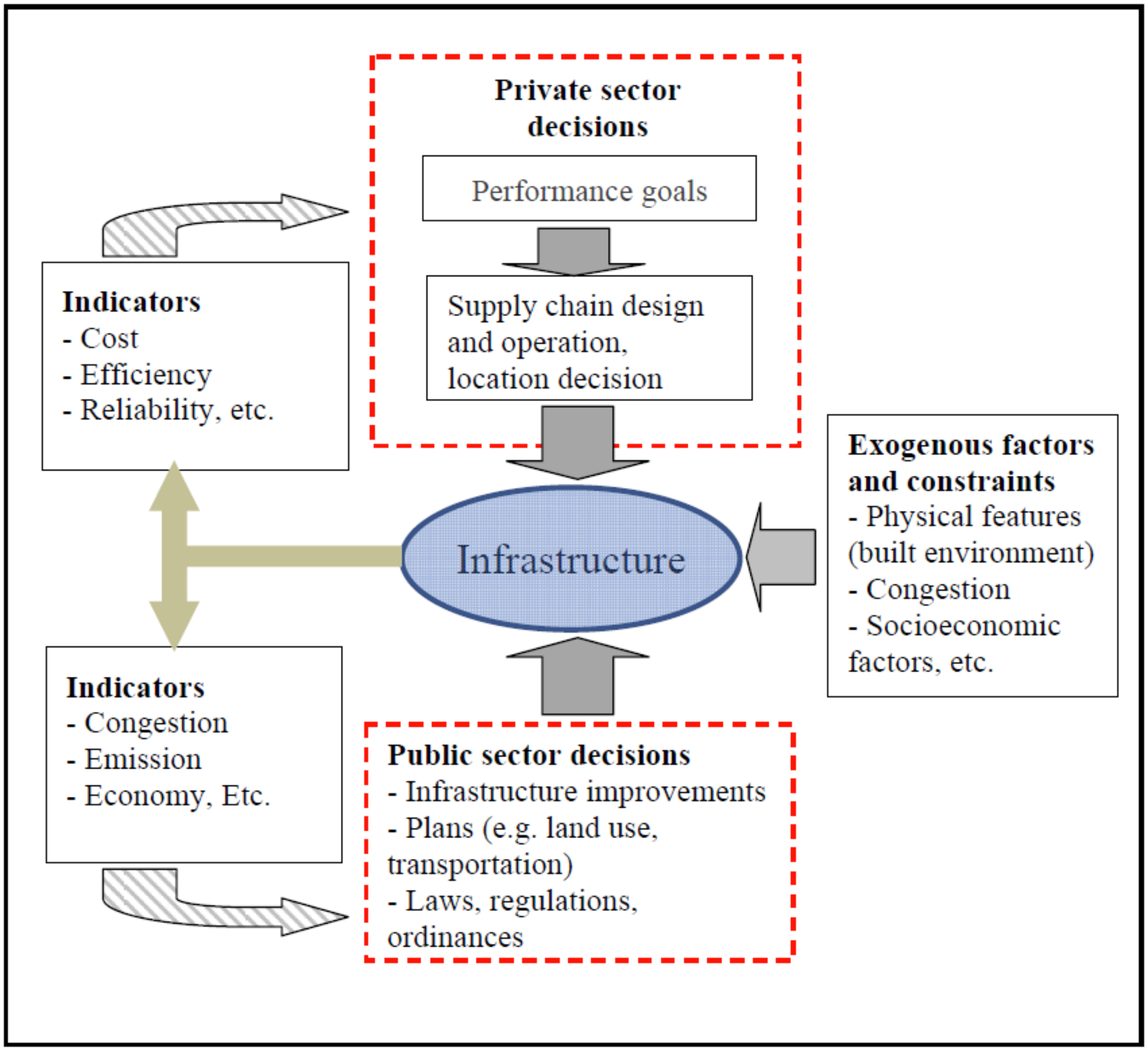
[12] A. Munnell. How Does Public Infrastructure Affect Regional Economic Performance? New England Economic Review. Sep/Oct. 1990.

[13]Aschauer, D., "Is Public Expenditure Productive?" Journal of Monetary Economics, Vol. 23, pp. 177-200. 1989

[14]Nadiri, M. Ishaq, M. and T. P. Mamuneas."Contribution of Highway Capital to Output and Productivity Growth in the US Economy and Industries". Report prepared for FHWA. 1998

Metropolitan Planning Organization (MPO) may decide to invest in transportation infrastructure hoping that it will entice businesses to locate there or increase purchase of goods and services. However, for that to happen, the investment first needs to improve the quality of the transportation system and that must be followed by the decision by the private sector to adjust the supply chain to invest more resources or move some of the functions to the area to take advantage of the improved service level.

Figure 1: Interactions between Supply Chain Stakeholders



Following is the list of research topics that will be the focus of this report. We developed the framework for this study to gain better understanding of the key interactions that are depicted in Figure 1. These research questions were developed based on the relevancy, either directly or indirectly, for public sector decision making and policy.

1. Effects of the performance of transportation infrastructure, as they relate to freight movement, on the regional economic indicators

2. Effects of the performance of transportation infrastructure, as they relate to freight movement, on the location decisions of various types of businesses,

3. Effects of built environment and socioeconomic characteristics on the demand for consumer goods.

4. Effects of built environment on the efficiency of freight movement for different components of supply chains.

While these topics do not comprise a complete list of critically important topics in understanding the land use – freight relationships, collecting information and advancing our understanding of these issues will establish a foundation for further studies to build on.

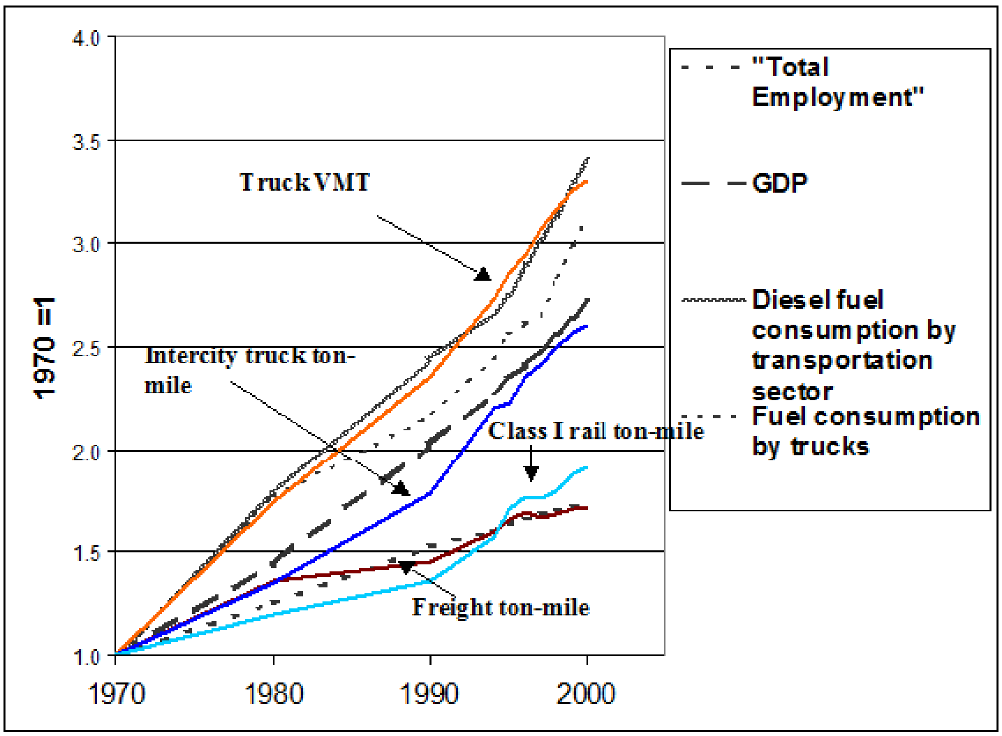
The secondary objective of this study is to develop a set of recommendations regarding the land use and infrastructure policies utilizing the assimilated knowledgebase. In order to successfully fulfill this objective, it is necessary to understand the interrelationships among these effects under various environmental conditions. Furthermore, motives, constraints, and rationale of each stakeholder that causes observed effects to occur must be understood in order for this research to produce knowledge that are transferable to practice. This study used a mixture of both quantitative and qualitative methods to accomplish these objectives.

The reminder of this report is organized according to the four research topics listed above. Chapter 2 addresses the first topic, the effect of transportation infrastructure on economy. Chapter 3 discusses the effect of built environment on the consumption of retail goods. Chapter 4 analyses both the second and the third topics on the list using the data collected from the interviews of stakeholders. Finally, Chapter 5 briefly summarizes the findings of the aforementioned chapters. Analysis of the relationship between trucking sector GDP and road density and congestion level at the MSA level, which is limited in scope due to data availability is included in the appendix.

Chapter 2. Transportation infrastructure and regional economic indicators

It is a widely recognized concept that the economic prosperity of a country is closely related to the efficiency and well-being of the freight transportation systems. Such concept has an intuitive appeal since everyone can understand that a wide variety of products that are produced by different industries and consumed by end users have to be transported on truck, rail, airplane, ship, or pipeline to reach intermediate or final destinations for the economy to keep functioning. The most notable anecdotal evidence of the connection between freight activity and economic growth is the close tracking between GDP growth and growth in truck VMT and also truck ton-miles over the last several decades, as shown in Figure 2[15].

Figure 2: GDP Growth and Freight Activity Indicators



According to the Federal Highway Administration[16], the US transportation system moved, on average, 53 million tons of freight worth $36 billion each day. As population and economic activity (as measured by the GDP) is expected to grow rapidly over the next decade, the transportation and warehousing sector is expected to grow, overall, at the same rate as other

[15]Midwest Regional University Transportation Center. Upper Midwest Freight Corridor Study – Final Report. 2004
[16]Federal Highway Administration, Freight Facts and Figures 2007 (Washington, DC: FHWA, November 2007)

industries. Trucks moved about 60 percent of freight by weight and about 67 percent of freight by value.

However, despite having doubled over the past two decades, truck traffic remains a relatively small share of total highway traffic and is estimated to have accounted for only about 8 percent of highway Vehicle Miles Traveled (VMT). FHWA (2005)[17] also reports that truck traffic is concentrated on major routes connecting population centers, ports, border crossings, and other major hubs of activity. Although truck traffic may be a small share in terms of traffic volume, the impact on capacity can be quite large. FHWA estimated the direct user cost of delay for trucks to be $7.8 billion per year. Also, for some highway segments, trucks contribute heavily to the congestion.

Many policy makers fear that not making adequate investment on freight infrastructure negatively affects freight productivity, and, in turn, economic growth at the regional and also national levels. Then, it is reasonable to ask whether it is worthwhile to invest in the development and maintenance of infrastructure systems to ensure that the movements of freight can occur efficiently, and also the level and type of investment that are most effective in achieving that goal. Those questions are of particular importance because of the rapid increase in good movement demand in the past few decades on one hand and deteriorating performance of the infrastructure systems in this country on the other. As discussed in this chapter, we try to address some of the knowledge gaps related to economic growth and transportation infrastructure at the scale of states and urban areas, instead of the nation.

There have been surprisingly small number of studies that examined the productivity of freight industry, especially trucking. Many of the existing literature[18,19, 20] focus on the effect of the 1980 deregulation of trucking industry. Those studies generally found that the deregulation led to increased productivity in the trucking sector. Hubbard[21] examined the effect of information technology and argued that technologies such as on-board computer can result in a large gain in productivity. The studies by Boyer et al[22,23] are of particular interest because they demonstrated that when productivity is measured as physical output (such as ton-miles) over input, change in trip length and input prices, mostly in the forms of labor and fuel, can explain productivity increase or decrease.

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22 Boyer KD, Burks SV, Drivers and Ballerinas: Productivity and Cost Trends in the Trucking Industry, 1997-1997, March 2004 available at: <http://www.ios.neu.edu/iioc2004/papers/s4i1.pdf>, Accessed April 14, 2010.

23 Boyer, Burks, Stephen V., stuck in the Slow Lane: Traffic Composition and the Measurement of Labor Productivity in the U.S. Trucking Industry, IZA Discussion Paper No. 2576, January 2007

This chapter addresses economic outcomes of the trucking industry and its relationship to the highway infrastructure. We focus on two economic outcomes in the trucking industry - employment and productivity. Two separate data sets, one at the state-level and the other at the Metropolitan Statistical Areas (MSA) levels were used for the analysis. The approach we employed at the state and MSA levels were influenced by the availability of data at those two spatial levels. Due to the availability of data, the state-level analysis allowed us to use sophisticated statistical analysis while the MSA level analysis used case-study approach combined with a simpler statistical tools. In this chapter, only a brief summary of the relevant findings from the MSA level analysis is given. The complete description of the MSA level analysis is included in the Appendix.

2.1 State-level analysis

2.1.1. Introduction

As in the case of previous research on transportation and economic development, we focus on the extent to which transportation infrastructure generates job opportunities in the economy [24,25,26,27,28] with our interest being primarily in trucking sector employment. We examine both total trucking employment, as well as trucking employment's share of total employment, during the study period.

We also consider output in the trucking industry and the effects of investments in highway infrastructure on productivity in the trucking industry, in the tradition of the highway investment and overall economic productivity relationship examined by several previous authors[29,30,31, 32,33,34,35,36,37]. In contrast to traditional freight productivity measures, which is

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[27]Duffy-Deno, K. T. (1998), The Effect of Federal Wilderness on County Growth in the Intermountain Western United States. Journal of Regional Science 38: 109-136.

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[30]Aschauer, David A. 1989. "Is public expenditure productive?," Journal of Monetary Economics, Elsevier, vol. 23(2), pages 177-200, March

[31]A. Munnell. How Does Public Infrastructure Affect Regional Economic Performance? New England Economic Review. Sep/Oct. 1990.

[32] A. H. Munnell, 1990. "Why has productivity growth declined? Productivity and public investment," New England Economic Review, Federal Reserve Bank of Boston, Jan, pages 3-22.

ton-miles of freight moved per unit of labor (either per employee or hours worked), we consider industry productivity or real Gross State Product (GSP) for the trucking industry. The primary reason for using this measure is that our interest is on industry productivity, measured at the level of establishments[38] within a state, and the economic value provided by the services generated by these trucking industry establishments to states.

We begin by presenting an overview of the trucking industry and by examining overall trends in the industry and the spatial distribution (at the state level) of trucking employment and labor productivity. We then go on to examine overall changes in highway infrastructure, as measured in lane miles of highways, VMT and related measures. We then consider statistical models of trucking employment and labor productivity.

The major sources of data used in the analysis are presented in Table 1. We used data from three sources: (1) Bureau of Economic Analysis (BEA) on employment and output; (2) U.S. Department of Transportation on highway statistics (Federal Highway Administration) and on airport freight/cargo activity (Federal Aviation Administration); and (3) U.S. Bureau of Census on state demographics and state expenditures that may also affect employment and economic output.

This section is organized as follows: in Section 2.1.2, we present major trends in trucking industry employment and statistical models of factors that may explain changes in trucking industry employment, including the effect of investments in highway infrastructure and other transportation factors. In Section 2.1.3, we consider the issue of the value of services generated by trucking establishments and also how such value may be affected by or related

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[33]Garcia-Mila, Teresa & McGuire, Therese J & Porter, Robert H, 1996. "The Effect of Public Capital in State-Level Production Functions Reconsidered," The Review of Economics and Statistics, MIT Press, vol. 78(1), pages 177-80, February

[34]Dalenberg, D.and R.W. Eberts, 1988. "Public infrastructure and economic development," Economic Commentary, Federal Reserve Bank of Cleveland, issue Jan 15.

[35]Hulten, C.R. and R. M. Schwab (1991)."Public Capital Formation and the Growth of Regional Manufacturing Industries." National Tax Journal, 43, 121-34

[36]Tatom, J. A. 1991. "Public capital and private sector performance," Review, Federal Reserve Bank of St. Louis, issue May, pages 3-15.

[37]Ford, Robert, and Pierre Poret. 1991. Infrastructure and Private-sector Productivity. OECD Economics Department Working Paper no. 91. Paris: Organization for Economic Co-operation and Development.

[38] An establishment, as defined by the Bureau of Labor Statistics, is the physical location of a certain economic activity—"for example, a factory, mine, store, or office". A single establishment generally produces a single good or provides a single service. An enterprise (a private firm, government, or nonprofit organization) can consist of a single establishment or multiple establishments. All establishments in an enterprise may be classified in one industry (e.g., a chain), or they may be classified in different industries (e.g., a conglomerate). (BLS; http://www.bls.gov/bls/glossary.htm#E Visited 10/15/2010)

to highway infrastructure and other transportation factors. Summary of the findings are given in 2.1.4.

Table 1: Sources of Data Used in Current Study

Dataset	Source
Employment by Industry Series SA25	Bureau of Economic Analysis
Real GDP (chained 2000 dollars)	Bureau of Economic Analysis
Highway Statistics Series	Federal Highway Administration
American Community Survey	U.S. Bureau of Census
Survey of State Government Finances	U.S. Bureau of Census
Air Carrier Activity Information System	Federal Aviation Administration

2.1.2. Trucking Employment

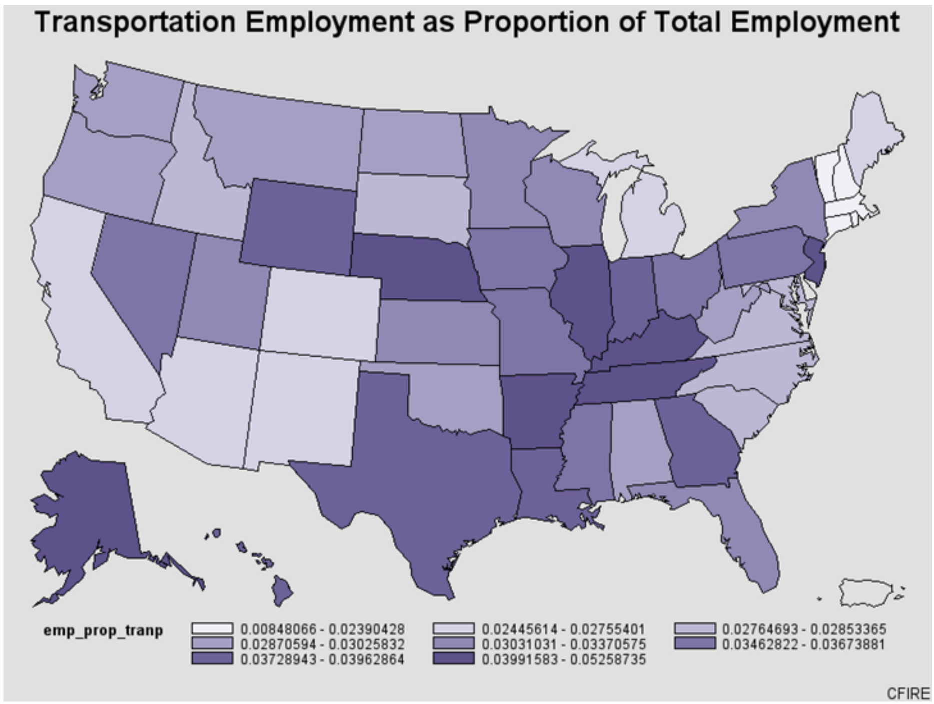
In 2007, there were an estimated 5.95 million employees in establishments that provide transportation of passengers and cargo, warehousing and storage for goods, scenic and sightseeing transportation, and support activities related to modes of transportation. These establishments comprise the transportation and warehousing industry and consist of the sectors given in Table 2. Overall, transportation and warehousing employment constituted 3.31 percent of all US employment, with the trucking industry comprising the largest share of that employment (2.18 million employees or 36.68 percent of transportation and warehousing employment).

Table 2: Transportation and Warehousing Employment in 2007

NAICS Sector No.	BEA Sector No.	Industry Sector	2007 Employment	Percent of Total 2007 Employment	Percent of 2007 Transportation & warehousing Employment
		Total employment	179,887,700	100.00	
48-49	800	Transportation and warehousing	5,949,900	3.31	100.00
481	801	Air transportation	513,300	0.29	8.63
482	802	Rail transportation	204,000	0.11	3.43
483	803	Water transportation	73,900	0.04	1.24
484	804	Truck transportation	2,182,600	1.21	36.68
485	805	Transit & ground passenger transportation	659,200	0.37	11.08
486	806	Pipeline transportation	41,900	0.02	0.70
487	807	Scenic and sightseeing transportation	43,500	0.02	0.73
488	808	Support activities for transportation	650,100	0.36	10.93
492	809	Couriers and messengers	861,700	0.48	14.48
493	811	Warehousing and storage	719,700	0.40	12.10

Figure 3 shows a map of transportation employment as a proportion of total employment by state. The highest rate of transportation employment over the 2001 through 2007 period is in the state of Alaska (at 5.3 percent), followed by Nebraska (at 4.8 percent) and then by Arkansas (4.7 percent), with the US average across states being 3.2 percent.

Figure 3: Transportation employment as proportion of total employment[39] (2007)



In terms of economic data, the trucking industry is comprised of two major categories of firms: those that offer general freight trucking and those that offer specialized freight trucking. These are given, along with their North American Industry Classification System (NAICS) code in Table 3.

Table 3: Trucking Industries and NAICS Codes

484 Truck Transportation
- 4841 General Freight Trucking
  - 48411 General Freight Trucking, Local
  - 484110 General Freight Trucking, Local
  - 48412 General Freight Trucking, Long-Distance
  - 484121 General Freight Trucking, Long-Distance, Truckload
  - 484122 General Freight Trucking, Long-Distance, Less Than Truckload

[39]Source: Bureau of Economic Analysis: SA25

4842 Specialized Freight Trucking
48421 Used Household and Office Goods Moving
484210 Used Household and Office Goods Moving
48422 Specialized Freight (except Used Goods) Trucking, Local
484220 Specialized Freight (except Used Goods) Trucking, Local
48423 Specialized Freight (except Used Goods) Trucking, Long-Distance
484230 Specialized Freight (except Used Goods) Trucking, Long-Distance

General Freight Trucking uses motor vehicles, such as trucks and tractor-trailers, to provide over-the-road transportation of general commodities and total close to 70,300 establishments across the United States, with 29,400 Local Trucking establishments, which carry goods primarily within a single metropolitan area and its adjacent non-urban areas and 40,000 Long-Distance Trucking establishments, which engage primarily in providing trucking between distant areas and sometimes between the United States and Canada or Mexico. *Specialized Freight Trucking* provides over-the-road transportation of freight using specialized equipment such as flatbeds, tankers or refrigerated trailers and includes the moving industry and also consists, like General Freight Trucking, of local and long-distance components. The specialized freight trucking sector contained 47,600 establishments in 2008.

Employment in the trucking industry comprises the largest share of transportation and warehousing sector employment (2.18 million employees or 36.68 percent of transportation and warehousing employment). The Bureau of Labor Statistics (BLS) noted that growth in the truck transportation and warehousing industry "reflects ups and downs in the national economy" and also that job opportunities are expected to be favorable for truck drivers and diesel service technicians[40]. BLS estimated that the number of wage and salary jobs in the truck transportation and warehousing industry is expected to grow 11 percent from 2008 through 2018, equal to the projected growth for all industries combined. In terms of productivity, with the three occupations with the greatest total projected job gains through 2014 being driver/sales workers and truck drivers; truck drivers, heavy and tractor-trailer; and truck drivers, light or delivery services. By examining past data, we seek to answer one important question that arises: the extent to which local trucking job growth can be affected by investments in highway infrastructure.

Most employees in the truck transportation and warehousing industry work in small establishments. Fewer than 5 workers are employed by 62 percent of trucking and warehousing establishments. Consolidation in the industry has reduced the number of small, specialized firms. Occupations with the trucking industry include four major occupational categories, including: (1) Management, business, and financial occupations, which comprise about 4 percent of all trucking industry jobs, and include management occupations and business and financial operations occupations; (2) Office and administrative support occupations, including customer service representatives, clerical positions, dispatchers and fillers – together they 16.6 percent of all trucking sector jobs; (3) installation, maintenance

[40]U.S. Bureau of Labor Statistics. Career Guide to Industries. 2010-2011 Edition

and repair occupations, comprising 4.2 percent; and (4) transportation and material moving occupations, including heavy and tractor-trailer truck drivers, light or delivery services truck drivers, industrial truck and tractor operators, supervisors, packers and packagers and laborers, stock and material movers. Overall, this fourth category of occupations constitute more than 70 percent of trucking sector jobs, with truck drivers forming the largest share of all trucking sector occupations (at 44 percent of the total number of trucking jobs).

In the truck transportation sector, the three occupations with the highest total projected employment are driver/sales workers and truck drivers; heavy and tractor-trailer truck drivers; and hand laborers and material movers[41]. The three occupations with the greatest total projected job gains are driver/sales workers and truck drivers; truck drivers, heavy and tractor-trailer; and truck drivers, light or delivery services.

From 1977 to 2000, which ends immediately prior to our study period, overall transportation investment (including household purchase of rolling stock) on average accounted for more than 6% of GDP[42]. Of this overall transportation investment, investment in rolling stock accounted for an average of 83%, and that in transportation infrastructure and other transportation equipment averaged 14% and 3%, respectively. The share of highways in the total infrastructure investment stayed almost the same, averaging 66%, but the relative shares for other modes changed significantly during 1977-2000, with air almost doubling and pipeline dropping by about 90%.

During the study period, lane miles of highways increased by 2.48 percent nationwide, while total VMT increased by 8.27 percent. There are large variations among states in the percentage increase in highway lane miles and total VMT. Several states which incurred higher percentage changes in lane miles such as Arizona, New Mexico, Florida, Alaska and Washington, are also states where trucking employment increased the greatest in the 2001 through 2007 period (as can be seen in Figures 4 and 5).

However, the relationships between highway infrastructure and trucking is far from clear, because states such as Nevada and Michigan where trucking employment greatly increased during this period, is also where, based on HPMS data, the stock of highways actually declined during this period due to decommissioning or other reasons. During the study period, there appears to be two “spatial bands” or clusters of proximate states, where trucking employment increased the greatest, one of which is in the south (including Texas, New Mexico, Arizona, Nevada, and to a certain extent, California) and the second along the middle of the country, starting with Michigan in the east, leapfrogging to Iowa and continuing to Nebraska and Wyoming. However, there was considerable amount of economic growth in some of these states with large gains in trucking employment.

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[41] ibid

[42] Transportation Investment and GDP, Some Concepts, Data, and Analysis. Bureau of Transportation Statistics. 2004

Figure 4: Percentage Change in Lane Miles and Total VMT (2001-2007)

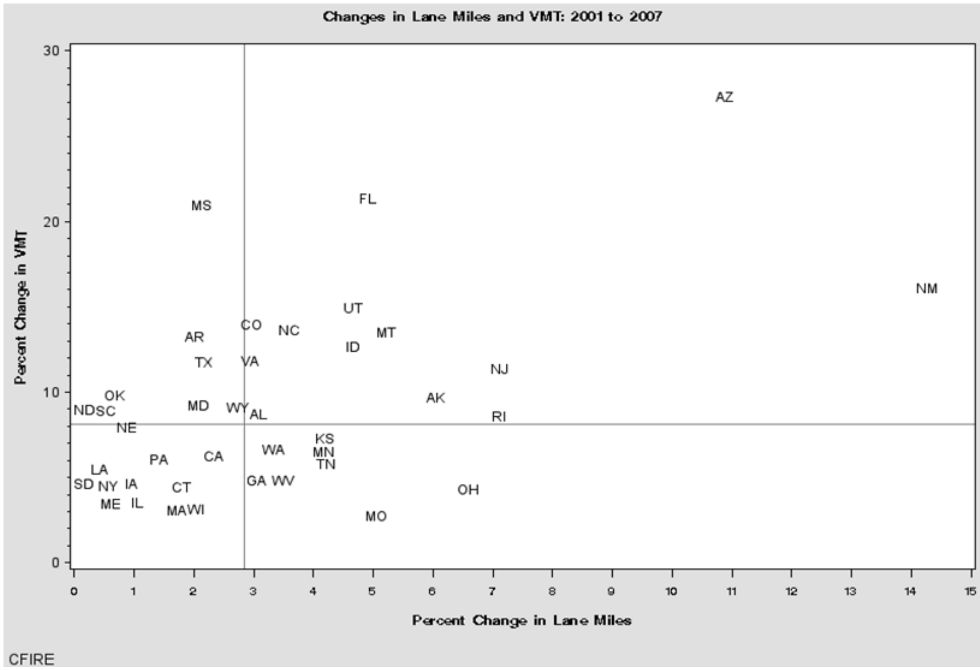
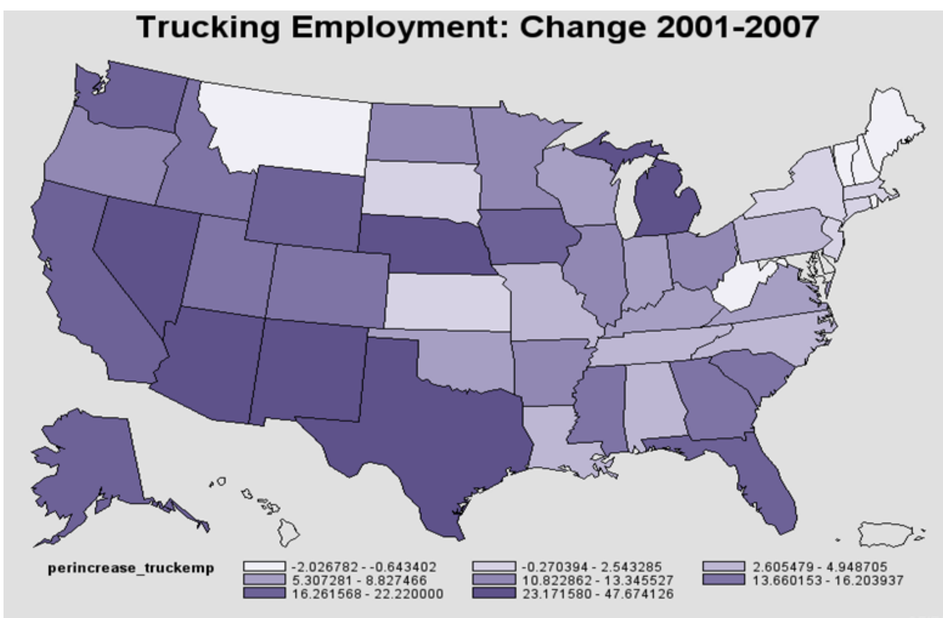


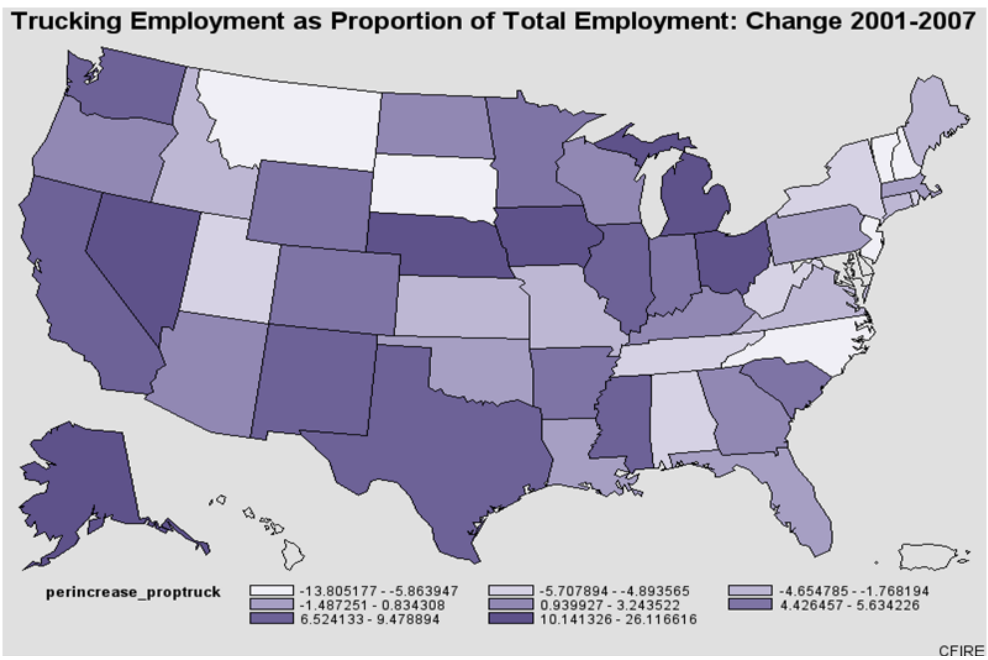
Figure 5: Percentage Change in Trucking Employment by State: 2001-2007[43]



43 Source: Bureau of Economic Analysis: SA25

Figure 6 shows percentage changes between 2001 and 2007 in trucking employment as a proportion of all employment. The southern "spatial band" becomes less prominent, but the Midwestern/Plains band remains, with a continuous "corridor" starting with Ohio in the east, continuing through Michigan, Indiana, Illinois, Iowa, Nebraska and Wyoming, indicating that in these states, trucking employment growth compared to all employment growth was stronger than in the rest of the country. Ohio, Michigan, Indiana, Illinois and Iowa also score among the top 20 states in lane mile per square mile of land, a measure of road density that will be subsequently used in the statistical analysis, although these states did not witness high rates of changes in lane miles during the study period (except for Ohio).

