

2014

Megaregions as a Framework for Integrating Supply Chain Dynamics and Freight Planning



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5/1/2014

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Introduction

This study applies a megaregions framework to supply chain management configurations. The study goal is to assess ways in which transportation planners may leverage the megaregions framework to enhance freight distribution. Megaregions have much in common with the scales at which private-sector freight distribution occurs because both conform to economic dynamics that cross political boundaries. While megaregions have an established position in the transportation planning field reinforced by many years of research and increasingly formalized practice, the concept has been applied much less frequently to private-sector freight activity.

There are several reasons to expect megaregions to contribute to supply chain efficiency. First, many megaregion dynamics are related to freight movement patterns. Transportation planning identified megaregions in hopes of contributing to fast and reliable freight movement in America's most productive areas. Transportation planning has been a primarily public sector-oriented activity. However, megaregions support private-sector activities as well. The megaregion framework may also help supply chain engineers and managers craft flexible and efficient distribution systems.

Second, megaregions concentrate a significant portion of the consumer demand and economic production that drive U.S. freight movement. Inexpensive transportation has allowed companies to locate each production and distribution step at the most advantageous point anywhere in the world. In many cases, megaregions house consumer purchasing power that creates the demand for products. Megaregions' population means that they consume large amounts of products. At the same times, megaregions are extremely productive in services, intellectual property, and physical products. Megaregions are centers of economic consumption and production, which links them with supply, demand, and distribution in faraway places on a continuing basis. Distribution systems that account for megaregions' concentrated buying and producing power may serve their customers more efficiently.

Finally, megaregions bring together multiple infrastructure modes that for robust supply chains need to operate. These modes include Interstate Highways, ocean ports, railroads, and major airports. These modes are in fact explicitly incorporated into megaregions' definition (Ross et al. 2009; Lang and Dhavale 2005). Megaregions may offer supply chain managers the infrastructure that they need to ensure efficient and reliable deliveries.

Megaregions are likely to benefit supply chain configurations at multiple scales. Even distribution networks that extend beyond megaregion boundaries may benefit from the agglomerative economies that exist in megaregions. This study examines supply chain and megaregions concepts to assess the synergies between the two concepts and potential applications for transportation planners, policy makers, and supply chain managers.

Section I: Literature Review

Megaregions

Megaregions are an observed spatial phenomenon composed of the agglomeration of urban, suburban, exurban, and rural areas through persistent links created by economic interdependence, passenger and freight movement, infrastructure, and social, cultural, and environmental characteristics. Geographer Jean Gottmann (1957) originally documented the phenomenon of continuous urban development in the Washington-Philadelphia-New York-Boston corridor.

Since then, researchers have identified ten or eleven American megaregions depending on the method employed. The Regional Plan Association (2006) identified eleven megaregions according to five characteristics: “environmental systems and topography, infrastructure systems, economic linkages, settlement patterns and land use, and shared culture and history” (Ross 2008). The Regional Plan Association’s characteristics capture the broad interactions and interdependencies that distinguish megaregions.

The Metropolitan Institute at Virginia Tech defined another process for identifying megaregions. The process examined adjacent metropolitan areas by transportation interconnectedness, projected populations, and urban development patterns to identify ten megaregions (Lang and Dhavale 2005). The Metropolitan Institute’s megaregions differ from those identified by the Regional Plan Association only slightly except for the Metropolitan Institute’s omission of a megaregion in the Denver, Colorado area.

The Center for Quality Growth and Regional Development identified megaregion core areas by their agglomerative characteristics, productivity, innovation, and transportation networks. It used proximity and commuting patterns to define areas of influence around each urban core, which it then clustered based on economic and travel interactions into megaregions. Social, economic, environmental, and political characteristics smoothed the county-level megaregion boundaries (Ross et al. 2009). Figure 1 shows the ten American megaregions as identified by Ross et al. (2009). The megaregions are very similar to those identified by the Regional Plan Association and the Metropolitan Institute. Like the Metropolitan Institute, the Center for Quality Growth and Regional Development did not identify a megaregion in the Denver area.

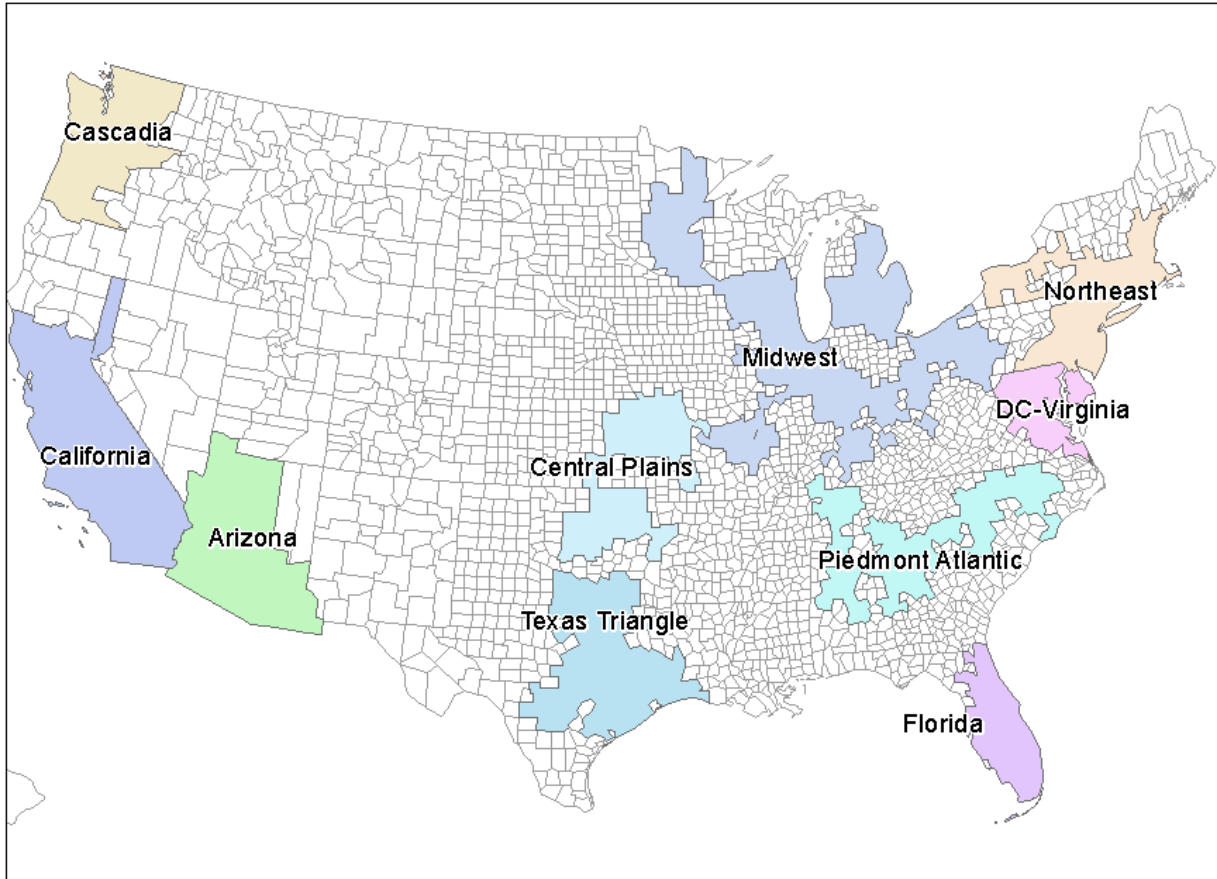


Figure 1: U.S. Megaregions

Source: Hylton, modified from Ross et al. (2009)

Megaregions are de facto global economic units because of their ability to leverage complementary industries and consumer demand (Ross et al. 2009; Ross 2008; Porter 2001; Jensen and Richardson 2001; Salet, Thornley, and Kreukels 2003). Megaregions concentrate far more economic activity and innovation than other areas of the country. Megaregions house 92% of U.S. Fortune 500 companies and are responsible for 86% of patents issued in the U.S (Ross and Woo, 2011). As of 2008, megaregions also are home to 77% of employment, 81% of gross regional product, and 77% of population despite covering only 30% of land area (Ross and Woo 2011). Megaregions benefit from clusters' ability to promote innovation that can drive productivity and competitiveness (Porter, 2001).

Foreign countries have also begun planning for megaregions. The European Union manages the European Regional Development Fund, which promotes social and economic integration and convergence among member states (Ross, Lee, and West 2013). The European Spatial Development Perspective likewise promotes polycentric development in order to harmonize economic opportunity and quality of life across the Union (Ross et al. 2011). Polycentricity as a core megaregion concept aligns with theories by Groth (2000) explaining how megaregions benefit from symbiotic relationships that are a function of their economic agglomeration. In a very different approach to megaregion development, the Chinese national government has raised several of its largest cities to provincial status, which has enabled them to coordinate

integrated transportation networks on large scales (Yang 2009). The result in the different cases is to promote transportation and economic integration along a large region with multiple functional nodes. This sort of economic and functional integration is a fundamental megaregion characteristic.

Multiple researchers have addressed questions of megaregion governance, which are major challenges because in most cases megaregions do not align with established political boundaries (Foster 2010). Researchers have addressed the roles of several different organizational levels in megaregion governance, including local governments, metropolitan planning organizations, states, the federal government, private companies, and community partners (Vega and Penne 2008; Bollens 1997; Innes, Booher, and Di Vittorio 2010; Innes and Booher 2010). Megaregions are generally seen as requiring informal and flexible decision making arrangements typical of governance to respond to their multiple stakeholders and effectively function across political boundaries (Foster 2010; Savitch and Vogel 2000; Innes, Booher, and Di Vittorio 2010). Still, Innes, Booher, and Di Vittorio (2010) acknowledge that informal governance will not likely be able to solve all megaregion problems and may entail inefficient decision making.

Megaregions also concentrate a disproportionate amount of truck traffic compared with non-megaregion areas (Amekudzi et al. 2009). Truck traffic in megaregions is expected to increase over the next decades, causing significant highway congestion in most megaregions unless there is concerted action to control highway demand or increase supply (Ross et al. 2011). For example, the I-85 and I-20 corridors are the spine of the Piedmont Atlantic Megaregion, and the corridors are expected to have to accommodate major increases in truck volume between 2002 and 2035 according to predictions in the Freight Analysis Framework 3 (Ross, 2011). The Piedmont Atlantic Megaregion is not alone. All megaregions are expecting large truck traffic increases, but they are most pronounced on major corridors in California, DC-Virginia, the Midwest, the Texas Triangle, and the Piedmont Atlantic Megaregion (Ross et al. 2011).

Freight Flows and Megaregions

Megaregions are particularly relevant to freight planning practice. Amekudzi, Thomas-Mobley, and Ross (2007) document the need for planning frameworks that are spatially and temporally broad. Planning's approach to handle challenges such as urban growth, congestion, and pollution must be as broad as the scales at which they occur. Public private partnerships (PPP) operated on a megacity or megaregion scale offer a means for partially overcoming financial limitations. Multi-state PPP may also be needed for megaregions to adequately address challenges to freight and passenger mobility, which may require changes to state and federal laws (Amekudzi, Thomas-Mobley, and Ross 2007).

Dewar and Epstein (2007) document the characteristics of five megaregion plans that address passenger and freight mobility, energy, employment, housing, and environmental protection. While Dewar and Epstein (2007) suggest that the national scale may be appropriate for much freight planning, converging interests at the megaregion level may make the megaregion a more viable level to mobilize political forces. Borders should remain flexible to address issues in the areas and at the scales at which they occur (Dewar and Epstein 2007). Barbour and Teitz (2006) agree that megaregion boundaries must be large enough to encompass the relevant problems. They found in California that locally made land use decisions created spillovers that caused congestion and threatened Southern California's logistics industry. Barbour and Teitz (2006) say that the threat that congestion poses to job creation has become a driver in megaregion discussions.

Researchers are laying the groundwork for states, the federal government, and multi-jurisdictional partnerships to address freight and passenger movement from a megaregions perspective (Vega and Penne 2008). Seedah and Harrison (2011) found freight on all modes in the Texas Triangle to be an important economic driver that nonetheless may be inhibited by congestion on state and interstate highways. The researchers studied Texas Triangle freight by overlaying freight transport's volume and economic importance with projected population growth. Based on their findings, the researchers recommended a megaregion planning framework with flexible geographic boundaries and a dedicated megaregion organization to "establish joint priorities, engag[e] stakeholders through visioning, and implement megaregions-scale initiatives" (Seedah and Harrison 2011). The authors say that the Texas Department of Transportation should manage highways from a megaregion perspective.

At a national scale, Gifford et al. (2010) used data from the Commodity Flow Survey to characterize megaregion freight flows. The data does not cover entire megaregion areas, but rather approximates freight generated in megaregions by focusing on core areas. Gifford et al. (2010) found that freight generated in megaregions was generally more valuable per ton than freight generated in non-megaregions. The research also indicates that each megaregion should be viewed individually because of the different freight flows in each. For example, the Midwest generated 18.6% of total freight tonnage versus 1.1% for Arizona (Gifford et al. 2010).

Supply Chain Management

Freight planning provides transportation infrastructure in the places, amounts, and types that serve freight movement. However, freight movement is not an isolated process; rather it is derived from economic processes of production, consumption, reuse, and disposal. Understanding these economic networks' dynamics can aid transportation planners and improve infrastructure investment decision making by optimizing place, delivery time, operational characteristics, cost, and level of service. Supply chain connections and nodes can ground megaregion-scale freight analysis.

Supply chain management (SCM) is an overarching term that holistically encompasses production, distribution, and sales processes. According to (Bowen 2008), SCM's purpose "is to accelerate the movement of goods, to ensure that the right goods get to the right place in the right amount at the right time, and to simultaneously lower the cost of transportation." Supply chain encompasses a series of activities that companies previously managed separately, including inventory, purchasing, transportation, production planning, warehousing, distribution planning and many others (Hesse and Rodrigue 2004). Their combination produces efficiencies.

Logistics refers to the supply chain segment that encompasses the physical distribution and materials management functions. Said in other words, logistics encompasses most of the supply chain functions except for information technology, marketing, and strategic planning (Hesse and Rodrigue 2004). Materials management refers to production, whereas distribution moves the goods from the point of production to the consumer. For Mentzer, Min, and Bobbitt (2004), effective logistics helps firms compete by mediating customer demand and firm supply. Firms can also use information-driven tools to increase their logistics effectiveness.

Logistics manifests itself on the ground in two ways that need to be understood for megaregions analysis. The first is transportation, which is the flow of goods between places of value-added activity in the production and distribution chain. The second is intermediate processes, which include breaking down and re-assembling shipments, picking, sorting, packaging, and other value-added functions that often occur in warehouses and distribution centers. Bowen (2008) describes warehouses as places that coordinate the distribution process to draw "far-flung production networks...together to make their complexity manageable." Complex supply chains increasingly require that warehousing pull goods together, manage and regulate transportation flows, prepare shipments, and perform other value-added activities mediating movement (Rodrigue 2006a). According to Rodrigue (2006a), the flows can go in both directions, where goods flow out of the warehouse towards retailers and consumers, while sales information, damaged goods, and returned goods may flow in the opposite direction.

Warehouses and distribution center share a history and most physical characteristics, but they have different functions. Warehouses tend to accept and make occasional, large shipments, whereas distribution centers' role as operations centers requires more frequent, smaller shipments to more destinations (Bowen 2008). Distribution centers' value added functions often require that they are larger than warehouses, and companies have been more apt to outsource

the distribution center function to third party logistics providers (3PL), who specialize in distribution to obtain economies of scale unavailable to individual retailers managing their supply chains.

Supply chain managers have conceived of their subject matter differently at various times. Hesse and Rodrigue (2004) depict the main management concepts by decade. These formerly fragmented concepts such as production, distribution, marketing, and sales have been consolidated into a single concept under the supply chain umbrella shortly after the turn of the millennium (Figure 2).

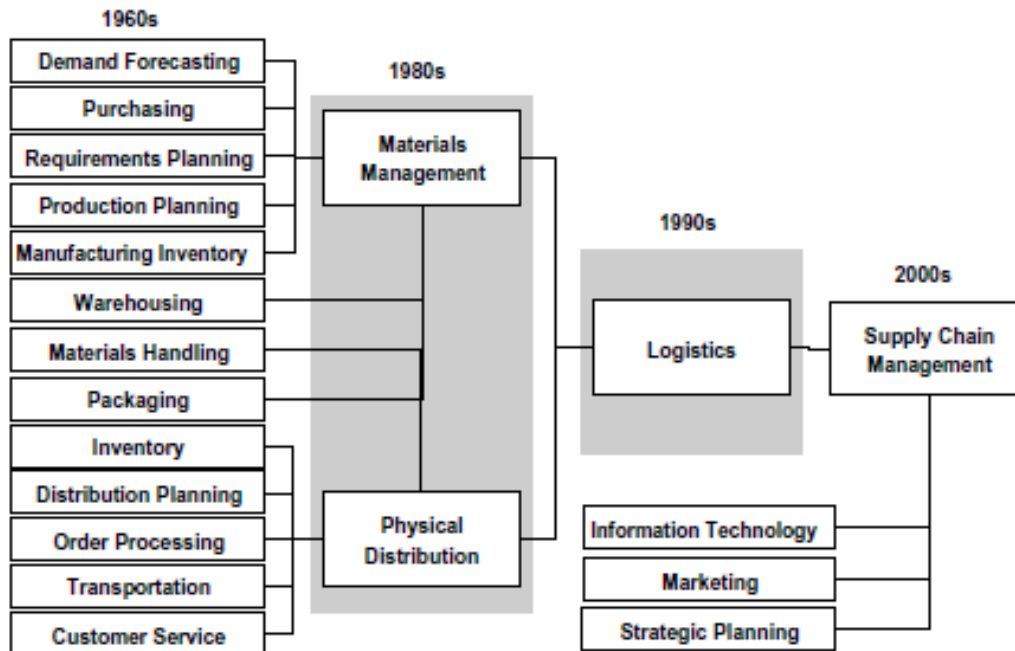


Figure 2: Supply Chain Management Integration

Source: Hesse and Rodrigue (2004)

Transportation flows and the different value-added functions both are manifested spatially in freight facility siting and freight flows on land, in the air, and at sea. Several transport geographers have analyzed the location of distribution centers in relation to the transportation infrastructure that permits movement to and from the distribution center. Christopherson and Belzer (2009) found that freight flows respond more closely to warehouse and distribution centers location than local characteristics. Warehouses and distribution centers are in some cases more closely connected to global supply chains than the local economic environment. Globalized supply chains make warehouses and distribution centers serve global rather than local needs (Christopherson and Belzer 2009). According to Bowen (2008), distribution center location at the county level is heavily driven by access to highways and airports, while access to rail lines and sea ports was not significant in the study. Lasserre (2004) echoes the finding that e-commerce and abundant shipment information have changed the criteria by which companies locate warehouses and distribution centers. Proximity to other supply chain actors is less important than the reliability and speed that airports can provide.

Similarly, Sivitanidou (1996) found that airport access, highway density, and proximity to highway interchanges are the most important factors in warehouse rent in the Los Angeles area, ostensibly because of their role in providing mobility. Woudsma et al. (2008) also found that highways and airports heavily influence logistics site selection. Impairments to mobility—like road congestion around an airport—discourage logistics activity from locating nearby, probably because of their deleterious effects on reliability.

The need for fast and reliable access to the transportation network has allowed warehouses to move from urban areas to suburbs (Cidell 2010). Distribution center suburbanization is not entirely a function of mobility, but also land price and availability. High traffic volumes and containerization has also promoted suburbanization because suburbs can accommodate large, efficient single-story distribution centers more easily than central cities (Cidell 2010). The phenomenal logistics growth at Dubai and China's Pearl River Delta are similarly a function of accessibility to the transportation network and information flows (Hesse 2010).

Freight flows have gained preeminence over place in global supply chains (Hesse 2010). Global supply chains have undergone functional integration, which rationalizes the supply chain process with regard to make it more efficient and information-dense, and geographic integration, which allows each portion of the supply chain to locate where it has the greatest comparative advantage. Functional integration allows the supply chain "to insure a better access to markets, labor, parts, or resources" and to integrate across geography with economical and reliable transportation (Rodrigue 2006b).

Rodrigue (2006b) believes that transportation is now so fundamental to the production process that viewing transportation as a derived demand no longer is appropriate. "Demand driven distribution systems" (e.g., just-in-time logistics) make inventory, transportation, and information sharing such an indispensable part of the supply chain because they allow for optimized configuration and operations. Inventory, transportation, and information converge in distribution centers, which regulate freight flows (Rodrigue 2006b).

Supply Chains and Megaregions

Megaregions are urban centers linked by economic, cultural, environmental, transportation, and infrastructure along with their surrounding suburban and rural areas. Megaregions are a spatial manifestation of both economic and transportation dynamics, and a means for orienting planning processes. Rodrigue's (2006a) analysis of distribution center locations bears on megaregions because it recognizes that different supply chain configurations require distribution centers to operate on different geographical scales from national or international to local or regional. Distributors locate freight facilities so as to balance the time required for transportation with the associated costs. This location may cause distribution networks to fragment into different areas of responsibility. While Rodrigue (2006a) does not explicitly analyze the fragmentation corresponding to the megaregion, the analysis does imply that distribution centers operate at multiple spatial scales, including the megaregion.

Christopherson and Belzer (2009) examine freight distribution trends, including the lower transportation costs, high value of time for some products, suburban and exurban distribution facilities, and the functions of inland ports. The freight distribution system is a "pass-through" because its global character disconnects it from regional economies except for the generally low-paying jobs produced at intermediate nodes. The researchers predict that higher transportation costs would severely strain shippers. However, shippers may not be able to reconfigure their supply chains because of significant sunk costs in spatially fixed freight facilities, such as distribution centers. Therefore, the researchers predict that the main spatial, modal, and organizational characteristics of today's distribution system will remain mostly fixed even as the economy and national priorities change. Shippers cannot quickly respond the changing energy prices either because their distribution centers lock them into certain geographical configuration.

Dablanc and Ross (2012) explicitly analyzed logistics from a megaregion perspective. The researchers examined distribution centers in the Piedmont Atlantic Megaregion (PAM) using 1998 and 2008 data from the National American Industrial Classification System (NAICS). The researchers found that the entire Atlanta metro region had decentralized between 1998 and 2008, but that distribution centers had decentralized more than the average of industries at the urban scale. Conversely, at the megaregion scale, distribution centers had agglomerated (i.e., "polarized") around metropolitan regions, which increased the absolute and relative role played by the Atlanta metro area in PAM. Dablanc and Ross (2012) also interviewed county officials in three metro Atlanta counties to determine attitudes towards logistics. The researchers found that the Atlanta metro region lacks inter-county and inter-municipal coordination in logistics planning, and that Atlanta's tax structures discouraged logistics development compared with surrounding counties. Finally, Dablanc and Ross (2012) analyzed long range transportation plans for major metropolitan planning organizations in PAM and statewide transportation plans for corresponding departments of transportation. They found that states and most major cities do not have a freight plan, and that very few recognize freight as a megaregion issue.

Supply Chain Trends

The literature documents several supply chain trends that may affect spatial supply chain manifestation. IDOM Consulting (2012) lists ten SCM trends: globalization, integrated planning, total landed cost, multimodality, go green, outsourcing, collaboration/integration, security, resilience, and information technologies. Globalization impacts supply chain structure; outsourcing (such as outsourcing the logistics function to third party logistics providers) could concentrate logistics flows and allow 3PLs to gain economies of scale by increasing distribution center size. Resilience could imply multiple distribution channels. However, most of IDOM Consulting's (2012) ten SCM trends do not affect freight flow or distribution center location.