Figure 6: Percentage Change in Trucking Employment Share of Total Employment by State: 2001-2007



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Our overall goal for the state-level analysis is to understand how states vary with the level of trucking industry employees and whether this relationship has changed over time. Additionally, we seek to understand the extent to which changes in transportation infrastructure, particularly highway lane miles, may have affected trucking sector employment. We utilize statistical techniques for this purpose. We have considered longitudinal data, from 2001 through 2007.

We present the results of a statistical model that relates highway infrastructure and performance measures to trucking employment. The panel data covers the period 2001 through 2007. The unit of analysis is a state. We posit an initial random effects model

$$trucking\_employment_{i,t} = X_{i,t}\beta + Z_i b_i + \varepsilon_i,\ i = 1,..,I, t = 1,..,T \quad (1)$$

where *trucking_employment* is the response vector of the trucking employment series for state i, I is the number of states, T is the number of years, X is a covariate matrix, Z is a matrix of random effects, β is the vector containing the fixed effect coefficients, b_i is the vector containing the random effect coefficients, and ε_i is the vector of residual components. The presence of the random effects explicitly recognizes natural heterogeneity amongst the states. The design matrix X consists of three classes of factors described in greater detail below: *SEF* are socioeconomic factors, *TF* are transportation factors and *LF* are location factors.

In the models considered here, we consider only one random effect, the intercepts, which are assumed to be state-specific. It might be noted that random effects for time-independent covariates might in general be interpreted as subject-specific corrections to the overall mean structure of *trucking_employment*. This makes them very similar to random intercepts, although time-independent covariates do enable one to model differences in variability between subgroups of respondents or measurements. The random intercepts allow us to account for natural heterogeneity amongst states as well as omitted variables relating to intrinsic factors that are not easily available from the observed data. We could have introduced additional random effects for those covariates that vary over time; however, our purpose here is to start with an initial model that allows to model the mean of $trucking\_employment_i$ adequately and yet identify outlying states, which is enabled by the introduction of random intercepts.

In initial models, we model $\varepsilon_i \sim N(0, \sigma^2 I_{n_i})$ which assumes that all the variability in the data, which is not taken into account by the random effects (which model the stochastic variability between subjects) is purely measurement error. Later on, this assumption is relaxed to allow for a more realistic covariance structure for the residuals, specifically an autoregressive structure, AR(1), is followed. It should be noted that we have not considered the effect of lagged variables in the modeling structure as yet; hence the assumption in the model is that input factors affect trucking employment within the year of measurement. It is possible that more sophisticated modeling structure such as autoregressive distributed lag models, may be a more realistic approach to modeling the structure. Currently, the model is not capable of yielding insights into any adjustments in levels of trucking employment that may occur with change in policy variables over time. Additionally, earlier attempts to assess endogeneity, using Hausman tests on cross-sectional data (for 2007), did not reveal the presence of reverse causality between trucking employment and infrastructure; such a result may be valid because trucking employment, overall, is only a small component of all state employment, but these effects should also be fully tested using the full panel dataset. The random effects is taken to be $b_i \sim N(0, D)$; the covariance structure for the random effects are modeled to be a general unstructured covariance matrix, i.e., a symmetric positive (semi-) definite matrix *D*, which does not assume the random effects covariance matrix to be any specific form.

The variables considered in explaining state-level trucking employment are give in Table 4. The major SEF's considered are overall state GDP, state population, two factors that attempt to measure working capacity and a final variable that captures the role of public investments in generating state level economic development. Limitations to workforce capacity is measured by the percent of workforce older than 65 years of age and percent of population without a high school degree. Given the role of state government expenditures on public services in determining state economic growth, we use data on real total state public expenditures to account for additional governmental interventions in promoting employment. The mean expenditure level, across all sectors, states and time periods considered, is $29.16 billion.

We considered three transportation variables to understand ways in which infrastructure may affect trucking employment. These are:

Lane Miles Per Square Miles: We took highway lane miles data available from the HPMS and divided it by total land area to create a measure of road density. Nationally, this measure changed from an average of 3.80 lane miles per square miles in 2001 to 3.91 in 2007 (excluding the District of Columbia). Ten states that gained the most in this measure are New Mexico, Arizona, New Jersey, Rhode Island, Ohio, Alaska, Montana, Missouri, Florida and Idaho.

Congestion Index: We created an index of congestion by divided total state annual Vehicle Miles Traveled (VMT) by total lane miles of highway. During our study period, this measure changed slightly, from 0.35 in 2001 to 0.37 in 2007. While the measure reflects how traffic demand has changed relative to highway infrastructure over time, this is admittedly a crude measure of congestion, since the largest bottlenecks are likely to be concentrated in urban areas within a state.

Landed Weight: Air freight had increased considerably during the study period, with strong implications for truck transportation. Hence we considered landed weight of cargo as obtained from the Air Carrier Activity Information System (ACAIS), a database that contains revenue passenger boarding and all-cargo data, which supports FAA's Airport Improvement Program (AIP)[44]. The data are for "qualifying cargo airports". Landed weight at qualifying airports was aggregated to the level of states. Air cargo had generated an average of 4179.71 million lbs of cargo landed weight in qualifying airports

[44] http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/

per state in 2001, which increased to 4992.71 million lbs in 2007. By this measure, Tennessee and Nevada experienced the largest increases in freight cargo during the study period. Overall, intermodal transportation will increasingly play an important role and the variables that capture the effects of ports and railroads should be included in future studies.

Total Tons of Cargo at Primary Ports: In order to investigate the effects of waterborne cargo on trucking employment and productivity, we use cargo data from principal U.S. Coastal, Great Lakes and Inland Ports[45]. The public domain data files used here contain state to state and region to region tonnages for 14 major commodity groups by origin and destination. Each file lists the state or region abbreviation for origin and destination, commodity code, tonnage and year. These numbers were aggregated over all commodity groups and over all cargo arriving into and departing from each state, to arrive at a single estimated level of water cargo per state per year.

As discussed earlier, state location potentially has a strong effect on trucking employment. Ideally, our model should have considered spatial effects and the potential for the presence of spatial autocorrelation in trucking employment by state. This highly important step is left for future research. To address the problem, and the impacts of spatial autocorrelation on inference, we decided to include "location" dummies that capture the location of the state within spatial clusters that are homogeneous with respect to their economic behavior. As a first step, we could have used the BEA clusters - the Bureau of Economic Analysis (BEA) has grouped the states into eight regions based primarily on cross-sectional similarities in their socioeconomic characteristics. This paper groups states into eight regions based on the similarities in state business cycles, based on a method given by Crone[46]. Dummy variables were created to indicate the cluster to which a state belongs (given in Table 4)

The results show that overall state output has a significant effect on trucking employment over time, potentially due to induced demand for goods associated with higher output. Population is also significantly related to trucking employment; an increase in population by a million people yields close to 2690 new trucking jobs, controlling for other factors. We did not find the proportion of seniors to have a discernible effect on trucking employment. However, the proportion of population without high school degree is significantly and positively related to trucking employment, leading to the policy conclusion that training in the trucking sector should continue to be a workforce development strategy for states with lower levels of high school graduates overall.

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[45] http://www.ndc.iwr.usace.army.mil//data/datapdom.htm

[46] Crone, Theodore .M. An Alternative Definition of Economic Regions in the United States Based on Similarities in State Business Cycles. The Review of Economics and Statistics. November 2005, Vol. 87, No. 4, Pages 617-626.

Table 4: Results of Trucking Employment Model

Parameter	Variable Type	Description	Mean	Parameter Estimates
Intercept		Intercept		-21,483.00
Socio-economic Factors				
GDP_All	Continuous	Total GDP (in million of USD)	257,313.80	0.11 *
population	Continuous	Population (millions)	5.94	2,711.34 *
propover65	Continuous	Percent over 65 years of age	0.07	219,022.00
propwhighed	Continuous	Percent without high school degree	0.22	80,675.00 *
total_stateexpenditure	Continuous	Total state expenditures on all sectors (in millions of USD)	29,158.57	-0.18 *
Transportation Factors				
lane_mile_per_sqmile	Continuous	Lane mile per square mile of land	4.97	616.20
congestion	Continuous	Total VMT per lane mile	0.37	-19,437.00 **
Landed_Weight	Continuous	Total landed cargo weight at qualifying airports (trillions lbs.)	2,515.13	-0.13 *
Primary_Port_Cargo	Continuous	Total freight originating & terminating in primary water ports	68,686,749	-0.0000077
Location Factors				
New_England	Dummy: (base Plains#)	Maine, New Hampshire, Vermont, Massachussetts, Rhode Island, Connecticut	0.12	-19,110.00
Mideast	Dummy: (base Plains#)	New York, New Jersey, Pennsylvania, Delaware, Maryland	0.08	-33,112.00 **
Southeast	Dummy: (base Plains#)	Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Mississippi, Arkansas	0.20	6,866.23
Great_Lakes	Dummy: (base Plains#)	West Virginia, Michigan, Ohio, Indiana, Illinois, Wisconsin, Minnesota	0.14	6,711.57
Northern_Mountains	Dummy: (base Plains#)	South Dakota, North Dakota, Idaho, Missouri	0.08	-2,161.33
Far_West	Dummy: (base Plains#)	Arizona, California, Nevada, Oregon, Washington	0.10	-14,742.00
Energy Belt	Dummy: (base Plains#)	Louisiana, Wyoming, Utah, Colorado, Texas, Oklahoma, New Mexico		2,711.01

* Significant at p<.01; ** Significant at p<.05; *** Significant at p<.10

[#] Plains Cluster consists of the states of Nebraska, Iowa, Kansas, Missouri

-2 Res Log Likelihood	5748.8
AIC (smaller is better)	5752.8
N	425

Overall state government expenditures have a significant and negative effect on trucking employment. Across the US, the largest state-level general expenditure, by function, is on education, followed by public welfare. It is possible that trucking employment is negatively affected by state expenditures due to its emphasis on increasing human capital and skill sets and public assistance, both of which are not necessary for the vast majority of trucking jobs. It should be noted that 6 percent of state expenditures are on highways, but we took these amounts out, in order to avoid double-counting due to the presence of the transportation variables in the model.

Except for the Mideast region (consisting of the states of New York, New Jersey, Pennsylvania, Delaware and Maryland), the other locational indicators are not significantly related to trucking employment (the base is the Plains states, consisting of Nebraska, Iowa, Missouri and Kansas). Controlling for the other factors, the New England, the Mideast, Northern Mountain and Far West states have fewer trucking employees than the Plains; the Southwest, the Great Lakes and the Energy Belt have more trucking employees.

The model provides evidence that controlling for other factors, congestion, as defined earlier, has a significant negative effect on trucking employment. This is intuitively reasonable since trucking establishments may be more likely to locate in states where congestion is lower. However, this result should also be interpreted with caution; a limited number of states which are very small, urbanized and highly congested based on our measure, may be having an undue effect on this estimate. Also, this variable may be simply capturing the degree of urbanization. This result should be further investigated.

Landed cargo weight has a significant positive effect on trucking employment, indicating the role that increased cargo and increased intermodal transportation may have on the future of trucking employment. As noted earlier, variables that capture the effects of ports and railroads should be included in future studies.

We find no evidence that lane miles per square miles is statistically related to trucking employment at any reasonable level of significance. This could be due to a number of reasons: first, the highway system is already very mature and additions to it over time has been very limited. Hence, its marginal effect on trucking employment may be negligible at this time. Second, highways, as noted by other researchers, may be a necessary but not sufficient condition to induce trucking employment. Third, the relationship between highways and trucking employment may be far more complicated than a one-way or even a two-way relationship, but may be mediated by intervening factors such as response in terms of increasing lane miles as a result of economic growth and overall increases in traffic, which in turn stimulates additional demands for trucking and hence, to trucking sector jobs. These linkages are best addressed in a structural equation modeling framework. Moreover, there may be long-term lagged adjustment effect, which our model is not capable of capturing. These limitations should be addressed in future research.

Based on the current set of results, an overall policy implication is that investments in additional highway lane miles may not be fruitful in increasing trucking employment unless congestion is inhibiting economic growth or attracting trucking businesses to the state. Infrastructure and operational strategies to address bottlenecks that are targeted to mitigating congestion may be more useful policy instruments. Providing for intermodal freight transportation and investments in such facilities may also be a fruitful venue towards increasing trucking employment. Workforce development initiatives in states with higher levels of population with low skills could generally be fruitful towards increased trucking sector jobs and for the attraction of trucking businesses there. Finally, the overall effect of increased economic output has many beneficial effects on society, with increases in trucking employment being a significant one, as our results show.

2.1.3. Productivity in Trucking Industries and Relationship to Highway Infrastructure and Performance

Since the late 1980s, a large amount of research has been conducted to measure the impact of public infrastructure (including highways) on economic performance, economic growth, and productivity[47]. The production function is a relationship between the total production of real output for an economy and the amount of inputs, which usually include capital and labor. Later, research used cost functions to estimate this type of relationship[48,49]. The cost function gives the minimum cost of producing a given level of output from a specific set of inputs. In this section, we use an empirical model to estimate the relationship that productivity (as measured by real GDP in the trucking sector per trucking industry employee) has to highway infrastructure and highway performance. We begin with an exploratory assessment of trucking industry productivity and then we go on to present the results of a statistical model of trucking industry productivity.

Real output (measured in terms of GDP per state in chained 2000 dollars thereby adjusting GDP for the effect of a change in the price level - thus, a measure of real growth without inflation) increased for all industries from $9.8 trillion in 2001 to $11.4 trillion in 2007 period (see Figure 7) with an average annual growth rate of 2.55 percent, but the rate of growth was

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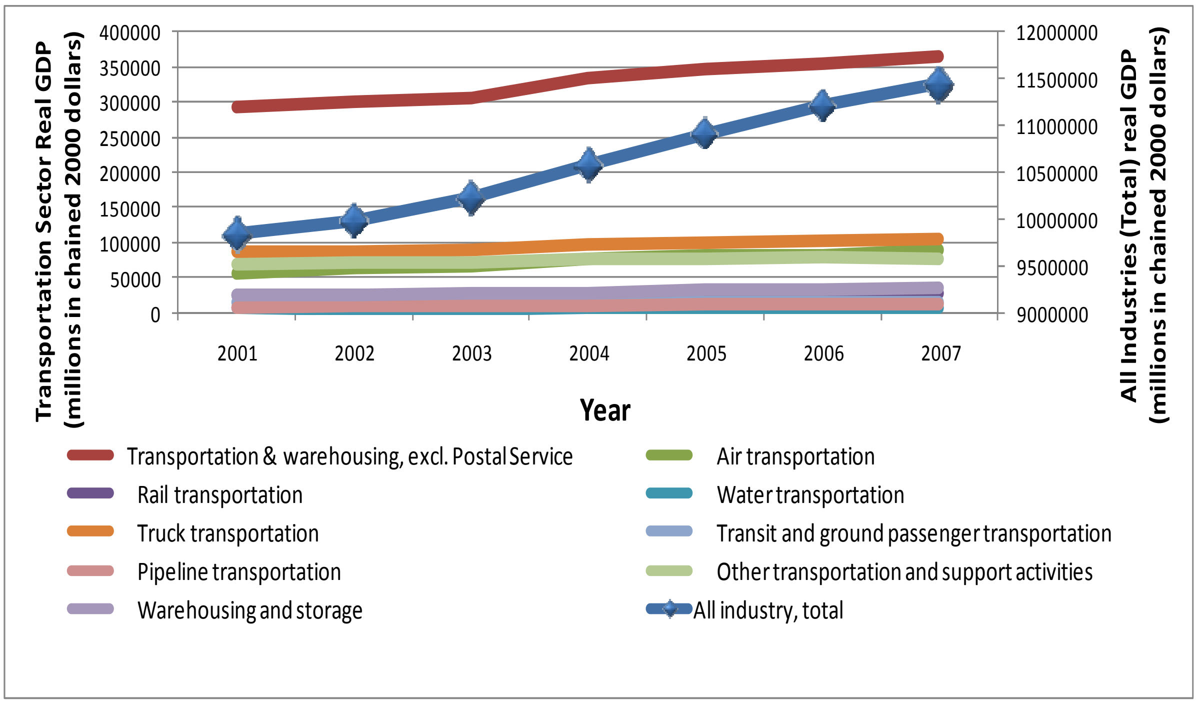
[47] See 2.1.1 for a list of literature on this topic

[48] T.E. Keeler and J.S. Ying, Measuring the benefits of a large public investment: the case of the US federal aid highway system, Journal of Public Economics 36 (1988), pp. 69–85

[49] Morrison, Catherine J., and Amy Ellen Schwartz. 1996. "State infrastructure and productive performance."American Economic Review. 86, 5: 1095–1111.

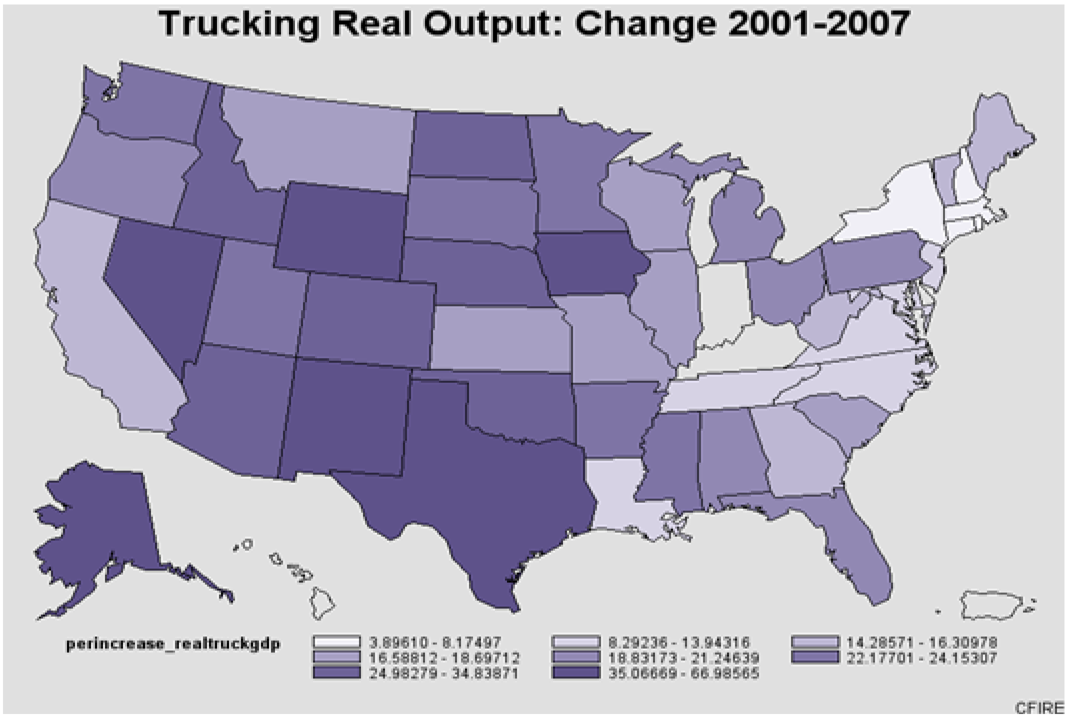
higher in the transportation and warehousing industry overall (at 3.1 percent). Transportation and warehousing output, overall, was an average of 3.09 percent of total industry output. Although rates of real output growth in trucking were outperformed by air, warehousing and storage and pipeline transportation industries, trucking output remained the largest share of total transportation and warehousing industry output by 2007, at close to 29 percent. It can be seen from the top panel of Figure 8 that real GDP for trucking increased considerably during 2001 through 2007 in certain states located in the central part of the country, including Wyoming, Nevada, New Mexico, Texas, Arizona, Oklahoma, and Idaho. When considered on a per trucking employee basis, the most significant gains are to a cluster of states in the north-central part (Wyoming, North and South Dakotas, and Montana) and the north-eastern (Vermont, Maine, Pennsylvania, and West Virginia) part of the country.

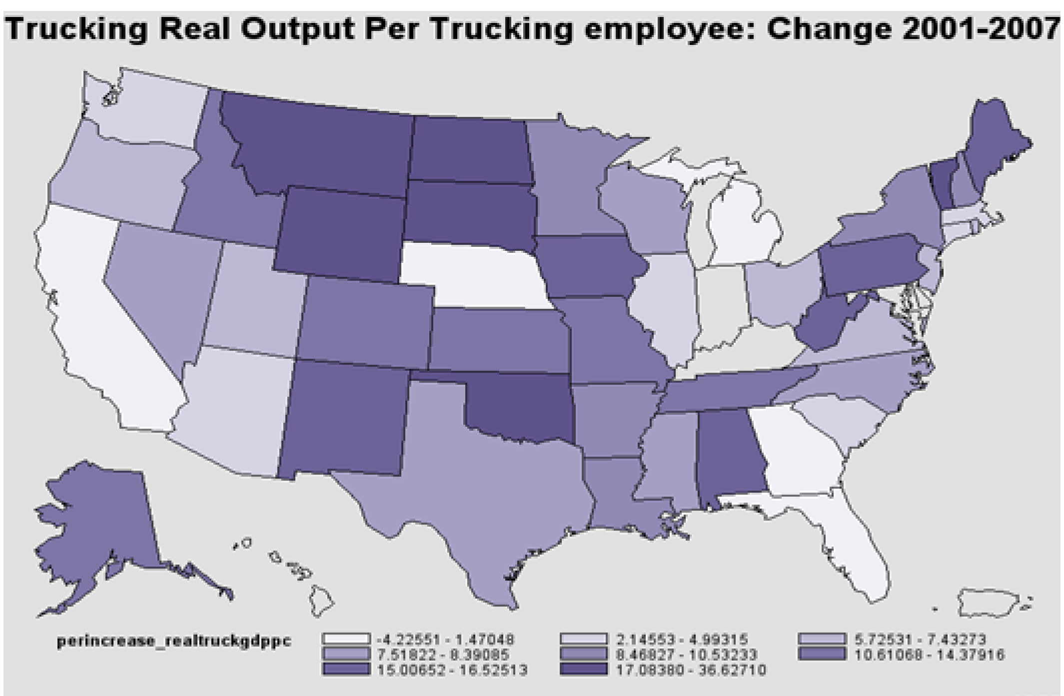
Figure 7: Real GDP (chained 2000 dollars in millions)for 2001 through 2007



One hypothesis is that the addition of highway capacity or changes in other measures of transportation performance affects productivity of the freight sector. As indicated earlier, most freight productivity measures uses estimates of ton-miles of freight moved per employee. Overall, trucking has been noted to be a "dynamic" industry, where, with declining price of transportation and costs of assembling loads, the quantity of freight and the average distance of freight movements has been noted to have increased. The trucking industry's adoption of information technology and the deregulation have led to rapid increases in freight ton-miles. Ton-miles as an output measure is appropriate when addressing the question of how improvements in transportation infrastructure through an area affect the efficient movement of freight through that area.

Figure 8: Changes in Trucking Output and in Output per Trucking Employee: 2001-2007





The focus of the current study is on local economic development and workforce development. Hence, we use more traditional measures of productivity, where the output is measured in real GDP. We note that BEA estimates trucking GDP by state (as it does for GDP estimates in a total of 64 industries) using three components: compensation of employees, taxes on production and imports less subsidies and gross operating surplus for establishments within an industry in a state. The estimates of real GDP by state are derived by applying national implicit price deflators to the current-dollar GDP by state estimates for the detailed industries[50]. These estimates of real GDP by state reflect the uniqueness of each state's industry mix, but they do not reflect differences by state in the prices of goods and services produced for local markets.

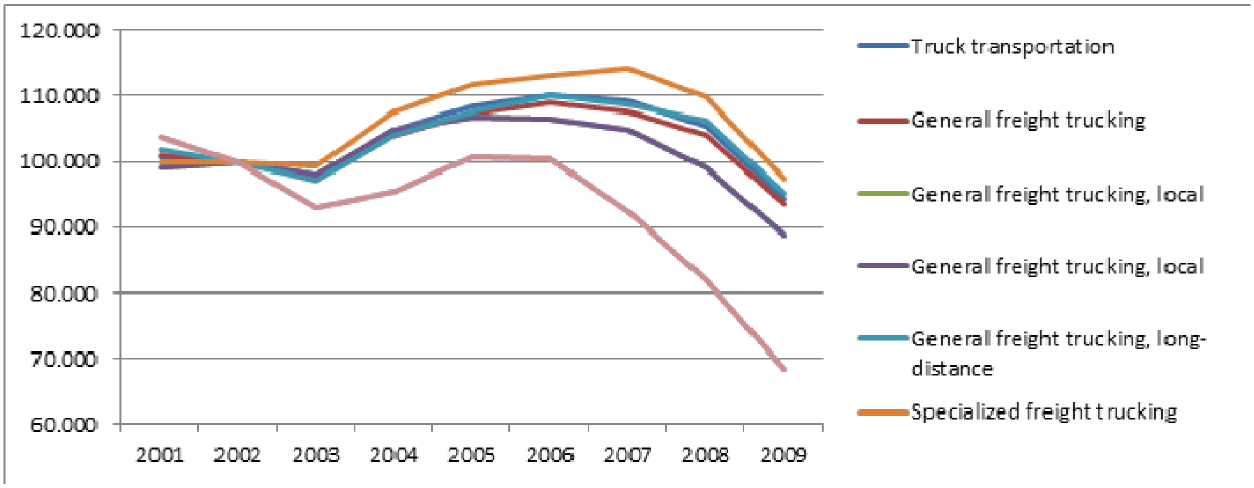
Productivity measures are typically given in terms of output per hour worked. According to BLS[51], in 2008, workers in the truck transportation industry averaged 41.5 hours a week, compared with 33.6 hours in all private industries.

There have been several major changes to the interstate truck drivers' hours of service regulation in the last decade. In 2003, the first major change in the hours of work since the 1960's went into effect. Before the change, drivers could drive 10 hours out of a 15-hour work day with a minimum of 8 hours of rest between driving. After 2003, however, drivers were permitted to drive 11 hours out of a 14-hour work day. The rule also limited the total hours of driving to 60 hours in a 7-day span or 70 hours in an 8-day span. In 2005, additional changes were made[52] to require drivers to take 10 hours of rest between driving. This increased the minimum "cycle time", the number of hours to complete the driving and required rest, from 18 to 21. But, a driver can "reset" the consecutive work time accumulation by taking a 34-hour break. Thus, a driver can accumulate 60 hours of driving in 5 days and then go into a 34-hour rest to reset the accumulated driving hours to zero. Hours for other workers in the industry (in managerial, office, sales, maintenance, laborer and support positions, for example) vary based on their duties.

Overall, the hours worked in the trucking industry has declined over time. Figure 9 shows an indexed series for the 2001 to 2009 nationally, of hours worked, with 2002 as base. Hours worked has declined more strongly in general freight trucking – a trend that started with a peak in 2006. By 2007, all major trucking industries experiences a decline in hours worked.

[50]http://www.bea.gov/newsreleases/regional/gdp_state/2010/pdf/gsp1110.pdf. Accessed
[51]U.S. Bureau of Labor Statistics.Career Guide to Industries. 2009
[52] There was a brief time period in 2004 during which the 2005 rule took effect, but it was vacated by the US court of Appeals decision.

Figure 9: Hours worked by type of trucking industry: Index with base year 2002



Source: Bureau of Labor Statistics, Industry Employment and Hours Worked data tables.

The analysis presented next uses real GDP per trucking employee, and not hours worked, due to data availability issues. A limitation of this approach is that the full intensity of labor input may not be appropriately captured by our measure of productivity. We use the same modeling specification as in the case of the model of trucking employment, but with slightly different SEL, TF and LF variables, with variable selection done on the basis of measures of fit. The variables used are given in Table 5.

We find that population density and the proportion of population over 65 years has a small but significantly negative relationship to trucking industry productivity. An increase in the proportion of individuals without high school level education leads to a decrease in trucking industry productivity; however, this effect is not significant. Trucking productivity in states located in the New England, Mideast and the Great Lakes areas are higher than those in the Plains states; states located in the Southeast, Northern Mountains, Far West and Energy Belt are less productive with respect to the trucking industry than industries in the Plains states. The location effects, however, are only statistically significant for Southeast and Energy Belt states.

The airport effect that we reported on with respect to trucking employment persists with respect to trucking productivity. States with high levels of airport cargo activity generally tend to have higher trucking industry productivity. The relationship of trucking employment to air cargo was previously explained by greater demand for landside freight transportation (and consequently, greater jobs in trucking). However, air cargo and trucking productivity may have a less obvious relationship. One reason could be that air freight generates high-value cargo. It generally is the case that transportation of high-value goods command higher rate. Thus, the states that generates large amount of air freight tend to produce greater amount of output per employee. Second, because of its technology and logistics focus, there may be reason to believe that air cargo stimulates higher wage labor than traditional trucking, and since GDP measurements include compensation of employees, taxes on production and imports less subsidies and gross operating surplus, these factors would be reflected in higher output, overall.

We find that, *ceteris paribus*, lane miles per square mile have a weakly significant and positive relationship with trucking industry productivity, whereas congestion, as measured by our index, does not. This finding is, of course, the reverse of what we found with trucking employment. Personal compensation per employee generally tends to rise with lane miles per square mile as seen in Figure 10; this indicates that states with greater lane density (which also tend to be states with greater population density, as shown in Figure 11, and are the more urbanized states) attracts trucking establishments with a workforce that is higher paid, thus leading to greater output, as measured by the GDP. Once again, this pattern is potentially correlated with differences in the type of cargo that is handled in higher density states versus lower density states, with a greater share of personal delivery-type operations in higher density states, utilizing higher technology operations, in contrast to moving or manufacturing related freight transportation.

2.1.4. Summary

In this section, the relationships between trucking sector employment and also productivity and highway infrastructure and truck travel were analyzed with annual data from 2001 to 2007 using statistical models. In the analysis, various socioeconomic factors were included to control for the effect of the overall size of state economy, population, educational attainment, etc.

We found that congestion as measured by total VMT divided by lane miles of highway has negative effect on trucking sector employment but not on productivity. Meanwhile, road density, measured in lane miles per square mile, has no effect on employment but has a weak effect on productivity. Therefore, we did not find a conclusive evidence that building roads increases trucking employment or productivity. The most important factor related to infrastructure seems to be the air cargo volume. Both employment and productivity are positively and significantly affected by the landing tons of air cargo.

Table 5: Model of Real GDP per Employee in the Trucking Industry

Variable	Variable Type	Description	Parameter Estimates
Intercept		Intercept	0.06413 *
pop_density	Continuous	Population per square mile	-6.33E-06 **
propover65	Continuous	Percent over 65 years of age	-0.1846 *
propwhighed	Continuous	Percent without high school degree	-0.02312
lane_mile_per_sqmile	Continuous	Lane mile per square mile of land	0.000903 ***
congestion	Continuous	Total VMT per lane mile	0.005957
landed_weight1	Continuous	Total landed cargo weight at qualifying airports (trillion lbs.)	1.13E-08 *
airport_no	Continuous	Number of qualifying airports	-0.00013
Primary_Port_Cargo	Continuous	Total freight originating & terminating in primary water ports	-9.36E-12 *
New_England	Dummy: (base Plains#)	Maine, New Hampshire, Vermont, Massachussetts, Rhode Island,	0.000374
Mideast	Dummy: (base Plains#)	New York, New Jersey, Pennsylvania, Delaware, Maryland	0.004788
Southeast	Dummy: (base Plains#)	Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Mississippi, Arkansas	-0.00713 *
Great_lakes	Dummy: (base Plains#)	West Virginia, Michigan, Ohio, Indiana, Illinois, Wisconsin, Minnesota	0.000259
Northern_Mountains	Dummy: (base Plains#)	South Dakota, North Dakota, Idaho, Missouri	-0.00183
Far_West	Dummy: (base Plains#)	Arizona, California, Nevada, Oregon, Washington	-0.00021
Energy Belt	Dummy: (base Plains#)	Louisiana, Wyoming, Utah, Colorado, Texas, Oklahoma, New Mexico	-0.00456 **

* Significant at p<.01; ** Significant at p<.05; *** Significant at p<.10

Plains Cluster consists of the states of Nebraska, Iowa, Kansas, Missouri

-2 Res Log Likelihood	-2867.6
AIC (smaller is better)	-2863.6
N	334

Interestingly, the percent of population without high school was found to be positively associated with trucking employment, suggesting that for people who do not complete high school, trucking is a viable form of employment (presumably because obtaining commercial driver's license does not require high school diploma).

One policy implication of this analysis is that streamlining operations, via targeted infrastructure improvements may be fruitful in jointly leading to overall increases in trucking industry productivity. Simply adding lane miles, as far as the analysis results are concerned, does not seem to contribute to the increase in the trucking sector productivity nor employment. A second implication is that increases in private trucking innovative technology approaches may lead to large gains in trucking industry productivity.

Current technology emphasis by means of US DOT's Intellidrive^{SM} program, use of 802.11P wireless communications and advancements in DSRC technology may be greatly important in future "jobless" growth in the trucking sector. It is quite likely that the types of trucking companies identified above will benefit from these advances. The real policy challenge will be to determine how labor-extensive trucking operations can benefit from these advancements and yet remain an important repository of low-skilled jobs, while improving overall productivity.

Figure 10: Private Compensation per Employee and Lane Mile Density

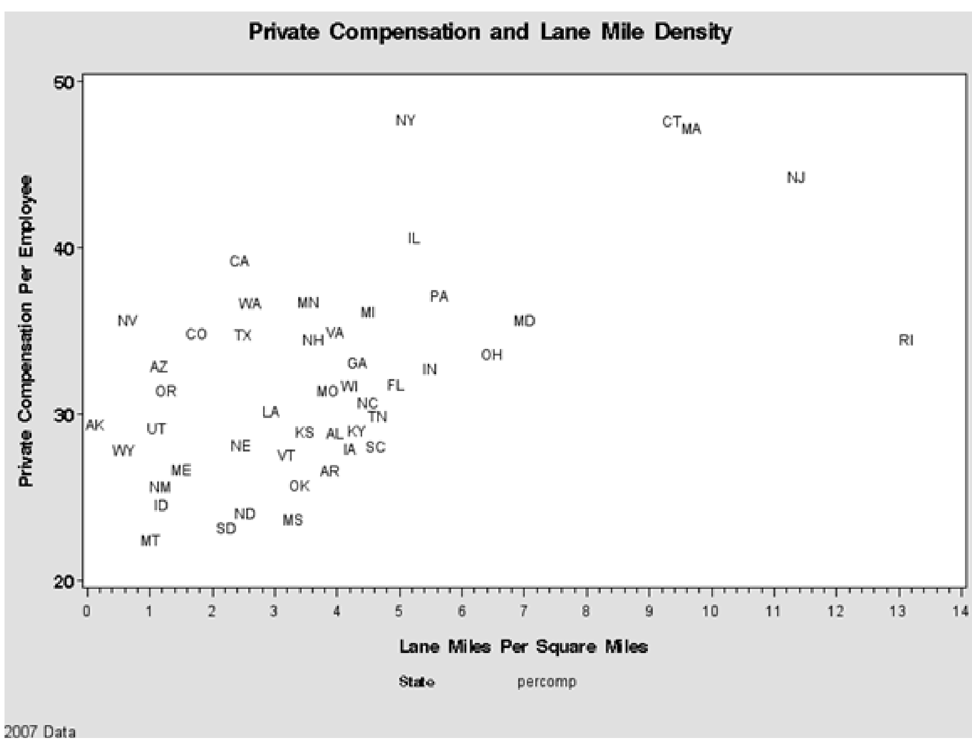
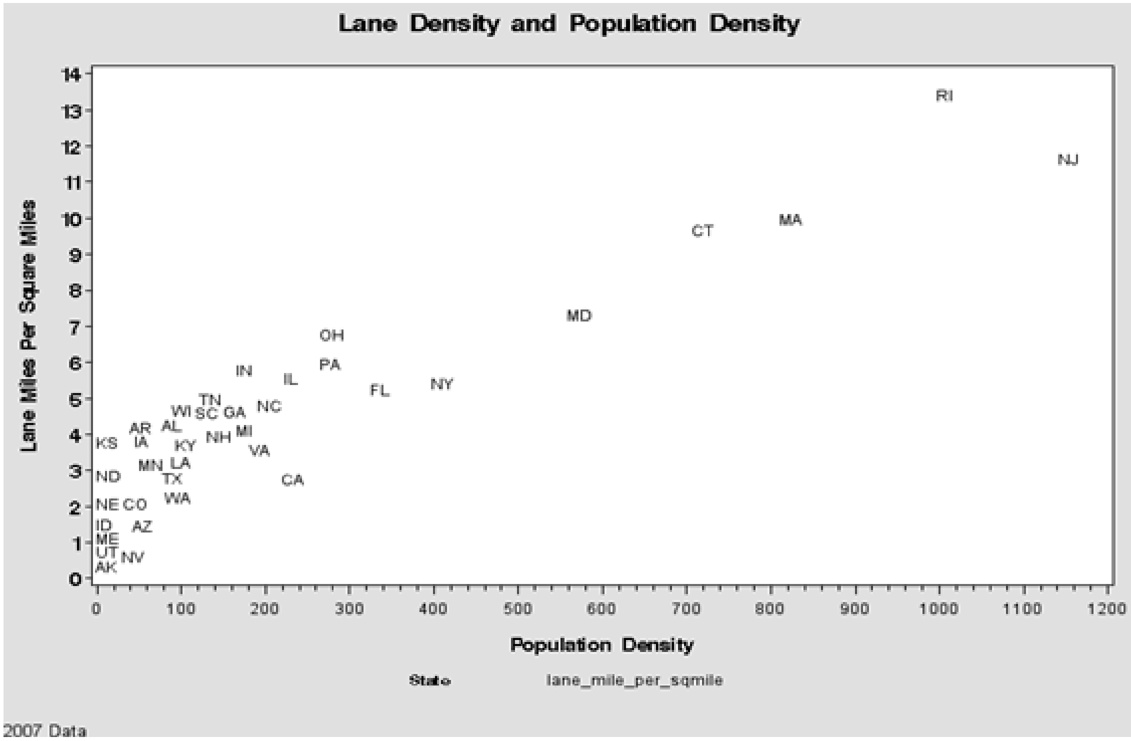


Figure 11: Lane Density and Population density



2.2 MSA-level analysis[53]

This section will look into some economic and infrastructure indicators at the Metropolitan Statistical Area (MSA) level that could potentially help interpret the interrelationships between freight infrastructure development, economic growth, and specifically, freight transportation productivity in the Upper Midwest Region. While available data at the MSA level are not as rich as those for the state-level analysis, the analysis conducted at a smaller spatial scale can possibly provide additional insights.

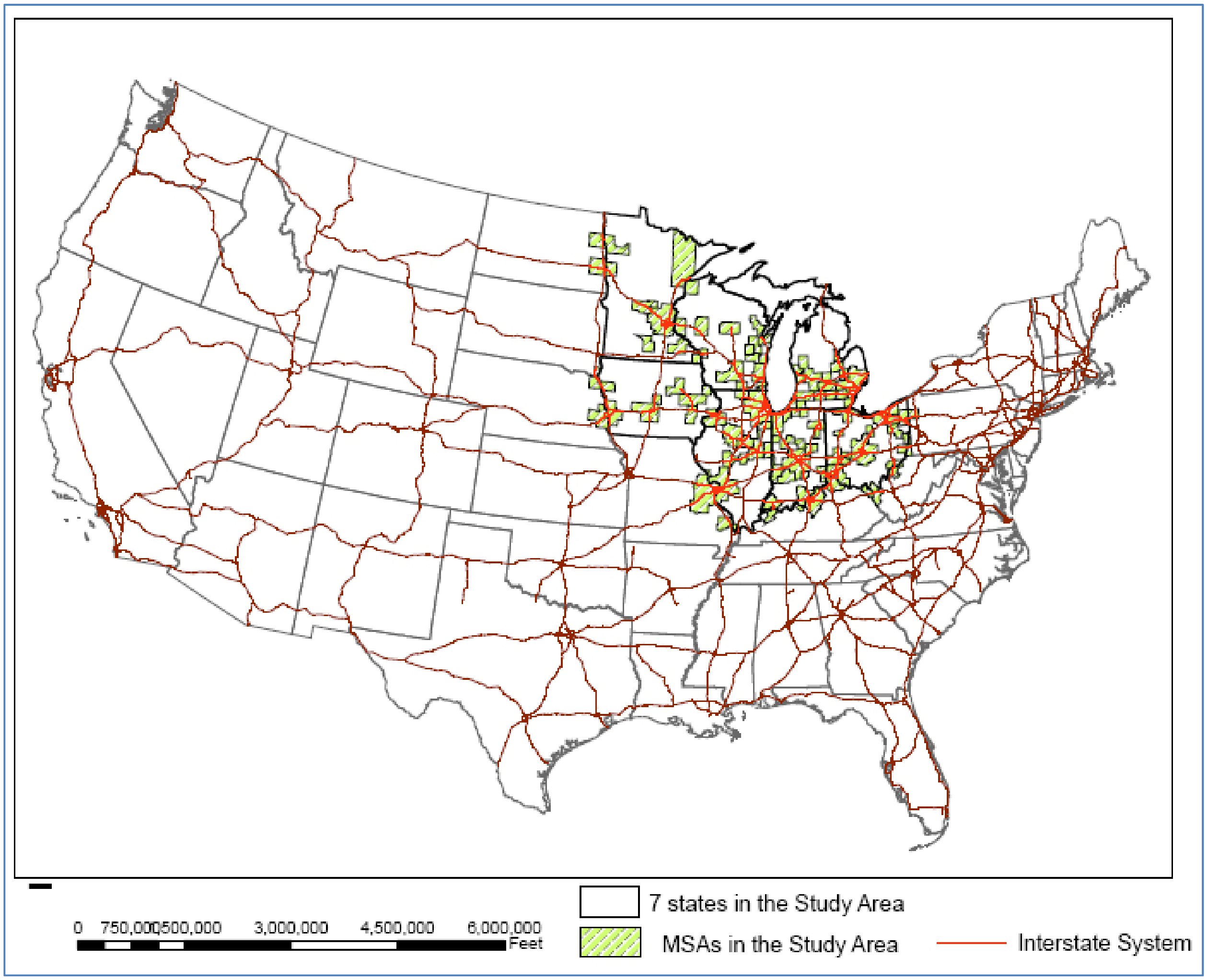
Bureau of Economic Analysis (BEA) defines the MSA as an area that has "at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties". Figure 12 shows the MSAs and the study area. There are a total of 83 MSA in the data set. The MSAs included in this analysis are in Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin. Minor sections of North Dakota, South Dakota, Nebraska, Kentucky, West Virginia, and Pennsylvania are also included because some MSAs extend across two states. The list of the MSAs that are included in the analysis is provided in the Appendix.

[53] This section is based on Rashidi, Laya. Relationship between Economic and Transportation Infrastructure Indicators and Freight Productivity. Master's Thesis.University of Illinois, Chicago.

2.2.1 Economic Indicators

An economic indicator for trucking sector is defined using publicly available data. Gross Domestic Products (GDP) for MSAs by each industry from years 2002 and 2007 are used for this purpose. The GDP data is obtained from the Gross Domestic Product by Metropolitan Area interactive tables of the Regional Economic Data, released by BEA (2010)[54].

Figure 12: Study Area Map – MSA-level Analysis



[54]Bureau of Economic Analysis (BEA), U.S. Department of Commerce, Regional Economic Accounts.http://www.bea.gov/regional/index.htm#gsp Accessed in May 2010.

2.2.2 Transportation Indicators

In addition to GDP, transportation infrastructure indicators, congestion (measured in terms of truck VMT divided by the total centerline road length) and road density (total centerline road length divided by total area) from 2002 are used to analyze fluctuations in the freight transportation productivity measure. Both VMT and centerline miles were estimated using the GIS data set for the 2002 Freight Analysis Framework (FAF)[55]. Table 6 provides a brief statistics of the transportation-related variables.

Table 6: Descriptive Statistics for Transportation Infrastructure Data

Variable	Mean	Standard Deviation
Vehicle Mile Traveled (VMT)	9586602.34	17207293.29
Road length (centerline lane mile)	501.01	568.85
Area (squared-mile)	1,768.14	1787.82
Congestion (VMT / road length)	15206.35	7051.20
Road density (road length / area)	0.292	0.010

2.2.3 Analysis

2.2.3.1 Trucking sector GDP

Growth in the trucking sector between 2002 and 2007 in each MSA was estimated by dividing the trucking sector GDP in 2007 by the trucking sector GDP in 2002. As shown in Table 7, Iowa City and Kankakee-Bradley experienced the highest growth of around 90 percent, followed by Decatur and Parkersburg-Marietta-Vienna MSAs with 80% and 70% growth, respectively. Of the ten MSAs with highest percentages of growth, the case of Iowa City is unique in two ways. It already had a decent-sized trucking sector in 2002, at 179 million dollars, which increased to 342 million in the next five years. In addition, its growth occurred in a relatively steady manner over the five-year period. In comparison, all other high-growth MSAs that appear in the table had significantly smaller trucking GDP in 2002, somewhere between 50 million and 100 million, and most of the growth in trucking GDP occurred around 2003 and 2004. For example, the trucking sector GDP for Kankakee-Bradley MSA increased from 34 million dollars to 72 million dollars with a large jump, 19 million

[55]Federal Highway Administration. "Freight Analysis Framework 2.2" FHWA, 2006, Washington D.C. http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm

dollars, between 2003 and 2004. While the large, one-time increases that are commonly found at smaller MSAs can be attributed to an opening of a large trucking terminal, it seems Iowa City has been able to sustain growth year after year.

Table 7: MSAs with Ten Highest and Lowest Growth (2002-2007)

MSA	Trucking GDP Growth (2002-2007) Rank	Trucking GDP Growth (2002-2007)
Iowa City, IA	1	1.91
Kankakee-Bradley, IL	2	1.89
Decatur, IL	3	1.81
Parkersburg-Marietta-Vienna, WV-OH	4	1.70
Bloomington-Normal, IL	5	1.66
Sioux City, IA-NE-SD	6	1.65
Anderson, IN	7	1.64
Ann Arbor, MI	8	1.62
Canton-Massillon, OH	9	1.62
Rochester, MN	10	1.57
Peoria, IL	75	1.09
Wheeling, WV-OH	76	1.03
Weirton-Steubenville, WV-OH	77	1.00
Mankato-North Mankato, MN	78	0.96
Duluth, MN-WI	79	0.96
Jackson, MI	80	0.95
Springfield, OH	81	0.94
Akron, OH	82	0.90
Champaign-Urbana, IL	83	0.58
Muncie, IN	84	0.58

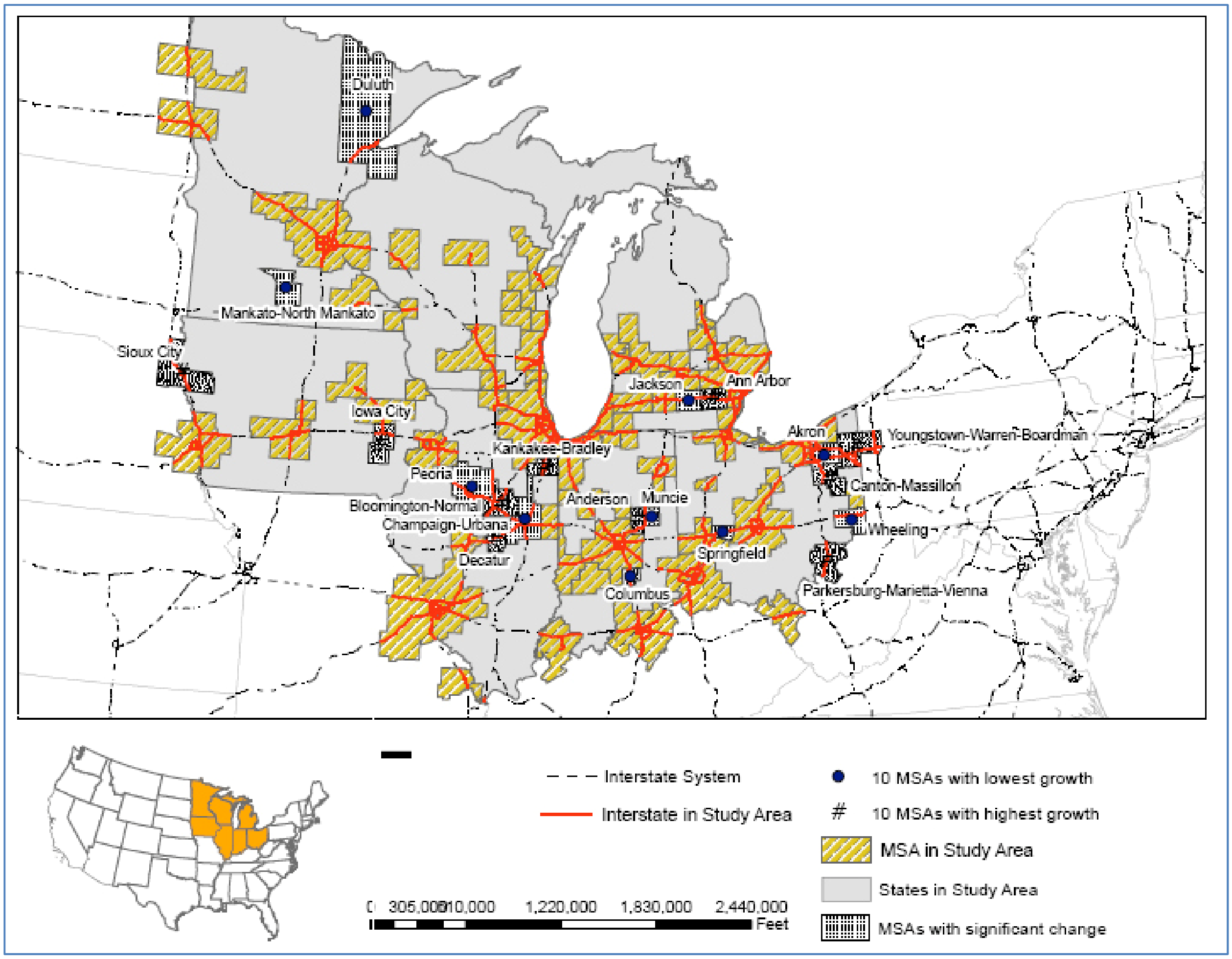
Muncie and Champaign-Urbana are the only MSAs that lost significant percentages, over 40%, of their trucking business between 2002 and 2007. In 2002, Muncie was ranked 59th with the trucking sector GDP of 40 million dollars, which reduced to just 23 million dollars in five years. Champaign-Urbana also experienced a sharp decrease in the trucking sector GDP during the same time period, with the trucking sector GDP going from 118 million in 2002 to just 69 million in 2007. For both Muncie and Champaign-Urbana MSAs, the decline of the trucking industry occurred over a short time period. For example, between 2002 and 2003, trucking sector GDP in Muncie went from 40 million dollars to 20 million.

Furthermore, the data from 2001, which is available for Muncie, indicate that in just one year, between 2001 and 2002, it lost 59 million dollars of trucking sector GDP, equivalent of 60% of its value. In just two years, between 2001 and 2003, Muncie experienced a staggering decrease of 88% in trucking sector GDP. In Champaign-Urbana MSA, a single large decline occurred in 2005. Between 2001 and 2004, the trucking sector GDP in Champaign-Urbana held relatively constant at around 110 million dollars a year. Then, between 2004 and 2005, it went from 114 million to 67 million dollars, a loss of 67% in just one year, and it never recovered. This could be attributed to several reasons, including use of heavier and more fully loaded trucks by Kraft, as the company with the largest private truck fleet in Champaign. Also, refinements in supply chain management strategies (e.g. repositioning hubs and other facilities) and logistic decisions (e.g. shift to rail and waterways) drastically reduced truck VMT in this area (Cassidy, 2009[56]; Dodson, 2009[57]).

Figure 13 depicts the locations of MSAs that experienced very high or low rates of growth in trucking sector GDP between 2002 and 2007. Interestingly, in many cases, a high-growth MSA is right next to a low-growth MSA, suggesting that trucking activities are to some degree zero-sum game within a broad economic region and when one MSA gains, there is a MSA that declined.

[56]Cassidy, William, 2009. Kraft Foods Cuts 50 Million Truck Miles. The Journal of Commerce, accessed at: http://www.joc.com/logistics-economy/kraft-foods-cuts-50-million-truck-miles
[57]Dodson, Don, 2009. Kraft, Supervalu among firms seeking heavier trucks. The News Gazette, accessed at: http://www.news-gazette.com/news/business/miscellaneous/2009-11-29/kraft-supervalu-among-firms-seeking-heavier-trucks.html

Figure 13: Growth of Trucking Sector GDP (2002 – 2007)



Overall, trucking sector experienced a healthy growth in the Upper Midwest states, going from a total GDP of $22.8 billion for the entire study area in 2002 to $30.5 billion in 2007, a 34 percent increase.

2.2.3.3 Trucking GDP Growth and Transportation Infrastructure

Figure 14 and Figure 15 depicts the relationship between trucking sector GDP growth and congestion and road density, both measured for 2002, respectively. Both graphs indicate a slight negative association between trucking GDP growth and respective transportation infrastructure indicators. However, Figure 14 also shows that the MSAs that experienced significant negative growth are not suffering from severe levels of congestion. Furthermore, Figure 15 reveals that many of the MSAs that experienced negative growth by no means suffer from a lack of road network.

Figure 14: Truck GDP Growth (2002-2007) and Congestion (2002)

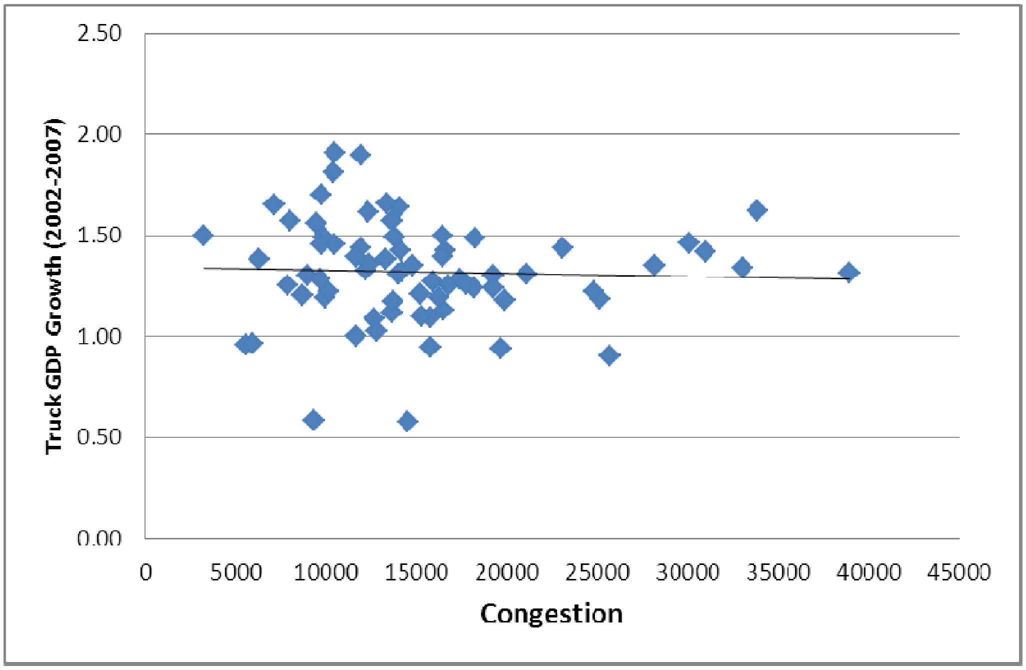
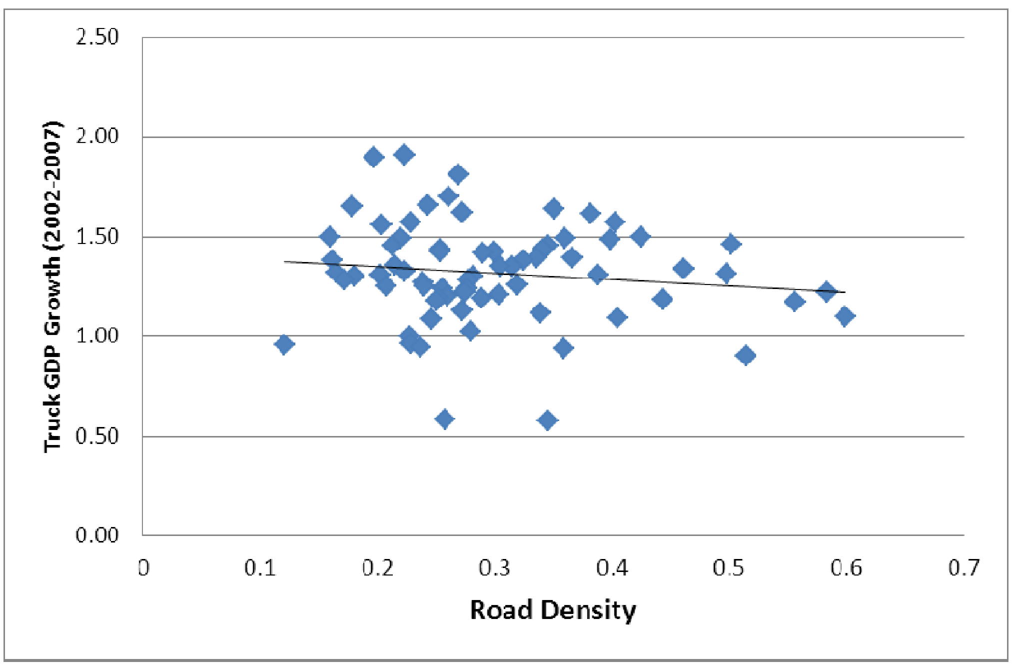


Figure 15: Truck GDP Growth (2002-2007) and Road Density (2002)



The associations between trucking GDP growth and transportation infrastructure indicators are performed using statistical tests. Two types of bi-variate correlation measures, namely

Spearman rank correlation[58] and Pearson's correlation[59] are used. The results, shown in Table 8, indicates the tests did not find statistically significant correlation between the transportation infrastructure indicators and the truck sector GDP growth. Although the small number of cases suggests that the probability for Type-II errors (i.e. false negative) is rather high, p-values are not close to being statistically significant. Thus, we found no evidence that the state of transportation infrastructure in 2002 affected the trucking sector GDP growth during the 5-year period that followed.

Table 8: Correlation between Trucking Sector GDP Growth (2002-2007) and Transportation Indices

Transportation infrastructure	Pearson Coefficient (p-value)	Spearman Coefficient (p-value)	Available cases
Congestion	-.043 (.723)	-.145 (.228)	71
Road density	-.131 (.276)	-.109 (.364)	71

2.2.4 Summary

Historically, economic output and freight transportation activity have exhibited a strong correlation. Freight ton-miles, employment and intercity truck mileage have closely tracked GDP. In terms of policy decision making, the main interest is whether or not increasing freight activity, or at least eliminating the factors that prevent it from growing, for example congestion, would result in economic growth. This section's focus has been to answer such question by examining the relationship between freight transportation activity and several indicators of transportation infrastructure and the economy at the MSA level for seven states in the Upper Midwest states.

Trucking GDP growth between 2002 to 2007 are economic indicators examined. We used congestion and road density for 2002 as two transportation infrastructure indicators. Potential correlations between dependent variables and economic and infrastructure indicators were examined using Spearman and Pearson correlations, along with scatter plots were used to describe the direction and the level of associations.

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[58] Spearman, C. "The proof and measurement of association between two things" Amer. J. Psychol. , 15 (1904) pp. 72–101

[59] Agresti, A., and B. Finlay.Statistical Methods for the Social Sciences (4th Ed.) Pearson. 2009

We did not find any evidence that suggested there is a correlation between transportation infrastructure indicators and the growth in the trucking sector GDP. This is mostly consistent with the findings from the analysis using the state-level data for the entire nation.

Since there are considerable variations in the trucking sector GDP growth among the MSAs, we examined some of the extreme cases, MASs with large and small (or negative) growths between 2002 and 2007, to find out the factors that made some MSAs more prosperous, in terms of trucking sector, and others less so. A detailed discussion of these cases is included in the Appendix. We found that in many cases, most successful MSAs and least successful ones are located close to each other. Along the way, the successful one attracted an anchor business while less successful one did not. Tax incentive seems to play a key role in at least some of the cases. Thus, we essentially found the adage that "transportation is a necessary but not a sufficient factor" applies to growth in trucking sector activity. In some cases, such as Iowa City or Green Bay, an urban area has been a home to a major freight business and as the company grew, so did their freight sector output. Replicating those kind of successes is challenging since the area must nurture a strong bond with the anchor business over a long time period in order to keep the business to remain there.

Chapter 3: Effects of Built Environment on Consumption of Freight

Although movements of freight are mostly driven by the private businesses in the U.S., the pubic sector decisions have critical and pervasive effects on the means and efficiency of freight movement in several fronts. Firstly, the transportation infrastructure is by and large still being provided, operated, and managed by the public sector. Even in the case of the rail roads that own and operate their infrastructure and vehicles, they must coordinate with municipalities and states to address negative impacts, e.g. rail crossings, noise, fumes, associated with their business activities. Secondly, land use decisions, implemented through regulations and local ordinances, affect the design and management of supply chains, including the placement of facilities. In the U.S., each municipality enjoys near total control over land use decisions, and their decisions often reflect parochial interests that place greater priority on job creation for their own city over regional benefits. Thirdly, land use determines the location and intensity of demand for freight movements. Recently, land use and transportation policies known as Smart Growth have dominated regional and local planning practices in the U.S. The conceptual cornerstone of the Smart Growth, as far as transportation is concerned, is based on the idea that land use and urban design that encourage non-motorized travel lead to less demand for travel by cars, and thus benefit the society. However, in most cases, the impacts of land use and urban design on the flow of goods are not examined, or even considered by the planners or policy makers. The main reason for this shortcoming in the policy realm is the lack of understanding regarding how various goods are shipped and delivered. According to Bronzini[60], “the goods delivery impacts are viewed as ancillary effects rather than primary planning goals”.