By contrast, Cottrill's (2013) four logistics trends heavily influence supply chain flows. The first trend is product densification. Products are becoming smaller at the same time that their value is increasing. Product densification may reduce the number and size of shipments, or allow for faster and more expensive shipment methods (e.g., air freight). Diversification of sales channels is the second trend. It denotes retailers using online, mobile, and traditional retail simultaneously. Online retail often ships directly to customers from distribution centers, bypassing stores or using fulfillment centers for customers to pick up online orders (Smith 2012). The third trend, decentralization of production, may radically change supply chain configurations if it allows production to occur on a smaller, more customized scale, closer to the consuming populations. Finally, digitization of product skips the physical supply chain entirely (Cottrill 2013). Digital products are non-physical items such as music and information transmitted electronically as zeroes and ones.

Several other supply chain trends may impact freight flow and distribution center locations. One of the University of Tennessee's (2012) supply chain trends is "incremental change to a transformational agile strategy." These strategies will emphasize the five dimensions of agility: "alertness, accessibility, decisiveness, swiftness, and flexibility," most of which speak to supply chain configuration. The University of Tennessee (2012) also posits a change from forecasting needs to demand management. Globalized production needs more time than local or regional production for shipments to reach destinations, which requires companies to forecast needs farther ahead. According to the University of Tennessee's survey of companies, many companies have great difficulty forecasting their needs accurately, which interferes with their ability to meet consumer demands. Demand forecasting inaccuracies speak to the challenges inherent in globalized supply chains and a potential movement towards bringing production closer to consumption. Price Waterhouse and Coopers (2013) confirmed both that (a) industry widely views logistics and warehousing as candidates for outsourcing and (b) that the uncertainties of distance make logistics and warehousing among the most frequent functions to be sourced regionally rather than globally. The reason may be related to the difficulty of forecasting that makes outsourcing hazardous even when it could economize. Distance to freight facilities increases the lead time required for production and transportation. Long lead times make production and transportation unresponsive to unforecasted consumer demand.

A final trend comes from the U.S. Energy Information Administration, which predicts that energy prices will increase through 2040 (Conti et al. 2013). Diesel fuel is expected to increase by

1.1% annually (2011 dollars) through 2040, crude oil is expected to increase by between 1.3% and 1.8% annually (2011 dollars), and natural gas price for transportation is expected to increase by 0.9% annually (2011 dollars). This will likely increase transportation costs and promote a shrinking of supply chains as suggested by the University of Tennessee (2012).

Methodology

Based on section 1 literature review findings, the study undertakes two types of analysis to determine the existing alignment of freight distribution networks with megaregions concepts. The study will focus on warehouses and distribution centers because they are the primary distribution nodes in providing products to stores and customers through either 'brick-and-mortar stores' or online sales. The literature review revealed that distribution centers house value-added processes related to online sales, product customization, returners, and information management and transferal up the supply chain. The analysis uses the terms 'warehouse' and 'distribution center' interchangeably since nationwide data does not distinguish between them.

The second section includes an analysis of North American Industry Classification System (NAICS) data to identify large concentrations of distribution and warehouse-related establishments. The number of distribution centers in each county approximates the scale of the county's logistics activity. County-level results are grouped by megaregion, and the relative size and spatial structure of logistics activity are analyzed with descriptive statistics and visual spatial examination. Based on the patterns, the study will draw conclusions about the alignment between megaregion boundaries and logistics activity.

The third study section includes distribution facility network case studies of Walmart and Amazon.com. Both companies are logistics leaders. The company selection also allows analysis of the different distribution networks that serve two primary company types, namely large brick-and-mortar retailers and e-commerce stores. The cases are not intended to produce statistically significant findings, but rather to point directions for follow-up research.

The fourth study section provides insights on how transportation planners can plan for freight distribution at the megaregion scale based on a survey of metropolitan planning organizations (MPO) and state departments of transportation (DOT). Researchers at the Center for Quality Growth and Regional Development administered the survey in fall 2012 as part of *The Architecture of the Megaregion* research project.

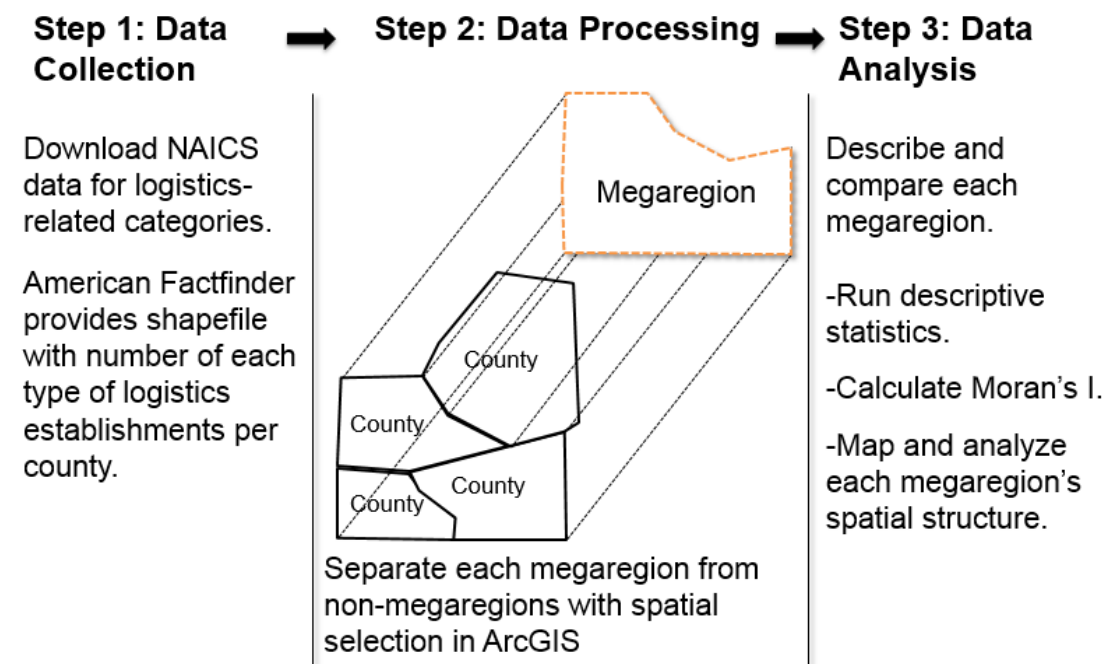
The final section combines findings from the literature review, nationwide distribution center analysis, the two case studies, and the megaregion survey to suggest ways in which transportation planners and supply chain managers can develop the megaregion concept to better serve product distribution. Findings are intended to guide future studies related to megaregions and supply chain management.

Section II: Aggregate Spatial Analysis

This section details the location of different types of logistics activity hubs at the in each megaregion and in non-megaregion areas. Rather than starting with accessibility furnished by transportation infrastructure (Christopherson and Belzer 2009; Bowen 2008; Lasserre 2004; Sivitanidou 1996), the section presents logistics activity aggregated to the megaregion level. It is expected that most types of logistics activity will concentrate in megaregions because of the high physical accessibility, concentrated and skilled workforce, well-developed transportation infrastructure, and supporting industries, and consumers that they provide.

Methodology

The aggregate spatial analysis involved three different steps, detailed in the diagram and paragraphs below.



Step 1 – Data Collection: The first step required collecting the raw logistics industry data by downloading county-level NAICS data from the American FactFinder (U.S. Census Bureau 2013a) for each NAICS category and downloaded a county map with the embedded data. This produced shapefiles of counties in the contiguous United States with the number of each type of logistics establishments.

It was important to select the NAICS categories that best capture freight-related activities. Some categories, notably for Air Transportation (NAICS 481), do not allow properly separating freight establishments from passenger transport establishments because most passenger airlines also transport freight below deck. If only air freight establishments had been selected, it would have shown only a partial and likely distorted picture of establishments processing freight because freight cannot be completely isolated from passenger air travel. Therefore, this

research uses the more generic air transport code capturing both cargo and passenger transport. A complete description of each NAICS code is available in Appendix 2.

Step 2 – Data Processing: Each county in a megaregion was spatially selected in ArcGIS for individual analysis. This research delineating megaregions according to the boundaries established by Ross et al. (2009) that account for travel volumes, infrastructure connections, and economic connections, as well as cultural, historical, and environmental similarities.

Step 3 – Data Analysis: The final step was to analyze the data. Descriptive statistics were the primary analytical tool, and they were complemented by visual inspection to better understand the structure of activity within megaregions (e.g., the activity's homogeneity across the megaregion, special concentrations or absences, patterns of activity distribution).

Moran's I describes spatial autocorrelation that shows activity concentration or dispersal. Moran's I varies from '-1' to '1,' where a value of '0' indicates a random spatial distribution, a value of '-1' indicates an evenly dispersed distribution, and a value of '1' indicates a segregated distribution (Moran 1950). The equation for Moran's I is below (Paradis 2009).

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^n (x_i - \bar{x})^2}$$

Where—

- 'I' is Moran's Index
- 'n' is the number of indexed spatial units
- ' w_{ij} ' is the weight between observations i and j
- ' x_i ' and ' x_j ' are the variable of interest at location i or j
- ' \bar{x} ' is the sample mean of variable i or j
- ' S_0 ' is the sum of all w_{ij}

Moran's I was calculated in the ArcGIS spatial analysis tool at the national and individual megaregion level.

Findings

The following section describes the findings for aggregate county-level logistics activity in each of the 10 documented megaregions and in non-megaregion areas. The NAICS codes examined are listed below.

- 481 Air Transportation
- 483111 Deep Sea Freight Transportation
- 483113 Coastal and Great Lakes Freight Transportation
- 483211 Inland Water Freight Transportation
- 484 Truck Transportation
- 484121 General Freight Trucking, Long-Distance, Truckload
- 484122 General Freight Trucking, Long-Distance, Less Than Truckload
- 488 Support Activities for Transportation
- 488510 Freight Transportation Arrangement
- 493 Warehousing and Storage

Almost all NAICS codes are more than 50% concentrated in megaregions, with the only exception being NAICS 483211 (inland water freight transportation). By contrast, NAICS 483111 (deep sea freight transport) is the most concentrated in megaregions, with 87.2% of such establishments in megaregions. Most of the remaining codes have between 58% and 81% of establishments in megaregions. Figure 3 below shows the megaregion percentage concentration for each NAICS code.

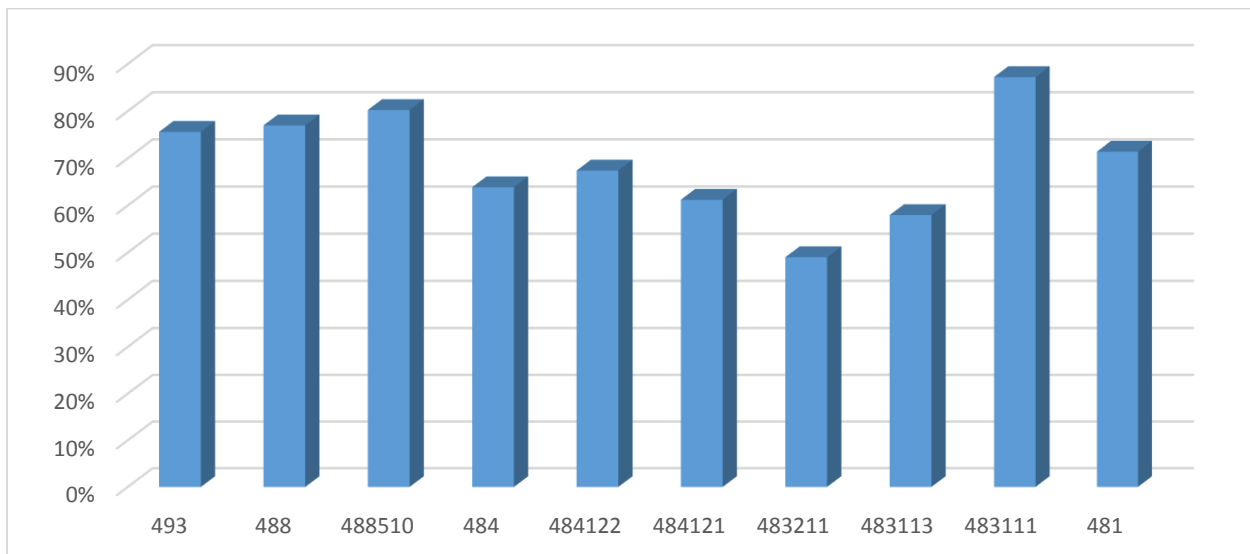


Figure 3: Megaregion percentage concentration by examined NAICS codes

Activity is not evenly disbursed in each megaregion. Generally, the Midwest, the Northeast, and the California Megaregions dominate logistics-related activity in order of decreasing intensity. For example, the Midwest has 18% of warehouse establishments, the Northeast 14%, and California 13%. This contrasts with the Arizona Megaregion, which contains less than 2% of

warehouse establishments. However, there are exceptions to the logistics dominance of the Midwest, the Northeast, and California. The Texas Triangle has the second highest amount of NAICS 483113 establishments (coastal and Great Lakes freight transport), with 9.1%, and Cascadia has the third largest amount of 483211 (inland water freight transport). Piedmont Atlantic has 7.3% of long-distance truckload shipment establishments (NAICS 484121), which is the second highest concentration. Finally, Florida performs well in coastal and deep sea freight, as well as air transportation (483113, 483111, and 481 respectively).

Waterborne freight transport demonstrated different geographical concentrations than ground logistics activity because of waterborne freight's dependence on the presence of immovable rivers, lakes, and oceans, as well as often old canal infrastructure. These may be one of the reasons for waterborne freight activity's relative dispersion compared with trucking-based activities, which more frequently follow population clusters and highways.

Table 1 below provides a complete list of NAICS code concentration in megaregions.

Table 1: Percentage of national establishments within megaregion

	Arizona	California	Cascadia	Central Plains	DC-Virginia	Florida	Midwest	Northeast	Piedmont Atlantic	Texas Triangle	Total Megaregion
Description											
Air Transport - 481	2.2%	11.6%	3.0%	2.0%	3.7%	9.2%	12.5%	14.2%	5.7%	7.3%	71.4%
Deep Sea Freight Transport - 483111	0.5%	13.3%	4.3%	0.5%	9.3%	17.0%	4.8%	23.1%	5.1%	9.3%	87.2%
Coastal and Great Lakes Freight Transport 483113	0.0%	4.0%	6.2%	0.0%	1.6%	8.6%	8.4%	19.2%	0.7%	9.1%	58.0%
Inland Water Freight Transport - 483211	0.3%	1.4%	5.3%	0.3%	3.1%	3.4%	14.8%	12.9%	2.8%	4.8%	49.0%
Truck Transportation - 484	1.3%	8.4%	2.9%	2.7%	2.7%	4.0%	20.2%	11.2%	5.8%	4.7%	63.9%
General Freight Trucking Long Distance Truck Load - 484121	1.4%	6.6%	3.0%	3.2%	1.9%	3.6%	22.4%	7.0%	7.3%	4.8%	61.2%
General Freight Trucking Long Distance LTL - 484122	1.4%	9.1%	2.7%	3.1%	2.3%	3.9%	21.2%	11.4%	7.9%	4.4%	67.4%
Support Activities for Transportation - 488	1.8%	13.5%	3.8%	2.2%	3.2%	9.2%	15.7%	14.8%	6.3%	6.5%	77.0%
Freight Transport Arrangement - 4885	1.7%	14.8%	3.6%	1.8%	2.5%	9.6%	16.4%	17.1%	6.6%	6.2%	80.2%
Warehousing and Storage - 493	1.8%	12.7%	3.4%	2.6%	3.4%	4.6%	18.1%	14.0%	9.0%	5.9%	75.6%

Ranking	
Largest (1st)	
2nd largest	
3rd largest	

A nationwide spatial autocorrelation analysis with Moran's I reveals an apparently random distribution for most logistics activities. All freight activities lean slightly towards spatial segregation (values above 0) except for 483111 (deep sea freight transportation), which leans towards a more even dispersal. NAICS 483211 (inland water freight transportation) leans most heavily towards spatial segregation (Moran's I of 0.17793), though the value itself remains very low. Truck-based freight, air transportation, warehousing, and support activities all approximate

random distributions at the national level, with index values between 0.1 and 0. Table 2 below provides a complete table of Moran's I.

Table 2: Moran's I at national scale by NAICS code

NAICS Code	Description	Moran's I	Expected Value	Z Score	p
481	Air Transport	0.06361	-0.00106	8.30	0.00000
483111	Deep Sea Freight Transport	-0.00159	-0.00735	0.48	0.62930
483113	Coastal and Great Lakes Freight Transport	0.06001	-0.00575	2.48	0.01302
483211	Inland Water Freight Transport	0.17793	-0.00556	8.92	0.00000
484	Truck Transportation	0.08554	-0.00033	29.52	0.00000
484121	General Freight Trucking Long Distance Truck Load	0.04057	-0.00037	19.23	0.00000
484122	General Freight Trucking Long Distance Less Than Truckload	0.02457	-0.00067	13.67	0.00000
488	Support Activities for Transportation	0.03437	-0.00043	18.99	0.00000
488510	Freight Transport Arrangement	0.03386	-0.00065	12.76	0.00000
493	Warehousing and Storage	0.04315	-0.00060	12.15	0.00000

In addition to a nationwide analysis, Moran's I may also describe patterns inside the megaregion. To demonstrate, Moran's I for NAICS 493 (warehousing and storage) establishments were calculated at the megaregion level. The limited number of counties resulted in much lower confidence levels than for the nationwide analysis, where confidence levels generally exceeded 95%. The Northeast demonstrates the most pronounced spatial segregation of warehouse establishments (Moran's I = 0.457), followed by the Arizona Megaregion and DC-Virginia. Piedmont Atlantic, Central Plains, Florida, California, and the Midwest demonstrate a more random distribution. Finally, Cascadia and Texas Triangle have more evenly distributed warehousing activity.

Some of the megaregions merit closer examination. The Midwest Megaregion's extremely low confidence interval does not indicate doubt in the megaregion's seemingly random spatial distribution of warehousing activity, but rather reinforces the random distribution because it shows that there is essentially no confidence that the observed distribution differs from the null hypothesis, which is a random distribution. DC-Virginia and Piedmont Atlantic have similarly low confidence intervals, which reinforce importance of randomness in the observed spatial distribution. Table 3 shows all megaregion-level results for Moran's I.

Table 3: Megaregion-level results for Moran's I

Megaregion	Moran's I	Expected Value	Z Score	P
Northeast	0.456594	-0.008696	9.177166	0.000000
Arizona	0.219081	-0.015625	2.126218	0.033485
DC-Virginia	0.101364	-0.017857	1.457775	0.144903
Piedmont Atlantic	0.092133	-0.303030	0.993669	0.320871
Central Plains	0.079147	-0.024256	2.452632	0.01418
Florida	0.078328	-0.003984	3.521485	0.000429
California	0.021962	-0.030303	-0.76836	0.44823
Midwest	-0.015188	-0.013494	0.026119	0.979162
Cascadia	-0.176528	-0.007874	3,590,749	0.00033
Texas Triangle	-0.290963	-0.100000	-1.44975	0.147129

NAICS 481 - Air Transportation

Air transportation includes both scheduled and nonscheduled cargo, passenger, and mixed air operations (Bureau of Labor Statistics 2014a) employing aerial movement by airplane or helicopter. Passenger and freight air establishments cannot be fully separated because large and growing percentages of cargo are transported in passenger aircraft under the main passenger cabin (Air Cargo World 2012). Therefore, this analysis uses the NAICS 481 code that includes both passenger and freight cargo.

Air transportation is heavily concentrated in megaregions. Possible reasons for concentration include the fact that population and business concentrations drive passenger and cargo demand, as well as the presence of major airports in megaregions. For example, eight of the 10 busiest American airports are located in megaregions (Federal Aviation Administration 2013). Figure 4 shows the percent of air transportation establishments in megaregions.

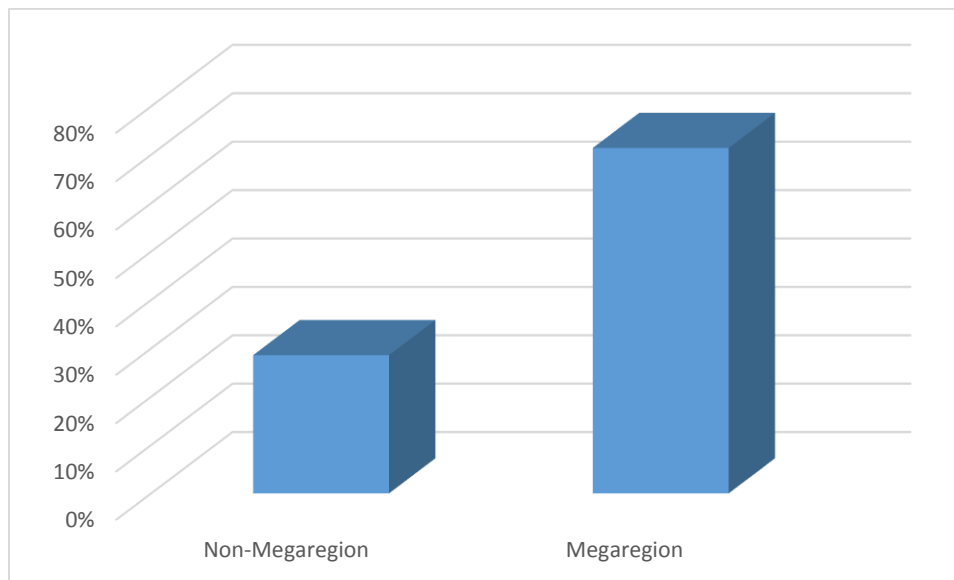


Figure 4: NAICS 481 Air Transportation - Percent of Total

The Northeast, the Midwest, and the California Megaregions have the most air transportation-related establishments, with 717, 631, and 586 respectively. By contrast, the Central Plains, Arizona, and Cascadia have the lowest number of air transportation establishments. Figure 5 below shows the number of NAICS 481 establishments in each megaregion.