Urban density and design can have profound impacts on both the volume and efficiency of freight movements for the "last mile" segments of a journey.[61,62,63] Also, while many cities strive to gentrify urban core areas with densification and transit-oriented development (TOD), very little attention is paid to the fact that such land use pattern may lead to an increase in the intensity of goods consumption per a unit of land area. Meanwhile, it is also plausible that compact land use pattern reduces consumption of freight because of the need to reduce inventory space. As a result, the overall intensity of freight demand per unit area may actually

[60] Bronzini, M. *Relationships Between Land Use and Freight and Commercial Truck Traffic in Metropolitan Areas. Special Report 298*. Transportation Research Board 2008

[61] Pivo, G. et al., *Learning From Truckers: Moving Goods in Compact, Livable Urban Areas.* Washington State Department of Transportation. Olympia, Washington. 1997

[62] Morris, Ann G. and Alain L. Kornhauser, Relationship of Freight Facilities in Central Business District Office Buildings to Truck Traffic, *Transportation Research Record 1707* 2000: 56-63.

[63] O'Laughlin, R. *Chicago Downtown Freight Study*. Presented at TRB AT025 Committee meeting. January 2008

decreases with density. A study by Kawamura and Lu[64] found that the demand for freight, measured in annual tons per capita or ton-miles per capita, varies significantly among countries. For example, they found that Italy has a considerably lower average annual ton per capita than other European countries and the U.S. They also found that the freight ton-miles per capita for the U.S. was as much as three times greater than those for most of European countries.

Most practical approaches for estimating truck trip generation can be broadly categorized as commodity-based or trip-based[65]. A common method used in the application of the trip-based approach is the use of trip rates, in which the rate of truck trips generated by a site is estimated based on rate(s) that capture the relationship between the truck trip generating potential of the site and the characteristics of the site such as land use, number of employees, floor area, etc. Brogan[66] calculated truck trip-generation rates for 10 land use categories. A more recent effort by Holguín-Veras and López-Genao[67] examined the trip generation rate at the terminals. They found that the rates varied among different parts of the country. Slavin[68] developed a trip-end model that captures the relationship between truck trip-ends and socio-economic activities in the various land uses. He found that there was a statistically significant relationship between the truck trip ends and the characteristics of land uses. Brogan[69] tested the sensitivity of trip-end estimation with respect to various stratification schemes using the regression model. He found that the regression stratified by land use categories provided the best results.

It should be noted that most of the studies were conducted for the purpose of improving the travel demand estimation of truck movements and did not specifically examine the relationship between the generation or consumption of freight by the end user and the land use. To our knowledge, no study has examined the relationship between consumer freight demand and built environment in an empirical manner. For passenger travel, the relationships between travel behavior and built environment (e.g. land use allocated for different industrial types, density) as well as socioeconomic characteristics have been studied extensively, e.g.

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[64] Kawamura, K. and Y.D. Lu. Effectiveness and Feasibility of Innovative Freight Strategies for the U.S. Urban Areas in E. Taniguchi and R. Thompson, ed. *Recent Advances in City Logistics*, Elsevier 2006

[65] Fisher, M.J. and M. Han, *NCHRP Report 298: Truck Trip Generation Data*, TRB, National Research Council, Washington, D.C. 2001

[66] Brogan, J.D. Development of Truck Trip-Generation Rates by Generalized-Land Use Categories. *Transportation Research Record 716* 1979: 38-43.

[67] Holguín-Veras, J. and López-Genao, Y. Truck Trip Generation at Container Terminals: Results from a Nationwide Survey. *Transportation Research Record 1790* 2002 89-96.

[68] Slavin, H.L. (1974). Demand for Urban Goods Vehicle Trips. *Transportation Research Record 591* 1974: 32-37.

[69] Brogan, J.D. Improving Truck Trip-Generation Techniques through Trip-End Stratification. *Transportation Research Record 771* 1980: 1-6

Ewing and Cervero[70]. This chapter discusses the findings from the analysis of how land use and socioeconomic factors influence the demand for freight transportation, using the data obtained in Texas. What distinguishes this effort from truck trip generation models is the focus on the influence of built environment. In addition, this analysis focuses on retail goods, not truck trips.

3.1 Research approach

3.1.1 Data

For developing the dataset, we combined three types of data, all at the Census tract level: 1) tons of retail goods delivered by trucks, 2) socioeconomic characteristics, and 3) build environment characteristics. The socioeconomic characteristics were obtained from the 2000 U.S. Census. Built environment variables include intersection density (number of intersections/area size), road density (road length/area size), and block size (road length/number of intersections), and household density. The data for the built environment were obtained from a study conducted by Zhang and Mohammadian[71,72,73]. Table 9 presents all the variables used in this study and their sources.

Table 9: Variables

Variable	Sources
Tons of retail freight delivered to each Census tract	Texas Survey
Road density	Zhang
Intersection density	Zhang
Block size	Zhang
Population density	2000 Census
Employment density	2000 Census
% born in the U.S.	2000 Census
% entered U.S. between 1990-2000	2000 Census
% (of foreign born) born in Asia	2000 Census
English at home	2000 Census

[70] Ewing, R. and R. Cervero, R. Travel and Built Environment - Meta Analysis. *Journal of American Planning Association* 2010, 76: 3, 265-294
[71] Zhang, Y. *Household Travel Data Simulation: Application of Spatial Transferability of Survey Data.* Dissertation. University of Illinois, Chicago 2007
[72] Zhang, Y., and Abolfazl (Kouros) Mohammadian. Bayesian Updating of Transferred Household Travel Data. *Transportation Research Record 2049*. 2008
[73] Zhang, Y. and Abolfazl (Kouros) Mohammadian. Examining Common Distributional Assumptions of Travel Characteristics for Data Simulation. *Transportation Research Record 2121*. 2009

Median HH Income	2000 Census
% of houses built after 1990	2000 Census
% of houses built before 1969	2000 Census
Median number of rooms	2000 Census
% moved to current house after 1995	2000 Census
% renter	2000 Census
% Single detached, unit houses	2000 Census
HH density	2000 Census

Tons of consumer products delivered to each Census tract was estimated from the survey conducted in Texas between 2002 and 2005[74,75]. The survey covered the Metropolitan Planning Organization (MPO) regions that are depicted in Figure 16: Austin, San Antonio, Amarillo, Valley, Lubbock, Midland/Odessa, Tyler, Longview, and Laredo. Only the San Antonio and Austin Metropolitan Areas are included in the data used for this study. The Valley area was excluded because of its closeness to the U.S/Mexico border. Amarillo and Lubbock metropolitan areas were excluded due to small sample sizes.

The survey randomly selected trucks from a database compiled from the vehicle registration records, motor carrier database, and employee database. The operators of the selected vehicles were asked to fill out an information form for the vehicle and also keep a travel log that records all the activities involving the truck for a 24-hour period. For all the deliveries completed by the survey participants, stop locations were recorded by latitude and longitude, which were later used to geocode them in GIS. Each stop location was also classified into one of 14 types. Table 10 shows the data collected for each of the stop recorded in the survey responses. For this survey, only the drop-offs at retail establishments were included in the analysis to capture the consumption of consumer goods.

The Texas survey data included the coordinates of the checkpoint locations; these coordinates were geocoded in a GIS environment and spatially joined to a 2000 tract level map in order to determine in which census tract they lay. If multiple checkpoints were within one tract, then the weight of each trip recorded was aggregated to that census tract. The data set consisted of 1,249 deliveries totaling 1.1 million pounds (0.499 million kg) of retail goods.

There are a total of 558 Census tracts, of which 132 received at least one delivery of consumer goods. In 2000, there were 2.8 million residents in the tracts included in the data set. Therefore, on average the survey captured 0.37 pounds of consumer goods per person.

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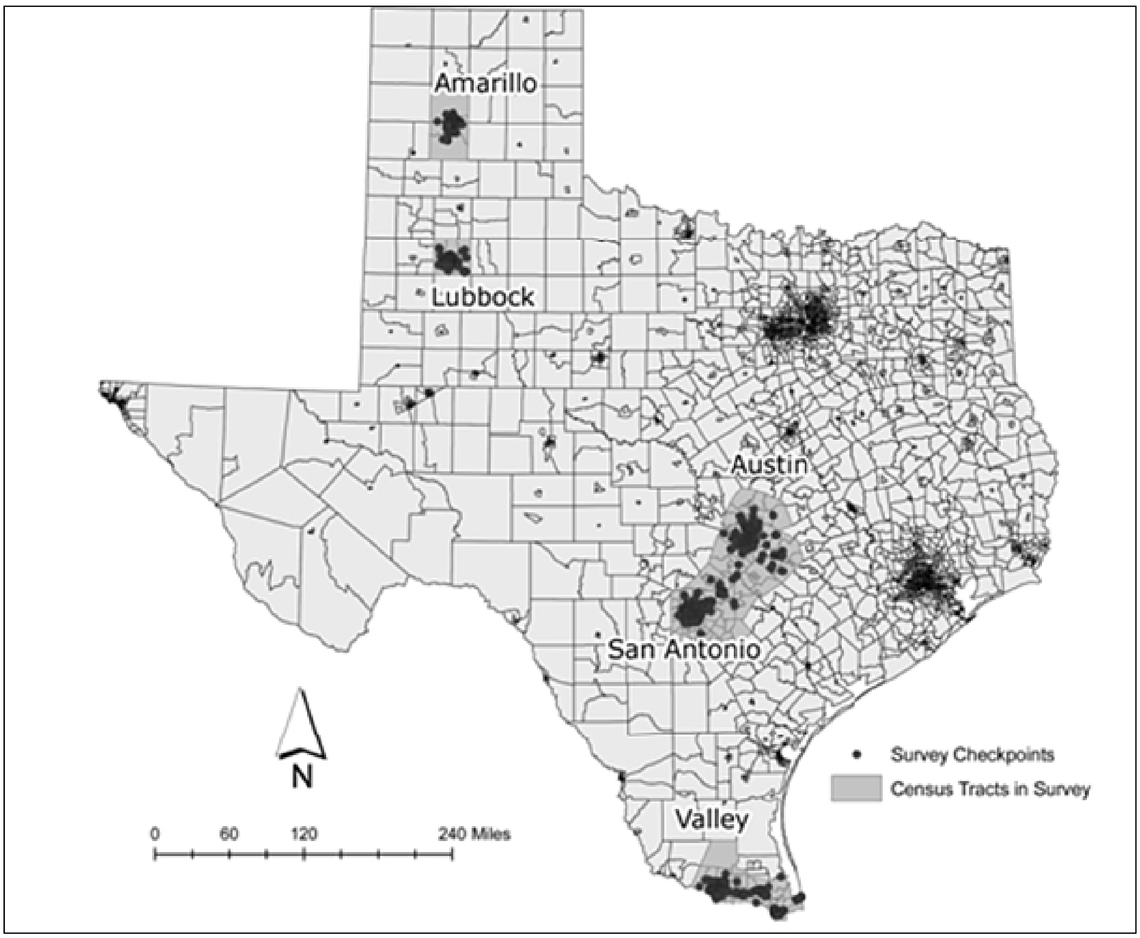
[74] Nepal, S., Farnsworth, S., & Pearson, D. 2005 *Amarillo Area Commercial Vehicle Survey Technical Summary*. 2007

[75] Prozzi, J., Mani, A., & Harrison. *Development of Sources and Methods for Securing Truck Travel Data in Texas*. Texas Department of Transportation. 2006

This amount is obviously less than the total amount of consumer goods needed to sustain a person. For example, according to the U.S. Department of Agriculture, the consumption of meat, dairy products, grain, and fruit and vegetables alone accounted for 1,694 pounds per capita per year, or 4.64 pounds per capita per day[76]. This suggests that the survey of delivery trucks captured only a part of the total retail goods that are consumed. However, as long as the omissions are not systematic, i.e. the sampling is random, then the relationship between the amount of retail goods consumption and the built environment can be captured accurately in the statistical analysis. It should be noted that the magnitude of the relationship, for example, the elasticity of actual retail goods consumption with respect to population density will not be accurately quantified from the data set.

Figure 16: Survey Locations



[76] U.S. Department of Agriculture. *2001-2002 Agriculture Fact Book.* U.S. Department of Agriculture.2003

Table 10: Stop-level Data Captured in the Survey

Stop-level attributes	Description
Longitude and latitude	Stop coordinates
Departure/arrival time	Departure/arrival time at stop
Total cargo weight	Weight of cargo loaded or unloaded
Cargo type (22)	1) Farm products, 2) Forest products, 3) Marine Products, 4) Metals and Minerals, 5) Food, Health, and Beauty Products, 6) Tobacco Products, 7) Textiles, 8) Wood Products, 9) Printed Matter, 10) Chemical Products, 11) Refined Petroleum or Coal Products, 12) Rubber, Plastic, and Styrofoam Products, 13) Clay, Concrete, Glass, or Stone, 14) Manufacturing Goods/Equip, 15) Wastes, 16) Miscellaneous Shipments, 17) Hazardous Materials, 18) Transportation, 19) Unclassified Cargo, 20) Driver Refused to Answer, 21) Unknown to Driver, 22) Empty
Activity type (9)	1) Base Location/Return to Base Location, 2) Delivery, 3) Pick-up, 4) Pick-up and Delivery, 5) Maintenance (fuel, oil, etc.), 6) Driver Needs (lunch, etc.), 7) To Home, 8) Others (specify), and 9) Refused/Unknown
Land use type (15)	1) Office Building, 2) Retail/Shopping, 3) Industrial/Manufacturing, 4) Medical/Hospital, 5) Educational (12th Grade or less), 6) Educational (College, Trade, etc.), 7) Government Office/Building, 8) Residential, 9) Airport, 10) Intermodal Facility, 11) Warehouse, 12) Distribution Center, 13) Construction Site, 14) Others (specify), and 15) Refused/Unknown.

The tonnage of goods delivered was calculated in two ways. The first was to simply record the total tonnage of goods dropped off within each tract. While this method captures the actual tonnage of delivery to the stores, it does not directly capture the amount of goods purchased by the consumers since shopping trips are not necessary contained within one tract. Meanwhile, the built environment variables are measured for individual tracts. Thus, we developed another approach that calculated the total tonnage of goods dropped off within a given distance, or buffer zone, from the centroid of each tract. We used the average length of shopping trips in the U.S., 7 miles, calculated from the 2001 NHTS, as the buffer radius. The logic behind this approach is that by drawing a buffer around each tract and totaling all the goods delivered to the stores within 7 miles, it is possible to estimate the consumption of goods by the nearby residents who shop in the tract. All other variables were calculated only for the tract that is at the center of the buffer.

The built environment variables were obtained from the dataset developed by Zhang. Using TIGER line and Census tract map files, Zhang estimated these variables for every census tract in the U.S. for the analysis of travel survey data transferability. Road density was calculated by dividing total road length in a tract by the area of the tract. Intersection density is the number of intersections, which is estimated by counting the intersecting points of lines in TIGER line map, by the tract area. Block size was estimated by dividing the total road length by the number of intersections in a tract.

3.1.2 Analysis methods

We used various techniques for analyzing the data both visually and statistically. We started by visualizing the spatial pattern in Geographic Information System (GIS). We used Moran's I[77] to test for the presence of spatial correlations at both global and local levels. Moran's I for a variable x is calculated as the following.

$$I = \frac{N}{\sum_i \sum_j W_{ij}} \frac{\sum_i \sum_i W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2} \qquad (1)$$

Where, N is the sample size and w_{ij} is the spatial weight between observations i and j. Essentially, Moran's I is the standardized slope of a scatter plot that has on the X-axis the variable of interest, and on the Y-axes the spatially lagged value of the variable for each observation. Moran's I can be applied to the entire data set (global) or for each observation

[77] Moran, P. The interpretation of statistical maps, *Journal of the Royal Statistical Society*. 1948. B 10, 24351.

(local). When applied locally, Moran's I is sometimes referred to as Local indicators of spatial association (LISA)[78].

Since the data is likely to include a significant spatial correlations among the data points, we also used Kendall's Tau-b test[79], which is a non-parametric test that examines the association between the rankings of each data points for different variables. Agresti[80] provides an excellent overview of the Kendall's Tau-b test.

Kendall's Tau-b test is strictly for bivariate analyses. Thus, in order to conduct multivariate analysis, we used Ordinary Least Squares (OLS) regression with transformation of both dependent and independent variables. The model is as follows.

$Y = \alpha + \beta X$, where
Y = tons of consumer products delivered by trucks
α = intercept
β = parameter
X = vector of variables (socioeconomic variables, built environment variables).

White test[81] was used for the detection of heterskedasticity. The multicollinearity condition number[82] of 20 was used as the threshold to detect multicollinearity problems. The inference for spatial dependencies among the data points was conducted using Moran's I and Lagrange Multiplier tests for correlation in both the error term (spatial error model) and the variables themselves (spatial-lag model). For the tests for spatial dependencies, the pattern of spatial correlation must be assumed a priori. Two most common assumptions regarding the spatial dependencies are proximity measured in terms of aerial distance, and adjacency, which is defined by two polygons sharing a border or vertices. Anselin[83] discusses different types of adjacency patterns. For calculating Moran's I, both distance-based and adjacency-based spatial dependencies were tested.

3.3 Analysis results

3.3.1 Spatial analysis

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[78] Anselin, L. Local indicators of spatial association – LISA. G*eographical Analysis,* 27. 1995. 93-115.
[79] Kendall, M.G. *Rank Correlation Methods*. 4th Ed. London: Charles W. Griffin. 1970
[80] Agresti, A. *An Introduction to Categorical Data Analysis*, 2nd ed.. Wiley. 2007
[81] White., H. A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica* 48 (4). 1980: 817–838
[82] Belsley, D.A., Kuh, E. and Welsch, R.E. *Regression Diagnostics. Identifying Influential Data and Sources of Collinearity*. New York: John Wiley & Sons. 1980
[83] Anselin, L. *Exploring Spatial Data with GeoDa: a Workbook.* Center for Spatially Integrated Social Science. 2005

Figures 17 and 18 depict the spatial distributions of the percentage of homes within the tracts that are single detached and also the percentages of houses that were built before 1969 against the pounds of retail goods delivered to each tract per capita. The classifications used in the figures depict all the variables in quintiles. One can hypothesize that there are more storage spaces in single detached houses and also they may require more consumer goods to maintain, resulting in greater amount of goods being consumed. Older houses tend to have smaller footprint and also less storage spaces, and thus the residents may purchase less goods.

The pictures suggest that, in general, most of the tracts in the top quintile for the amounts of goods delivered are in the suburbs and outer-suburbs. As the spatial distribution of the percentages of single detached houses is difficult to decipher from the map, it is not clear whether or not there is an association with the amount of retail good delivered per capita. The map showing the age of the houses, on the other hand, indicates that older houses are concentrated in the central part of each metropolitan area, and thus a relationship with the amount of retail goods delivered seems to exist.

Figure 17 Percent of Single Detached Homes and Retail Goods per Capita

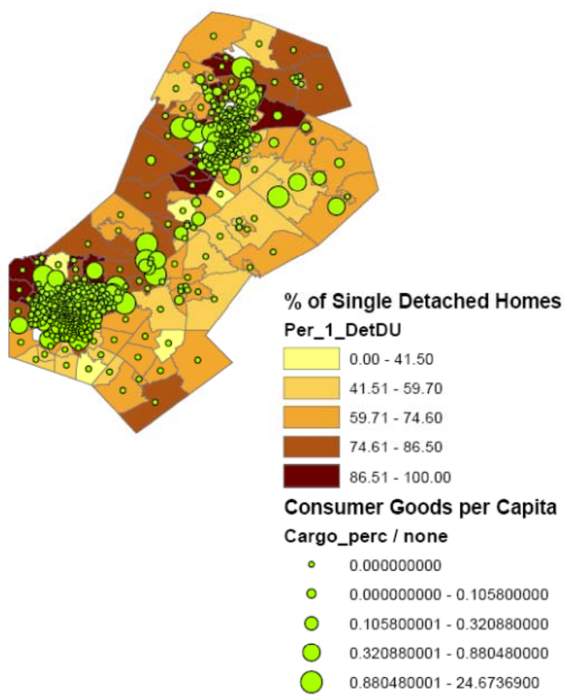
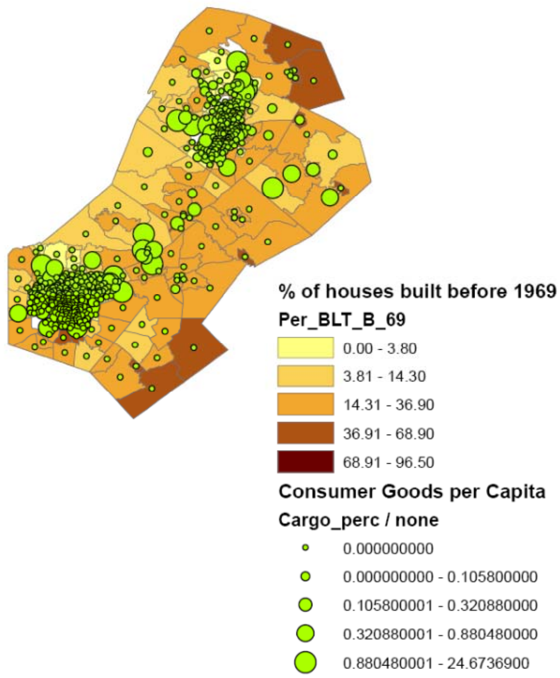


Figure 18 Percent of Houses Built before 1969 and Retail Goods per Capita



The tests for spatial dependencies using Moran;s I showed the adjacency-based spatial weight using the 2nd Order Rook consistently produced the strongest indication of spatial correlation. The global Moran's I for the weight of retail goods delivered to each census tract per person is 0.0534 and statistically significant at the 99% confidence level, indicating that there is a weak pattern of spatial dependencies, or clustering, of retail goods consumption.

Figure 19 shows the pattern of clustering using the local Moran's I. High-High and Low-Low indicate the clusters that are showing positive associations, meaning that tracts with high levels of retail goods delivery are likely to be surrounded by tracts with high levels, or vice-versa. On the other hand, High-Low and Low-High clusters indicate negative associations. The map indicates that the clusters, both positive and negative, are more likely to be located in the suburban or rural areas.

Figure 20 shows the local Moran's I for the amount of retail goods delivered calculated with 7 miles buffer. The figure shows even stronger propensity for clustering. Also, there is a clear trend for the clusters in the central part of the metropolitan areas to have the Low-Low type of spatial dependencies. These results are not surprising, since by definition, using buffers introduces spatial dependencies.

Figure 19 Plot of Local Moran's I - Retail Goods per Capita without Buffer

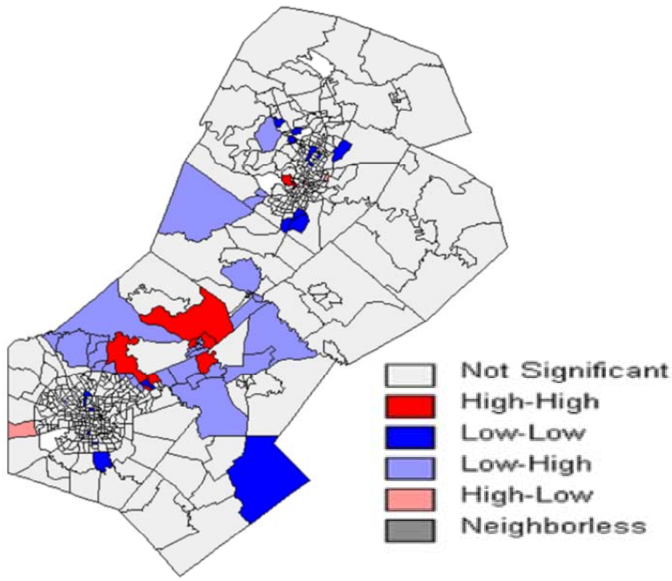
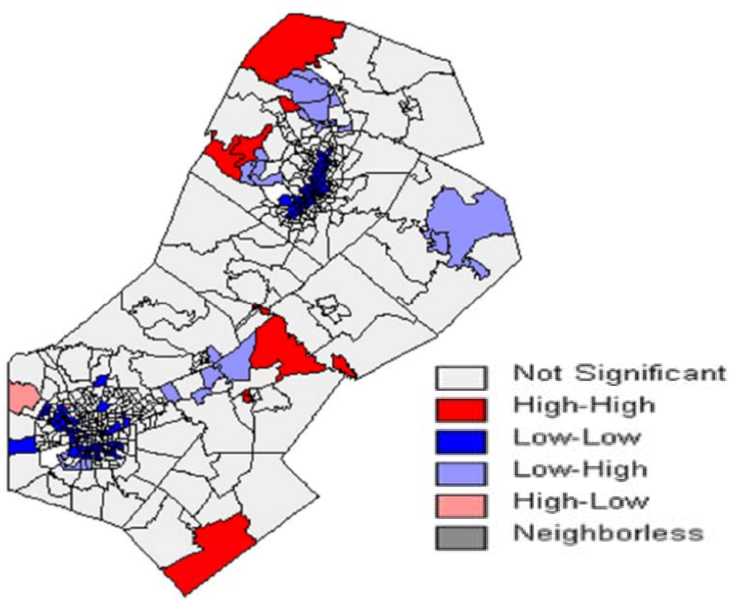


Figure 20 Plot of Local Moran’s I – Retail Goods per Capita with Buffer



3.3.2 Statistical inference

This section discusses the results of the statistical analyses of the relationship between the retail commodity weight per capita and socioeconomic and built environment variables. As before, the analyses were conducted for the commodity weight calculated with and without the 7 miles buffer around each census tract. First, the results of the non-parametric analysis will be discussed, followed by the multiple regression analysis.

Table 11 shows the results of the Kendall's Tau-b test of the association between the weight of retail goods delivered per capita and various explanatory variables. To control for the income effect, tracts were divided into quartiles according to the median income and the tests were conducted separately within each quartile. The table shows only the results that are significant at the 95% confidence level. As shown, there are only a few associations that are statistically significant, and none of the explanatory variables are significant for all four income groups. For the lowest income quartile, population density shows a negative associated with the amount of retail goods delivered. Other variables that have a negative effect are percent of resident who were born in the U.S. and household density. It is somewhat surprising that the tracts that have higher foreign-born population tend to have greater amount of retail goods delivered. One may expect foreign-born population to have purchasing habits that are fit for compact developments that are more common in foreign countries. There are three variables that show a positive association. Interestingly, all three are related to the timing of the development or move. The results seem to indicate that tracts that have newer development and thus a higher percent of the residents moved to the tract during the preceding decade tend to have greater amount of retail goods delivered.

The analysis of the buffered data, summarized in Table 12, revealed a greater number of statistically significant associations. Both road density and intersection density are shown to have positive association with the amount of retail goods delivered across all four income groups, suggesting that residents in the tracts with greater intensity of road infrastructure tend to consume more goods. Those tracts are concentrated in the center of the metropolitan areas rather than the suburbs as shown in

Figure 21. The variables that show positive association are mostly related to the intensity of land use. Population density, employment density, and household density all have a positive association, indicating that the higher the intensity of development, in terms of both land and road infrastructure, the greater the amount of retail goods delivered, and presumably consumed by the residents.

Table 11: Non-parametric analysis – without buffer

Explanatory variable	Income Q1 (N=139)	Income Q2	Income Q3	Income Q4
Road density				
Intersection density				
Block size				
Population density	-0.150			
Employment density				
% born in the U.S.			-0.131	
% entered U.S. between 1990-2000			0.238	
% (of foreign born) born in Asia				
English at home				
Median HH Income				
% of houses built after 1990				0.232
% of houses built before 1969				
Median number of rooms				
% moved to current house after 1995				0.207
% renter				
% Single detached, unit houses				
HH density				-0.128

Figure 21: Intersection Density (number of intersections per square mile)

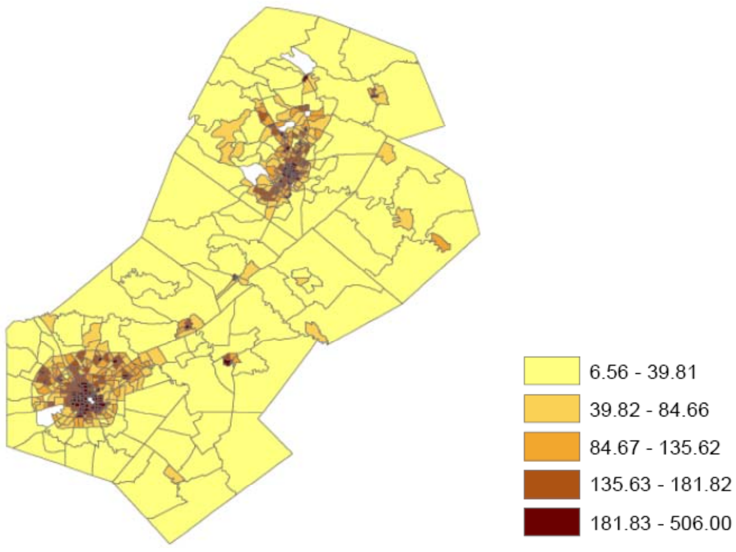


Table 12: Non-Parametric Analysis - with Buffer

Explanatory variable	**Income Q1 (N=139)**	**Income Q2**	**Income Q3**	**Income Q4**
Road density	0.255	0.205	0.319	0.171
Intersection density	0.233	0.198	0.305	0.164
Block size		-0.122	-0.268	-0.127
Population density		0.153	0.280	0.151
Employment density		0.157	0.264	0.141
% born in the U.S.			-0.238	
% entered U.S. between 1990-2000				
% (of foreign born) born in Asia				
English at home	-0.117			
Median HH Income	-0.176			
% of houses built after 1990	-0.240	-0.178	-0.201	-0.128
% of houses built before 1969	0.234			
Median number of rooms				
% moved to current house after 1995			0.118	
% renter		0.189	0.262	
% Single detached, unit houses				
HH density		0.197	0.290	0.152

Table 13 shows the results of the OLS model applied to the square root of tons of retails goods delivered, calculated without buffer. The tests for hetroskedasticity, multicollinearity, and spatial dependencies all indicate the model does not violate critical assumptions for the OLS. To correct for the heavy heteroskedasticity, the response variable was transformed with square root. The right-hand side of the model includes only those explanatory variables that are statistically significant at 95% confidence level except for per capita income and block size that are used as control variables. The fit of the model is poor (R^2 of 0.011) and the only variable that was found to be statistically significant was household density. The parameter estimate indicates that census tracts with higher household density tend to receive smaller amount of retail goods.

Table 13: Results of OLS Regression – without Buffer

Response variable: Square root of commodity weight per capita calculated without buffer		
N = 558, R^2 = 0.011	**Parameter Estimates**	**t-statistic**
Intercept*	0.279	0.012
HH Density*	$-5.18x10^{-5}$	0.022
Per capita income	$6.48x10^{-7}$	0.713
Block size	-0.176	0.769
Multicollinearity condition number	10.4	
White test p-value	0.175	
Moran's I (2nd order Rook) test for error correlation p-value	0.194	
Lagrange multiplier test for spatial lag correlation p-value	0.245	

* significant at 95% level

Table 14 shows the output of the OLS model with the square root of the weight of retailed goods delivered, calculated with the 7 mile buffer as the response variable. The result suggests that household density and median number of rooms have a negative effect on the amount of retail goods delivered while income and block size have a positive effect. While it seems unintuitive to find the median number of rooms to have a negative impact on the amount of retail goods delivered, it is likely that the houses with greater number of rooms are in older neighborhoods and have less storage spaces relative to modern counterparts. In general, the model suggests that more compact land use, i.e. smaller block size and higher household density, is associated with lower amount of retail goods consumed.

Table 14: Results of OLS Regression – with Buffer

Response variable: Square root of commodity weight per capita calculated with buffer		
N = 558, R^2 = 0.096	**Parameter Estimates**	**t-statistic**
Intercept	148.7	0.094
HH Density*	-0.0511	0.000
Per Capita Income*	0.00418	0.000
Block size*	616.6	0.033
Med. No. Rooms*	-32.30	0.011
Multicollinearity condition number	19.5	

White test p-value	0.204	
Moran's I (3rd order Rook) test for error correlation p-value	0.987	
Lagrange multiplier test for spatial lag correlation p-value	0.816	

* significant at 95% level

3.4 Discussion

Table 15 summarizes the results of the statistical analyses. The table shows that the manner that the dependent variable, tons of retail goods delivered, was calculated has a profound effect on the outcomes. This is not surprising since the buffers are 7 miles in radius and thus the tonnages are vastly different between the two. In general, stronger associations between the built environment variables and the response variable are observed when the latter is measured using the buffer. Also the findings are affected by the statistical method used. In some cases, the results are statistically significant for both Kendall's Tau-b and OLS, but in opposite directions. It is possible, however, to draw some insights from the analysis results. The amount of retail goods delivered per person seems to decrease with household density, which may suggest that living in a compact dwelling unit has an effect of reducing goods consumption. At the same time, poor fit of the model indicates that there are other factors that our analysis was not able to capture.

It should be kept in mind that when dealing with spatial data, there are numerous potential sources for biases. Tons of retail goods that are delivered to a tract may not be a good proxy for the consumption of those goods by the people who live in the tract. Therefore, it is safe to say that our findings confirm a need for further research, especially of the proper technique to calculate the consumption of goods at the household level. This study is still very preliminary and further research must be carried out to understand the effects of built environment on the consumption of goods.

Table 15: Summary of Analysis Results

Variable (tested against retail tons per capita)	Without buffer		With buffer	
	Kendall's Tau-b	**OLS**	**Kendall's Tau-b**	**OLS**
Road density			+	
Intersection density			+	
Block size			-	+
Population density	-		+	
Employment density			+	
% born in the U.S.	-		-	
% entered U.S. between 1990-2000	+			
% (of foreign born) born in Asia				
English at home			-	
Median HH Income			-	
% of houses built after 1990	+		-	
% of houses built before 1969			+	
Median number of rooms				-
% moved to current house after 1995	+		+	
% renter			+	
% Single detached, unit houses				
HH density	-	-	+	-
Per capita income				+

+ indicates positive associations that are statistically significant
- indicates negative associations that are statistically significant

Chapter 4: Land Use and Freight

4.1 Introduction

Despite their obvious importance to the general quality of living for any urban area, the interaction between land use and various aspects of freight transportation (e.g. demand for goods movement, employment generation, supply chain operation, etc.) have not been studied extensively. The state of the practice seems to recognize the link between land use and freight planning as a relevant issue, but there are significant gaps in both the conceptual understanding and information that can facilitate policy making. Some regional freight plans, such as, the San Francisco Bay[84] area and also the Greater Atlanta area[85], actually include chapters on land use and provide wide-ranging practical strategies, but they are exceptions.

In recent years, the relationship between land use policies and goods movement has attracted attention as indicated by the Research Needs Statements submitted by TRB committees AT045 - Intermodal Freight Transport, ADD30 - Transportation and Land Development, and AT025 - Urban Freight. Recognizing the research needs, the Federal Highway Administration (FHWA) has contracted with a consulting firm to prepare a Freight and Land Use Handbook to document the existing knowledge and practices[86].

Following is a list of often-overlooked land use issues that can affect urban goods movements:

- increase in the spatial density (densification) that leads to greater concentrations of demand for goods consumption and congestion as well as competition for space
- urban renewal (gentrification) that leads to local opposition to freight facilities and limit the availability of suitable urban sites for freight facilities
- sprawl of industrial sites including freight terminals

Basically, all these issues can be attributed to the lack of a coherent approach for incorporating freight facilities in land use planning. Most urban planners and decision makers do not have sufficient knowledge and understanding of freight issues to take urban goods movement into consideration. Although certain measures such as freight villages have a potential to address some of the freight and land use problems at both local and national

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[84]HausrathEconmic Group and Cambridge Systematics. MTC Good Movement Study - Phase 2: Task 11 Working Paper (A Land Use Strategy to Support Goods Movement in the Bay Area). September 2004.
[85]Atlanta Regional Commission.Atlanta Freight Mobility Plan - Final Report. February 2008
[86]Federal Highway Administration.Talking Freight Seminar series. “Freight and Land Use: Making the Connection”. December 15, 2010.
http://www.fhwa.dot.gov/planning/freight_planning/talking_freight/10talking.cfm (Accessed December, 2010)

levels, they often face serious challenges in the implementation stage due to the lack of availability of suitable land. A freight village is a "defined area within which all activities relating to transport, logistics and the distribution of goods, both for national and international transit, are carried out by various operators"[87]. Furthermore, freight villages must be Finally, "it is imperative that a freight village be run by a single body, either public or private[88]". This last point distinguishes freight-oriented developments in the U.S. from true freight villages. As noted by Kawamura and Lu[89], in the U.S. there are already several freight-oriented developments, for example Logistics Park Chicago, that are functionally indistinguishable from European freight villages. However, those developments were initiated and implemented largely by the private sector, with cooperation from the local entities as opposed to the European cases where EU injected public funding to set up quasi-public entities to manage every aspect of freight villages. In that sense, freight villages work similarly to some of the airports in the U.S. There may not be a need for the public agencies to take on the risk by injecting funding or proactively planning for freight villages as the complexity and volatility of the commercial real estate development makes the long-term success of such endeavor highly unpredictable. Furthermore, freight villages do not address the issue of the "last mile" portion of the freight movement which is the focus of this study.

Freight facilities, especially when they are consolidated, require large parcels of land with relatively easy access to large urban core areas. In addition, developers must overcome negative perceptions by communities of freight facilities. Cases like Union Pacific's Global III Intermodal terminal, which had to settle for a site that is 80 miles from Chicago, are common.

The problem is not just limited to suburbs and exurbs. Within the inner city, there is great political and economic pressure to convert existing industrial areas into other types of land use through gentrification. (See, for example, the land use plan for the Greenpoint-Williamsburg area in New York City[90]). While those decisions are based on broad trends such as the decline of manufacturing sectors and population growth in urban areas, opportunities to convert manufacturing sites into freight and/or supply chain centers are being lost.

The overarching goal of this section is to report on the preliminary findings from our effort that examined the perceptions and knowledge of the stakeholders involved in urban freight movement and commercial real estate development regarding the relationship between land

[87] http://www.freight-village.com/definition.php (Accessed August 29, 2011).
[88] Ibid
[89] Kawamura, K. and Y.D. Lu. "Effectiveness and Feasibility of Innovative Freight Strategies for the U.S. Urban Areas" in Recent Advances in City Logistics (Taniguchi, E., and R. Thompson, ed), Elsevier. 2006
[90] http://www.nyc.gov/html/dcp/html/greenpointwill/greenplan5.shtml (Accessed May 15, 2008).

use and freight. In this section, we first provide an overview of the theoretical aspects of land use - freight interaction. This discussion will focus mostly on the freight movements that take place in urban areas, namely, the shipments to regional distribution centers (regional DCs) and final customers. We will then present the research approach that we have employed to collect pertinent information and to analyze the collected data. The section will conclude by presenting findings from the analysis of the data. As the term "land use" is understood by many to mean the use of land and do not correctly convey the scope of the analysis that include road design characteristics, density, aesthetics, and so on, we will use the term "built environment" hereafter to represent the broad characteristics of a space.

4.2 Built environment - freight interaction

While most of past research efforts have focused on the effect of freight transportation on business locations, or in many cases, economic development, the interaction in the opposite direction, namely the effect of land use on freight transportation should not be overlooked. Although policy makers and urban planners tend to behave reactively to "fix" the problems related to freight movement, e.g. too much truck traffic in neighborhoods, rail-crossing delay, etc., there are opportunities to employ integrative approach to the planning of land use and freight transportation system to prevent the problems from materializing in the first place.

Such an environment makes it difficult to build an effective planning process. Figure 22 presents an example of a "last-mile" part of a retail supply chain system typically found in U.S. cities. The figure also shows the institutional layers that affect this particular link in the supply chain. As described below, developing and operating a supply chain involves numerous actors that are spread across space and institutions. It should be noted that the entire supply chain for goods such as toys, automobiles, and apparel may extend across hundreds of government jurisdictions in many countries and states. To keep the study from being intractable, we have focused on the last part of the supply chain shown in this figure that typically, in the U.S., is contained within one or two urban regions.

Although movements of freight are mostly driven by private businesses in the U.S., public sector decisions have critical and pervasive effects on the means and efficiency of freight movement in several fronts. First, transportation infrastructure is by and large still being provided, operated, and managed by the public sector. In recent years, even the railroads are seeking substantial support from the government to upgrade their infrastructure. Secondly, land use decisions, implemented through regulations and local ordinances, affect the design and management of supply chains, including the placement of facilities. In the current land use decision process, each municipality is likely to consider, in a parochial manner, pros (jobs and economic benefits) and cons (negative externality) of having a freight facility in their community. Not surprisingly, many municipalities do not welcome a proposal for a major freight facility even if that may force the facility to locate in a sub-optimal location from the regional stand point[91]. Also, it should not be overlooked that land use determines the location and intensity of demand for freight movements. For example, urban density and design have profound impacts on both the volume and efficiency of freight movements for the "last mile" segment of journey[92,93,94]. While many cities strive to gentrify urban core areas with densification and transit-oriented development (TOD), very little attention is paid to the fact that such land use patterns may lead to an increase in the intensity of goods consumption per unit of land area and also pose various problems for logistics operations.

From the perspectives of the businesses involved in the movement of freight, the number of government institutions that can affect the components of their supply chains is mind-boggling. Consequently, it is likely that businesses will view the government and government policies as one of the exogenous factors similar to labor market or fuel price that they must "deal" with, rather than "work" with, even when the government is eager to reach out to the businesses in the planning process. They do not feel sufficiently empowered or have the time and resources to collaborate with the government entities to address problems or develop long-term strategies to improve the business environment.

Meanwhile, real estate businesses that participate in the planning and implementation of commercial developments that are consumers of freight and customers of the freight sector businesses are likely to invest resources to proactively interact with certain government agencies. Although they tend to approach municipalities and sometimes states to communicate their concerns and needs, it is not well known whether or not they expect substantive response in terms of transportation policies or infrastructure issues. In other words, it is plausible that when it comes to transportation issues, especially those related to freight, real estate industry shares similar passive attitudes as that of freight businesses. Furthermore, it is not clear whether the real estate developers have a clear understanding of the issues related to freight transportation because different types of commercial developments pose different sets of problems (e.g. hazardous material transport, truck size and weight regulations, etc.), and it takes years of experience to develop adequate expertise.

It becomes apparent that the stakeholders do not have a full understanding of the issues when it comes to dealing with outside their domain of expertise. It is therefore important to design an approach that will explore some of the key issues/factors across stakeholder groups and

91 For example, it is well known that Union Pacific's Global III terminal had to locate some 80 miles from Chicago due to the lack of takers.

92Gary Pivo et al., "Learning From Truckers: Moving Goods in Compact, Livable Urban Areas," (Olympia, WS: WSDOT, 1997)

93 Anne G. Morris and Alain L. Kornhauser, "Relationship of Freight Facilities in Central Business District Office Buildings to Truck Traffic,"Transportation Research Record 1707 (January 2000): 56-63.

94 R. O'Laughlin. Chicago Downtown Freight Study.Presented at TRB AT025 Committee meeting. January 2008

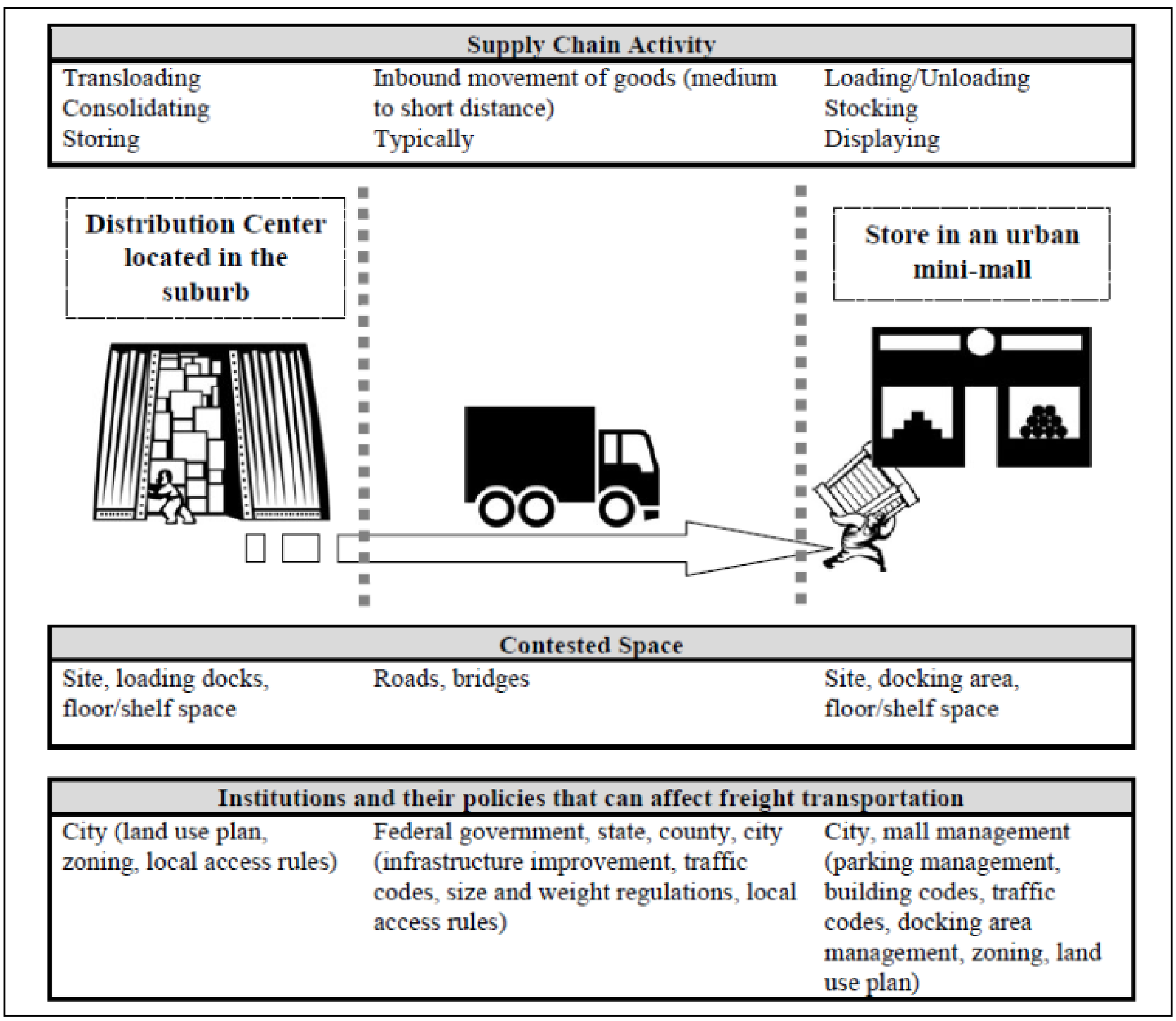
provide a better understanding of the relationship between freight movement and the built environment.

4.3 Study Approach

The work described in this section was conducted to address two of the research issues described in the first chapter of this report. They are:

- Effects of the performance of transportation infrastructure, as they relate to freight movement, on the location decisions of various types of businesses,
- Effects of land use on the efficiency of freight movement for different components of most common types of supply chains

Figure 22: Last-Mile Component of a Retail Supply Chain



While finding the answers to these questions will help address existing knowledge gaps, we also approach this study with a specific hypothesis in mind. We believe the fundamental problem that leads to many ill-advised land use and transportation policy decisions related to freight can be attributed to the absence of common knowledge base and/or misconception about these issues among the institutions in both private and public sectors.

4.3.1 Interviews

The research team conducted in-person interviews of stakeholders in municipalities, economic development agencies, third-party logistics (3PL) companies, trucking companies, and industrial real estate development firms to collect information on their views on various issues related to built environment and freight relationship.

The interviews were conducted in a semi-structured format. For carrying out the interviews, a list of questions was developed to explore the stakeholder perspectives in the following areas:

1) Effect of built environment on the "last mile" part of the freight movement (e.g. congestion, competition for loading spaces, delivery time restrictions, turning radius and height restrictions, etc.).

2) Effect of the performance of transportation infrastructure on the supply chain management decisions (e.g., does congestion affects the location of the distribution centers?)

3) Effect of the cost of freight transportation on the location choices of businesses in different industries, and

4) Necessary conditions for the development of a large-scale development of supply chain-oriented industry centers

The objective is to test the hypothesis that these issues are perceived differently by different stakeholders, especially between private and public sectors, resulting in ineffective public policies and also private investment decisions.

The list of stakeholders was compiled from the membership lists of various industry associations and attendees of conferences related to freight. Initial contact was made by a letter addressed to each individual in the list explaining the scope of the study and asking their participation. The letter was followed by a phone call to obtain their response to the solicitation, and if they are willing, to set up the interview.

A total of 214 individuals were contacted by letter. Follow-up phone calls yielded 22 interviews. In addition, two more individuals whose participation was certain, due to their relationship with the University, were interviewed. The Table 16below shows the breakdown of the interviewees by sector. All of these were located in the Greater Chicagoland area.

Table 16: Interviewees by Sector

Sector	Completed Interviews
Real estate developers	5
Government	8
Non-profit	5
Trucking	4
3PL	2
Total	24

The interviews were conducted face-to-face, typically involving two researchers. A questionnaire was developed by the researchers and this was used to facilitate the discussion and the interviews with the stakeholders. The questions were framed to get insight into the aforementioned set of issues and prompts were used to guide the conversation. One instrument was used for all interviews except for the government sector stakeholders. For government sector interviewees, questions regarding the inter-municipality or inter-agency coordination, and about the planning process were added. Photographs of an older Central Business District with mid-rise commercial buildings (in Chicago), a newer transit-oriented development (in Oakland, CA), a commercial strip mall (in suburban Chicago), and an aerial shot of a vast concentration of mid-rise buildings (of Tokyo) were used to visually convey the context of the terms "land use" and "built environment" used during the interviews. Most interviews lasted between 45 minutes and one hour. The lists of questions that were used to facilitate the interviews are included in the Appendix. The questionnaire along with the study approach was screened by the Institutional Review Board (IRB) at UIC and the researchers had to be certified by the IRB before conducting the interviews.

4.3.2 Cognitive Mapping

The analysis process, with theoretical underpinnings in cognitive mapping, makes use of Strategic Options Development Analysis (SODA), a qualitative approach steeped in public participation theory through the software Decision Explorer. The method is systemic in nature and looks at the system as a whole rather than take the reductionist approach of breaking it into parts. The literature on the impacts of built environment on freight movement is divided into four distinct categories: (1) direct impact of the built environment – such as turning radius, viaduct clearance etc, (2) factors impacting the optimal use of the supply chain, including delivery times etc, (3) decisions/factors pertaining to site selection of distribution centers, and (4) other factors including the socio-political landscape that impacts most major transportation outcomes. The interviews with each stakeholder group were conducted in a semi-structured format with a series of questions culled out from the four categories mentioned in the previous sentence. The responses from the interviews were accordingly divided into the following distinct categories – (1) those pertaining to the impact of the built environment, (2) supply chain, (3) site selection, and (4) other general observations.

Upon completion of the interviews, each interview was digitally transcribed. Decision Explorer cognitive mapping software was used to develop connected cognitive maps for each interview. Each map is a series of "concepts" which are derived from interview transcripts. Direct quotes in response to the interview questions, were included in the map for each stakeholder interview and the maps were then analyzed for emerging themes.

The concepts in each map were color-coded according to the major thematic areas reflected in the semi-structured interview questionnaire and the literature review. The color-coding allowed the research team to compare within stakeholder categories or across categories about the responses within each theme area. These thematic areas were instrumental in creating merged maps for each stakeholder group. For example, the research team interviewed five real estate firms as part of this research project and created five individual maps, one for each real estate firm. In order to capture and represent the combined views of the different real estate firms, a merged map was created to reflect the most important and pertinent viewpoints of these firms.

A merged cognitive map of the trucking sector is shown below (Figure 23) as an example. It is a large and complex map that consists of numerous concepts identified by the stakeholders due to the broad nature of inquiry. Arrows connecting the concepts show the causal relationship between the concepts, from the interviewee's point of view. Beyond mapping, Decision Explorer contains advanced techniques used to analyze relationships in the interview findings. The software produces two types of statistics: central scores and potency scores. The central score, which represents direct and indirect links to particular concept, represents the level of influence that a concept has in relation to other concepts in the model, while the potency score, which is the count of direct links, reflects the extent to which a peripheral concept contributes to the higher order central concepts[95].

To understand the stakeholder's perspective for each of the topics discussed during the interview, we calculated the centrality scores for the concepts within each topic. The central analysis traces all issues which are connected to the central issues both directly and indirectly. The centrality scores are derived by adding the total number of arrows coming in and leaving a concept with diminishing weight of each successive layer. For example, direct connections between concepts are assigned a weight of 1; concepts connected indirectly in the second layer are given a weight of ½; and those connected through the third layer are given a weight of 1/3, and so on.

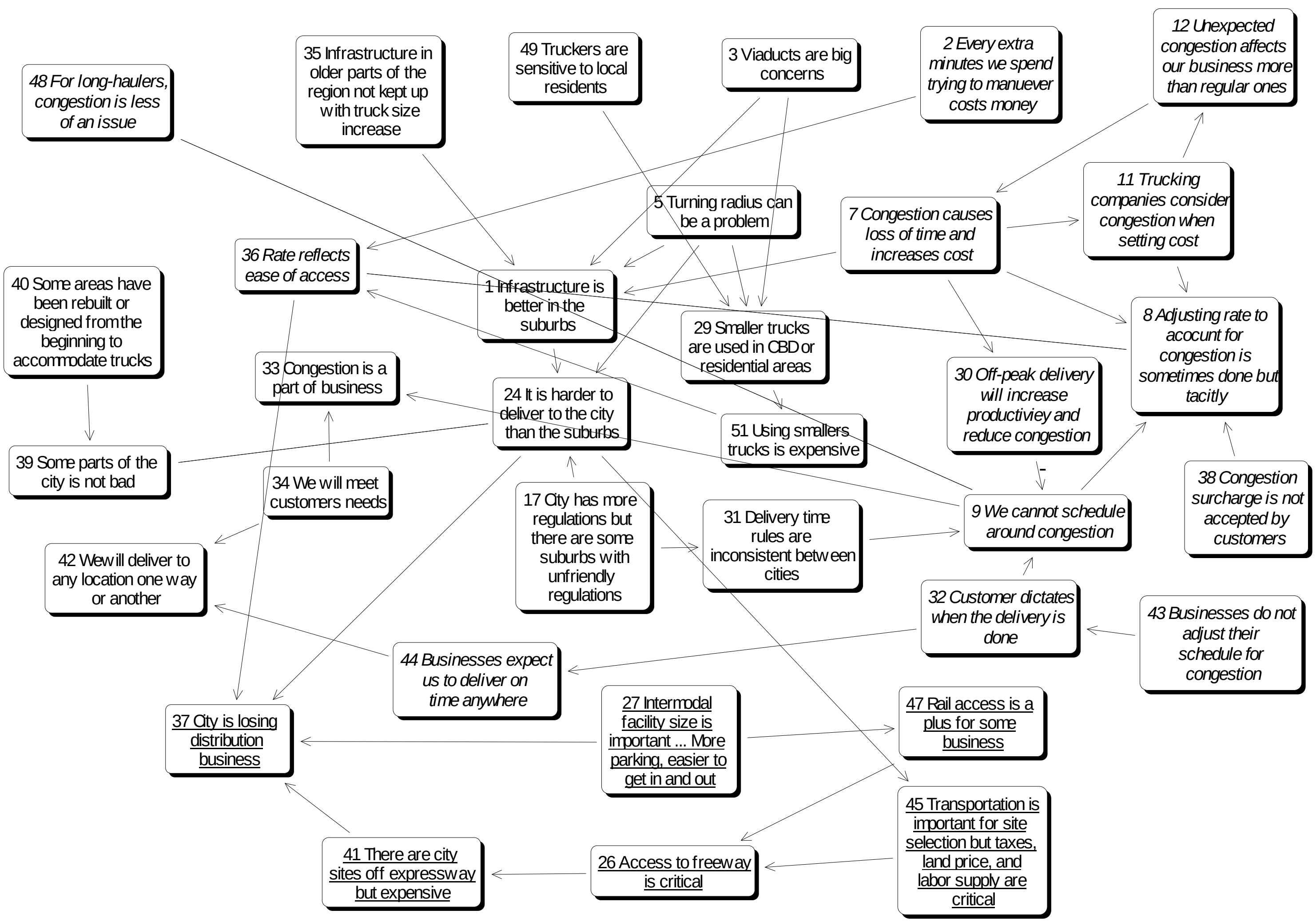
Central and periphery scores were calculated from cognitive maps developed for each stakeholder. Calculating the central and potency scores for each stakeholder allowed the research team to identify the more important concepts within each thematic bin for each stakeholder. The prioritized thematic concepts were included in the merged map for each stakeholder group. This process was repeated for each stakeholder group resulting in merged maps for real estate, municipalities, shippers/3PL, truckers, and the MPO for the region. These merged maps provided the aggregate views for each stakeholder category pertaining to the research question of impact of the built environment on the last mile portion of freight movement.

The results of this exercise are tabulated in Table 17 through Table 20. The tables reflect the prioritized opinions of the stakeholders about issues related to freight movement. Often, the discussion covered the issues that were peripheral to the central topic, but were nevertheless provided valuable information that have a potential to be developed into policy recommendations. The concepts obtained from those discussions are tabulated in the "other" category.

The merged maps and the table provide an understanding of the salient factors that should be taken into consideration when drafting policies that will impact freight movement for a region. Furthermore, by comparing the merged maps and central concepts of different stakeholder groups enable us to understand the difference in the perspectives and knowledge about the critical issues related to the relationship between built environment and freight. This is important because of the fact that this research throws light on the complexity involved in the decision-making process when taking a multitude of viewpoints into account.

[95] Ackermann, F., C. Eden, and S. Cropper. "Getting Started with Cognitive Mapping" http://www.banxia.com/pdf/de/GettingStartedWithCogMapping.pdf

Figure 23: Merged Cognitive Map for Trucking Firms



4.5 Findings

Table 17 shows the concepts identified by the stakeholders in the trucking sector, ordered by the centrality scores. The concepts listed in the Built Environment category show that the interviewees in the trucking business strongly felt that it is difficult to make deliveries to the destinations in the city boundary of Chicago. It is explained by the fact that the condition of the infrastructure in the city, especially the presence of viaducts with limited height clearance, and street design that restrict turning radii. They pointed out that the presence of viaducts forces them to take many detours that waste fuel and time, and contribute to congestion in the city. While they are aware of the viaduct database on the Internet, they commented that the information is sometimes obsolete and not accurate. They also pointed out that some cities in the suburbs may have restrictive rules regarding truck access. The last concept listed in the Built Environment category represents a prevailing view that truckers are willing to make deliveries that customer expect and to stay in the business, it is necessary to be able to do so.

Table 17: Central Concepts for Trucking Firms Identified by Centrality Scores

Topical area	**Trucking**
Built Environment	1. It is harder to deliver to the city than the suburbs 2. Infrastructure is better in the suburbs 3. Viaducts in the city waste fuel and time and documentation is not up to date 4. Turning radius can be a problem in the city 5. City has more regulations but there are some suburbs with unfriendly regulations 6. We will find a way to make delivery anywhere, any time
Supply Chain	1. Rate reflects ease of access 2. Adjusting rate to account for congestion is sometimes done but tacitly 3. Not possible to schedule around congestion (customers set delivery times) 4. Congestion causes loss of time and increases cost 5. Off-peak delivery will increase productivity and reduce congestion
Site Selection	1. City is losing distribution business 2. Transportation is important for site selection but taxes, land price, and labor supply are critical 3. There are city sites off expressway but expensive 4. Intermodal facility size is important ... More parking, easier to get in and out 5. Access to freeway is critical
Other	1. Delivery time rules are inconsistent between cities

The concepts in the "Supply Chain" category reveal that congestion does affect the productivity, but at the same time, they feel that they have no means to avoid congestion. Customers do not take the effect of congestion into consideration when setting the delivery time window. While they consider the effect of congestion when adjusting rates they charge for deliveries, it is done tacitly. This is an important point since while the trucking firms can justify to their customers that surcharges depend on the location of the delivery, they are not able to base surcharge on the time of delivery. They fear that openly adding surcharges to offset the cost of congestion would prompt the customers to look for other companies that are willing to deliver at a lower rate. In some cases, they sign a long-term contract with a customer and even if congestion worsens due to unforeseeable reason (e.g. construction), they cannot adjust the rate. They regard off-peak deliveries as one of the ways to improve the efficiency of their business and also reduce congestion.

While trucking businesses do not get involved in the site selection process of their customers, they provided insights based on their observations. They feel that their customers have gradually moved out from the city of Chicago to the suburbs. They believe that while transportation access is important for site selection, other factors such as tax incentives and price are at least as important. That being said, proximity to interstate expressway interchanges is a necessity for a site to be attractive to their customers. The availability of land to build spacious facility makes suburbs attractive to many of their customers. In terms of their view on the local governments, they are frustrated with the regulations related to delivery times that vary considerably among the cities.

Table 18 summarizes the concepts identified by the interviewees from the real estate sector. Their perspectives on the built environment effect on trucking operation are similar to those gathered from the interviewees from the trucking sector, indicating their familiarity of the industry. Their views on the effects of transportation infrastructure on the supply chain also echo that from the truckers with similar views on the effect of congestion on the efficiency and also the rate of deliveries. They also understand that truckers have little control over the timing of the shipments. These stakeholders are probably the most knowledgeable among the interviewees about the business site selection. They stressed that each site selection process is unique and there is no set formula that businesses use. However, they observed that tax incentives often play a critical role, and businesses may tolerate certain level of congestion in order to reduce tax burden. They stated that Cook County, which include Chicago and the inner suburbs, as not being attractive to freight-related businesses due to the high tax, congestion, and lack of available land. Similar to the truckers, they also believe off-peak delivery can be an effective tool to mitigate congestion.

Table 18: Central Concepts for Real Estate Sector Identified by Centrality Scores

Topical area	**Real Estate**
Built Environment	1. Infrastructure in the city was built when trucks were smaller... suburbs have newer infrastructure 2. Viaducts in the city is a serious problem 3. Delivery in the CBD is difficult because buildings may have small interior docks, tight exterior docks, or trucks hanging into streets 4. The toughest part is getting equipment in and out
Supply Chain	1. Congestion affects cost and driver hours of service, impact productivity 2. Carriers can charge lane by lane, lanes with heavier congestion may have added cost 3. Most delivery appointments will be set around heavily congested times - shippers don't care about costs rising 4. Companies tend to have their preferred operations already figured out, they know there's no point in shipping at that time if they're going to sit there
Site Selection	1. Site selection varies distinctly for every single use, proper balance between costs and demand 2. Tax incentives are critical in site location 3. Companies prefer congestion to paying higher tax 4. Cook county has higher taxes, more congestion, and less land 5. For supply chain centers, availability of low cost and suitable labor, business friendly attitude are important factors
Other	1. Communities need to be open to mitigation techniques, which is to allow deliveries at off-peak times

The concepts shown in Table 19 present, for some issues, perspectives that are contrasting to the previously discussed stakeholder groups. Not surprisingly, they view the relationship between built environment and truck operation in terms of the negative impacts on its residents. While truckers do not consider curbside loading space as an important issue, it is the highest ranked concept by the municipal staff. The incompatibility of trucking operations with the surrounding land use is a serious concern for the cities. In terms of the effect of congestion on supply chain, they expect trucking firms to be able to charge the customers for the additional cost of congestion while the stakeholders in the trucking sector stated that they can do so only tacitly and not for all the customers. The municipal staff also thought commercial deliveries are mostly done during the off-peak periods. This misperception may be due to the fact that many of the deliveries are made in the mid-morning, after the morning rush hour. However, from the truckers' point of view, any delivery made during the day time must navigate the congestion. For truckers, evening or late night is considered off-peak. They are not necessarily supportive of the night-time delivery ban that some of the municipalities enforce at some sites. However, they are also sensitive to the demand from the residents.