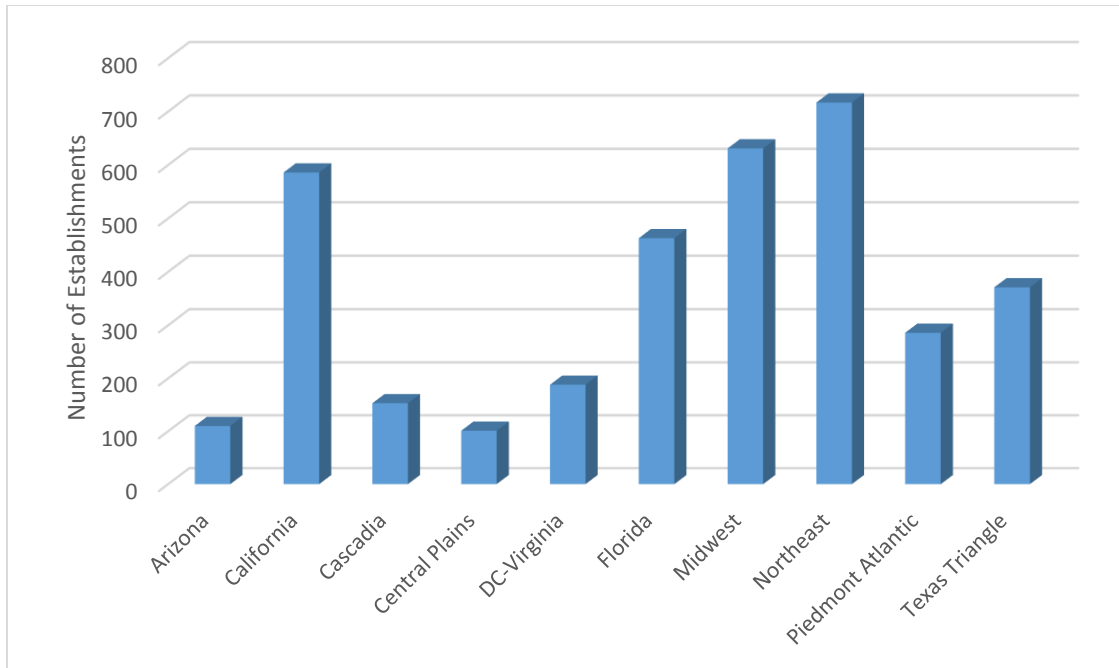


Figure 5: NAICS 481 Air Transportation - Total Establishments by Megaregion

Visual inspection reveals the largest concentrations of air transportation establishments (Figure 6), which mirror the locations of some of the busiest cargo airports. Particularly notable concentrations are in Los Angeles and San Bernardino Counties, California; Maricopa County, Arizona; Dallas, Tarrant, and Harris Counties, Texas; Fulton and DeKalb Counties, Georgia; Dade and Broward Counties, Florida; Fairfax County, Virginia; New York, New York; and Cook County, Illinois. These are near the airports in Los Angeles, Dallas-Fort Worth, Houston, Atlanta, Miami, Washington DC (Dulles and Reagan National), New York (LaGuardia, John F. Kennedy, and Newark), and Chicago. There is also a large concentration near Memphis, Tennessee and Louisville, Kentucky, which may reflect those airports' hub role for FedEx and UPS respectively. Memphis is not in a megaregion, while Louisville is in the Midwest Megaregion.

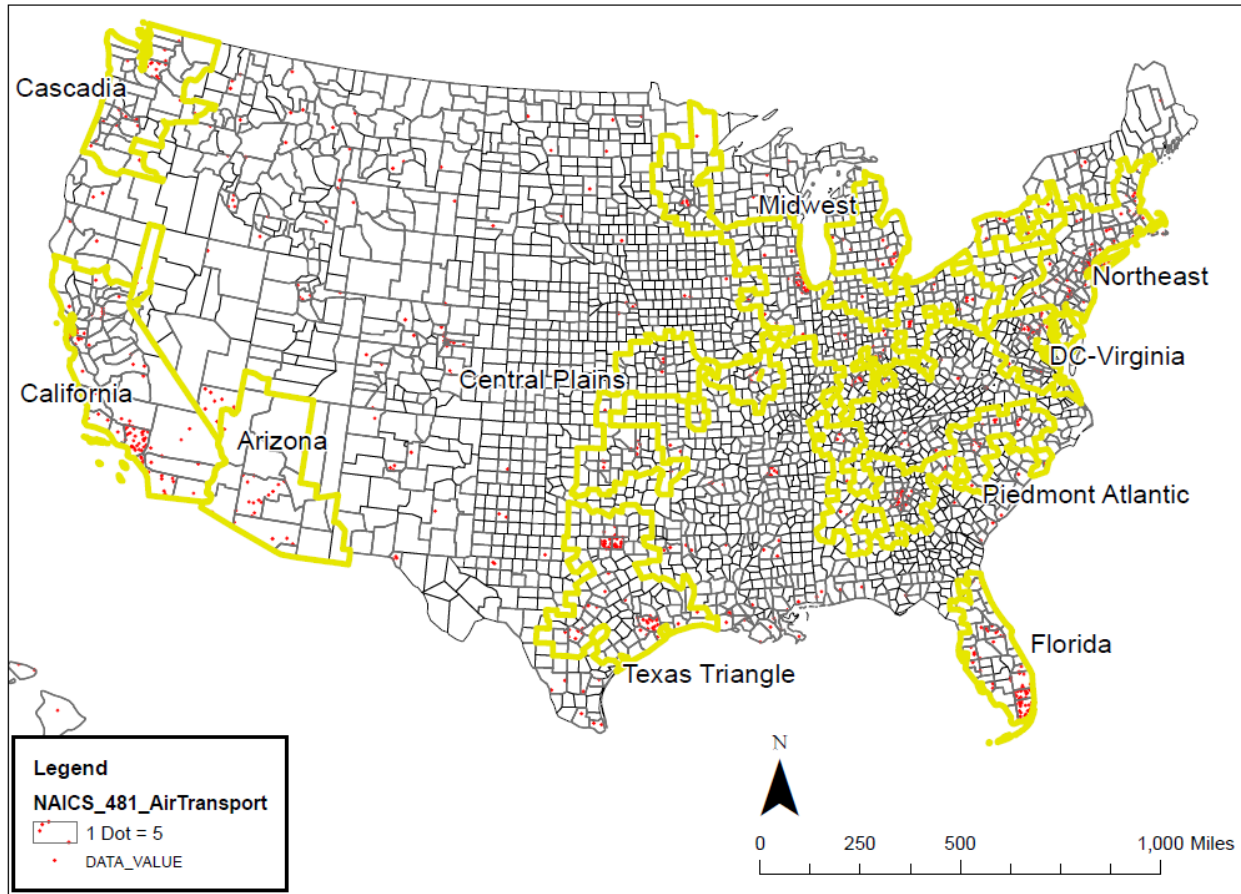


Figure 6: NAICS 481 Locations

Air transportation activity is heavily concentrated in megaregions, especially the Northeast, Midwest, and California. Within megaregions, air transportation-related establishments cluster in the counties with and adjacent to the busiest airports. Air transport activity is heavily concentrated around a few very large airports in megaregions.

NAICS 483111 - Deep Sea Freight Transportation

NAICS code 483111 includes businesses engaged in deep sea freight activity to and from foreign ports. It does not include inland or ocean-going freight between domestic ports (U.S. Census Bureau 2014b). Most 483111 establishments are located on the coast, though some are inland, possibly providing sales or auxiliary services to deep sea shippers and shipping companies.

NAICS code 483111 is the most heavily concentrated logistics-related activity in megaregions, with 87% of establishments in megaregions (Figure 7). The fact that ocean ports are generally located in or near a major city may increase deep sea freight's activity to occur in megaregion, although there are some exceptions (e.g., the Port of Savannah, the Port of Charleston, the Port of New Orleans, the Port of Mobile).

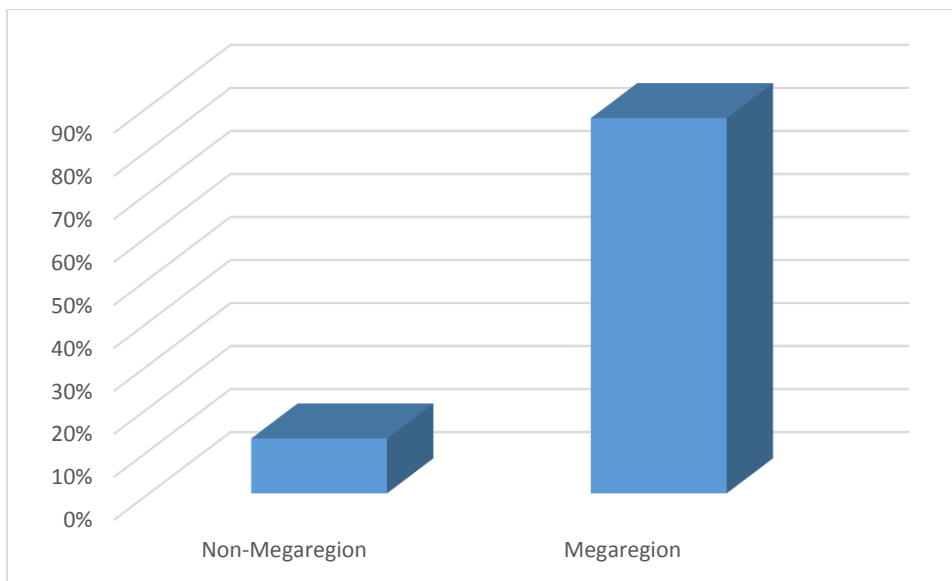


Figure 7: NAICS 483111 Deep Sea Freight Transportation - Percent of Total

The Northeast Megaregion has by far the greatest number of deep sea freight-related establishments, with 87 establishments. The number of deep sea freight establishments in the Northeast may reflect the region's historic importance to the ocean going trade, particularly around the Port of New York. The Florida Megaregion and the California Megaregion have the second and third highest number of deep sea freight-related establishments respectively. California's relatively low number is surprising due to the presence of the country's largest port at Los Angeles/Long Beach. The Arizona and Central Plains Megaregions have negligible amounts of deep sea freight activity as they are both landlocked. However, Cascadia, the Midwest, and Piedmont Atlantic also have very low levels of deep sea freight activity. Figure 8 below shows the number of NAICS 483111 establishments in each megaregion.

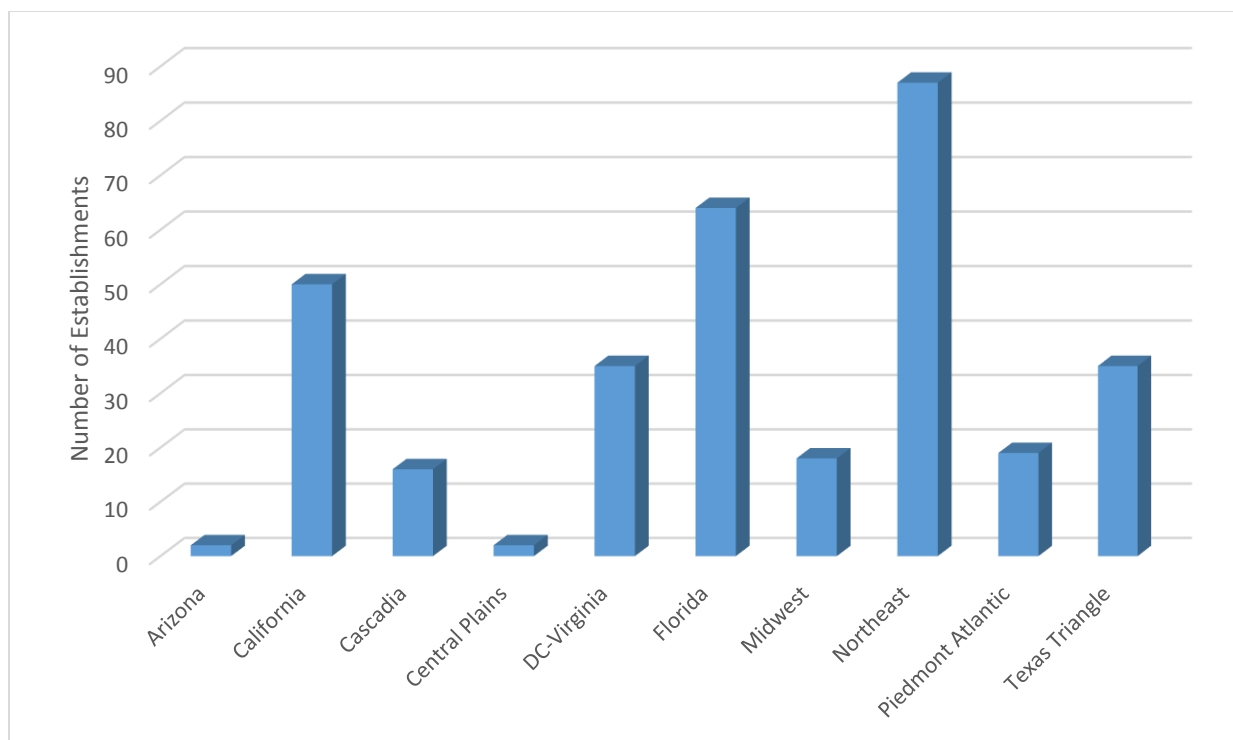


Figure 8: NAICS 483111 Deep Sea Freight Transport - Total Establishments by Megaregion

Figure 9 shows the location of establishment clusters in NAICS activity category 483111. The largest coastal clusters are near Los Angeles, California; San Francisco, California; Miami and Fort Lauderdale, Florida; Houston, Texas; Seattle, Washington; New York, New York; and Boston, Massachusetts. Inland clusters exist both in megaregions (e.g., Dallas, Texas; Chicago, Illinois; northeastern Pennsylvania; Atlanta, Georgia; Charlotte, North Carolina; Kansas City, Missouri) and outside of megaregions (e.g., Memphis, Tennessee; southeastern Georgia).

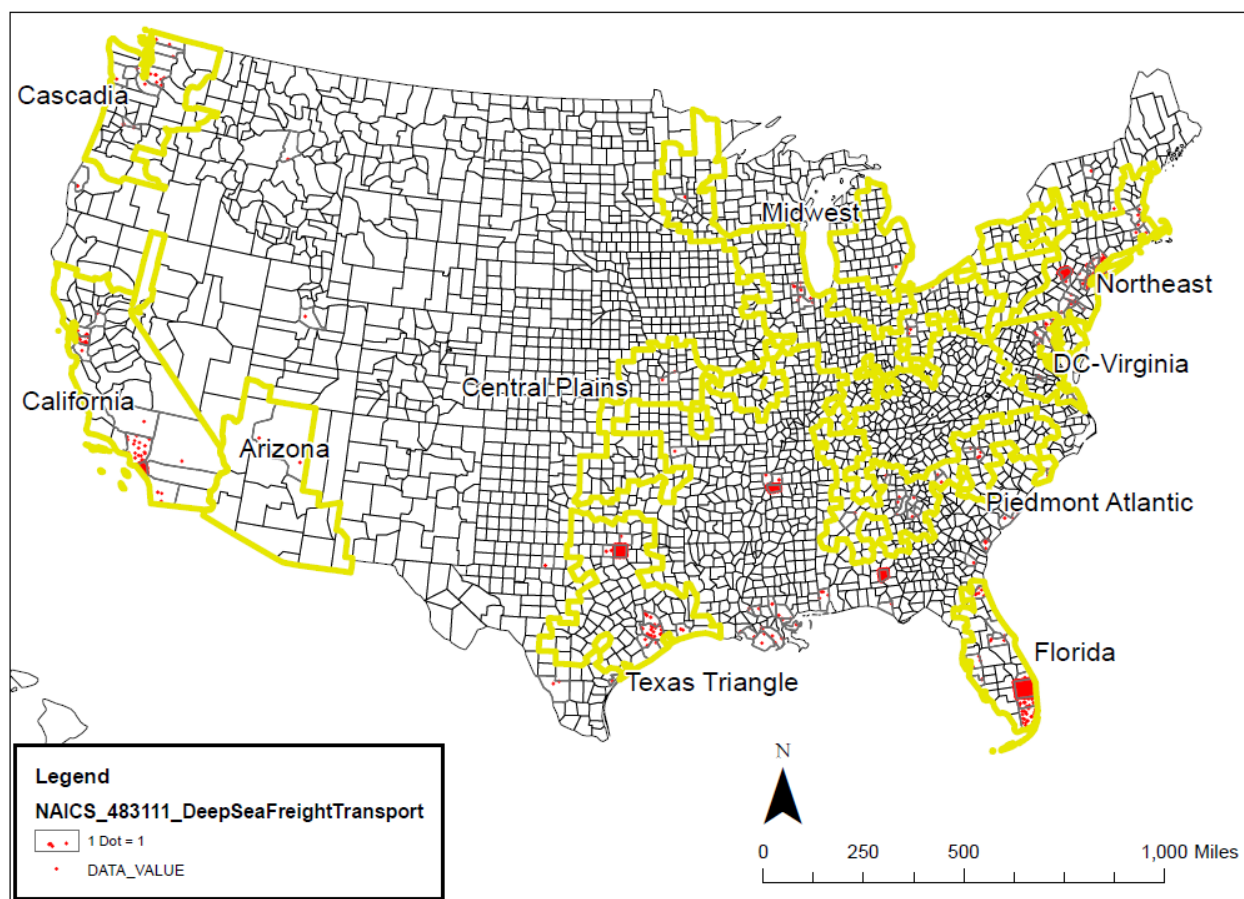


Figure 9: NAICS 483111 Locations

In sum, deep sea freight activity is heavily concentrated in coastal megaregion cities near ports. Several inland clusters exist in urban areas. However, deep sea freight remains heavily concentration in just a few megaregions, most importantly the Northeast, Florida, and California Megaregions.

NAICS 483113 - Coastal and Great Lakes Freight Transportation

NAICS 483113 describes establishments whose activity relates to freight transport in the Great Lakes, along coastal waterways, or in the ocean between American ports (U.S. Census Bureau 2014c). NAICS 483113 is concentrated in megaregions more than non-megaregions, though the concentration is less pronounced than for deep sea freight transportation (Figure 10).

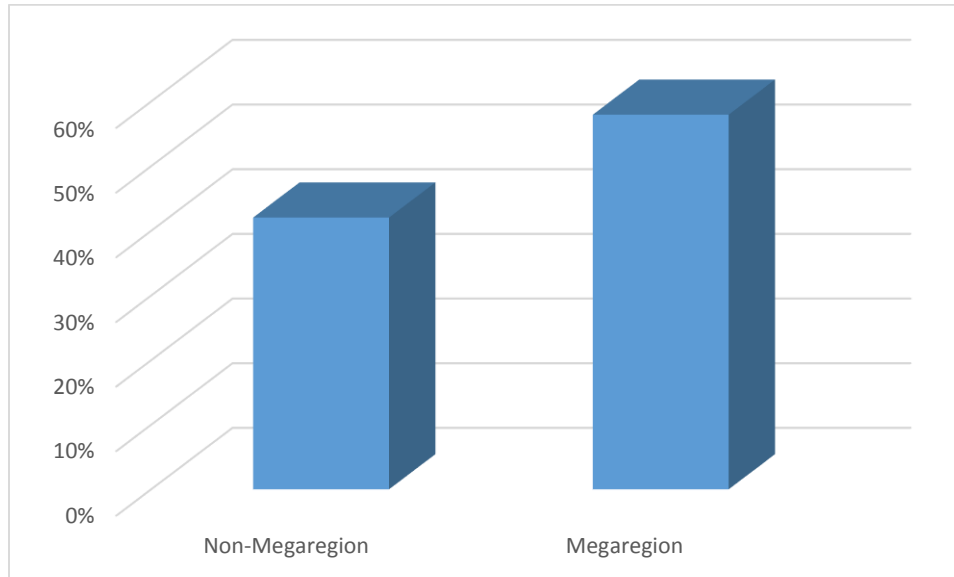


Figure 10: NAICS 483113 Coastal and Great Lakes Freight Transportation - Percent of Total

The Northeast Megaregion is most heavily represented in Coastal and Great Lakes Freight Transportation with 105 establishments. This is over twice as many as in the next highest megaregions, which are Texas Triangle, Florida, and the Midwest at nearly identical levels. Landlocked Arizona and Central Plains have negligible activity, while Piedmont Atlantic and DC-Virginia have very low levels of coastal freight transportation establishments. Figure 11 below shows a complete list of NAICS 483113 activity by megaregion.

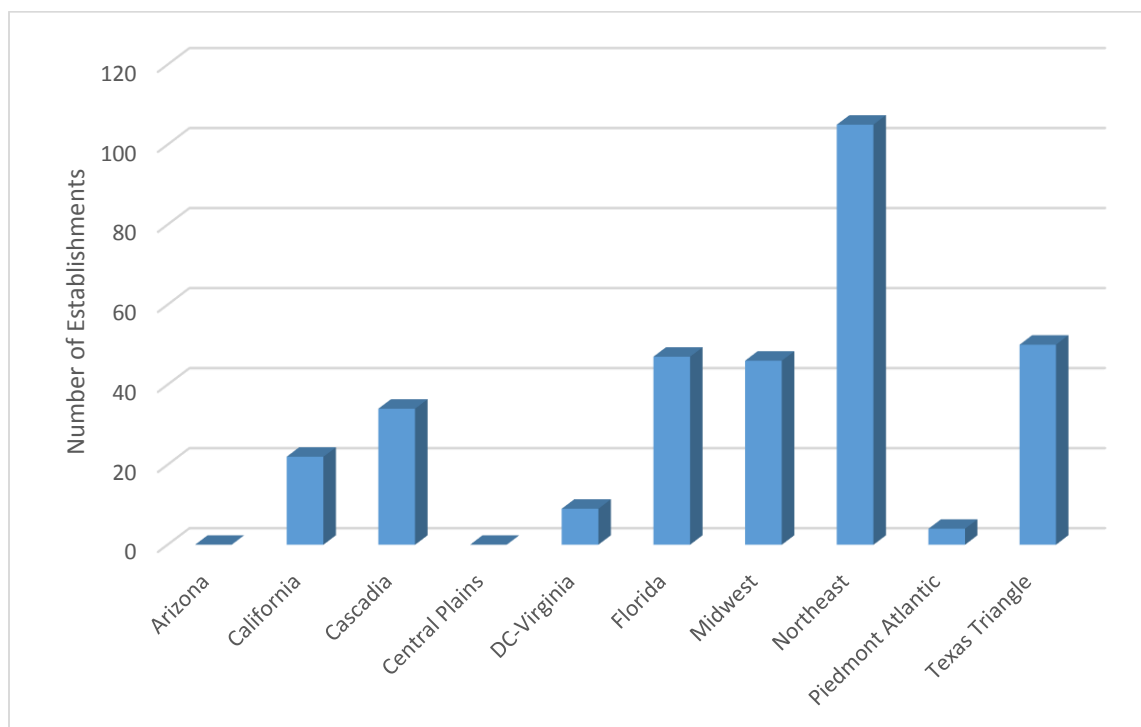


Figure 11: NAICS 483113 Coastal and Great Lakes Freight Transportation - Total Establishments by Megaregion

Figure 12 below shows the spatial concentrations of NAICS 483113 establishments. The greatest non-megaregion concentration is along the Louisiana Delta. Megaregion concentrations are in the New York metro area, the east Florida coast, the Houston metro area, southern and northern California, and the Puget Sound region in Washington. There are also megaregion activity concentrations around the Great Lakes, notably near Chicago, Cleveland, Detroit, Buffalo, and several parts of rural Michigan.