When it comes to the business site selection, their views are similar to those expressed by the interviewees from the real estate sector. However, they seem to underestimate the effect that tax burden has on the location choice. While they recognize the potential economic benefit that large logistics centers may bring to the city, their comments also underscore political sensitivity associated with such developments. The interviews also highlight the fact that these municipalities communicate with neither the neighboring communities nor the regional agency regarding the decisions that may have an effect on the regional freight movements. In one case, a municipality that is mostly residential is located adjacent to a city that relies on truck terminals and warehouses for their tax base. The city staff commented that trucks passing through their city are having negative impacts on residents' quality of life and admitted that there was little knowledge about the future plan of their freight-oriented neighbor. This stakeholder also stated that while the city has not allowed large-scale development of freight-related sites in the past, it may have to consider such option due to the recent economic downturn.

Table 19: Central Concepts for Government Sector Identified by Centrality Scores

Topical area	**Government**
Built Environment	1. Curbside loading space is an issue 2. Turning radius is an issue 3. Because of noise, no one wants live near trucking facilities
Supply Chain	1. Congestion is worse if it is unexpected 2. Trucks and shippers should be able to charge extra for congestion 3. Off-peak delivery is best 4. Commercial deliveries normally happens off-peak 5. 24-hour delivery is unreasonable
Site Selection	1. Having logistics center will lead to increase in jobs, tax revenue 2. Congestion can deter firms to locate here 3. Industrial corridors next to Interstate are appealing because of the access 4. Using land for things like DC's and terminals is not the vision elected officials want 5. Even without tax incentives they would stay because of access and location
Other	1. Communities want things to work better, they ought to plan a little better about when those deliveries arrive 2. Delivery time restriction is hard to enforce 3. Do not coordinate with CMAP at all; Not really with IDOT 4. We do not have good communication with neighboring communities 5. General ordinance do not restrict off-peak deliveries

The Chicago Metropolitan Agency for Planning (CMAP) is the Metropolitan Planning Organization (MPO) for the Chicago region. In recent years, it has undertaken a major effort to develop a set of recommendations to address the issues related to the movement of freight. The interview with the MPO staff, summarized in Table 20revealed that the MPO has mostly accurate grasp of the key issues raised by other stakeholders such as viaduct and weight restrictions, inefficiencies caused by congestion, and the outbound migration of supply chain businesses. Facilitating the coordination among the municipalities in the region is the role that MPO is expected to assume. Its vision is to rationalize the freight infrastructure system in the region by identifying corridors of critical importance and identifying bottlenecks that will be targeted for improvements. The freight plan produced by CMAP[96] reflects such vision and in large part succeeds in identifying the projects of critical importance. However, there are some challenges as well. Municipalities often fail to report changes in truck route designations to MPO or Illinois Department of Transportation (IDOT) although they are required by law to do so. While it is mostly due to negligence, in some cases, the designation of a new truck route can stoke the ire of the residents and thus the cities prefer not to publicize it. Also, coordinating the development of freight-oriented businesses is challenging since municipalities are competing against one another to attract those businesses and do not like to share information or openly discuss the developments being considered. Thus, in reality, it is very difficult to actually coordinate the development of industrial sites with the infrastructure projects that can facilitate the movement of freight.

Table 20: Central Concepts for MPO Identified by Centrality Scores

Topical area	**MPO**
Built Environment	1. IDOT/Municipalities can designate their own truck routes 2. Bridge weight and height restrictions are important as it causes detours
Supply Chain	1. Congestion adds cost to businesses 2. Trucks do not use the most direct route, leading to excess congestion
Site Selection	1. Congestion causing some freight activity to move to Greenfield sites 2. Conditions for site selection vary by industry
Other	1. Rationalize the freight system by prioritizing freight movements to deal with congestion 2. We need good access for Chicago to be an important manufacturing center 3. Reduce overall inefficiencies for everyone's benefit 4. Communities need to coordinate better to reduce overall VMT 5. Conflict between communities about commercial development exists

[96]Chicago Metropolitan Agency for Planning. Freight System Planning Recommendations Project Final Report.http://www.cmap.illinois.gov/freight-system-planning. 2010. Accessed March, 2011.

4.6 Summary

While examining the central concepts identified by each stakeholder groups provide rich information about their perceptions of the relationship between built environment and freight, in order to derive the insights that can lead to policy recommendations, an analysis of the similarities and differences in their views are needed. As stated earlier, our hypothesis is that many of the issues related to the movement of freight are caused by the lack of communication and misperceptions.

The review of the central concepts from the stakeholder groups as a whole revealed a surprisingly high consistency in the knowledge levels about freight industry but also pointed out some institutional issues.

4.6.1 Built Environment

In terms of the physical aspects of built environment, all the stakeholders pointed out the viaducts as a serious problem that contributes to inefficient routing and increased level of congestion. However, while the stakeholders in the government sector pointed to the Internet-based database, developed by the city of Chicago, as the solution, the stakeholders in the trucking industry pointed out that the information is not always reliable, and the lack of accurate and current information about the clearance is an on-going issue. When it comes to inadequate turning radii often seen in some parts of the region, the trucking industry sees it as no more than an inconvenience that skilled drivers should be able to navigate through one way or another, while the municipal staff see it as a serious problem for their residents. We believe this difference in the perception comes from the fact that for truckers', the main concern is whether or not they can deliver the load to the customers, while the cities are concerned about the inconvenience to other drivers while the trucks negotiate the turns. A similar explanation can be applied to the slight difference in the perception about the loading areas. Trucking firms can charge extra for having to use curb space to load/unload freight, and they do not seem to be troubled by it. For the cities, it is a highly visible issue that affects public perception of trucking industry.

4.6.2 Congestion

There is a high level of agreement on the negative impacts of congestion on freight operations. All the stakeholders understand that trucks have little choice over the selection of delivery times, and that the shippers give little consideration for the added cost and also negative externalities when deciding on the delivery time windows for shipments. However, the stakeholders from the public sector tend to believe that trucking firms are able to pass on the added cost associated with congestion to the customers while it is often not an option according to the truckers. Nearly everyone interviewed, except for some from the municipalities, view off-peak delivery (i.e. nighttime) as a promising option to improve the efficiency of trucking operations and reduce congestion. However, some stakeholders pointed out that the real problem is the complexity of delivery time restrictions that are inconsistent among the cities and even within a city, which is corroborated by the statements made by some of the municipal staff. In many cases, night-time delivery restrictions are implemented on site-by-site bases in response to complaints from the neighbors. There is little documentation and often the drivers who regularly deliver to the restricted site are the only ones who are actually aware of the restriction. For municipalities, enforcing delivery time restriction is “a nightmare”, according to one staff.

Although nighttime delivery certainly is an attractive idea, further research need to be carried out before it can be adopted in the Chicago region. It should be noted that the shippers, whose cooperation is essential for the implementation of nighttime deliveries, were not included in the study. Some of the stakeholders in the trucking sector are actually the operators of private fleet and thus they are shippers/receivers. They are the most vocal supporters of night-time delivery. However, their opinions are likely to be different from the shippers/receivers that rely on trucking firms for transportation and thus are not able to internalize the efficiency improvements that can be achieved by night-time delivery.

4.6.3 Business Site Selection

The stakeholders were unanimous in stating that access is only one of the factors that are involved in the site selection for freight-intensive businesses. While not being close to expressway ramps excludes most of the sites from consideration, it is not a sufficient condition for the site to be ultimately selected. It is important to point out that there are some differences among the stakeholder groups in the stated reasons that make the proximity to expressways such a critical factor in site selection. While municipal staffs commonly attributed it to the cost of transportation, truck operators’ views were more nuanced. Truck operators felt that being close to expressways enabled them to reduce the number of uncertainties such as construction projects, truck routes changes, weight restrictions, and congestion, which ultimately result in an increased reliability in delivery times and cost. Managing uncertainty is especially important when they need to make a commitment to a long-term contract with a customer. Having to cross many jurisdictional boundaries (and neighborhoods) to make a delivery brings increased level of uncertainty in their operation. One truck operator commented that it takes only one person complaining to the city to make their operation very difficult. Real Estate professionals also pointed out that the freight-intensive businesses are sensitive about the attitude of the local government toward freight traffic and also other potential source of conflicts. Therefore, having to go through a quiet residential neighborhood to reach an Expressway interchange would make the site less attractive for those businesses.

The view on the access to rail is also consistent in that it is important for some businesses that deal with bulk freight, but for others it is not relevant. Tax incentives are listed by many as critical. However, there are considerable differences in how the stakeholders view other factors such as labor supply and site characteristics. Some view labor supply as an afterthought due to the abundant supply of willing work force due to the economic downturn, while others argued that it is critical.

4.6.4 Institutional issues

While none of the stakeholders, except for the MPO staff, provided in-depth opinion about the institutional issues that are contributing to the inefficiencies in the movement of freight, we have been able to extract insights from the analysis of the merged cognitive maps and central concepts.

The first observation is that overwhelmingly, local governments place priority on the management of negative externalities instead of proactive and strategic actions to address issues related to freight transport. Many recognize the need for integrated planning of land use and transportation infrastructure for freight, but none of the communities have taken a credible step toward actually developing one. Exception is the city of Chicago that has launched an initiative called Chicago Sustainable Industries with the goal to bring back the manufacturing businesses to Chicago by developing and implementing a broad-scoped plan that encompasses key areas such as: infrastructure systems (including but not limited to freight transportation), labor force, land use, and sustainable business practices. While a similar initiative involving other municipalities will be immensely beneficial, our interviews revealed that political reality is complex and there is no clear solution on the horizon. As such, the state of the practice is to treat individual problems, e.g. noise, turning radius, etc., as they emerge without coordination across political boundaries and long-term vision.

Another finding is that the municipalities do not have an effective channel of communication to collect accurate information on the various issues related to trucking. From the truck operators' point of view, voicing their concerns to the local government where they are making deliveries is not an effective way to address an on-going problem since they are not a member of the community. The customer, e.g. shipper or consignee, would have a greater credibility with the local government. However, our interviews found that trucking firms rarely communicate their concerns to the customers out of the fear that they will be seen as incompetent or too demanding. Several truck operators stated that they are paid to deliver a load to the customer and they are expected to deal with the multitude of challenges they face on a daily basis, such as poorly documented viaduct clearances, inadequate turning radii, inconsistent and sometimes irrational truck routes, without involving the customer. Our interviews indicate that this culture creates a gap in the feedback system depicted in the figure in the opening chapter, which is reproduced below, that assume that market signals will be fed back to the shippers and consignees when the transportation infrastructure is not providing adequate performance. Only exception is the businesses that operate private fleets since the communication between the logistics and other parts of the business is open.

Fortunately, CMAP has been proactive in seeking input from various stakeholders in the freight industry, and the newly developed freight plan incorporates their concerns. However, the plan falls short of coordinating land use and infrastructure investments for the specific intent of improving the efficiency of freight movement.

Chapter 5: Summary and Conclusion

This study strived to address some of the critical knowledge gaps associated with the relationship between land use and freight. Two main themes were examined using a mix of quantitative and qualitative analysis tools. The first theme, included in Chapter 2, examined the effect of transportation infrastructure on the freight sector output, employment, and productivity at both state and urban area levels. The goal of the analysis was to obtain insights that may help the decisions makers to assess the potential benefit of investments in transportation infrastructure for creating jobs in the freight sector and increase the productivity.

The findings suggest that the supply of road capacity do not stimulate the growth of freight sectors nor improve their productivity. Rather, strategies that stimulate the growth of industries that intensively rely on freight transport, tax incentives for example, are probably the right approach.While some communities have been able to enjoy tremendous increase in the freight sector output, transportation infrastructure nor the level of congestion can explain their success.At the MSA level, we found that the growth in trucking sector seems to become a zero-sum game in which the growth for one MSA translates to a decline in another. The urban areas that engaged in aggressive economic development initiatives often emerged as winners. We did find evidences that increasing air cargo activity is correlated with both trucking sector employment and productivity. In general, increasing the value of goods being transported seems to be the key to increasing the output of the freight sector since the freight rates tend to reflect the value of goods that are being transported. As a future study, it will be beneficial to examine the causal relationship between the growth in the manufacturing of high-value goodsand the productivity of the freight sector (and possibly congestion) to determine whether the efficiency of freight transport has effect on specific economic activities that are highly dependent on the sophisticated supply chain.

In Chapter 3, we shifted our attention to the interaction between the built environment and freight operations and also business location choice process at a much smaller geographical scale. Our analysis underscores the importance of involving broad spectrum of stakeholders in the discussion of freight issues. Especially, the participation and cooperation of shippers are critical in implementing nighttime deliveries that are seen by all the stakeholders asa promising strategy to address congestion and inefficiency. It is also our recommendation that a regional coordination committee to be set up and operated by the MPO or state department of transportation for each urban area to facilitate open exchange of information since our analysis indicated that currently there is no mechanism for the stakeholders to communicate.

Appendix

MSA-level analysis[97]

This section will look into some economic and infrastructure indicators at the Metropolitan Statistical Area (MSA) level that could potentially help interpret the interrelationships between freight infrastructure development, economic growth, and specifically, freight transportation productivity in the Upper Midwest Region. While available data at the MSA level are not as rich as those for the state-level analysis, the analysis conducted at a smaller spatial scale can possibly provide additional insights.

Bureau of Economic Analysis (BEA) defines the MSA as an area that has "at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties". Figure 12 shows the MSAs and the study area. There are a total of 83 MSA in the data set. The MSAs included in this analysis are in Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin. Minor sections of North Dakota, South Dakota, Nebraska, Kentucky, West Virginia, and Pennsylvania are also included because some MSAs extend across two states. The list of the MSAs that are included in the analysis is provided in the Appendix.

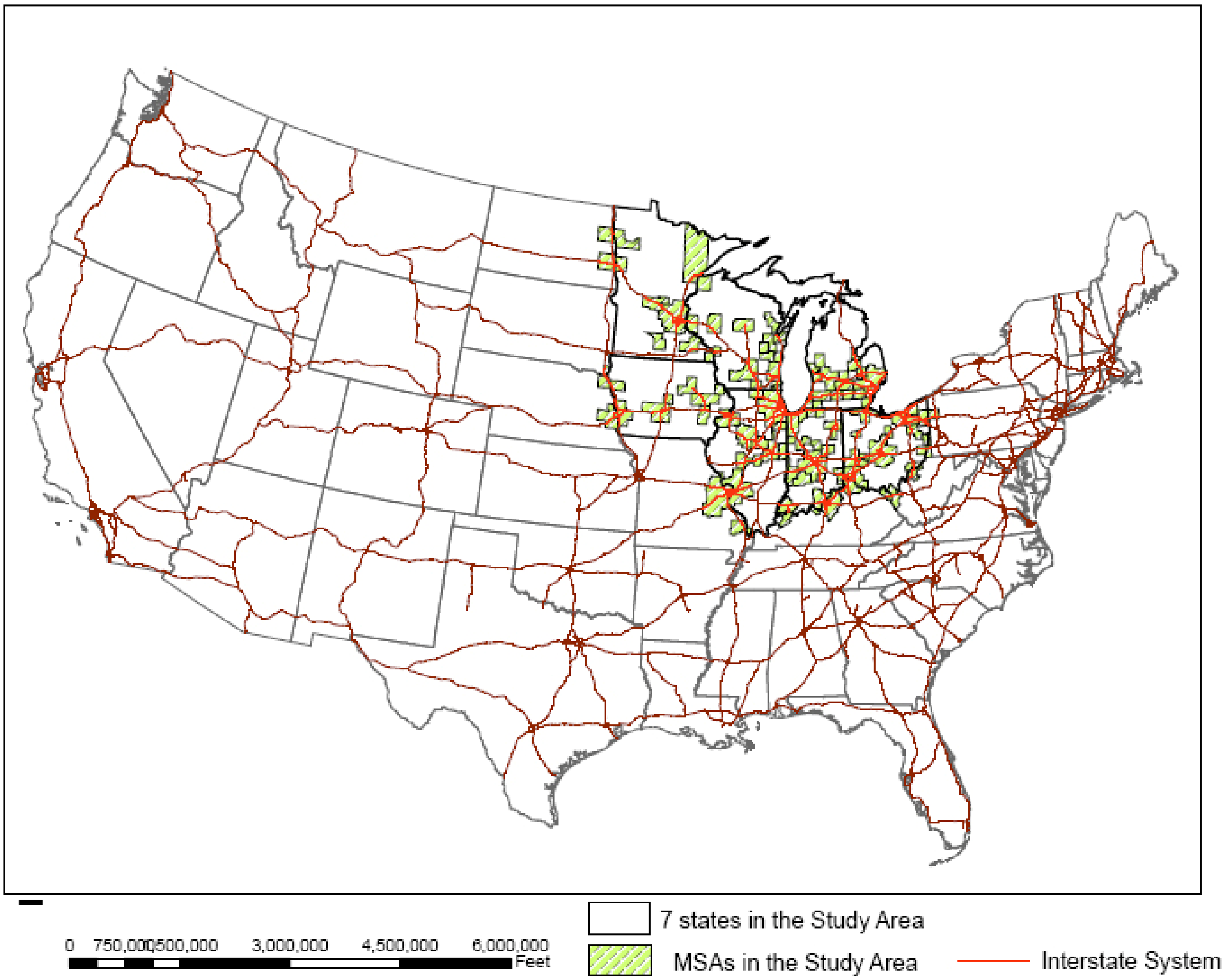
A.1. Economic Indicators

An economic indicator for trucking sector is defined using publicly available data. Gross Domestic Products (GDP) for MSAs by each industry from years 2002 and 2007 are used for this purpose. Due to the limitation in the publically available data, it is not possible to calculate the trucking sector productivity by using the approach employed for the state-level analysis (i.e. sector GDP divided by sector employment). Employment by industry can be obtained from the Local Area Personal Income interactive tables of the Regional Economic Data by the U.S. Bureau of Economic Analysis (BEA, 2009)[98]. BEA defines the employment as the number of total full-time and part-time employees at each NAICS (North American Industry Classification System) industry class at one digit level. The employment estimation of 2001-2006 are based on 2002 NAICS industry definitions, and for 2007 is based on 2007 NAICS. In addition to the employment by industry, the data contains variables such as total employment and farm/nonfarm employment as well. Unfortunately, the employment data at the MSA level is released only for the major NAICS industries. For each year, BEA has released employment data just for 25 major industrial groups. For instance, employment is

[97] This section is based on Rashidi, Laya. Relationship between Economic and Transportation Infrastructure Indicators and Freight Productivity. Master's Thesis.University of Illinois, Chicago.
[98]Bureau of Economic Analysis (BEA), U.S. Department of Commerce, Interactive Tables, <http://www.bea.gov/interactive.htm>, modified on 2009. Accessed on March, 2010.

given for the transportation and warehousing industry, which is a major industry, but not for truck, air, and rail transportation separately, as those are the minor industries within transportation and warehousing. For 25 major industries for which employment data is released, about 45 percent of employment data sets are missing.

Figure 24: Study Area Map – MSA-level Analysis



The GDP data is obtained from the Gross Domestic Product by Metropolitan Area interactive tables of the Regional Economic Data, released by BEA (2010)[99]. According to the documentation by BEA, "the estimated GDP is based on the county earnings by industry estimates from local area personal income accounts, and on the GDP-by-state estimates"

[99]Bureau of Economic Analysis (BEA), U.S. Department of Commerce, Regional Economic Accounts.http://www.bea.gov/regional/index.htm#gsp Accessed in May 2010.

(BEA, 2009[100]).For each year, BEA has released GDP for about 25 major and 95 minor industries. Almost 60 percent of the GDP data set is coded as “missing or suppressed”. Fortunately, about 88 percent of trucking sector GDP are available.

In addition to the trucking sector, economic indicators for two other industries, manufacturing and construction sectors that are highly dependent on trucking industry,are compiled. For manufacturing and construction, separate employment figures are readily available at the MSA level with only a few missing or suppressed entries[101]. Thus, we are able to calculate productivity by dividing the sectorial GDP by employment. Manufacturing productivity is defined as the ratio of manufacturing GDP over manufacturing employment. Construction productivity is also defined in the similar fashion.

A.2. Transportation Indicators

In addition to these economic indicators, transportation infrastructure indicators, congestion (measured in terms of truck VMT divided by the total centerline road length) and road density (total centerline road length divided by total area)from 2002 are used to analyze fluctuations in the freight transportation productivity measure. Both VMT and centerline miles were estimated using the GIS data set for the 2002 Freight Analysis Framework (FAF)[102].The FAF network is derived from the National Highway Planning Network (NHPN), developed by the Federal Highway Administration (FHWA). FAF network includes: "National Highway System (NHS) links, National Network (NN) links, rural minor arterials for counties not served by either NN or NHS, and urban streets as appropriate for network connectivity". (Battelle Memorial Institute, 2002)[103]. FAF defines VMT by multiplying average daily traffic (ADT) by the link length for all types of vehicles and roads (ICF Consulting, 2004)[104].

The road length variable is defined as the length of arc chain in miles. The variable includes all types of roads that are rural principal arterial (Interstate and other), rural minor arterial, rural major collector, rural minor collector, rural local, urban principal arterial (Interstate, other freeways and expressways, and other), urban minor arterial, urban collector, and urban local (FAF, 2006). Total road length in each MSA was then estimated by aggregating

[100]Bureau of Economic Analysis (BEA), U.S. Department of Commerce.Local Area Personal Income and Employment Methodology. April 2009

[101] Manufacturing employment does not have any missing values, and less than 3 percent of the construction employment values are missing.

[102]Federal Highway Administration. “Freight Analysis Framework 2.2” FHWA, 2006, Washington D.C. http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm

[103]Battelle Memorial Institute. Freight Analysis Framework Highway Capacity Analysis Methodology Report. April 2002. page 4

[104]ICF Consulting, Sample Methodologies for Regional Emissions Analysis in Small Urban and Rural Areas-Final Report, Prepared for: Federal Highway Administration U.S. Department of Transportation, October 2004, http://www.fhwa.dot.gov/environment/conformity/emission/emismeth1.htm, accessed on July 2010.

county-level information. It should be noted, however, that the two transportation infrastructure variables are only available for 2002, and dataset does not have any missing values. Also, when a link straddles the boundary of a MSA, the FIPS code designation in the FAF road network was used to determine whether or not the link is to be included in the MSA. Table 6provides a brief statistics of the transportation-related variables.

Table 21: Descriptive Statistics for Transportation Infrastructure Data

Variable	Mean	Standard Deviation
Vehicle Mile Traveled (VMT)	9586602.34	17207293.29
Road length (centerline lane mile)	501.01	568.85
Area (squared-mile)	1,768.14	1787.82
Congestion (VMT / road length)	15206.35	7051.20
Road density (road length / area)	0.292	0.010

As mentioned earlier, conducting analysis at the MSA level is made challenging due to the lack of data and transportation infrastructure data is no exception. One of the key data limitations is that the road lane mile, which was used in the state-level analysis, is not available. Using the center-line road length may introduce bias in the analysis.Also, we were able to obtain VMT and centerline road miles only for 2002 and 2007. Thus, longitudinal analysis was not feasible with this data set. Furthermore, employment for trucking industry is not available at the MSA level for the years that GDP figures exist[105].Thus, unlike the state-level analysis, it is not possible to derive the productivity measure for the trucking sector by dividing the GDP by the trucking sector employment.

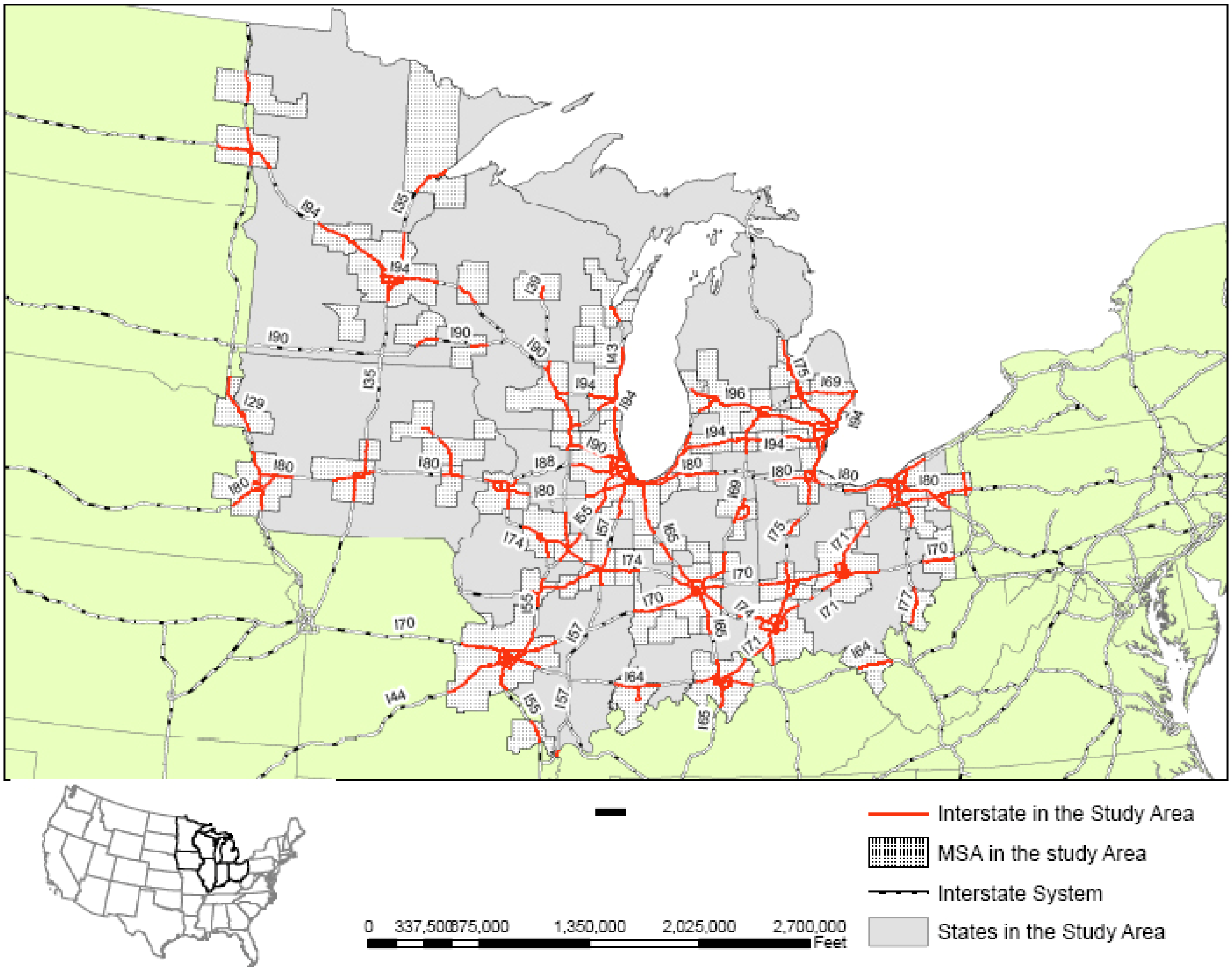
A.3. Analysis

A.3.1 Transportation Infrastructure

Figure 25 illustrates MSAs within 7 major states of the study area with Intestate corridors that runs through them. Chicago-Naperville-Joliet has the highest number of Interstate corridors (I90, I94, I88, I80, I65, I57, and I55) that cross through this MSA.

[105] Employment for the entire Transportation and Warehousing sector that includes trucking and other modes is available at the MSA level

Figure 25: MSAs and Interstate system within study area[106]



As discussed in the previous chapter, congestion indicator is defined as the ratio of VMT over road length, while road density is defined as road length over the area of each MSA. Both indicators are only available for the year 2002. The analysis of the congestion level, Table 22 , shows that Detroit-Warren-Livonia, Ann Arbor, Chicago-Naperville-Joliet, Indianapolis-Carmel, and Cleveland-Elyria-Mentor were some of the most congested MSAs in the study area in 2002. Except for Ann Arbor, the other four MSAs are large urban areas that rank among the top five MSAs in terms of high levels of truck activity, as shown in the next section. Ann Arbor, on the other hand, is a college city and the finding seems counter-intuitive at the first glance. However, a significant portion of the traffic to and from Detroit goes through Ann Arbor area, which explains the high level of VMT for this MSA. I94

[106] Source of Interstate Corridor: FAF2.2.

corridor, which crosses from industrial and congested MSAs such as Chicago-Naperville-Joliet, and Detroit-Warren-Livonia, also passes Ann Arbor and thus inflates the VMT. The table also indicates that Grand Forks, Duluth, Mankato-North Mankato, and Fargo are the urban areas with least levels of congestion. Interestingly, all of them are in Minnesota. Grand Forks is the 11th largest MSA of the study area that includes many rural roads and arterials. Grand Forks ranks 21st in terms of total road length, while it has only one Interstate. These circumstances contributed to unusually low VMT relative to total road miles for this MSA. As discussed earlier, the use of centerline miles as the denominator to calculate the congestion indicator tend to inflate the values for larger MSAs with many multi-lane highways. That being said, the differences in the indicator values between the most and least congested MASs are considerable.

Table 22: Ten Most and Least Congested MSAs

MSA	Congestion rank (2002)	Congestion (2002)
Detroit-Warren-Livonia, MI	1	38,903
Ann Arbor, MI	2	33,813
Chicago-Naperville-Joliet, IL-IN-WI	3	32,962
Indianapolis-Carmel, IN	4	30,930
Cleveland-Elyria-Mentor, OH	5	30,050
Monroe, MI	6	28,129
Columbus, OH	7	27,807
Akron, OH	8	25,650
Flint, MI	9	25,085
Milwaukee-Waukesha-West Allis, WI	10	24,768
Fond du Lac, WI	75	8,648
Rochester, MN	76	7,993
Dubuque, IA	77	7,855
Cape Girardeau-Jackson, MO-IL	78	7,081

Sioux City, IA-NE-SD	79	7,064
Waterloo-Cedar Falls, IA	80	6,917
Fargo, ND-MN	81	6,250
Mankato-North Mankato, MN	82	5,947
Duluth, MN-WI	83	5,495
Grand Forks, ND-MN	84	3,200

Table 23 shows MSAs with highest and lowest values of road density in the study area. Ten MSAs with the highest density of road include some of the most congested areas such as Milwaukee-Waukesha-West Allis, Cleveland-Elyria-Mentor, Detroit-Warren-Livonia, and Chicago-Naperville-Joliet, along with some MSAs that have a comparatively small area such as Sandusky and Racine. Racine is located between Chicago-Naperville-Joliet and Milwaukee-Waukesha-West Allis, while Sandusky is bounded between Cleveland-Elyria-Mentor and Toledo. They are the first and second smallest MSAs, by geographical area, that are located just between two major urban areas, thus having numerous major highways going through them. Five out of the ten MSAs with the lowest values of road density are amongst the ten least congested MSAs. Duluth is the second largest MSA in the study area and at the same time the MSA with the lowest road density.