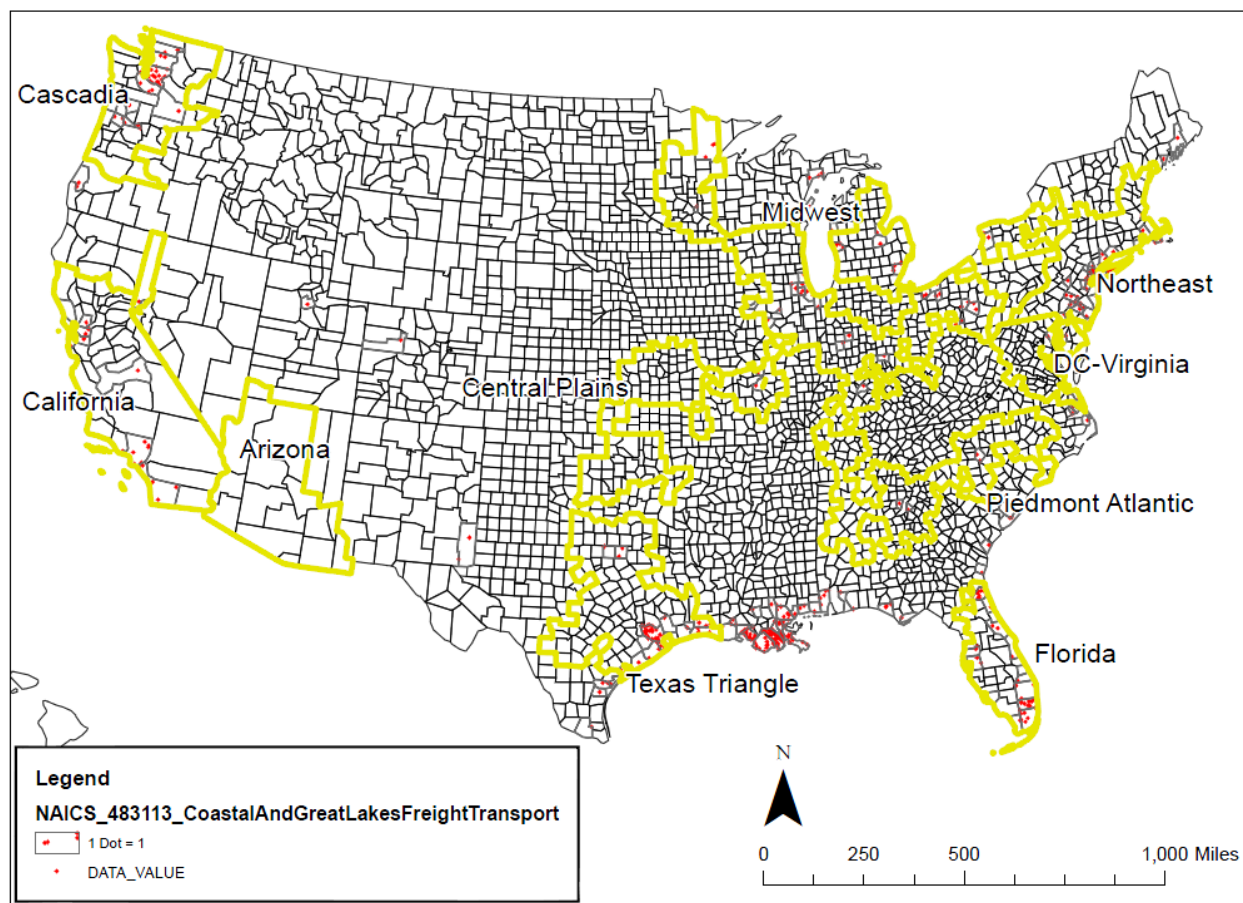


Figure 12: NAICS 483113 Locations

Coastal and Great Lakes freight transportation is primarily concentrated on adjacent to the ocean and the Great Lakes. Non-megaregion areas appear to play an important role, particularly in southern Louisiana. Within megaregions, the Northeast leads the category's activity, followed by Florida, the Midwest, and the Texas Triangle.

NAICS 483211 - Inland Water Freight Transportation

NAICS code 483211 includes water-borne freight transport on lakes and rivers, except for the Great Lakes (U.S. Census Bureau 2014d). Unlike other logistics activities, a slight majority (51%) of inland water freight transportation establishments are in non-megaregions (Figure 13). Megaregions are more likely to follow interstate highways than navigable waterways, which may tend to leave water freight activity relatively dispersed.

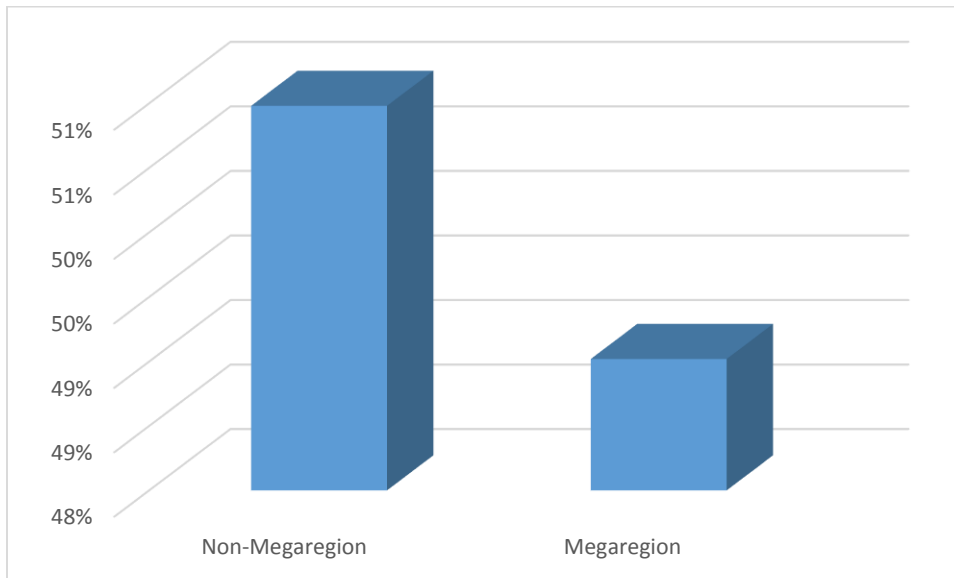


Figure 13: NAICS 483211 Inland Water Freight Transportation - Percent of Total

Even though the category excludes Great Lakes transport, the Midwest and Northeast have the most establishments engaged in inland water freight transportation, possibly because of an outsized role of major rivers like the Ohio, Mississippi, Delaware, and Hudson. The presence of lakes and rivers is of primary importance. Arizona, which lacks navigable rivers, and the Central Plains have the lowest number of establishments in inland water freight, as they do for other water-borne freight categories. Figure 14 below shows the activity category by megaregion.

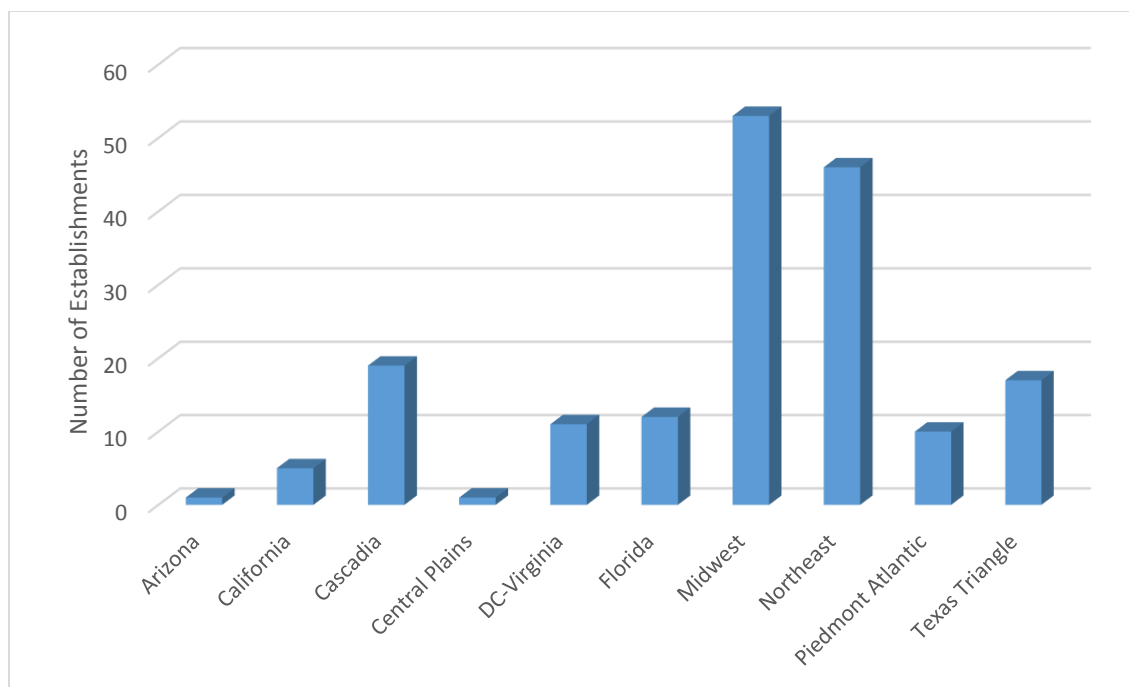


Figure 14: NAICS 483211 Inland Water Freight Transportation - Total Establishments by Megaregion

One of the largest NAICS 483211 concentrations is in southern Louisiana, near the mouth of the Mississippi River. The southern Louisiana concentration visually appears to account for the majority of non-megaregion activity. There are several non-megaregion concentrations along the Mississippi River, as well as megaregion concentrations in counties adjacent to the Mississippi and Ohio Rivers (Midwest), Delaware and Hudson Rivers (Northeast), Columbia River (Cascadia), and Trinity Bay (Texas Triangle). The greatest activity is near rivers, though a portion also exists near oceans or bays (e.g., southern California, southeastern Florida). Figure 15 below shows the major concentrations of NAICS 483211 activity.

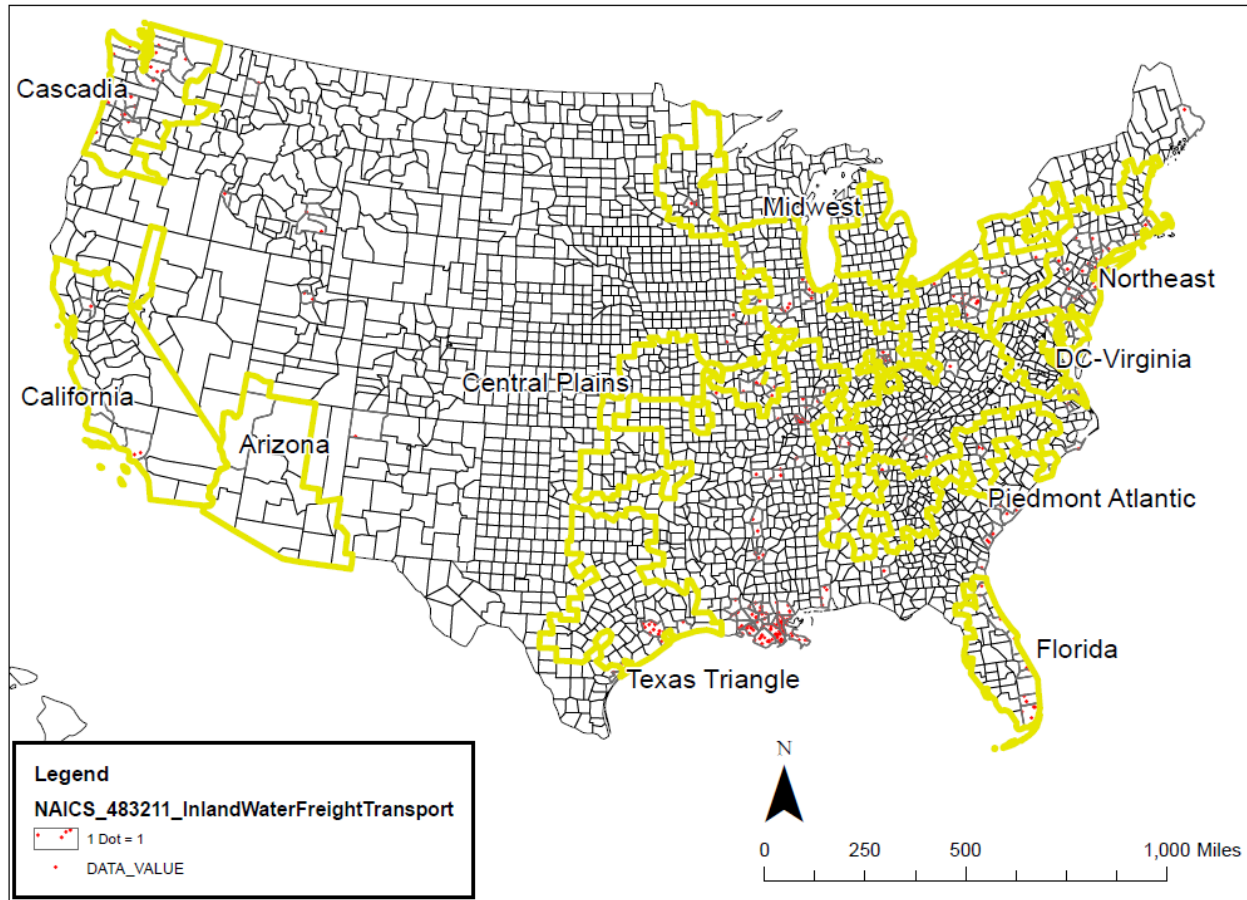


Figure 15: NAICS 483211 Locations

Inland water freight transportation is the only logistics activity examined that is more concentrated in non-megaregions than in megaregions. The non-megaregion concentrations are at the Mississippi River's mouth, and along the length of the Mississippi and Ohio Rivers. Megaregion activity clusters are strongest in the Midwest and Northeast, both of which have large and historically vibrant inland water transportation networks buttressed by rivers and, in some cases, canals. Inland water transportation is likely to remain fixed largely outside of megaregions because of the locations of many primary waterways in non-megaregions, though there may also be potential to use unused capacity in and outside of megaregions to support growing freight transportation in some locations.

NAICS 484 - Truck Transportation

NAICS 484 encompasses all commercial truck-based freight movement, including specialized, general, scheduled, non-scheduled, truckload, and less than truckload services (Bureau of Labor Statistics 2014b). Following sections exam some of the most important components. Truck transportation is a major employer and one of the largest activities examined. Trucking employs over 1.3 million Americans (Bureau of Labor Statistics 2014b).

Truck transportation is disproportionately used in megaregions compared with non-megaregions (Ross et al., 2009), possibly because of the important role of Interstate Highways in connecting the urban areas that form megaregions. As such, 64% of truck transportation establishments are located in megaregions (Figure 16).

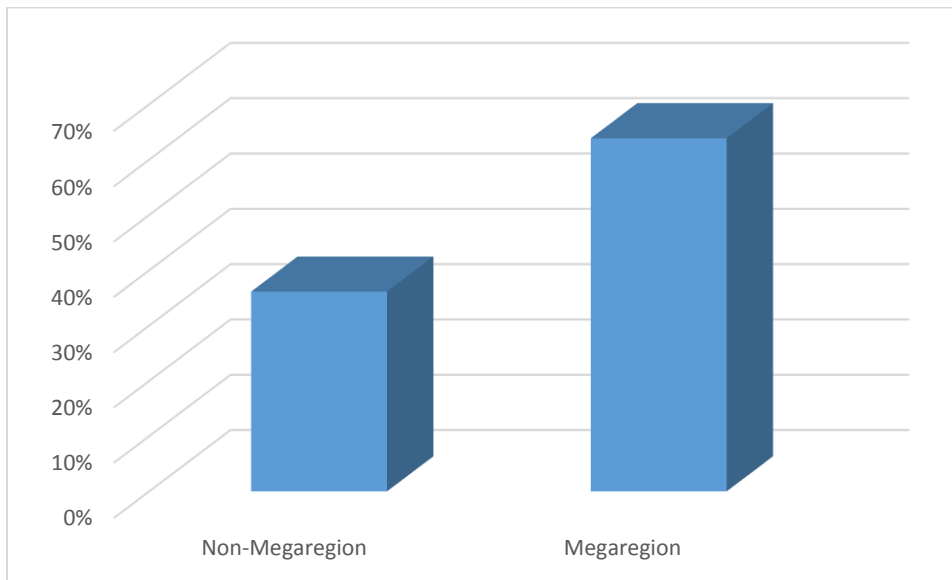


Figure 16: NAICS 484 Truck Transportation - Percent of Total

The Midwest has the highest concentration of truck transportation establishments, several times higher than most other megaregions. The Midwest Megaregion has over 22,000 establishments, compared with approximately 12,000 in the Northeast and 9,000 in California. The Arizona Megaregion has the lowest number of establishments (1,392), which may be due to its relative economic size compared with other megaregions more than a shift to other modes. Cascadia, the Central Plains, DC-Virginia, Florida, Piedmont Atlantic, and the Texas Triangle all have several thousand truck transportation establishments, albeit an order of magnitude less than Midwest. Figure 17 below shows the number of truck establishments in each megaregion.

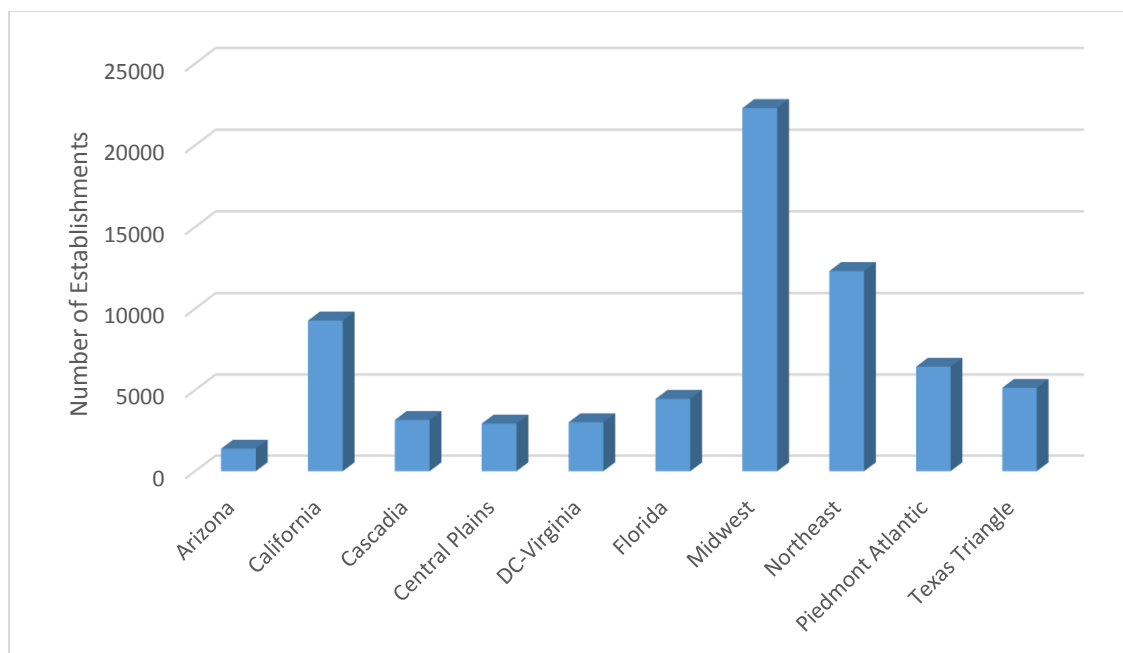


Figure 17: NAICS 484 Truck Transportation - Total Establishments by Megaregion

The number of truck establishments is several orders of magnitude higher than for the other activities examined, which required increasing the number of activities represented by each dot on the establishment map by ten times. The map (Figure 18) still shows much higher levels of activity nationwide than for the other freight modes examined. The first finding is that truck transportation establishments exist essentially everywhere there are people, which speaks to the truck's role in providing freight to areas both urban and rural. Roads go many more places than rail, airports, or waterways, which gives trucks incomparable access.

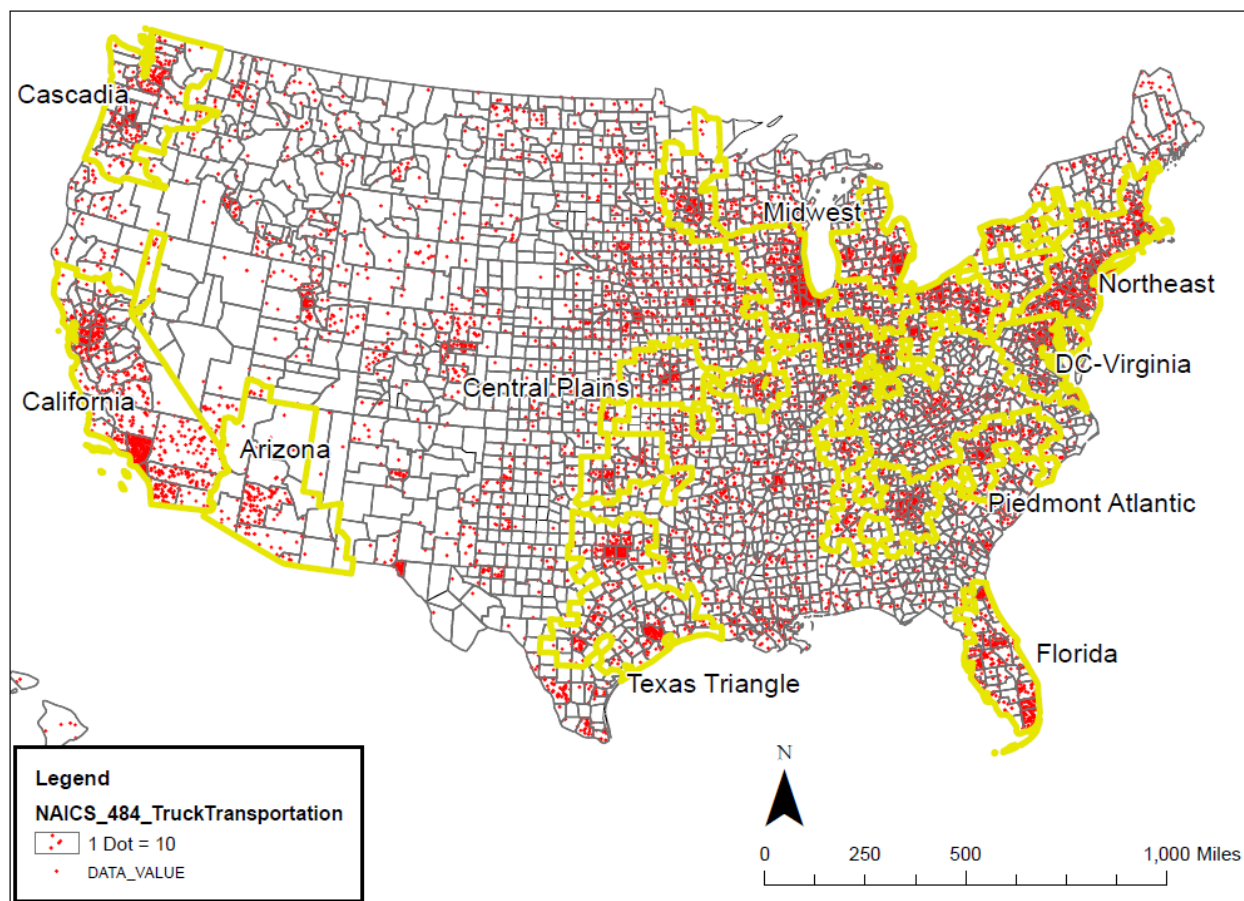


Figure 18: NAICS 484 Locations

Even though truck transportation establishments exist nationwide, they still concentrate around the large cities and corridors that anchor megaregions. The largest clusters are in the Midwest, the Northeast, Piedmont Atlantic, and California. Truck transportation exists in large numbers all over the country. The establishment-type's ubiquity speaks to the trucks role in providing freight mobility nationwide.

NAICS 484121 - General Freight Trucking, Long-Distance, Truckload

NAICS 484121 describes long-distance truckload freight establishments. Truckload carriers provide shipment from an origin to a destination to a load in a dedicated truck rather than combining the load with other loads for part of the trajectory. Truckload shipping establishments are in megaregions at a similar proportion to truck transportation (NAICS 484) as a whole, at 61% in megaregions (Figure 19).