Table 23: MSAs with Ten Highest andLowest Road Density

MSA	Road density rank (2002)	Road density (2002)
Sandusky, OH	1	0.599
Milwaukee-Waukesha-West Allis, WI	2	0.584
Racine, WI	3	0.556
Akron, OH	4	0.515
Cleveland-Elyria-Mentor, OH	5	0.501
Detroit-Warren-Livonia, MI	6	0.497
Chicago-Naperville-Joliet, IL-IN-WI	7	0.462

Flint, MI	8	0.443
Elkhart-Goshen, IN	9	0.425
Niles-Benton Harbor, MI	10	0.405
Kankakee-Bradley, IL	75	0.197
Danville, IL	76	0.180
Sioux City, IA-NE-SD	77	0.179
Cape Girardeau-Jackson, MO-IL	78	0.176
Wausau, WI	79	0.172
Bloomington, IN	80	0.166
Kokomo, IN	81	0.164
Fargo, ND-MN	82	0.162
Grand Forks, ND-MN	83	0.160
Duluth, MN-WI	84	0.120

A.3.2 Trucking sector GDP

Figure 26 shows ten MSAs with the highest trucking sector GDP in 2002. Table 24 also shows ten MSAs with highest and ten MSAs with lowest average annual trucking sector GDPs for the time period between 2002 and 2007. Chicago-Naperville-Joliet has the highest trucking sector GDP in the region with a value around three times that of Detroit-Warren-Livonia, which has the second highest value, validating Chicago's position as the freight industry powerhouse in the Midwest. Minneapolis-St. Paul-Bloomington, Indianapolis-Carmel, Columbus-OH, and Cleveland-Elyria-Mentor with trucking sector GDPs of around 1 billion dollar are also ranked high. Five out of ten MSAs with the highest value of trucking sector GDP in the year 2002 are also in the top ten in terms of road density. They are Chicago-Naperville-Joliet, Detroit-Warren-Livonia, Milwaukee-Waukesha-West Allis, Cleveland-Elyria-Mentor, and Akron. Of course, the association does not indicate causality. Most likely, those large MSAs with a long history of industrial economic activities have developed infrastructure systems that support the economic engine for the region. As in the table, Wheeling, Weirton-Steubenville, Bloomington, and Bay City have the lowest trucking sector GDP of around 35 millions of dollars.

Figure 26: MSAs with Ten Highest Trucking Sector GDP in 2002

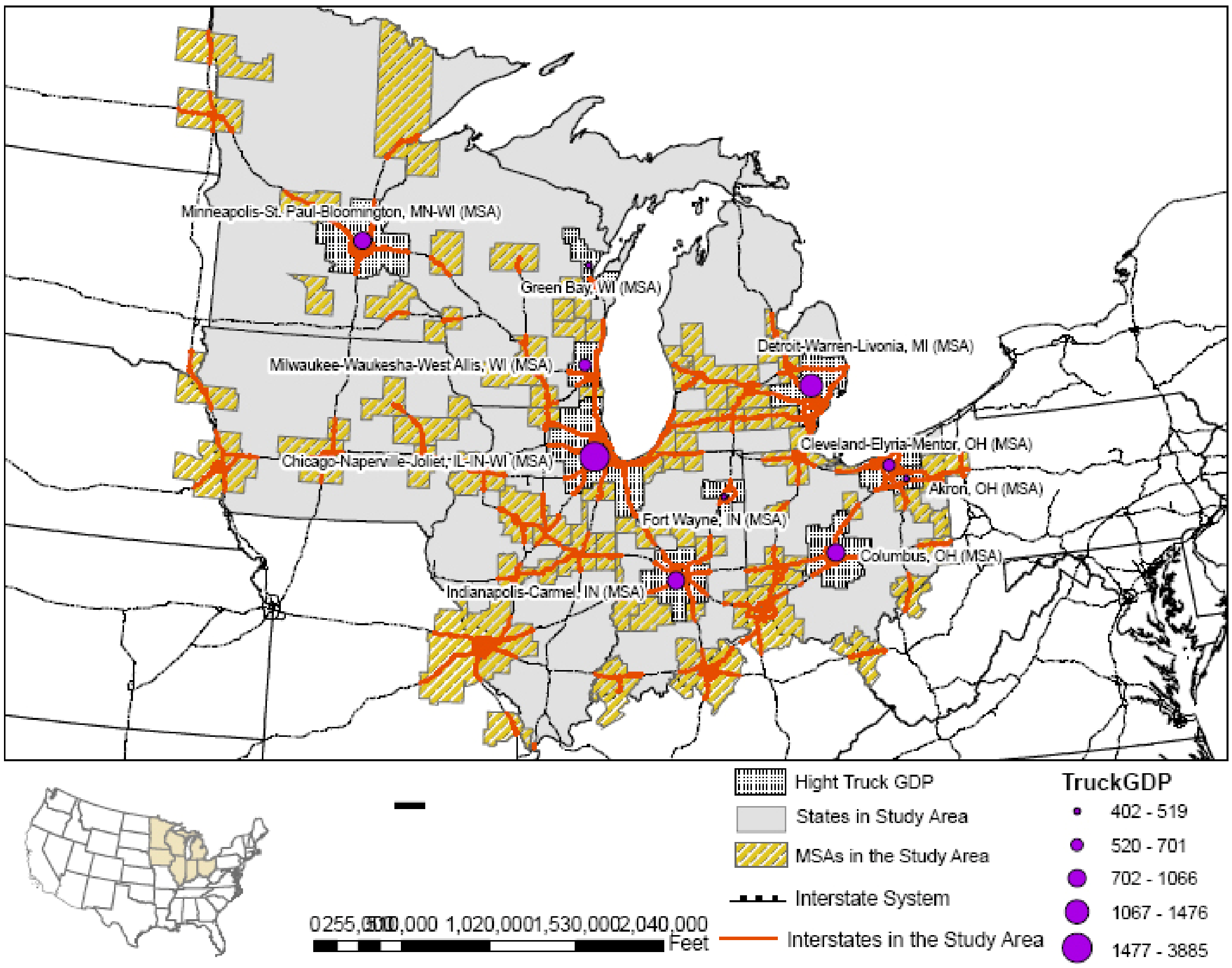


Table 24: MSAs with Ten Highest and Lowest Average GDP (2002-2007)

MSA	Avg. Trucking GDP (2002-2007) Rank	Avg. Trucking GDP (2002-2007)in $million
Chicago-Naperville-Joliet, IL-IN-WI	1	4,603
Detroit-Warren-Livonia, MI	2	1,660

Minneapolis-St. Paul-Bloomington, MN-WI	3	1,213
Indianapolis-Carmel, IN	4	1,135
Columbus, OH	5	957
Cleveland-Elyria-Mentor, OH	6	892
Milwaukee-Waukesha-West Allis, WI	7	735
Green Bay, WI	8	491
Fort Wayne, IN	9	468
Akron, OH	10	463
Wheeling, WV-OH	75	37
Weirton-Steubenville, WV-OH	76	34
Bay City, MI	77	33
Bloomington, IN	78	33
Kokomo, IN	79	26
Mankato-North Mankato, MN	80	26
Muncie, IN	81	25
Battle Creek, MI	82	22
Muskegon-Norton Shores, MI	83	18
Ames, IA	84	14

Growth in the trucking sector between 2002 and 2007 in each MSA is also estimated by dividing the trucking sector GDP in 2007 by the trucking sector GDP in 2002. As shown in Table 25, Iowa City and Kankakee-Bradley experienced the highest growth of around 90 percent, followed by Decatur and Parkersburg-Marietta-Vienna MSAs with 80% and 70% growth, respectively. Of the ten MSAs with highest percentages of growth, the case of Iowa City is unique in two ways. It already had a decent-sized trucking sector in 2002, at 179 million dollars, which increased to 342 million in the next five years. In addition, its growth occurred in a relatively steady manner over the five-year period. In comparison, all other high-growth MSAs that appear in the table had significantly smaller trucking GDP in 2002, somewhere between 50 million and 100 million, and most of the growth in trucking GDP occurred around 2003 and 2004. For example, the trucking sector GDP for Kankakee-Bradley MSA increased from 34 million dollars to 72 million dollars with a large jump, 19 million dollars, between 2003 and 2004. While the large, one-time increases that are commonly found at smaller MSAs can be attributed to an opening of a large trucking terminal, it seems Iowa City has been able to sustain growth year after year.

Table 25: MSAs with Ten Highest and Lowest Growth (2002-2007)

MSA	Trucking GDP Growth (2002-2007) Rank	Trucking GDP Growth (2002-2007)
Iowa City, IA	1	1.91
Kankakee-Bradley, IL	2	1.89
Decatur, IL	3	1.81
Parkersburg-Marietta-Vienna, WV-OH	4	1.70
Bloomington-Normal, IL	5	1.66
Sioux City, IA-NE-SD	6	1.65
Anderson, IN	7	1.64
Ann Arbor, MI	8	1.62
Canton-Massillon, OH	9	1.62
Rochester, MN	10	1.57
Peoria, IL	75	1.09
Wheeling, WV-OH	76	1.03
Weirton-Steubenville, WV-OH	77	1.00
Mankato-North Mankato, MN	78	0.96
Duluth, MN-WI	79	0.96

Jackson, MI	80	0.95
Springfield, OH	81	0.94
Akron, OH	82	0.90
Champaign-Urbana, IL	83	0.58
Muncie, IN	84	0.58

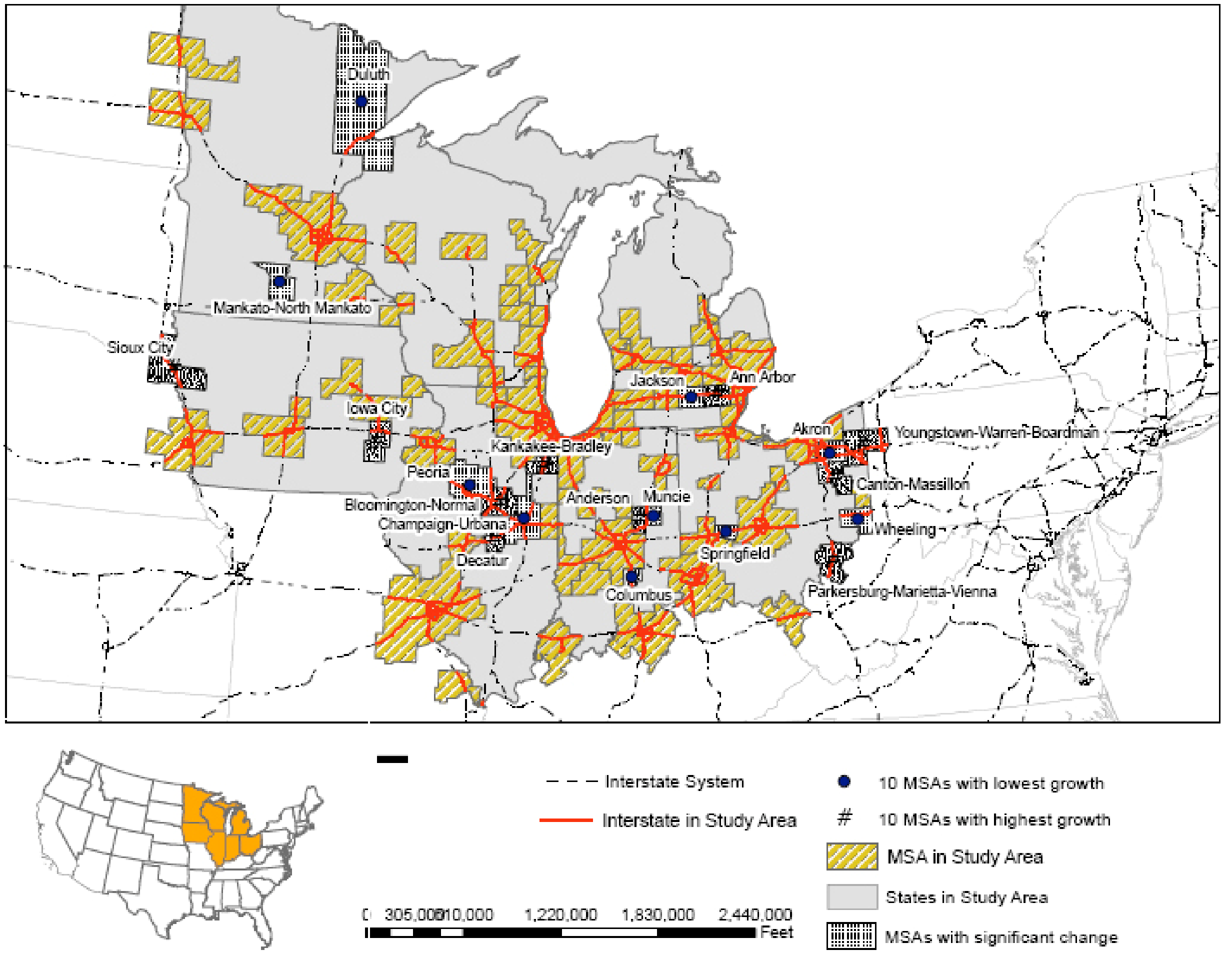
Muncie and Champaign-Urbana are the only MSAs that lost significant percentages, over 40%, of their trucking business between 2002 and 2007. In 2002, Muncie was ranked 59th with the trucking sector GDP of 40 million dollars, which reduced to just 23 million dollars in five years. Champaign-Urbana also experienced a sharp decrease in the trucking sector GDP during the same time period, with the trucking sector GDP going from 118 million in 2002 to just 69 million in 2007. For both Muncie and Champaign-Urbana MSAs, the decline of the trucking industry occurred over a short time period. For example, between 2002 and 2003, trucking sector GDP in Muncie went from 40 million dollars to 20 million. Furthermore, the data from 2001, which is available for Muncie, indicate that in just one year, between 2001 and 2002, it lost 59 million dollars of trucking sector GDP, equivalent of 60% of its value. In just two years, between 2001 and 2003, Muncie experienced a staggering decrease of 88% in trucking sector GDP. In Champaign-Urbana MSA, a single large decline occurred in 2005. Between 2001 and 2004, the trucking sector GDP in Champaign-Urbana held relatively constant at around 110 million dollars a year. Then, between 2004 and 2005, it went from 114 million to 67 million dollars, a loss of 67% in just one year, and it never recovered. This could be attributed to several reasons, including use of heavier and more fully loaded trucks by Kraft, as the company with the largest private truck fleet in Champaign. Also, refinements in supply chain management strategies (e.g. repositioning hubs and other facilities) and logistic decisions (e.g. shift to rail and waterways) drastically reduced truck VMT in this area (Cassidy, 2009[107]; Dodson, 2009[108]).

Figure 27 depicts the locations of MSAs that experienced very high of low rate of growth between 2002 and 2007. Interestingly, in many cases, a high-growth MSA is right next to a low-growth MSA, suggesting that trucking activities are to some degree zero-sum game within a broad economic region and when one MSA gains, there is a MSA that declined.

[107] Cassidy, William, 2009. Kraft Foods Cuts 50 Million Truck Miles. The Journal of Commerce, accessed at: http://www.joc.com/logistics-economy/kraft-foods-cuts-50-million-truck-miles

[108] Dodson, Don, 2009. Kraft, Supervalu among firms seeking heavier trucks. The News Gazette, accessed at: http://www.news-gazette.com/news/business/miscellaneous/2009-11-29/kraft-supervalu-among-firms-seeking-heavier-trucks.html

Figure 27: Growth of Trucking Sector GDP (2002 – 2007)



Overall, trucking sector experienced a healthy growth in the Upper Midwest states, going from a total GDP of $22.8 billion for the entire study area in 2002 to $30.5 billion in 2007, a 34 percent increase. Not surprisingly, most of the MSAs experienced positive changes in trucking GDP. In fact, Muncie, Champaign-Urbana, Akron, Springfield-OH, Jackson, Duluth, and Mankato-North Mankato are the only MSAs where trucking sector GDP declined from 2002 to 2007.

3.3. Trucking GDP Growth and Transportation Infrastructure

Figure 28 and Figure 29 depicts the relationship between trucking sector GDP growth and congestion and road density, both measured for 2002, respectively. Both graphs indicate a slight negative association between trucking GDP growth and respective transportation infrastructure indicators. However, Figure 14 also shows that the MSAs that experienced significant negative growth are not suffering from severe levels of congestion. Furthermore, Figure 29 reveals that many of the MSAs that experienced negative growth by no means suffer from a lack of road network.

Figure 28: Truck GDP Growth (2002-2007) and Congestion (2002)

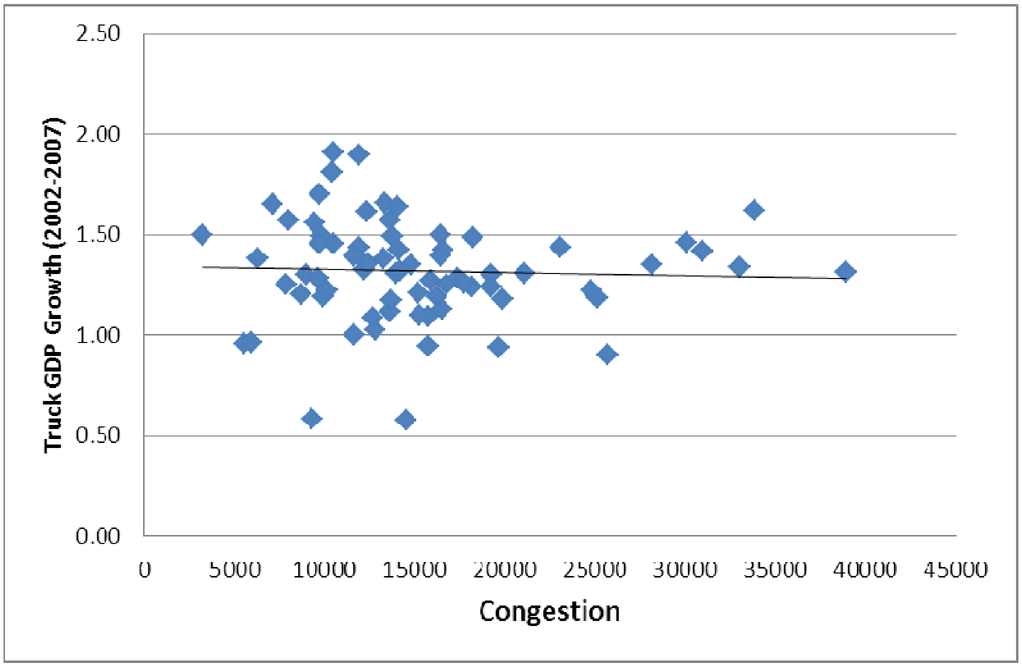
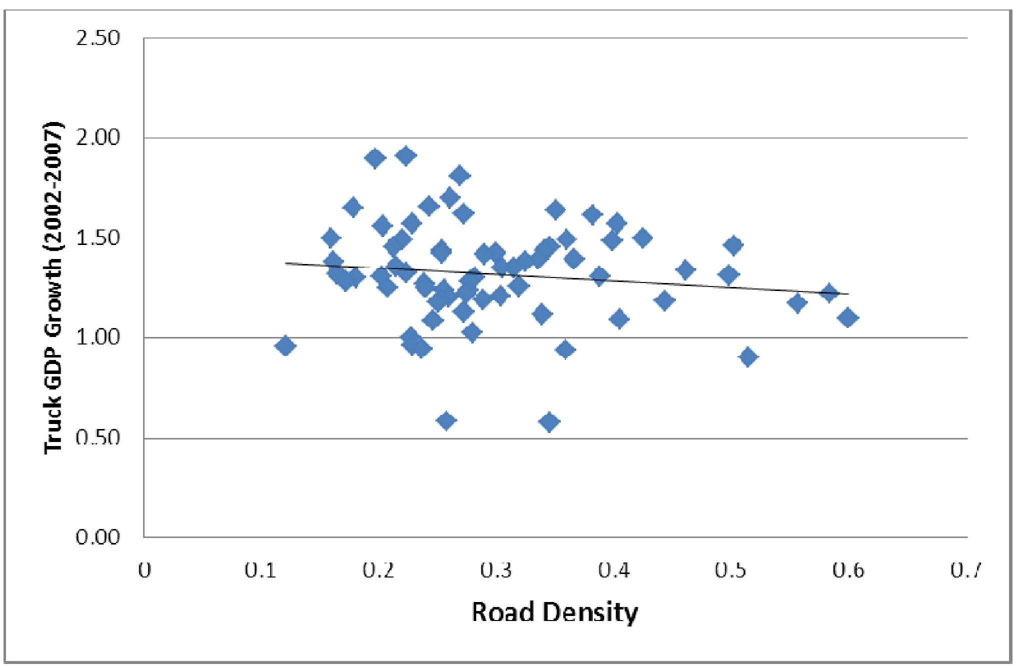


Figure 29: Truck GDP Growth (2002-2007) and Road Density (2002)



The associations between trucking GDP growth and transportation infrastructure indicators are performed using statistical tests. Two types of bi-variate correlation measures, namely Spearman rank correlation and Pearson's correlation are used. In 1896, a British statistical scientist, Karl Pearson, proposed the Pearson correlation, which, in fact, is a standardized version of the slope of a linear equation[109]. A nonparametric rank statistic measure that parallel's Pearson's coefficient was proposed by Spearman in 1904[110]. This measure only takes into account the rank of each case in two variables of interest and does not employ assumption about the actual distribution of the variable. The Spearman coefficient could be simply defined as the Pearson correlation coefficient between the ranked variables. When the distribution of the data in Pearson's correlation is undesirable, the Spearman rank correlation can be used[111]. Unlike Pearson correlation, Spearman's correlation does not limit the analysis to linear correlations. A common way to test the significance of a Spearman coefficient is to estimate the probability that it would be greater than or equal to the observed value. To calculate the correlation between X and Y using the Spearman's coefficient, the rank of each observation should be obtained firstly. If x and y represent rank of each X and Y observation, respectively, Spearman correlation coefficient between X and Y can be formulated as shown in Equation 1.

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}} \qquad (1)$$

The results, shown in Table11, indicates the tests did not find statistically significant correlation between the transportation infrastructure indicators and the truck sector GDP growth. Although the small number of cases suggests that the probability for Type-II errors (i.e. false negative) is rather high, p-values are not close to being statistically significant. Thus, we found no evidence that the state of transportation infrastructure in 2002 affected the trucking sector GDP growth during the 5-year period that followed.

Table 26: Correlation between Trucking Sector GDP Growth (2002-2007) and Transportation Indices

Transportation infrastructure	Pearson Coefficient (p-value)	Spearman Coefficient (p-value)	Available cases
Congestion	-.043 (.723)	-.145 (.228)	71

[109] Agresti, A., and B. Finlay.Statistical Methods for the Social Sciences (4th Ed.) Pearson. 2009.

[110] Spearman, C. "The proof and measurement of association between two things" Amer. J. Psychol. , 15 (1904) pp. 72–101

[111] Weisstein, E.W. Concise Encyclopedia of Mathematics CD-ROM. Boca Raton, FL: CRC Press, 1999.

Road density	-.131 (.276)	-.109 (.364)	71

A.3.4 Qualitative Analysis

As discussed earlier, there are some MSAs that experienced considerable changes in trucking GDP between 2002 and 2007. This section provides a brief overview of the economic profiles of four MSAs, Kankakee-Bradley, Anderson, and Iowa City that experienced significant increases, and Champaign-Urbana that had suffered around 40 percent decline in trucking GDP, to examine the context behind those noteworthy changes in trucking GDP. Economic development trend of each MSA could help the reader better understand some underlying factors that have contributed to this unusual change in trucking GDP in just five years.

Kankakee-Bradley, IL

Most of the area in this MSA is within the Kankakee County, which can trace its root to the construction of the Illinois Central Railroad line in 1853[112]. The growing economy of the region was struck by the Great Depression that started in 1929, and then again boomed from the late 1940's till the mid 1980's[113]. A period of economic downturn in Kankakee started in the summer of 1983 with the loss of the Roper facilities which had employed more than 2,800 persons in 1978. With the loss of these vital industrial jobs, Kankakee County unemployment skyrocketed to 21.4% by February 1984[114]. A.O. Smith kept only five percent of its employees by 1988 and Kroehler's Furniture Manufacturing filed a bankruptcy in 1986 [115]. The General Foods dog food plant, also, declined and was closed forever in Kankakee in 1998 [116]. This economic crisis resulted in an outflow of population seeking jobs elsewhere. The City of Kankakee that used to have a population of nearly 30,000 in 1970 became a city of little over 26,000 residents in 2003[117].

The City experienced a solid recovery after the election of Mayor Donald Green in 1993. The new administration increased sales tax revenue from $2.99 million in 2002 to $6.0 million in

[112]Lauriers Don des & Hinton Mardene, Riverview Historic District: 1866-1935, Kankakee County Historical Society, 1997.
[113]Byrns William P., Seil William and Wasson Donald L., Days Gone By: A Pictorial History of Kankakee County, The Kankakee County Bicentennial Commission, 1977.
[114]The Daily Journal, "3 face kidnap, murder charges," Tuesday, July 15, 1986.
[115]The Daily Journal, "Kankakee area has faced hard times before", January 14, 1994.
[116]The Daily Journal, "Heinz plant sold, to be redeveloped", June 12, 1998.
[117]U.S. Census Bureau, http://www.census.gov/, Accessed July 2010.

2007[118]. This was achieved by entering into the Sales Tax Sharing Agreement, according to which the City partially shares the sales tax generated by the firms located within the City of Kankakee. This agreement was a key reason that some major retailers come to this area, which led to the recovery of employment base. Some large firms came or remained in Kankakee, such as Armstrong World Industries, a manufacturer of flooring, ceilings, and cabinets; Cognis Corporation, a supplier of chemicals and nutritional ingredients; Aventis Behring, a company in the research, development, manufacturing and marketing of plasma protein biotherapies; CIGNA Insurance Claims, a healthcare insurance provider. Distribution centers of two large retailers (Sears and K-Mart) were also opened in this region and more businesses are expected to grow in near future.

The growing economy of Kankakee-Bradley MSA led to a significant increase in the trucking sector GDP from 34 million dollars in 2002 to 72 million dollars in 2007. This jump in the trucking industry GDP introduced Kankakee-Bradley as the MSA with the highest rate of trucking industry grows in the Upper Midwest during 2002 to 2007.

Anderson, IN

Anderson was a small village until Indianapolis Bellefontaine Railroad boosted the industrial engine of this region in the early 1850's[119]. Natural gas was also discovered in 1887 and provided a cheap source of energy for several factories rushing into Anderson. This source of energy began to run out after just about 25 years, urging many industries to relocate and leave Anderson, once the Queen City of the Gas Belt. Auto industry had been the most important industry in Anderson during the 20th century. General Motors was deeply involved in the local economy for around 80 years till 1999, when General Motors sold its last Anderson subsidiary. General Motors had so many plants that one third of Anderson residents used to work for GM 40 years ago, when Anderson was a city with one of the largest concentrations of GM operations in the U.S.[120]. Anderson, once home to more than 70,000 people in 1970, experienced a significant population decline in the early 2000’s and currently has less than 58,000 people, most of whom are GM retirees. Meanwhile, Indianapolis experienced around 8 percent increase in population in just eight years.

Potential spillover from Indianapolis, and more importantly, excellent infrastructures that had been developed during the economic boom of Anderson and was being used under the

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[118]City of Kankakee, Illinois, Comprehensive Annual Financial Report for the Fiscal Year Ended April 30, 2007.

[119]Anderson public library, History of Anderson and Madison County, Indiana, 2004, http://www.and.lib.in.us/indianaroom/history/andersonhistory.shtml, Accessed in July 2010.

[120]Peters Jeremy W. and Maynard Micheline, A town in danger of dying out as GM falters, The New York Times, February 2006, http://www.nytimes.com/2006/02/20/business/worldbusiness/20iht-gm.html?_r=2, Accessed in July 2010.

capacity or left vacant in the last few years, makes the people optimistic about the city's future and economic growth[121]. Anderson was ranked 98th in the Forbes 2007 List for 100 Best Places for Businesses among Smaller U.S. Metro areas[122]. Recently, a total of $529 million investment by Nestlé, a global company, created hundreds of new jobs in Anderson. They are also planning to expand to more than a million square feet. Flagship Enterprise Center[123] has helped to start 55 new companies with around 1200 job opportunities since 2005. As stated, vacant infrastructures in Anderson provided valuable opportunities for new businesses to come to this region. For instance, Advanced Magnesium Alloys Corporation[124], the largest magnesium recycling facility in the world, occupied one of the G.M.'s former plants in Anderson. Similarly, HY-Tech Machining Systems[125] bought another G.M.'s former Plant and expanded its business in Anderson. This could, arguably be a possible explanation for Anderson that had a large trucking GDP growth from 2002 and 2007. Anderson, Muncie, and Columbus are all located near Indianapolis, but only the Anderson MSA achieved a high rate of growth while other two experienced very low or in Muncie's case, negative, changes.

Iowa City, IA

Iowa City is a very special case in our study, as it is among the ten MSAs with highest percentages of trucking GDP growth and also had a decent-sized trucking sector in 2002 with a GDP of around 179 million dollars. All other MSAs that show a substantial growth in the trucking industry had significantly smaller trucking GDP in 2002, somewhere between 50 million and 100 million. Iowa City has been able to sustain growth year after year and achieved the greatest trucking GDP growth in the Upper Midwest region. Iowa City had the second highest trucking GDP in 2007, after Green Bay, home to Schneider National, a large logistics and transportation services company. Meanwhile, Iowa City is home to Heartland Express, which is a smaller company with about 450 million dollars in annual sales (Hoover's Inc, 2010)[126]. Heartland is one of the larger short-to medium haul specialists that operate mostly in the Upper Midwest states[127].

Champaign-Urbana, IL

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[121]Chapman, Mary M., Piecemeal Recovery Fills Void in a Former G.M. Town, The New York Times, March 2009, http://www.nytimes.com/2009/03/05/business/05anderson.html, Accessed in July 2010.
[122]Forbes,"100 best Places for Businesses among Smaller U.S. Metro areas". May 2007.
[123]Flagship Enterprise Center, http://www.flagshipenterprise.org/, Accessed in July, 2010.
[124]Advanced Magnesium Alloys Corporation, a member company of phoenix global holdings, LLC, http://www.amacor.us/, Accessed in July, 2010.
[125]HY-TECH MACHINING SYSTEM LCC, Merging Enterprise & Precision With Technology, 2007, http://www.htmachines.com/, Accessed in July, 2010.
[126]Hoover's Inc., http://www.hoovers.com/, Accessed on July 2010.
[127]Dayrit Anthony, A Look Ahead to the Future of the Trucking Market, Seeking Alpha, March 2010, http://seekingalpha.com/article/194233-a-look-ahead-to-the-future-of-the-trucking-market, Accessed July 2010.

Champaign-Urbana is well known for the University of Illinois at Urbana-Champaign, one of the largest public universities in the country. The economy of this MSA is mainly based on this university and as declared by the Champaign County Economic Development Corporation[128], University of Illinois, Carle Clinic Association, Carle Foundation Hospital were top three employees in 2009. Champaign Schools Unit 4 was ranked fourth and placed before Kraft Foods with less than 1400 employees . Most of the employees in this MSA have direct association with the University, and many of them are serving the university students, faculty, and staff. Kraft Foods and Kirby Foods are major businesses that are not in the healthcare or educational services in this area, and are more dependent on trucking industry. Kraft, for instance, is the company with the largest private truck fleet in Champaign. Therefore, to better understand the underlying reasons and possible explanations of this drastic decline of around 40 percent in trucking GDP in just five years shipping behaviors of Kraft Foods should be looked into. Kraft Foods reduced 50 million truck miles in its global distribution operations by the use of heavier and more fully loaded trucks. Also, refinements in supply chain management strategies (e.g. repositioning hubs and other facilities) and logistic decisions (e.g. shift to rail and waterways) drastically reduced truck VMT in this area[129,130]. It can be said that increase in the efficiency of trucking operations, aggressively pursued by Kraft, has resulted in the decline in the economic base for the community. It should be noted that this is an example where using ton-miles as the indicator of trucking productivity would have failed to identify the negative effects it had on the community.

These case studies suggest that the MSAs that have been successful in attracting various types of businesses have also been successful in growing the trucking sector. This leads to the competition among the communities for trucking businesses. It is common to find MSAs with high growth in trucking GDP right next to the one with low growth. In many cases, these situations seem to occur around major urban areas such as Indianapolis, but there are cases that MSAs are not near a major urban area but connected by a highway corridor.

A.3.5 Manufacturing and Construction Sectors

These examples strongly suggest that the growth in the trucking sector is dependent on the health of the businesses that rely heavily on trucking to move the products or raw material.Thus, in this section, the relationship between the productivities of two industries

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[128]Champaign County Economic Development Corporation, http://www.champaigncountyedc.org/TopEmployers.html, Accessed in July 2010.

[129]Cassidy, William, 2009. Kraft Foods Cuts 50 Million Truck Miles. The Journal of Commerce, accessed at: http://www.joc.com/logistics-economy/kraft-foods-cuts-50-million-truck-miles. Accessed in July, 2010

[130]Dodson, Don, 2009. Kraft, Supervalu among firms seeking heavier trucks. The News Gazette, accessed at: http://www.news-gazette.com/news/business/miscellaneous/2009-11-29/kraft-supervalu-among-firms-seeking-heavier-trucks.html. Accessed in July, 2010

that are important users of trucking services, manufacturing and construction, and the transportation infrastructure indices is examined.

Using 2002 standard make and use tables from the BEA benchmark input-output account, the dependency of manufacturing and construction with truck industry is determined (BEA 2010[131]). According to this data, trucking sector had a share of around 2.7% and 2% of total financial flow into the construction and manufacturing industry sectors, respectively. Among 94 different industry sectors that have an input to construction industry, trucking sector is ranked 10th. Meanwhile, trucking is ranked 14th among 112 industries that have an input to the manufacturing sector. Therefore, construction and manufacturing have a considerable dependency on trucking industry.

Table 27 shows that manufacturing productivity has a significant Spearman and Pearson correlation with congestion and road density at 95 percent confidence interval. The analysis also confirms that construction productivity is statistically correlated with total employment, trucking sector GDP, congestion, and road density at a 95 percent confidence interval. The fact that the construction productivity is positively associated with the trucking sector GDP suggests that, compared against manufacturing sector, construction sector exhibits a sign of economy of scale in relation to the use of trucking. At a first glance, it is counterintuitive to find that both congestion and road density have positive correlation with both manufacturing and construction productivities. However, if congestion and road density are capturing the level of agglomeration, then the result means that the benefit of agglomeration is exceeding the negative effects of congestion. The data set shows that Detroit-Warren-Livonia, Ann Arbor, Indianapolis-Carmel, and Flint are among the MSAs with highest construction productivity and also congestion.

Table 27: Trucking GDP, Transportation Infrastructure Indicators, and Manufacturing and Construction Sector Productivity (2002)

Indicators	Economic variables	Pearson Coefficient (p-value)	Spearman Coefficient (p-value)	Cases
Trucking sector GDP				
	Manufacturing productivity	.087 (.472)	.032 (.794)	71

[131]Bureau of Economic Analysis (BEA), U.S. Department of Commerce, Industry economic accounts, Benchmark Input-Output Data, 2002 Standard Make and Use Tables at the summary level, modified May 2010, http://www.bea.gov/industry/io_benchmark.htm, accessed in July 2010.

	Construction productivity	.493 [a] (.000)	.415 [a] (.000)	70
Congestion				
	Manufacturing productivity	.415 [a] (.000)	.424 [a] (.000)	78
	Construction productivity	.481 [a] (.000)	.261 [b] (.022)	77
Road density				
	Manufacturing productivity	.253 [b] (.025)	.315 [a] (.005)	78
	Construction productivity	.277 [b] (.015)	.232 [b] (.042)	77

[a]Significant at the 0.01 level.
[b]Significant at the 0.05 level.

4. Summary

Historically, economic output and freight transportation activity have exhibited a strong correlation. Freight ton-miles, employment and intercity truck mileage have closely tracked GDP. In terms of policy decision making, the main interest is whether or not increasing freight activity, or at least eliminating the factors that prevent it from growing, for example congestion, would result in economic growth. This section's focus has been to answer such question by examining the relationship between freight transportation activity and several indicators of transportation infrastructure and the economy at the MSA level for seven states in the Upper Midwest states.

Trucking GDP, trucking GDP growth, manufacturing GDP, manufacturing productivity, construction GDP, and construction productivity for the years 2002 to 2007 are economic indicators examined in this study. This study also used congestion and road density for the year 2002 as two transportation infrastructure indicators. Potential correlations between dependent variables and economic and infrastructure indicators were examined using Spearman and Pearson correlations, along with scatter plots were used to describe the direction and the level of associations.

We did not find evidence that suggested there is a correlation between transportation infrastructure indicators and the growth in the trucking sector GDP. This is mostly consistent with the findings from the analysis using the state-level data for the entire nation. Since there are considerable variations in the trucking sector GDP growth among the MSAs, we examined some of the extreme cases, MASs with large and small (or negative) growths between 2002 and 2007, to find out the factors that made some MSAs more prosperous, in terms of trucking sector, and others less so.

We found that there are fierce competitions for businesses among MSAs and the ones that have enjoyed a high rate of growth in trucking are those that have succeeded in attracting major business investments that create need for trucking. While transportation infrastructure is important, the fact of matter is that there are many MSAs that enjoy locational advantage (e.g. proximity to a large urban area) and transportation access. We found that in many cases, most successful MSAs and least successful one are located close to each other. Along the way, the successful one attracted an anchor business through luck and clever and aggressive incentive while less successful one did not. Tax incentive seems to play a key role in at least some of the cases. Thus, we essentially found the adage that "transportation is a necessary but not a sufficient factor" applies to growth in trucking sector activity. In some cases, such as Iowa City or Green Bay, an urban area has been a home to a major freight business and as the company grew, so did their freight sector output. Replicating those kind of successes is very difficult since the area must nurture a strong bond with the anchor business over a long time in order to keep the business to remain there.

Table 28: MSAs included in the MSA-level Analysis

Code of MSA	Name of MSA
10,420	Akron, OH
11,180	Ames, IA
11,300	Anderson, IN
11,460	Ann Arbor, MI
11,540	Appleton, WI
12,980	Battle Creek, MI
13,020	Bay City, MI
14,020	Bloomington, IN
14,060	Bloomington-Normal, IL
15,940	Canton-Massillon, OH

16,020	Cape Girardeau-Jackson, MO-IL
16,300	Cedar Rapids, IA
16,580	Champaign-Urbana, IL
16,980	Chicago-Naperville-Joliet, IL-IN-WI
17,140	Cincinnati-Middletown, OH-KY-IN
17,460	Cleveland-Elyria-Mentor, OH
18,020	Columbus, IN
18,140	Columbus, OH
19,180	Danville, IL
19,340	Davenport-Moline-Rock Island, IA-IL
19,380	Dayton, OH
19,500	Decatur, IL
19,780	Des Moines-West Des Moines, IA
19,820	Detroit-Warren-Livonia, MI
20,220	Dubuque, IA
20,260	Duluth, MN-WI
20,740	Eau Claire, WI
21,140	Elkhart-Goshen, IN
21,780	Evansville, IN-KY
22,020	Fargo, ND-MN
22,420	Flint, MI
22,540	Fond du Lac, WI
23,060	Fort Wayne, IN

24,220	Grand Forks, ND-MN
24,340	Grand Rapids-Wyoming, MI
24,580	Green Bay, WI
26,100	Holland-Grand Haven, MI
26,580	Huntington-Ashland, WV-KY-OH
26,900	Indianapolis-Carmel, IN
26,980	Iowa City, IA
27,100	Jackson, MI
27,500	Janesville, WI
28,020	Kalamazoo-Portage, MI
28,100	Kankakee-Bradley, IL
29,020	Kokomo, IN
29,100	La Crosse, WI-MN
29,140	Lafayette, IN
29,620	Lansing-East Lansing, MI
30,620	Lima, OH
31,140	Louisville-Jefferson County, KY-IN
31,540	Madison, WI
31,860	Mankato-North Mankato, MN
31,900	Mansfield, OH
33,140	Michigan City-La Porte, IN
33,340	Milwaukee-Waukesha-West Allis, WI
33,460	Minneapolis-St. Paul-Bloomington, MN-WI

33,780	Monroe, MI
34,620	Muncie, IN
34,740	Muskegon-Norton Shores, MI
35,660	Niles-Benton Harbor, MI
36,540	Omaha-Council Bluffs, NE-IA
36,780	Oshkosh-Neenah, WI
37,620	Parkersburg-Marietta-Vienna, WV-OH
37,900	Peoria, IL
39,540	Racine, WI
40,340	Rochester, MN
40,420	Rockford, IL
40,980	Saginaw-Saginaw Township North, MI
41,060	St. Cloud, MN
41,180	St. Louis, MO-IL
41,780	Sandusky, OH
43,100	Sheboygan, WI
43,580	Sioux City, IA-NE-SD
43,780	South Bend-Mishawaka, IN-MI
44,100	Springfield, IL
44,220	Springfield, OH
45,460	Terre Haute, IN
45,780	Toledo, OH
47,940	Waterloo-Cedar Falls, IA

48,140	Wausau, WI
48,260	Weirton-Steubenville, WV-OH
48,540	Wheeling, WV-OH
49,660	Youngstown-Warren-Boardman, OH-PA

Interview Questionnaire

Thank you for taking the time to meet with us. I am a student on the Research Project evaluating the impact of the built environment on freight movement and congestion. I am here to talk to you today to get a more-informed understanding of your organization's outlook as it pertains to your site selection, operations, supply chain decisions, etc.

This interview is the first part of a multi-phased research project. Your contributions today will help us understand the various aspects that lead to a successful freight operations plan within organizations.

I am not recording your name, and will maintain confidentiality around the information that you share with me today. I am asking each participant the same series of questions.

Just to let you know, I aim to keep this interview to approximately 60 minutes.

Are you ready to begin?

(Start tape; Note the number assigned to the interviewee, date, and time)

Draft of Interview Questions/Talking points

- Please describe the role of your department within your organization
- Please describe your individual responsibilities within your department

Issue 1: Effect of Built Environment

1) What is the effect of the built environment on the "last mile" part of the freight movement?

Prompt: How is congestion affecting the last mile of freight movement?

Prompt: How about competition for curb side loading space,

Prompt: Any delivery time restrictions by the community?

Prompt: Physical limitations/geographical limitations:

turning radius?

height restrictions?

weight limit?

Prompt: Any other factors affecting the last mile?

ASK for examples

2) When shippers or receivers designate delivery time window, do they consider congestion?

3) If the delivery must be made during congested time or in the areas prone to congestion or need to go through the areas with congestion, can you charge extra?

Prompt: Is it possible to include surcharge in the contract?

Prompt: Are there instances where cost was underestimated because of congestion?

4) Does built environment, e.g. viaducts or bridges that are restrictive or toll ways, affect the rate?

Prompt: Detours that need to be made

Prompt: Fees for overweight load

Prompt: Tolls

5) How about construction? Do you look at construction schedules when setting the rate?

Prompt: Have you underestimate the cost due to unexpected construction-related delay?

6) Is it harder or easier to deliver the loads in the suburbs or CBD and why?

Prompt: Is delivering to CBD require altered operation from ideal conditions, e.g. schedule delivery time to avoid congestion,

Prompt: Tricks to avoid certain areas

Prompt: Congestion - weight and height limit

Prompt: Can you give examples of neighborhoods that are hard or easy to make deliveries?

7) How compatible does the built environment and the regulations resulting from it is to freight movement (including passing by an area on the way to the destination)?

> Prompt: Congestion - pedestrians, other cars
>
> Prompt: Delivery time restrictions
>
> Prompt: Regulations, right turn, red lights, etc.
>
> ASK FOR Examples

8) How supply chain management decisions (e.g. location of the distribution centers or factories, port of entry, selection of suppliers) are affected by the following characteristics of transportation infrastructure?

> Prompt: Congestion
>
> Prompt: Tolls
>
> Prompt: Loading/unloading - space,
>
> Prompt: Time restrictions
>
> Prompt: Turning radius, congestion, height restrictions
>
> Prompt: Designated truck routes - how do those affect operations

9) Do you plan operations around congestion?

> Prompt:
>
> Prompt:
>
> Prompt:

10) Is congestion acceptable as long as it is predictable?

> Prompt: Is accident worse than every-day bottlenecks?
>
> Prompt:

Prompt:

11) What are the constraints and challenges related to the site selection for freight facilities such as intermodal terminals, rail yards, and warehouses?

Prompt: Tax incentives?

Prompt: Access to rail?

Prompt: Relationship with local community?

Prompt: Access to highway?

Prompt: Access to port?

Prompt: Access to labor?

Can you rank those factors?

12) How big does the site have to be?

Prompt: Best intermodal terminal and why

Prompt: *Joliet arsenal - why?

Prompt: Rochelle why? - UP main line?

13) What are the necessary conditions for the development of large-scale supply-chain-oriented industry centers?

Prompt: Is direct connection to Class I Mainline important?

Prompt: Tax incentives?

Prompt: Expressways?

14) How is the cost of freight transportation affecting the location choices of businesses in different industries?

Prompt: Retailers

Prompt: Manufacturers

Prompt: Supply chain and logistics

15) Do the businesses run cost-benefit analysis for alternative sites?

Prompt:

Prompt:

Prompt:

16) Are there businesses that are particularly sensitive to transport cost? Are there businesses that are particularly insensitive to transport cost?

Prompt:

Prompt:

17) What will be the effect of rising fuel cost and truck driver shortage on these issues?

Prompt: How about businesses' reliance on rail intermodal?

Prompt: Is there any evidence that the recent fuel price increase and driver shortage have led to more localized operations for some industries

18) What are the capabilities of existing travel demand models and land use models to provide information that can be used to incorporate freight-related activities and land uses in the plans and policies?

Prompt:

Prompt:

Prompt:

Introduction for Stakeholders (version 5 - Government, 6/9/10)

Thank you for taking the time to meet with us. I am a student on the Research Project evaluating the impact of the built environment on freight movement and congestion. I am here to talk to you today to get a more-informed understanding of your organization's perspective on trucking activities and freight in general.

This interview is the first part of a multi-phased research project. Your contributions today will help us understand the various aspects that lead to efficient freight operations in urban areas with various land use patterns.

I am not recording your name, and will maintain confidentiality around the information that you share with me today. I am asking each participant the same series of questions.

Just to let you know, I aim to keep this interview to approximately 60 minutes.

Are you ready to begin?

(Start tape; Note the number assigned to the interviewee, date, and time)

Draft of Interview Questions/Talking points

Please describe the role of your department within your organization

Please describe your individual responsibilities within your department

A. Built environment and regulations

1) What is your community's vision for land use planning?

2) What are the greatest concerns for your community regarding freight transport?

3) I would like to ask about your perspective on various effects of built environment on the "last mile" part of the freight movement

[show pictures to explain the definition of "built environment"]

> Prompt: How is congestion affecting the last mile of freight movement?
>
> Prompt: How about competition for curb side loading space,
>
> Prompt: Any delivery time restrictions by the community?
>
> Prompt: Physical limitations/geographical limitations:
>
> > turning radius?
> >
> > height restrictions?
> >
> > weight limit?
>
> Prompt: Any other factors affecting the last mile?
>
> ASK for examples

4) Is it harder or easier to deliver the loads in the suburbs or CBD and why?

> Prompt: Congestion - weight and height limit
>
> Prompt: Can you give examples of neighborhoods that are hard or easy to make deliveries?

5) How do you plan the truck routes in your community?

6) What is the best way for truckers to find out the designated truck routes within your community?

7) How do you coordinate with neighboring municipalities about managing truck traffic including truck routes and other regulations?

8) How do you coordinate with CMAP and IDOT about managing truck traffic including truck routes and other regulations?

9) How do you obtain input from trucking community about problems and suggested improvements?

10) Are the issues related to truck traffic considered when reviewing development proposals

11) Are the issues related to delivering necessary goods (for both businesses and residents) considered when reviewing development proposals?

Note: Do they consider the fact that more intense the land use, the greater the demand for goods per unit area, and also do they think about the possibility that it may be more efficient to bring goods closer to people than making people travel to shops.

B. Business decisions and preferences

1) In your view, how supply chain management decisions (e.g. location of the distribution centers or factories, port of entry, selection of suppliers) are affected by the following characteristics of transportation infrastructure?

Prompt: Congestion

Prompt: Tolls

Prompt: Loading/unloading - space,

Prompt: Time restrictions

Prompt: Turning radius, congestion, height restrictions

Prompt: Designated truck routes - how do those affect operations

2) What are the constraints and challenges related to the site selection for freight facilities such as intermodal terminals, rail yards, and warehouses?

Prompt: Tax incentives?

Prompt: Access to rail?

Prompt: Relationship with local community?

Prompt: Access to highway?

Prompt: Access to port?

Prompt: Access to labor?

Can you rank those factors?

3) Do the businesses run cost-benefit analysis for alternative sites?

Prompt:

Prompt:

Prompt:

4) Are there businesses that are particularly sensitive to transport cost? Are there businesses that are particularly insensitive to transport cost?

Prompt:

Prompt

Figure 30: Merged Cognitive Map – Government

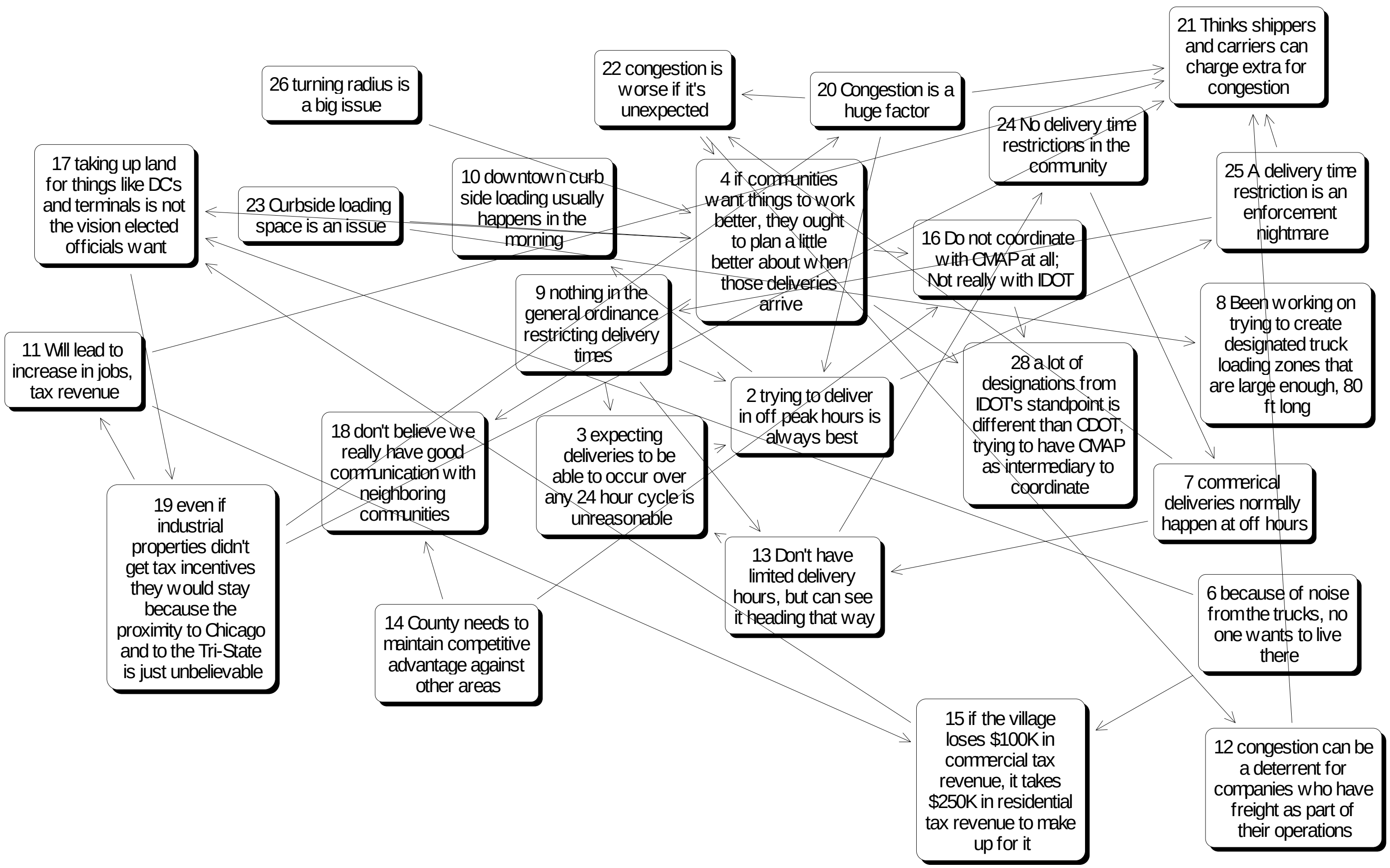


Figure 31: Merged Cognitive Map – Trucking Sector

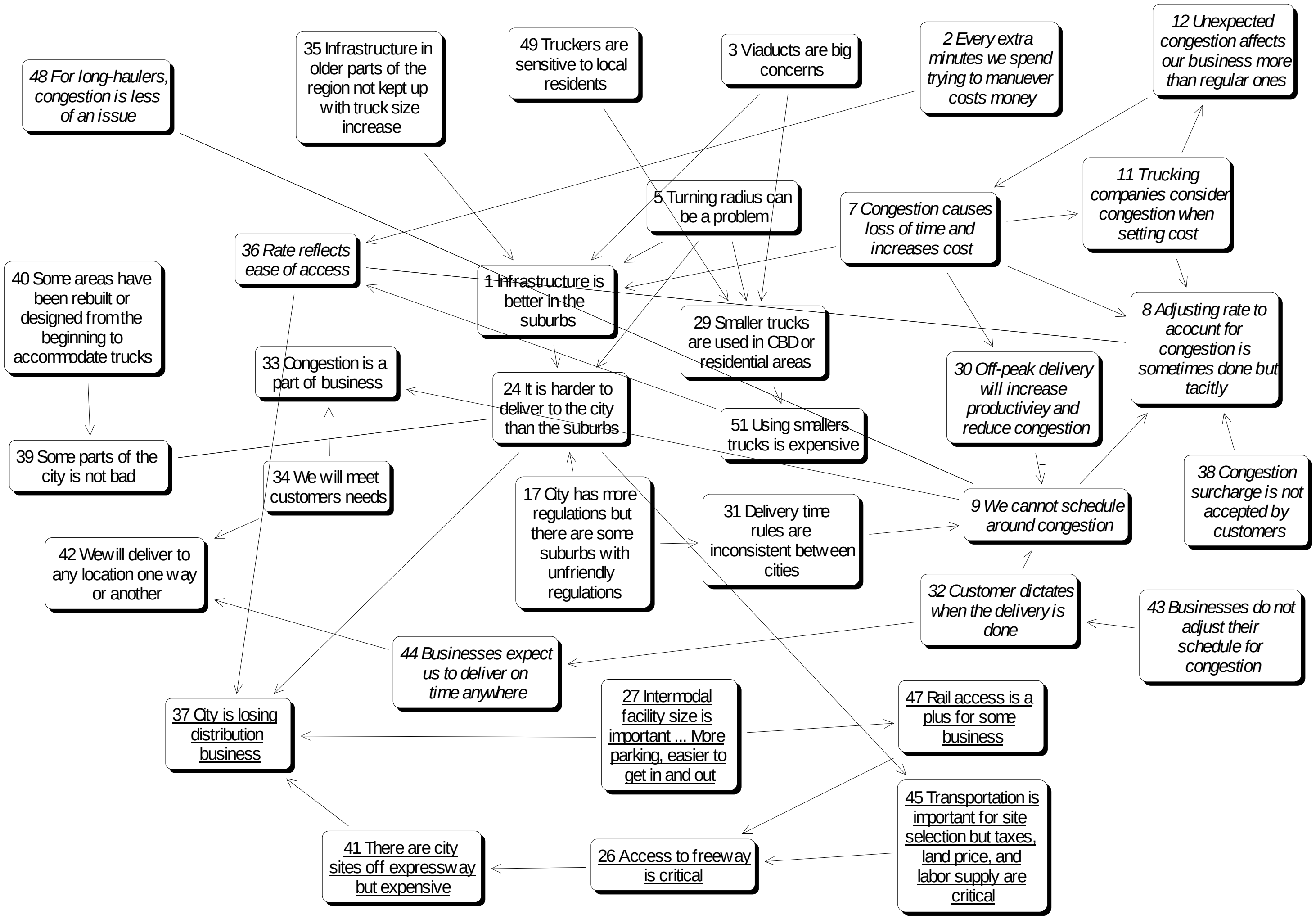


Figure 32: Merged Cognitive Map – Real Estate

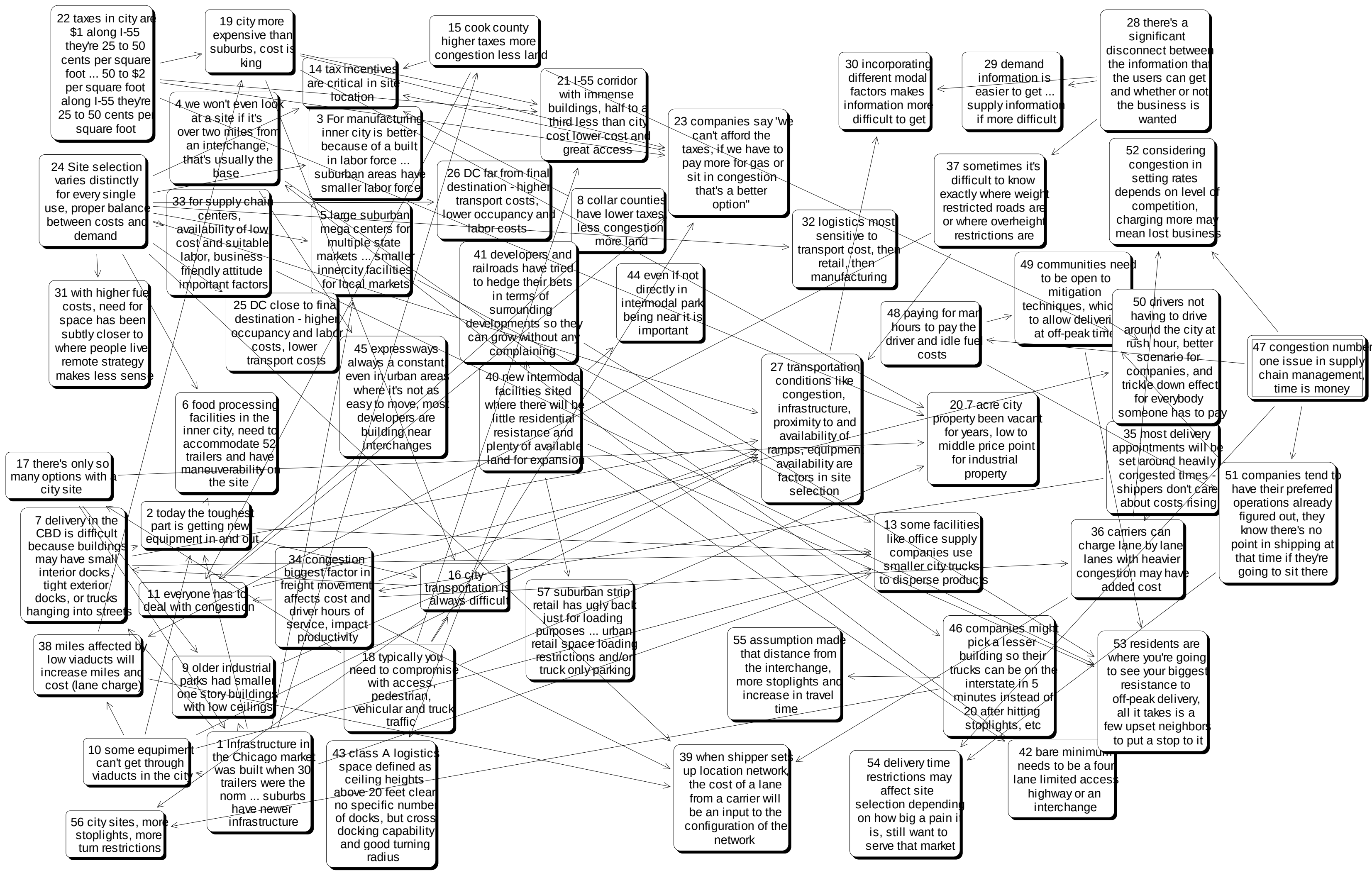
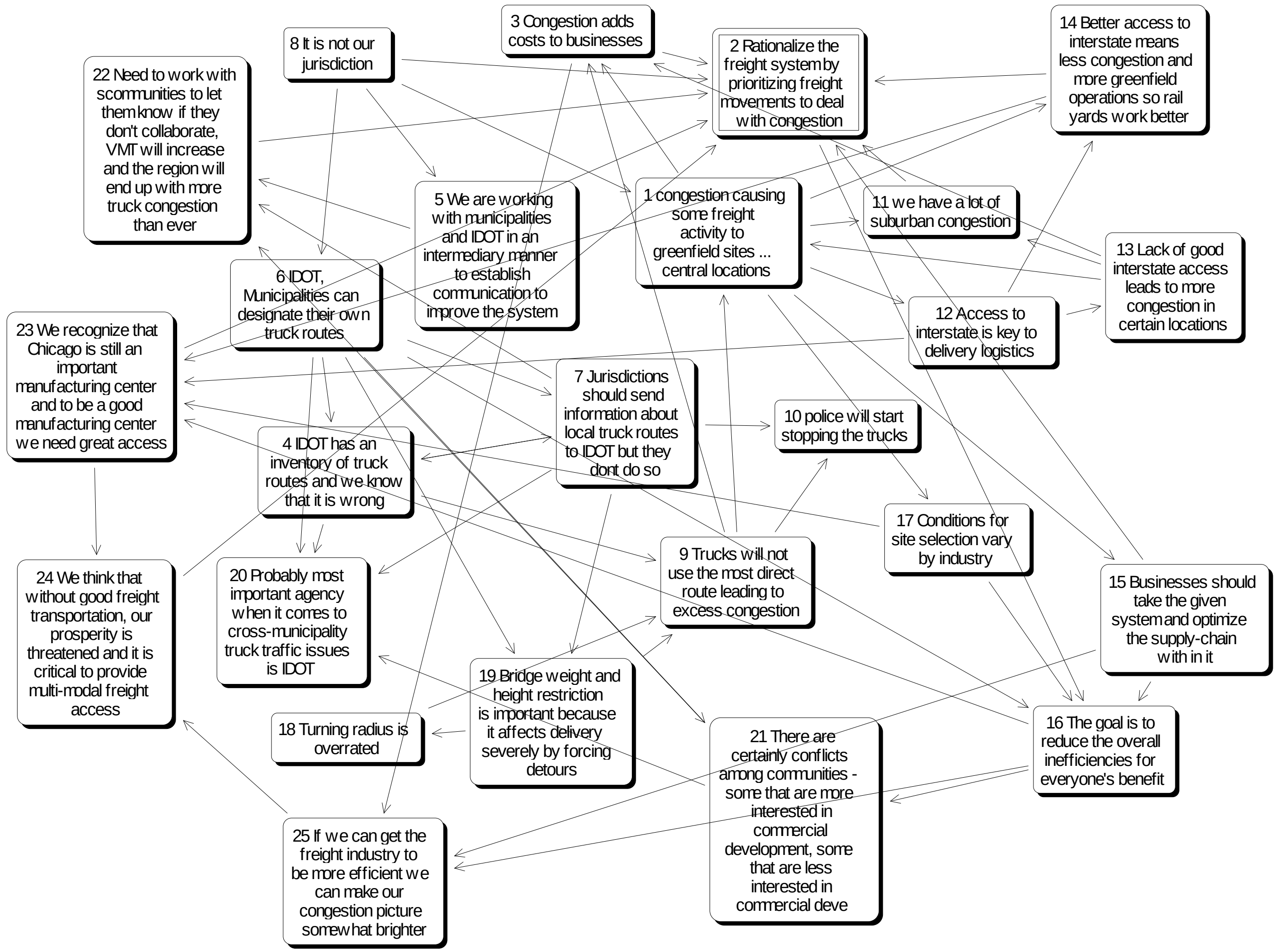


Figure 33: Merged Cognitive Map – MPO



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