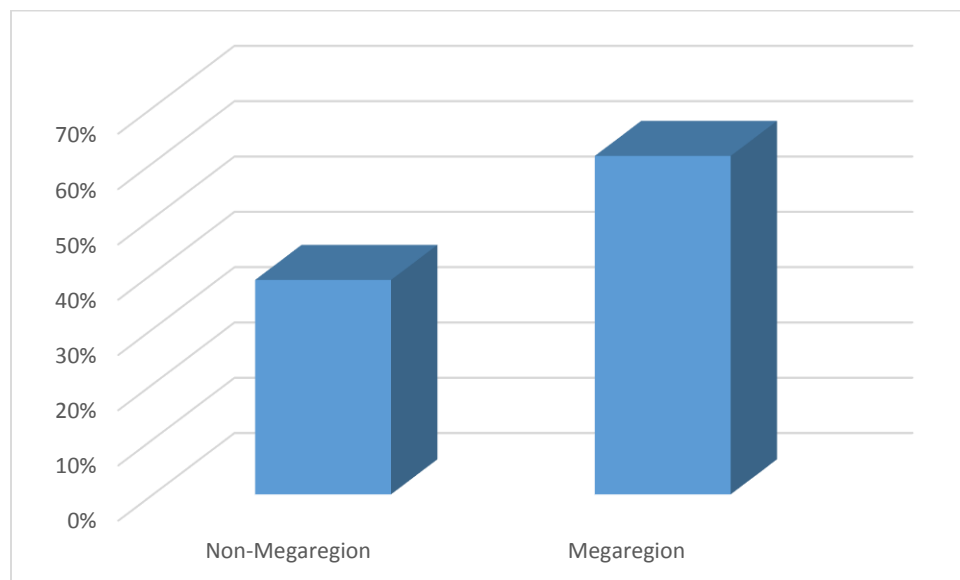


Figure 19: NAICS 484121 General Freight Trucking, Long-Distance, Truckload - Percent of Total

The Midwest Megaregion has by far the most truckload establishments, with 6,558 establishments. Piedmont Atlantic, Northeast, and California Megaregions follow Midwest with approximately 2,000 establishments each. Arizona and DC-Virginia have the fewest truckload establishments. Figure 20 below shows the number of establishments of NAICS activity code 484121 in each megaregion.

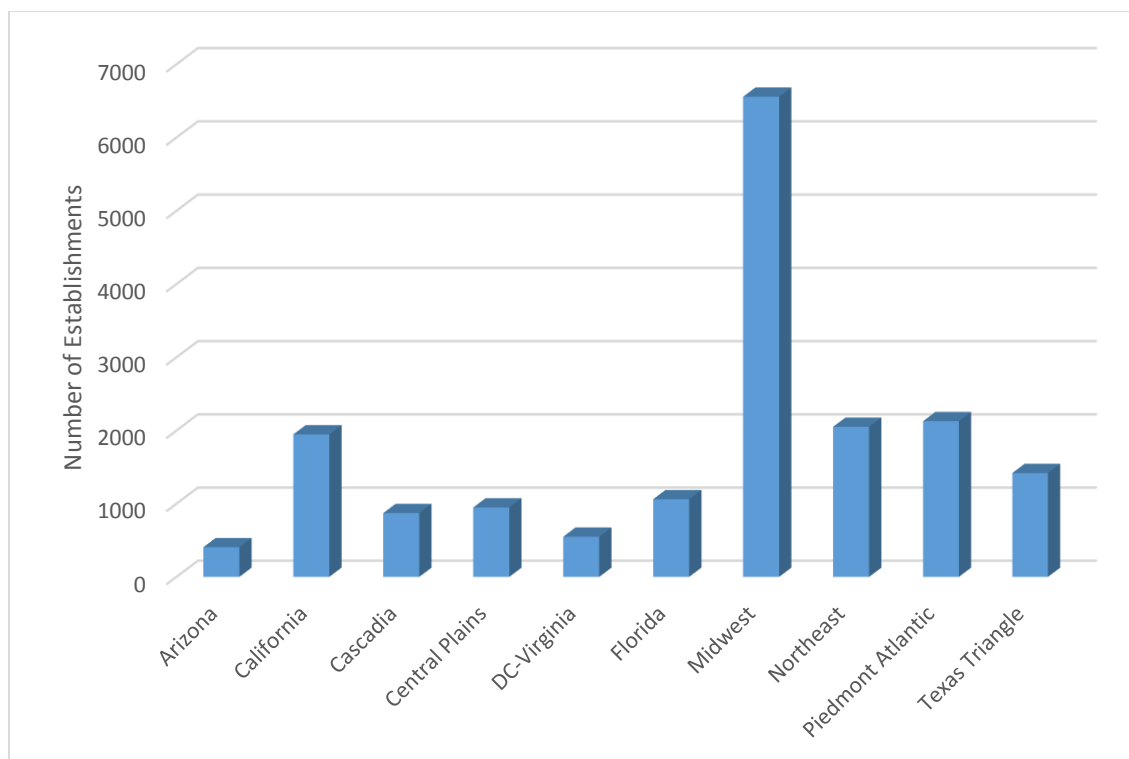


Figure 20: NAICS 484121 General Freight Trucking, Long-Distance, Truckload - Total Establishments in Megaregion

Like truck transportation, NAICS 484121 is spread in many parts of the country. However, it clusters especially around large metropolitan areas and connecting corridors. The Midwest Megaregion still shows major concentrations of truckload establishments in a nearly continuous line, with major concentrations around Chicago, Detroit, Indianapolis, and Cleveland. The Northeast and Piedmont Atlantic show similar configurations. California trucking concentrates around the Bay Area and Los Angeles. Trucking is also dispersed in rural Midwestern and Southeastern areas. Denver and Salt Lake City are non-megaregion hubs. Figure 21 below shows truckload establishments' spatial distribution.

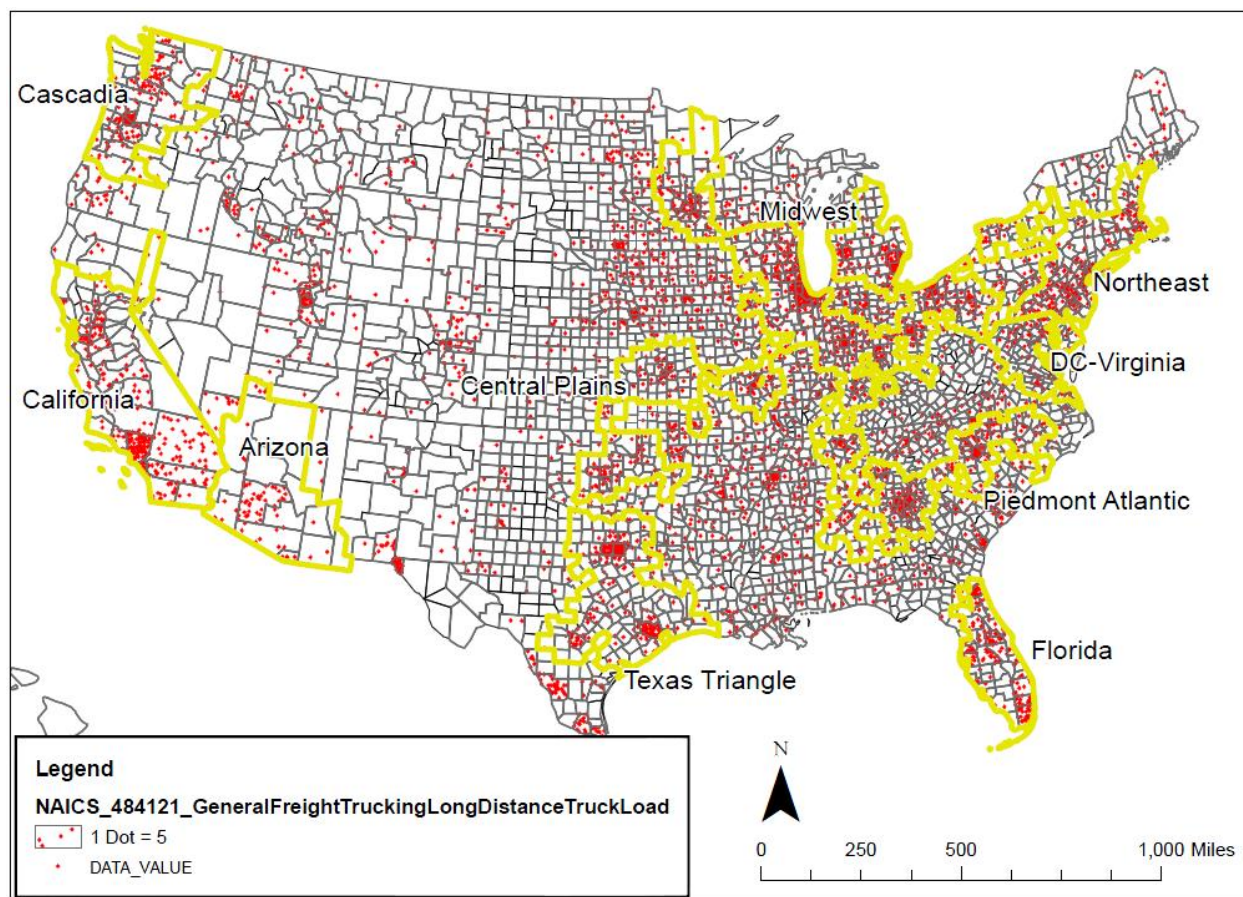


Figure 21: NAICS 484121 Locations

Truckload freight establishments concentrate in megaregions and particularly in the Midwest megaregion. However, they are still prominent in fewer numbers of other metro areas as well as in less dense rural concentrations.

NAICS 484122 - General Freight Trucking, Long-Distance, Less Than Truckload

NAICS 484122 describes establishments that operate long-distance truck-base less than truckload (LTL) shipping. Less-than-truckload combines multiple small shipments into a single truck for movement on line hauls. LTL often involves local pickup and delivery, with sorting, consolidation and de-consolidation in intermediate warehouses (U.S. Census Bureau 2014e). LTL shipping is concentrated in megaregions at 67% of establishments (Figure 22).

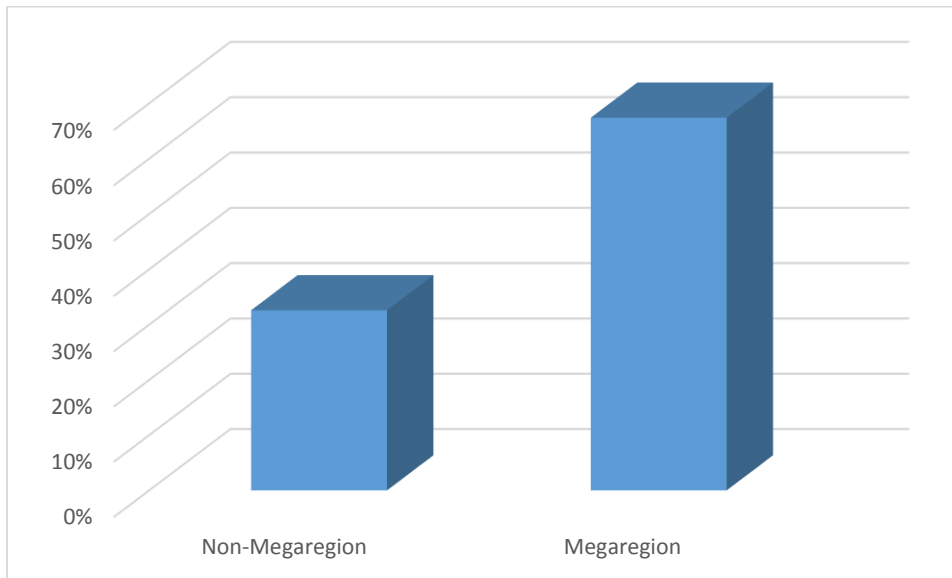


Figure 22: NAICS 484122 General Freight Trucking, Long-Distance, Less-than-Truckload - Percent of Total

The Midwest, Northeast, and California Megaregions have the most LTL shipments, though the Midwest has about one third as many LTL shipments as truckload shipments. Arizona and DC-Virginia again have the fewest LTL establishments. Figure 23 below shows the number of LTL establishments by megaregion.

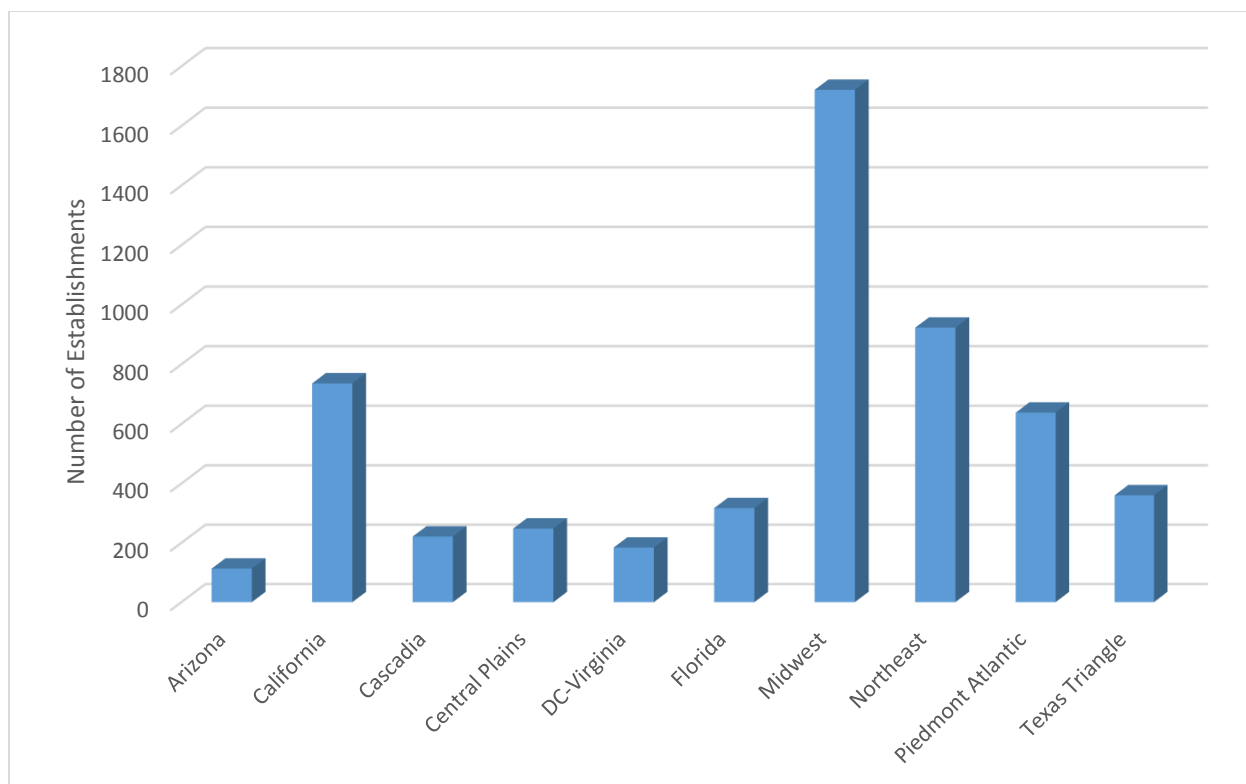


Figure 23: NAICS 484122 General Freight Trucking, Long-Distance, Less-than-Truckload - Total Establishments in Megaregion

Figure 24 shows that LTL establishments are not as widely spread as truckload establishments. Most megaregions have LTL clusters in their large metro areas, while CSA clusters also exist around smaller locales in and out of megaregions.

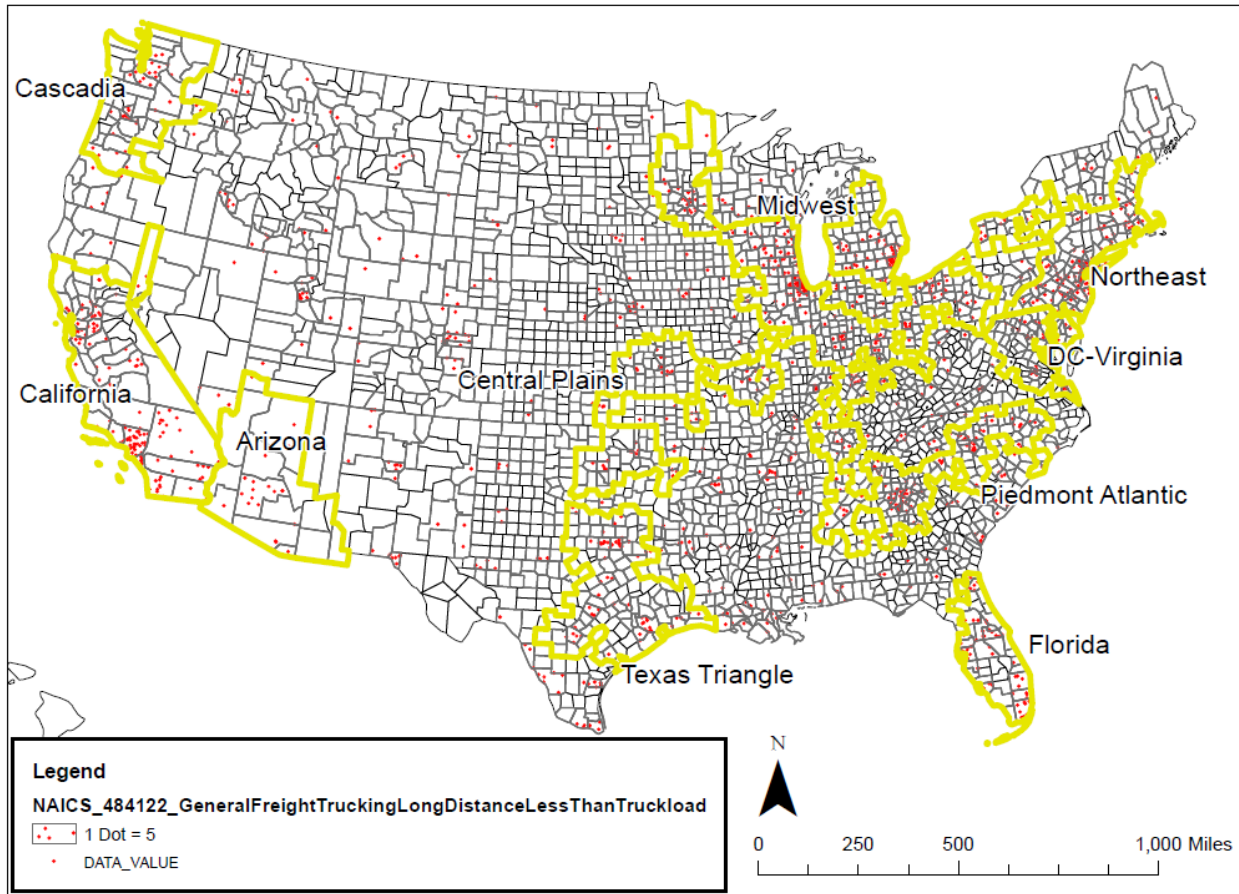


Figure 24: NAICS 484122 Locations

NAICS 484122 (LTL establishments) are less widespread than their truckload counterparts, and they cluster in megaregions in similar numbers. They also show the same disproportionate influence of a few megaregions that contain the majority of megaregion LTL establishments. It would merit further examination to assess how the need to consolidate shipments affects LTL shipment routing through megaregions and non-megaregions.

NAICS 488 - Support Activities for Transportation

NAICS 488 (Support Activities for Transportation) includes a variety of support services that companies may lend to shippers or to the general public. Support activities include air traffic control, port and harbor operations, navigation, towing, freight transport arrangement, and packing (Bureau of Labor Statistics 2014c). NAICS 488 encompasses various activities that allow multiple modes of freight transport to operate. Megaregions play an important role in freight support services, with 77% of such establishments in megaregions (Figure 25).

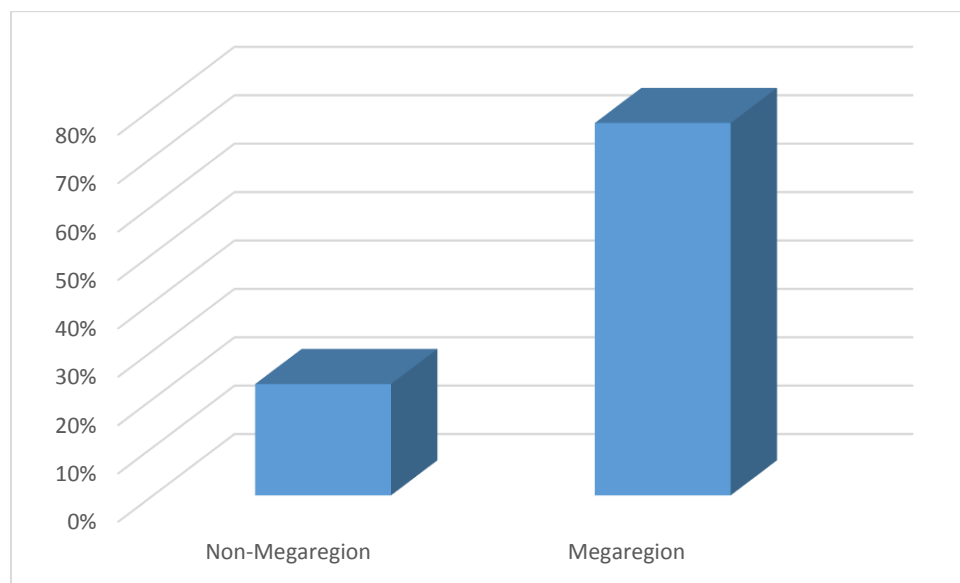


Figure 25: NAICS 488 Support Activities for Transportation - Percent of Total

The Midwest, the Northeast, and California have the most support establishments, while Arizona Megaregion, Central Plains, and DC-Virginia have the fewest. Figure 26 below shows the number of support establishments in each megaregion.

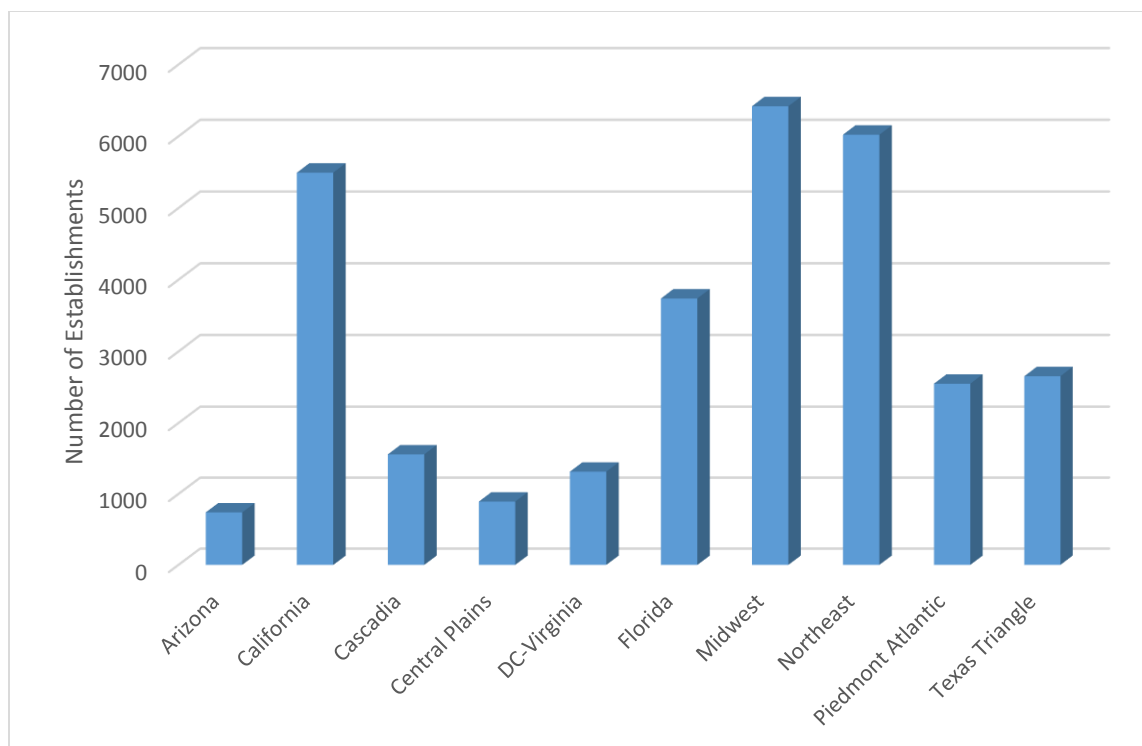


Figure 26: NAICS 488 Support Activities for Transportation - Total Establishments in Megaregion

Figure 27 shows support establishment clusters in the Northeast, Midwest, and California. Florida has a large support establishment cluster. There are also clusters around major metropolitan areas in Cascadia, the Central Plains, Arizona, Texas Triangle, and Piedmont Atlantic.

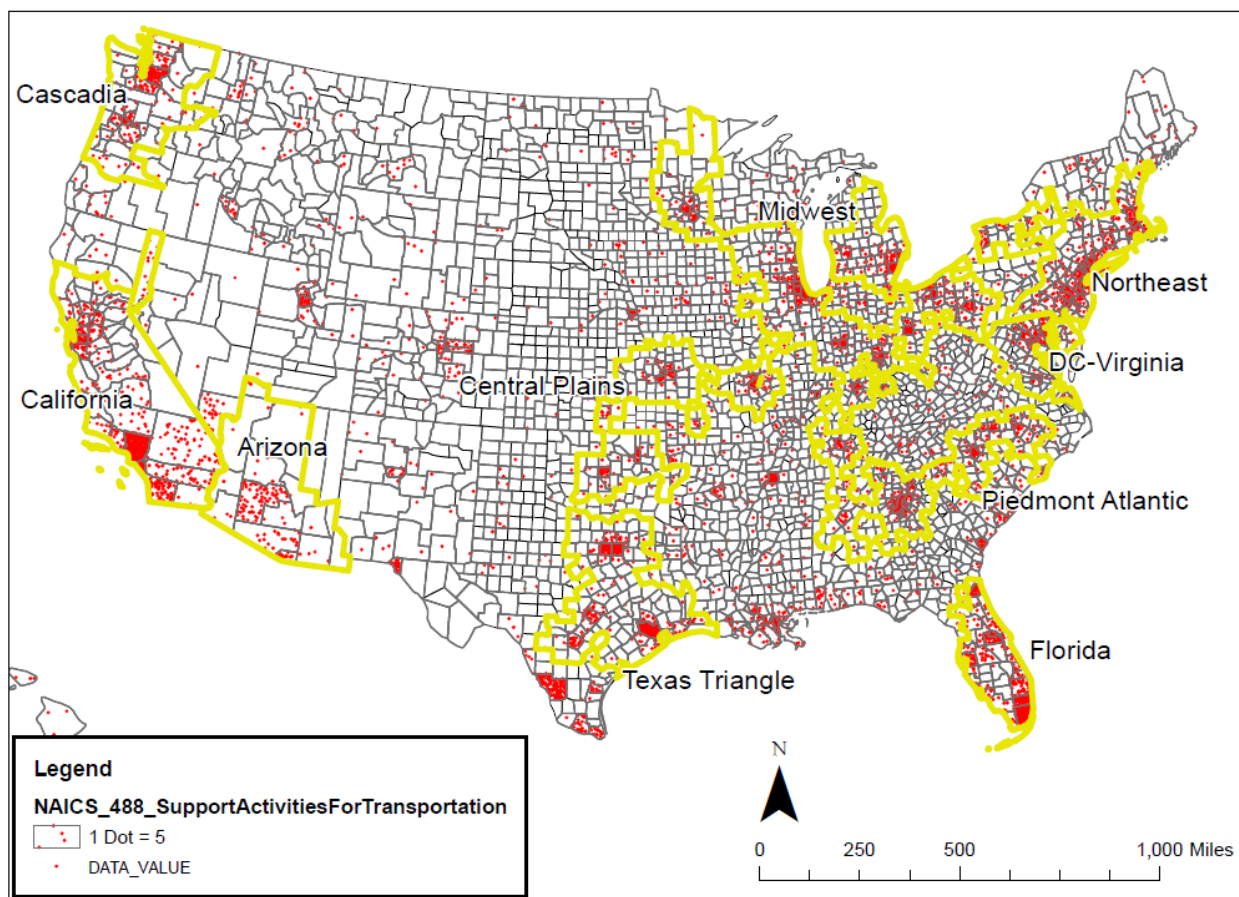


Figure 27: NAICS 488 Locations

Support activities for transportation exist in all megaregions, though they are strongest where other freight establishments are most concentrated. This makes sense because support establishments depend on other freight activity for their business.

NAICS 488510 - Freight Transportation Arrangement

NAICS 488510 (Freight Transportation Arrangement) includes freight forwarders and customs agents who act as their party agents to arrange freight movement for clients (U.S. Census Bureau 2014f). They are a sub-category of freight support activities. Like freight support activities, they are 80% concentrated in megaregions (Figure 28).

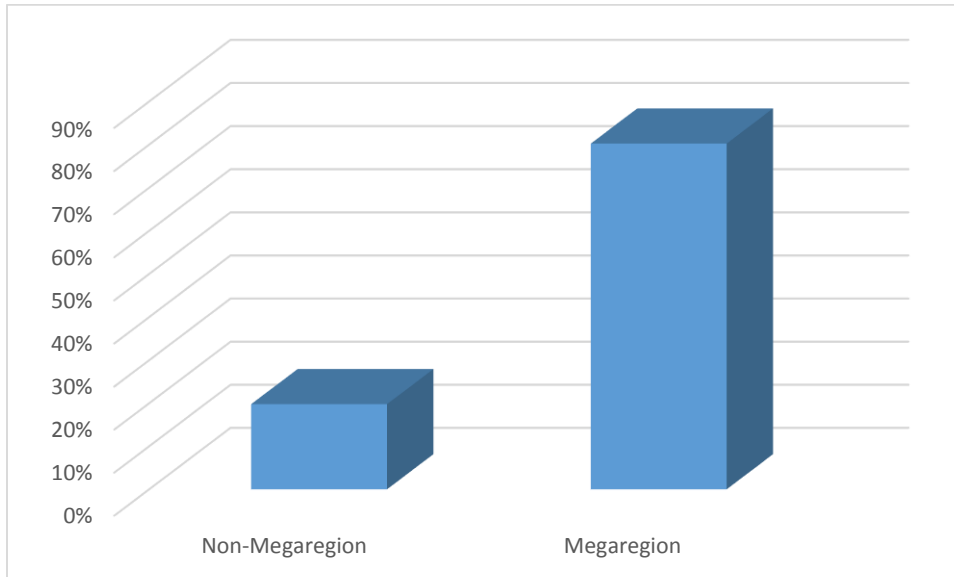


Figure 28: NAICS 488510 Freight Transportation Arrangement - Percent of Total

Freight transportation arrangement mirrors freight support activities spatial arrangement. The Northeast, Midwest, and California have the greatest concentrations, while Arizona, Central Plains, and DC-Virginia have the lowest. Figure 29 shows the number of freight establishments in each megaregion.

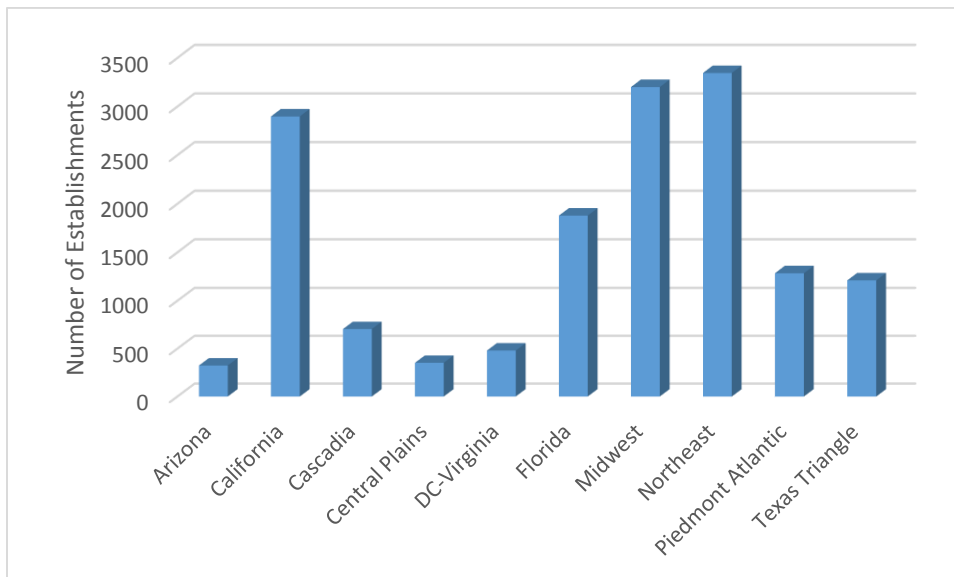


Figure 29: NAICS 488510 Freight Transportation Arrangement - Total Establishments in Megaregion

Figure 30 below shows freight transportation arrangement clusters primarily around metropolitan areas. Establishments' location may depend on clients' and shippers' location rather than infrastructure since freight transportation arrangement establishments do not usually operate freight equipment themselves. Proximity to clients may be more important than proximity to carriers.

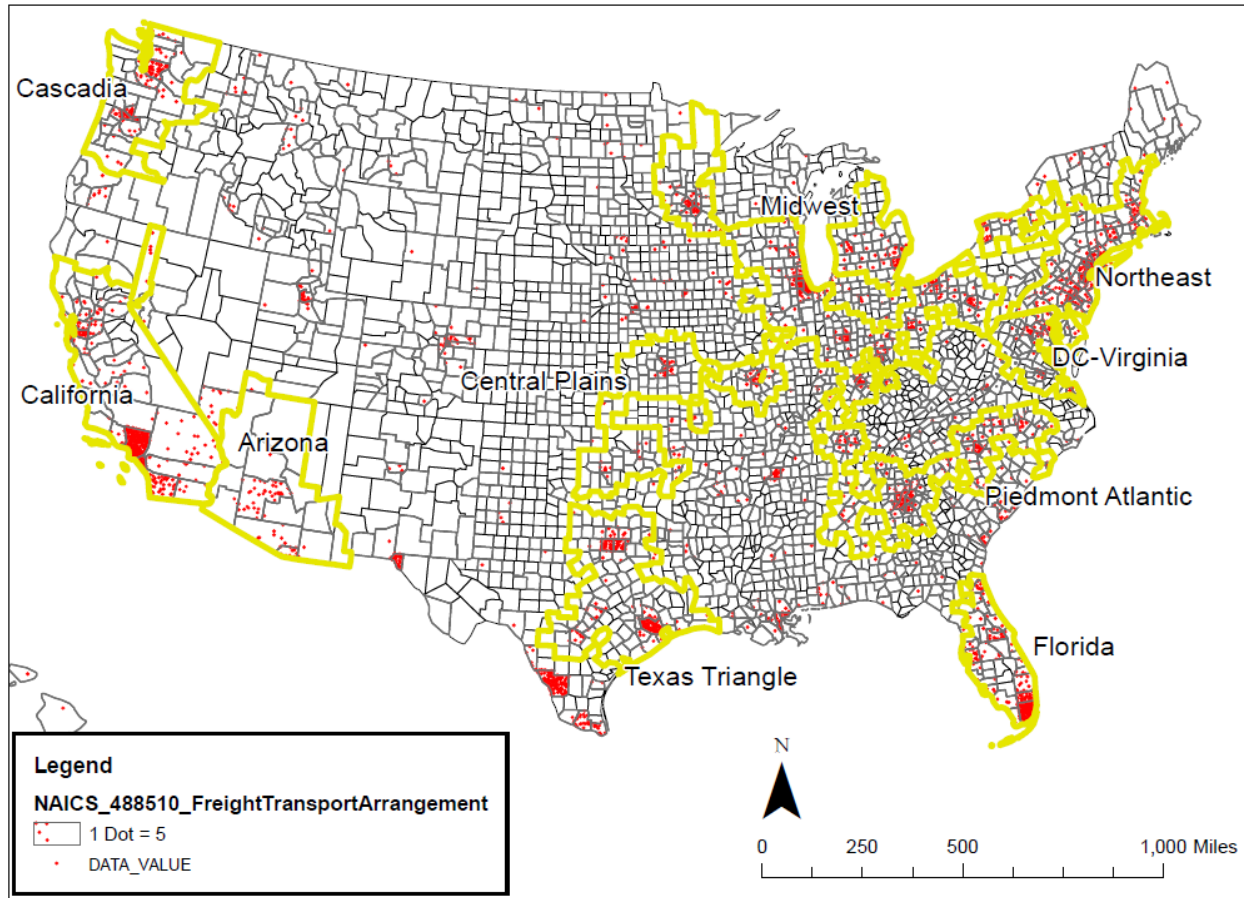


Figure 30: NAICS 488510 Locations

NAICS 488510 mirrors support activities (NAICS 488) on a smaller scale. Distribution within and among megaregions is similar. Establishments appear to locate near clients and freight providers since freight transportation arrangement is an auxiliary demand to other freight services.

NAICS 493 - Warehousing and Storage

NAICS 493 (warehousing and storage) refers to a variety of storage of processing services that happen within the supply chain between shipment modes (Bureau of Labor Statistics 2014d). Such services include storage, labeling, packaging, picking products for shipment, and transportation arrangement among others. Warehousing employs approximately 7,000 people (Bureau of Labor Statistics 2014d). Seventy-six percent of warehouse establishments are in megaregions (Figure 31).

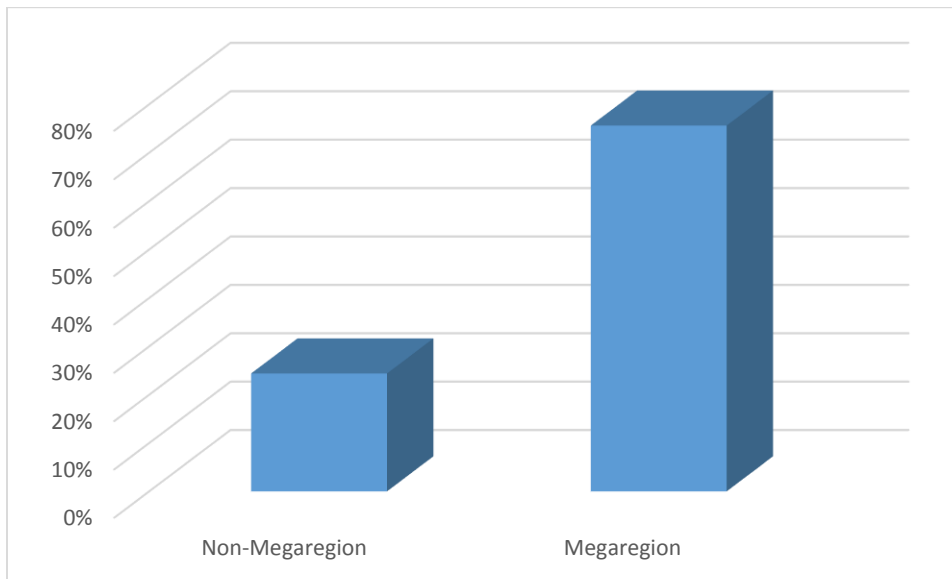


Figure 31: NAICS 493 Warehousing and Storage - Percent of Total

The Midwest, the Northeast, California, and Piedmont Atlantic have the most warehouses, while Arizona, Central Plains, Cascadia, and DC-Virginia have the fewest warehouses. The distribution among megaregions roughly mirrors the distribution of truck transportation establishments. Figure 32 below shows the distribution of warehouses among megaregions.

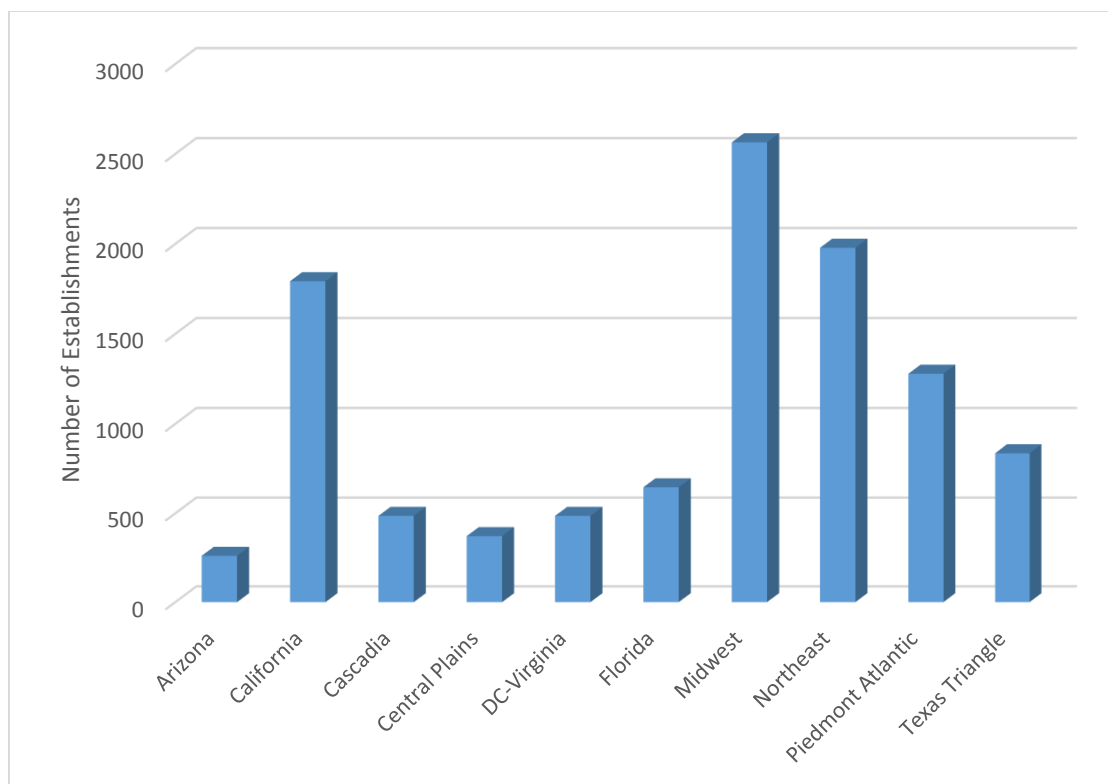


Figure 32: NAICS 493 Warehousing and Storage - Number of Establishments in Megaregions

Figure 33 below shows that warehouses are primarily located in megaregion metropolitan areas. There are several linear clusters in the Northeast and Midwest. Several megaregions have multipolar or bipolar arrangements, notably California (bipolar), Cascadia (bipolar), and Texas Triangle (multipolar).

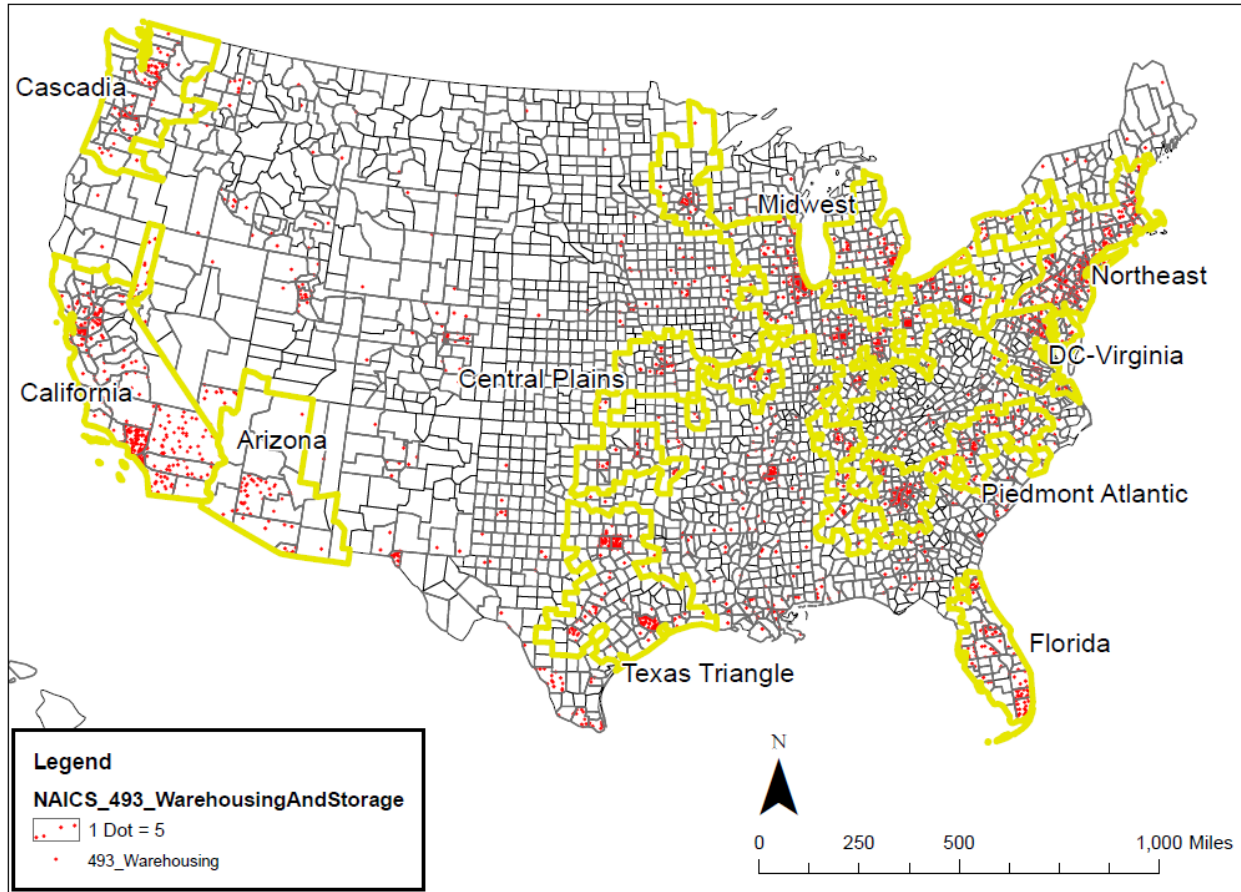


Figure 33: NAICS 493 Locations

NAICS 493 warehousing is an important part of global and national supply chains that provides value-added processing. Warehouses cluster around megaregion metropolitan areas, which may provide the greatest access to transportation services as well as proximity to consumers or producers, especially for retail distribution. The Midwest Megaregion has the most warehouses.

Megaregion Profiles

The follow section profiles the ten U.S. megaregions from the perspective of overall logistics-related activity. Warehouse locations (NAICS 493) are analyzed as an example of the visual spatial analysis possible with NAICS data. The goal is to compare each megaregion's logistics size and spatial configurations in a way that can be replicated for other specific logistics activities.

Arizona

The Arizona Megaregion is quickly growing (Center for Quality Growth and Regional Development 2014), but it is not currently among the largest megaregions from a freight activity perspective in any of the categories examined. Arizona represents below 2.5% of the contiguous U.S.'s total establishments. Arizona is particularly absent from water-based transport. However, its greatest relative strength is in air transportation, which may benefit from the location of the Phoenix Sky Harbor International Airport.

While this section does not exam each individual NAICS code, NAICS 493 (warehouses) does provide a snapshot of the spatial location of supply chain activities within the megaregion. The Arizona Megaregion's warehouses (NAICS 493) are concentrated in the south, around the cities of Phoenix and Tucson. The north appears to have less logistics activity than the south, particularly the Phoenix-Tucson corridor. Figure 34 below shows the megaregion's warehouse establishments.

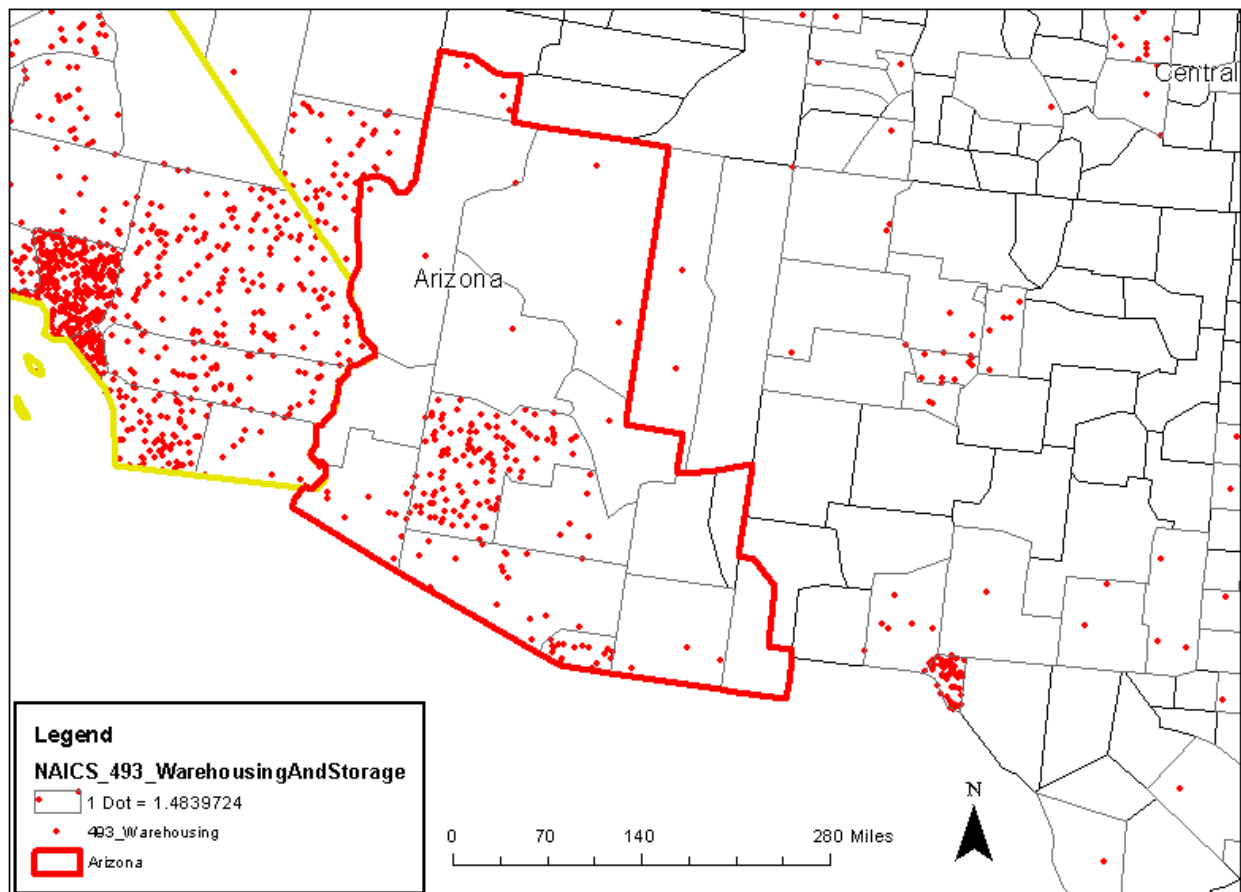


Figure 34: NAICS 493 in Arizona Megaregion

California

The California megaregion's logistics activity reflects its important economic place. California has the third most establishments for seven of the 10 categories examined, with the only exceptions being coastal and inland shipping, and truckload truck transportation. California's greatest strengths are in freight transportation arrangement (14.8% of nation's establishments), freight support activities (13.5%), deep sea freight (13.3%), and warehousing (12.7%).

All of California's activity concentrates around its twin economic hubs of Los Angeles and the San Francisco Bay area. There are still important logistics activities occurring in between, near San Diego, and near Reno Nevada, though not of the same scale as the two hubs. Figure 35 below shows the megaregion's logistics establishments.

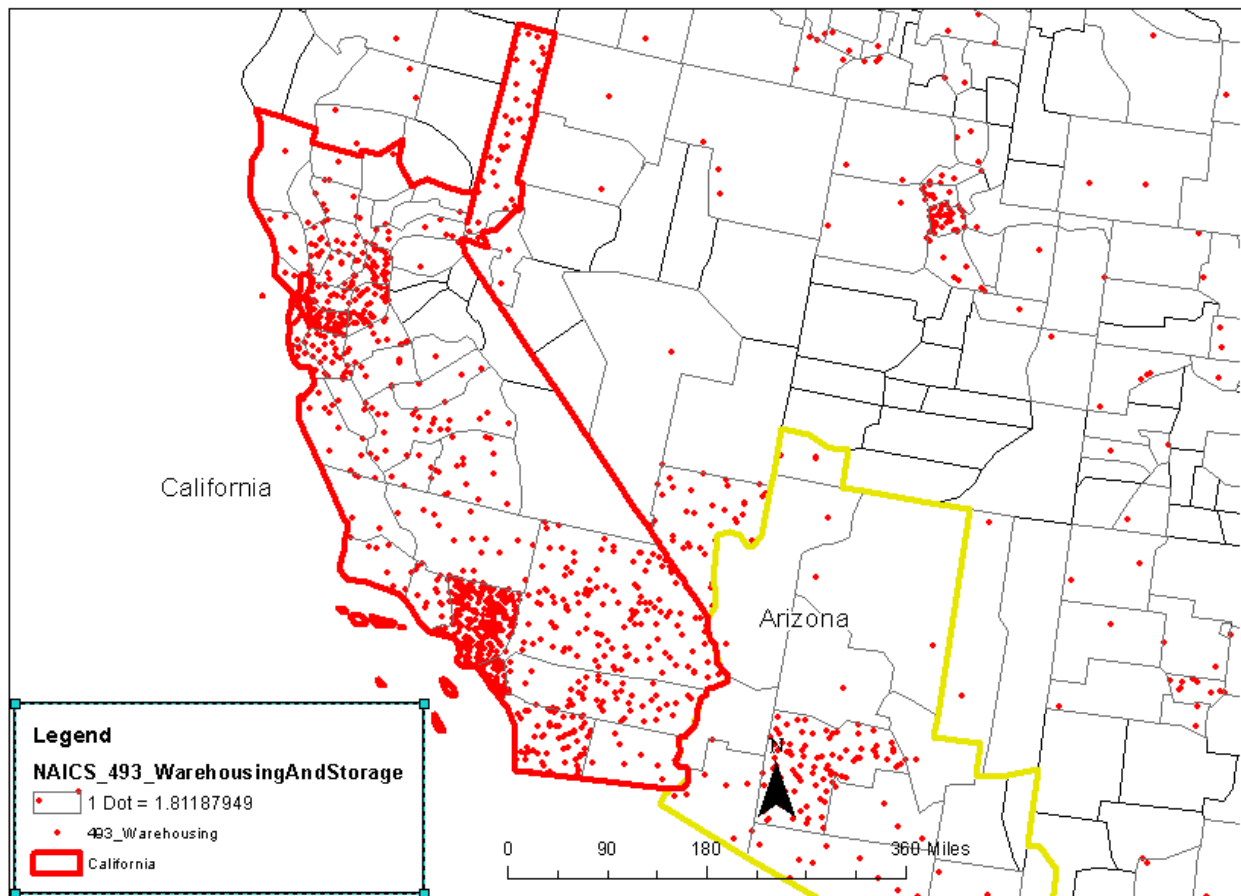


Figure 35: NAICS 493 in California Megaregion

Cascadia

Cascadia is built around the twin economic hubs of Seattle and Portland, though important activity occurs elsewhere in the megaregion. It is not the largest megaregion economy, and its logistics role reflects its economic size. Cascadia's greatest relative strength is inland water freight transportation, of which it has the third largest amount of establishments of any megaregion. All water based freight modes have above 4% of the nation's establishments, whereas all other categories examined are below 4% of the nation's establishments. Truck-related establishments have the lowest percentage among the NAICS categories examined, with all categories at or below 3% of nationwide establishments.

Figure 36 below shows Cascadia's warehouse (493) establishments. The Seattle metro area has the largest warehouse concentration, though the Portland area and cities further south including Salem and Eugene also have important warehouse concentrations.

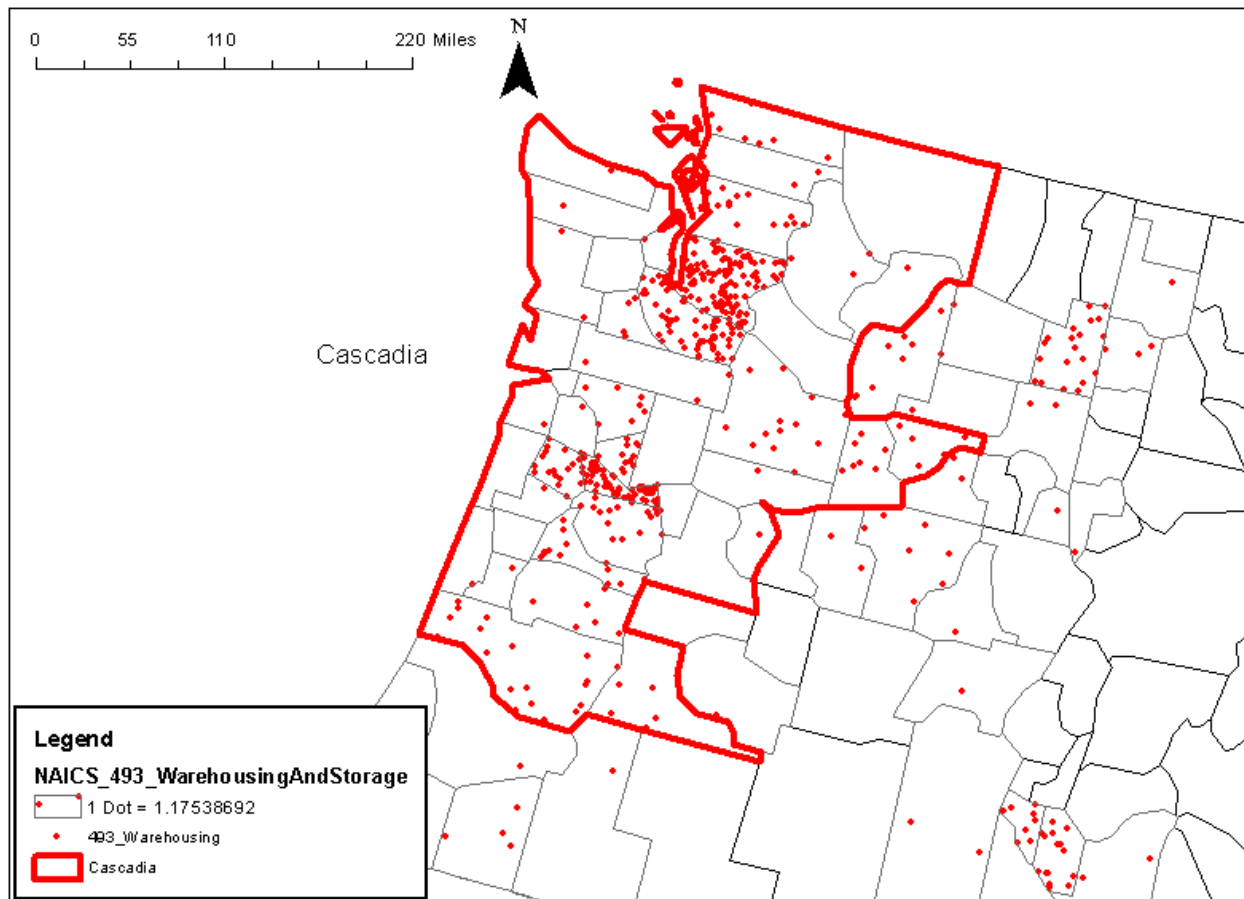


Figure 36: NAICS 493 in Cascadia Megaregion

Central Plains

The Central Plains Megaregion is one of the smallest megaregions from a logistics perspective. The Central Plains is not among the top three megaregions in any NAICS category examined, and it is particularly absent from water-based transportation establishments. Its greatest concentration is in long-distance truckload transportation (3.2% of nation's establishments).

The economic strength of Oklahoma City, Tulsa, Wichita, and Kansas City is obvious when examining warehouse locations in the Central Plains. Warehouses imitate other logistics establishments by clustering around these four economic centers. Figure 37 below shows warehouse locations in the Central Plains.

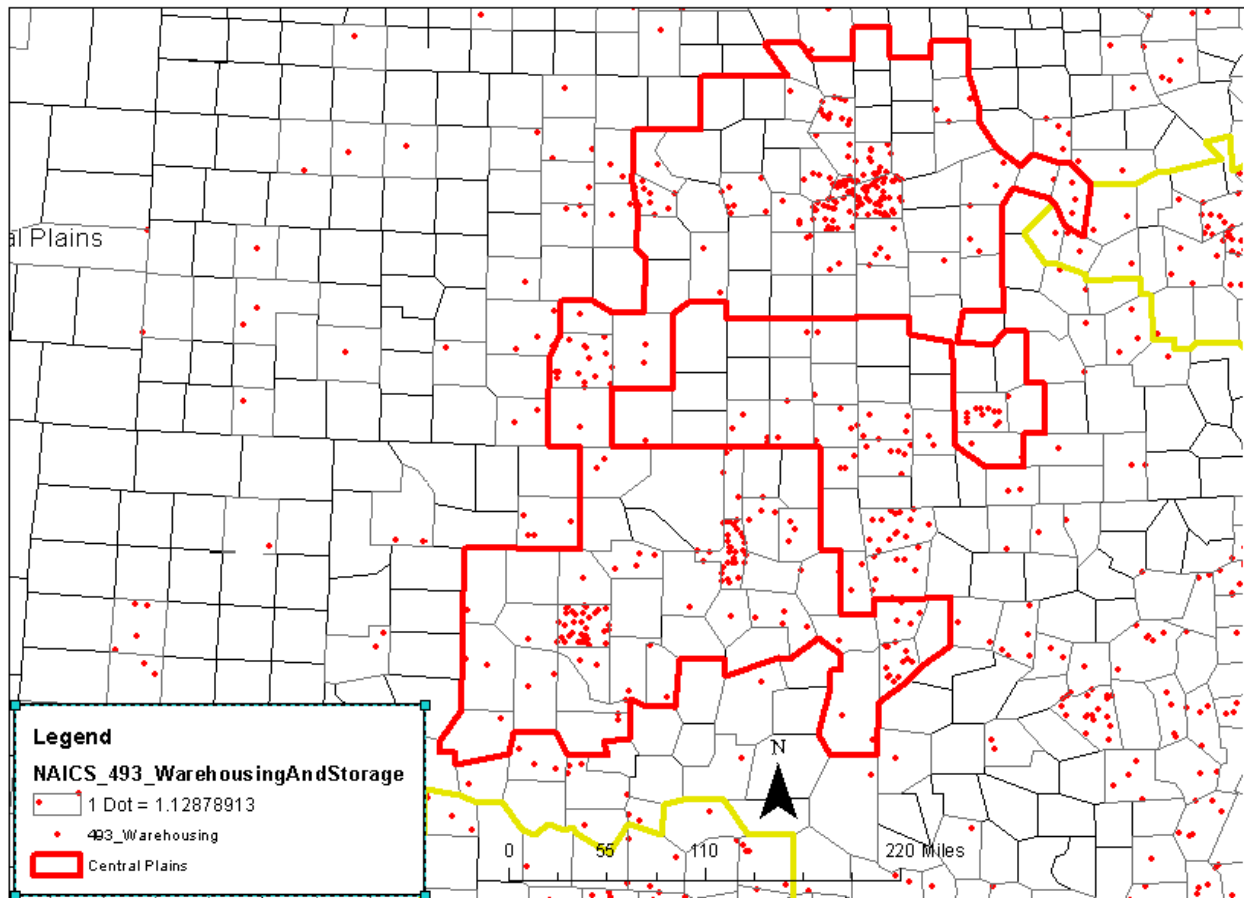


Figure 37: NAICS 493 in Central Plains Megaregion

DC-Virginia

DC-Virginia is a small to medium-sized megaregion from a logistics perspective. It is not among the top three in any NAICS category examined, but it is consistently near the lower end of the middle grouping. DC-Virginia's greatest concentration is on deep-sea related establishments, ostensibly because of its excellent deep sea port facilities in Hampton Roads and Baltimore.

There are several warehouse clusters in DC-Virginia. The largest is in the greater DC-Baltimore area, with secondary concentrations in Hampton Roads, greater Richmond, eastern Maryland, and the Hagerstown area. Figure 38 below shows warehouse concentrations.

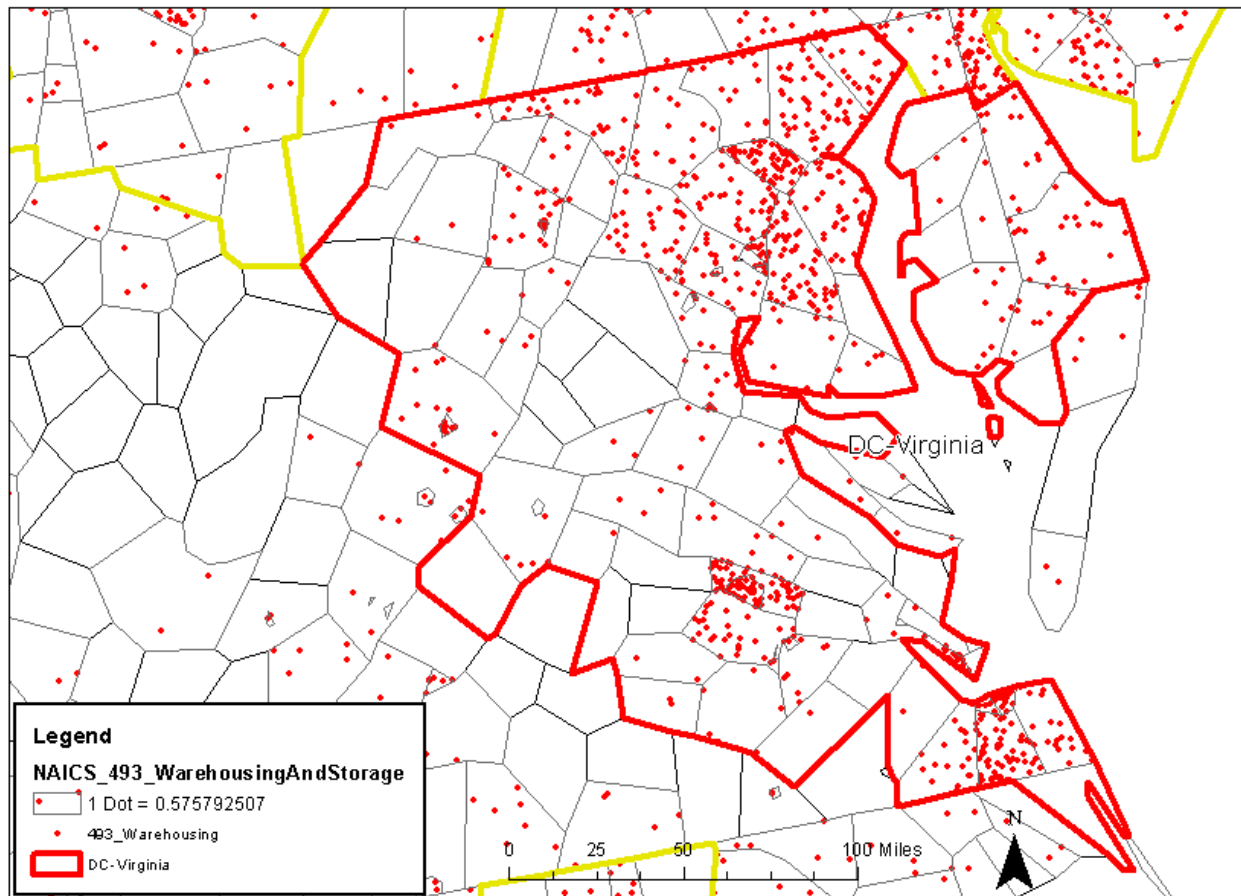


Figure 38: NAICS 493 in DC-Virginia Megaregion

Florida

The Florida Megaregion is especially important in three logistics activity types. The first is water-borne freight. The Florida Megaregion contains 17.0% of deep sea freight establishments and 8.6% of intercostal waterway freight transportation establishments. The second is air travel, for which it has 9.2% of the nation's establishments. Finally, 9.6% of transportation support establishments and 9.2% of those in freight transportation arrangement call the Florida Megaregion home.

The largest warehouse cluster is around Miami-Fort Lauderdale, and secondary clusters are around Orlando, Tampa, and Jacksonville. However, the Florida megaregion also has logistics activity spread along the Atlantic coast and south of Tampa on the Gulf coast. Figure 39 below shows Florida warehouses.

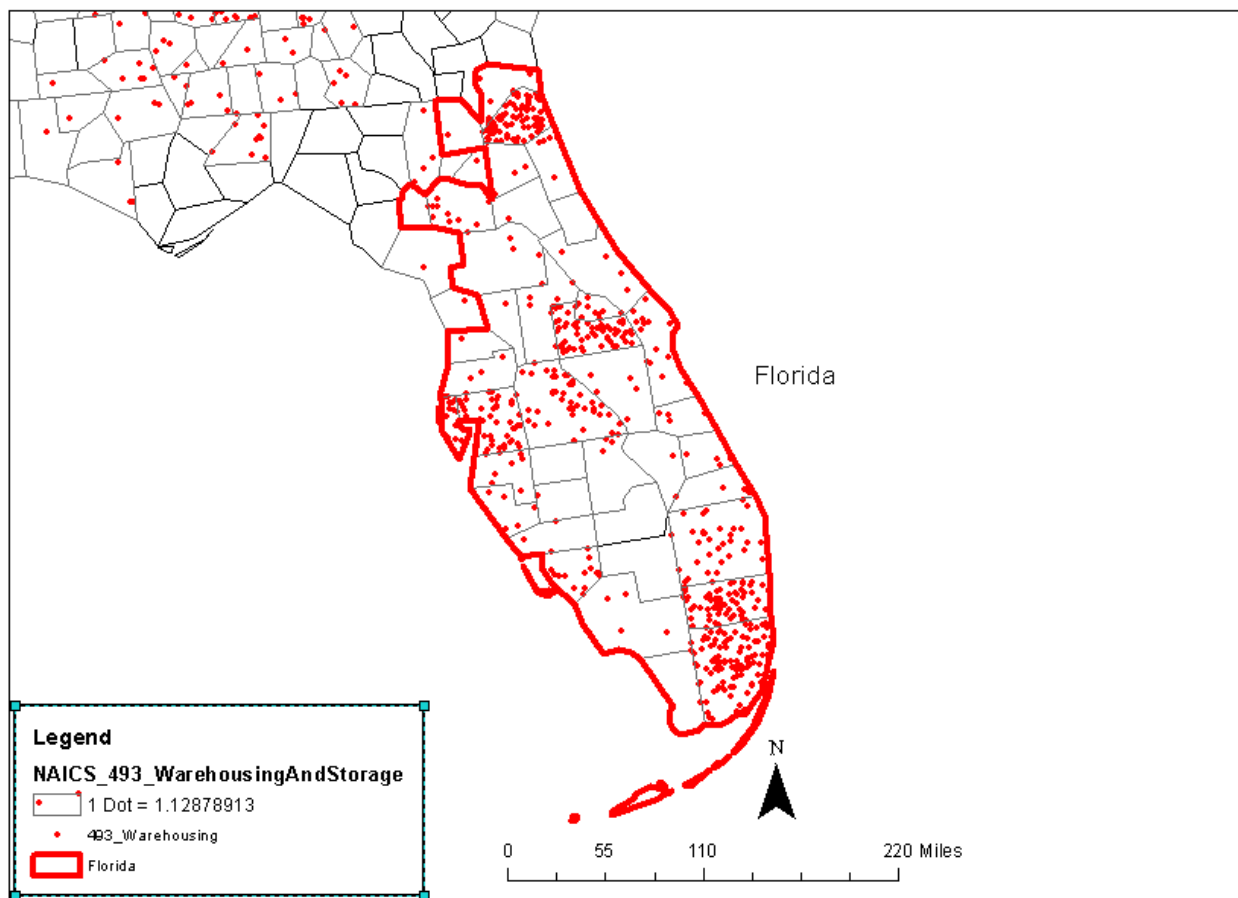


Figure 39: NAICS 493 in Florida Megaregion

Midwest

The Midwest Megaregion is the country's logistics powerhouse, particularly for ground-based activity. It has the most establishments of any megaregion for six of the 10 categories, and the second most for a seventh category. The Midwest's greatest strengths are in warehousing (18.1% of nation's establishments), truck transportation (20.2%) and related activities, transportation support (15.7%), freight transportation arrangement (16.4%), inland water freight (14.8%), and air transportation (12.5%).

The Midwest megaregion is a complex galaxy-like formation with many nodes connected by sinews into a large web. Its warehouse distribution, pictured in Figure 40, demonstrates the complex multipolar formation. Hubs include Chicago, Minneapolis, Detroit, Indianapolis, Cleveland, Columbus, Cincinnati, Louisville, and St. Louis. The megaregion's size comes from the ways in which these activity nodes interact and are summed into a larger area.

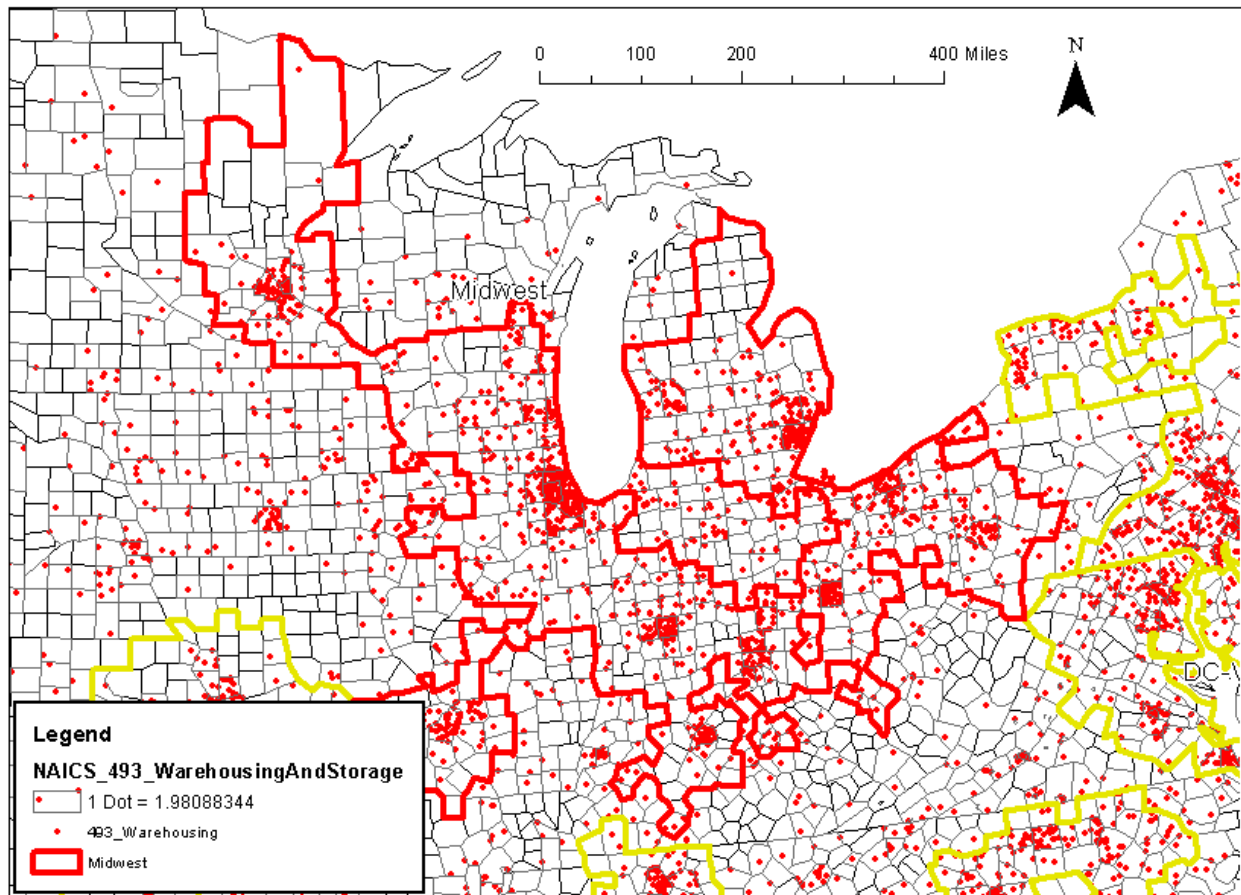


Figure 40: NAICS 493 in Midwest Megaregion

Northeast

The Northeast Megaregion is also a huge logistics powerhouse. The Northeast is either the first, second or third largest megaregion in every logistics category. The Northeast dominates in deep sea freight (23.1% of nation's establishments), coastal and Great Lakes freight transportation (19.2%), and freight transportation arrangement (17.1%). Only one category is below 10% (truckload freight transportation).

The megaregion's section between Boston and Wilmington more perfectly resembles a continuous corridor than any other megaregion, with also significant warehouse agglomerations in eastern Pennsylvania. The megaregion's section in upstate New York is sparser in warehouses than the coastal portion, but it still contains important concentrations among Rochester, Syracuse, and Buffalo. Figure 41 below shows the megaregion's warehouse concentrations.

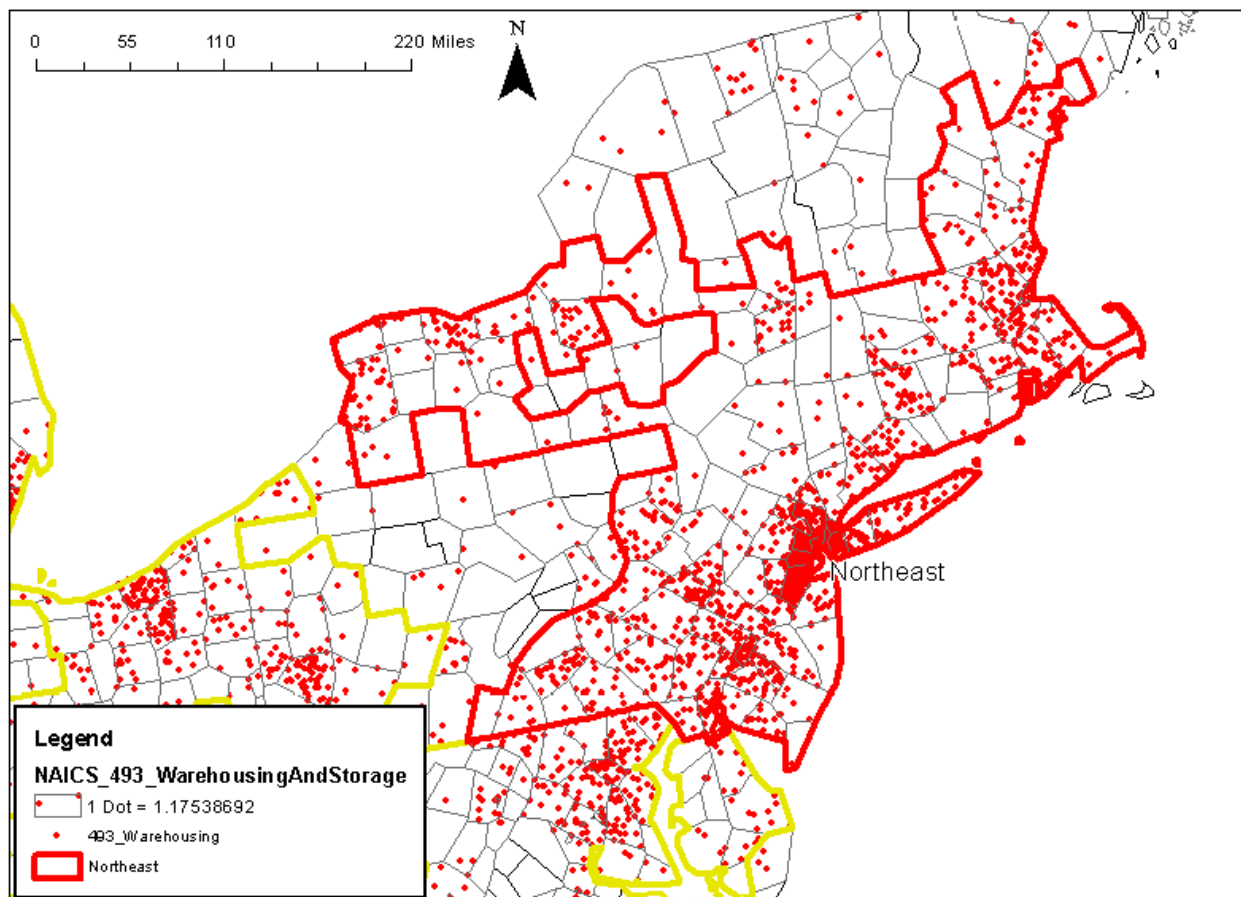


Figure 41: NAICS 493 in Northeast Megaregion

Piedmont Atlantic

The Piedmont Atlantic Megaregion is a medium-sized logistics center in most activity categories. Its greater logistics clusters are warehousing (9.0% of nation's establishments), truckload (7.3%) and less-than-truckload freight transport (7.9%). It is least present in inland and coastal shipping, which is unsurprising since Piedmont Atlantic has few navigable rivers and little coastline.

The Piedmont Atlantic Megaregion is a galaxy-type formation with warehouse concentrations around the Atlanta metro area. Secondary concentrations cluster around Nashville and surroundings, Chattanooga, Birmingham, and Huntsville. The megaregion also evidences a corridor-type formation from Birmingham through Atlanta, Greenville, Spartanburg, Charlotte, Greensboro, Durham, and Raleigh into a more dispersed warehouse arrangement in eastern North Carolina (Figure 42).

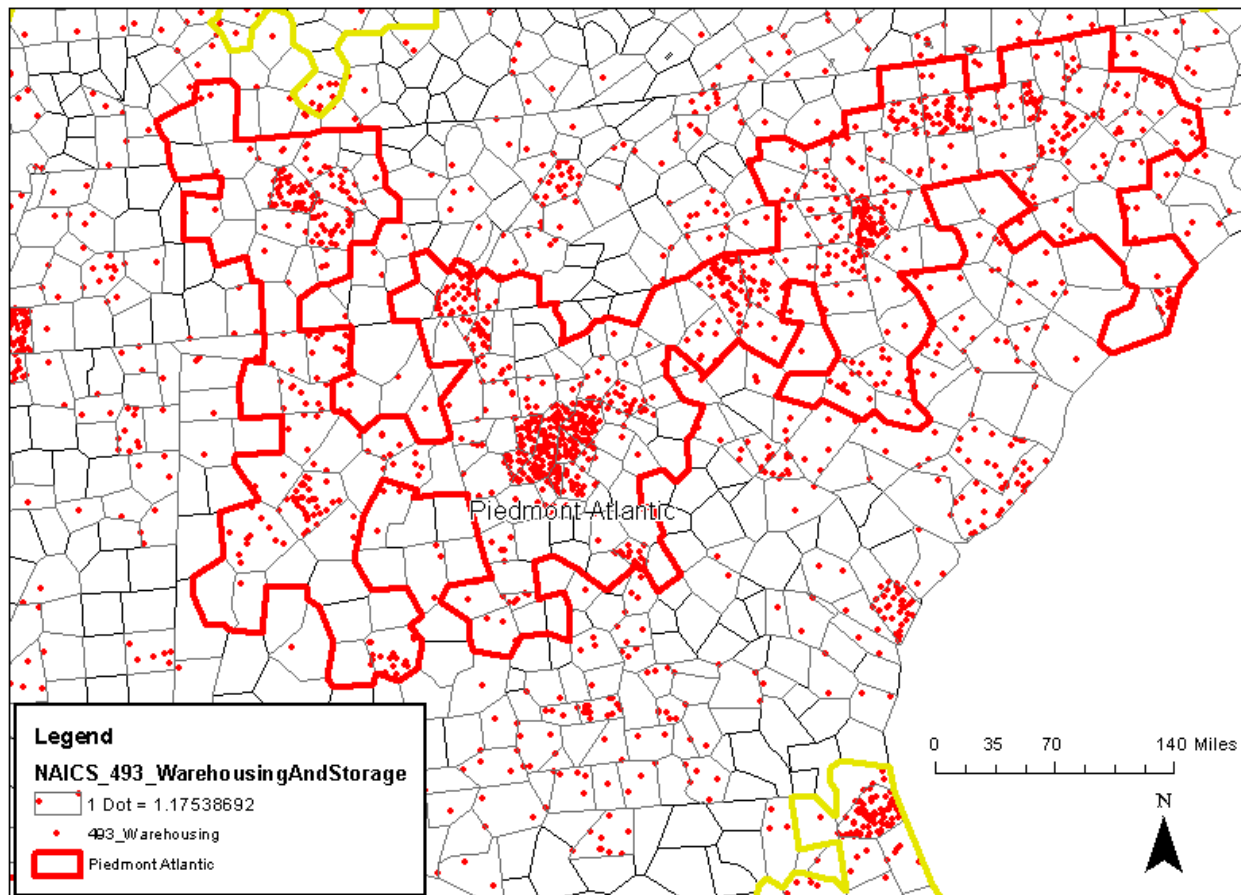


Figure 42: NAICS 493 in Piedmont Atlantic Megaregion

Texas Triangle

The Texas Triangle is a medium-size megaregion similarly to the Piedmont Atlantic Megaregion. It has more than 4% and fewer than 10% of establishments in all areas examined. Its greatest concentrations are in deep sea freight, coastal and Great Lakes freight, and air transportation.

Warehouse distribution in the Texas Triangle is a multipolar arrangement anchored by strong concentrations in the Dallas-Fort Worth, Houston, Austin, and San Antonio areas, with evidence of a warehouse corridor along I-35 between San Antonio and Dallas. Figure 43 below shows the megaregion's warehouse distribution.

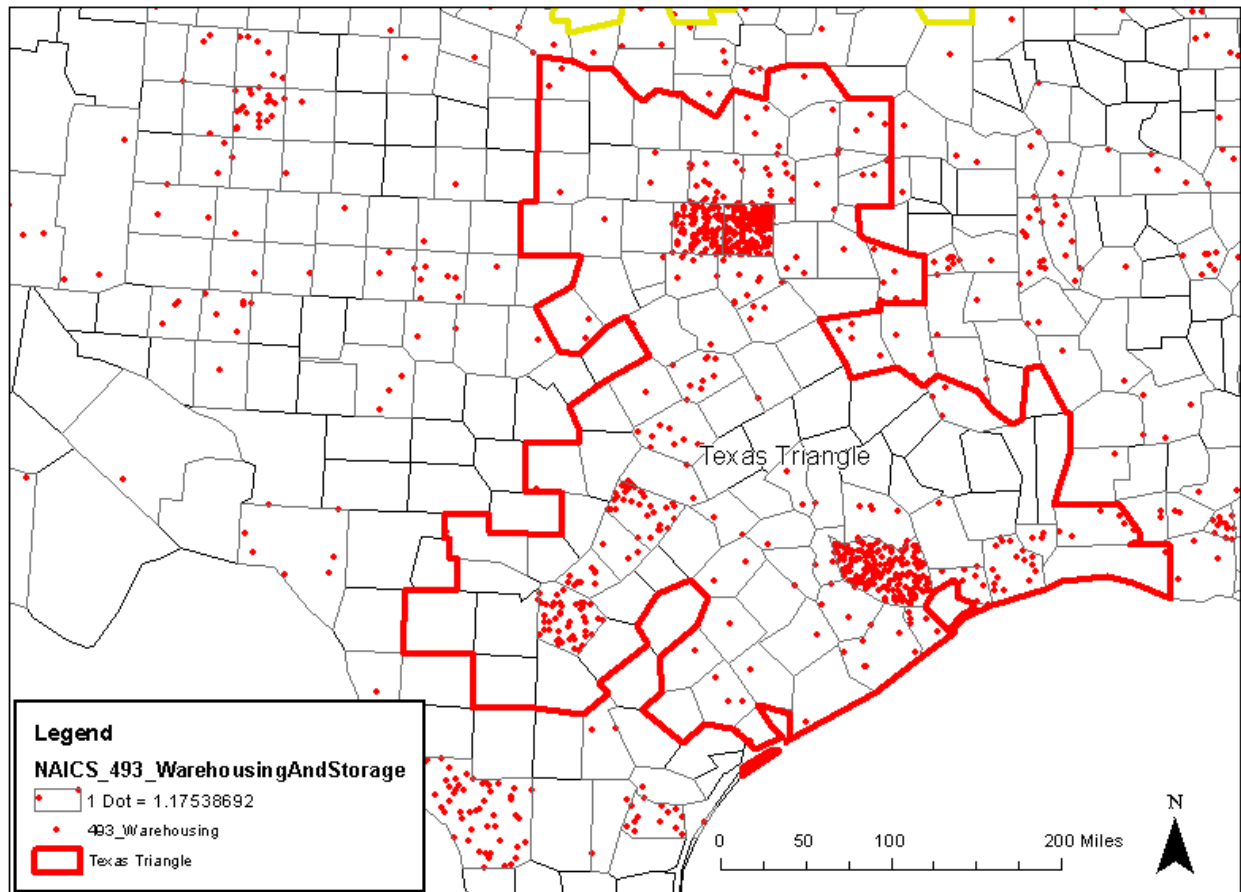


Figure 43: NAICS 493 in Texas Triangle Megaregion

Conclusions

The aggregate analysis of logistics analysis leads to several conclusions about the nature and composition of the logistics activity that supports American supply chains.

Megaregions must be examined comparatively. While each megaregion has been identified because of economic, transportation, and other relationships, not all megaregions are arranged in the same ways or have logistics activities of equivalent sizes. Many of the logistics activities in the Midwest, the Northeast, and California are nearly an order of magnitude larger than the logistics activities in the Arizona Megaregion or the Central Plains. The comparison provides a scale for understanding them and—when joined with aggregate movement data in the Freight Analysis Framework—it may provide a means for assessing regional and national infrastructure needs to support economic growth.

Megaregions show different spatial arrangements of logistics activities. While some megaregions are multipolar, others have just two primary centers. The Midwest Megaregion has a galaxy-type formation, while Cascadia shows characteristics of a bipolar corridor. Finally, logistics activity can be differently concentrated or dispersed. Most logistics activity in the California Megaregion is densely concentrated around Los Angeles or San Francisco areas, while the Midwest and Florida often have continued occurrences of logistics activities along a wide geographical area.

Several megaregions account for a disproportionate amount of logistics activity. The Northeast, the Midwest, and California account for a majority of logistics-related activity in megaregions, while the smaller megaregions account for a much smaller fraction. While all megaregions merit certain attention, the largest megaregions may require attention in different national or global settings that aligns with their outsized role in global shipping and distribution. Nevertheless, it is still important to account for future growth that will increase the absolute logistics activity and its proportion, which is pronounced in megaregions such as Arizona that are expected to experience long-term continued growth.

Infrastructure's logistics-shaping capacity should not be underestimated. In a sense, infrastructure is destiny. Whether it is the presence of roads, railways, airports, or waterways, logistics activity cannot occur without the appropriate infrastructure. The finding appears commonsensical, but it is important to remember because transportation planning recommendations may otherwise gloss over the infrastructure requirements. Trucking's size is partially due to the ubiquity with which roads exist, while shipping of all types is much more geographically limited by natural water features or the locations of expensive canals. Given the infrastructure requirements, it is likely that there will be long-term limitations in the extent to which rail is able to supplant road-based traffic, while eventual aerial mode developments will remain heavily dependent on technological development.

Section III: Case Studies

The previous section presented logistics activities' alignment with the megaregion framework with nationwide aggregate data. Some of the NAICS categories corresponded with ground freight (i.e., NAICS 484, 484121, 484122), air freight (i.e., NAICS 481), or sea freight (i.e., NAICS 483111, 483112, 483211). The research examined warehouse locations (NAICS 493), which generate transportation flows and add value to the supply chain. Other NAICS categories explored locations for services that facilitate freight movement and likely locate near customers or carriers (e.g., 488, 488510). They contribute to a national evaluation of supply chains, which shows that some megaregions carry outsized importance.

Aggregate freight analysis provides valuable insights. However, it does not describe supply chain configurations at the firm level. Understanding firms' physical supply chain configurations may provide lessons for national transportation policymakers who are seeking to build a megaregions policy that enables companies to build and maintain efficient and effective supply chains that are also adaptable to business and technological changes. The primary aim is to ensure that eventual megaregion planning policies support shippers' and distributors' needs as well as possible. Examining firm-level supply chain configurations may also help companies plan supply chains that better incorporate megaregion's relative advantages in terms of mobility, workforce, or cost. Thus, firm-level analysis offers advantages that past research has not yet explored to policy makers, transportation planners, and supply chain managers.

Methodology

This section studies firm-level logistics activity locations through a case study approach. Generalizability depends on the cases selected. The ideal cases would provide two contrasting examples that together provide a more complete picture of two of the dominant logistics ‘types.’ Trendsetting organizations will be most relevant to policy formation and transportation planning because other organizations are most likely to imitate their arrangements, increasing the analyses’ generalizability.

The researcher selected two logistics types based on changing retail trends. The majority of retail sales continue to occur in a brick-and-mortar store setting. Brick-and-mortar sales and the supply chains that support them are the dominant retail paradigm. No company has epitomized leadership in brick-and-mortar retail logistics more than Walmart. Walmart is the world’s largest retailer with over \$328 billion in sales in 2012 (Shultz 2013). Savvy supply chain management has enabled Walmart’s success (Appelbaum and Lichtenstein 2006). Walmart is the traditional retail case.

E-commerce, characterized by sales on internet-based platforms, is growing much faster than traditional retail in the United States. While it is not clear to what extent e-commerce may ultimately displace traditional retail, there is a large marketplace for goods purchased online and delivered to homes or businesses. E-commerce likely requires different supply chain configurations than traditional retail, and understanding those differences can help policymakers better grasp future supply chain transportation needs and configurations.

Amazon.com has emerged as the largest and one of the fastest growing e-commerce portals (Shultz 2013). Its 2012 sales exceeded \$34 billion, which represented a 30% growth rate compared with 2011. Amazon is not just an online store—it operates a complex distribution network in North America, Europe, and Asia with its own distribution centers to send products to buyers. As a large, fast-growing e-commerce trend-setter, Amazon is the most appropriate case to understand e-commerce logistics in megaregions. The following analysis will examine Amazon’s network of United States warehouses and distribution centers.

Walmart

Walmart is the country's largest retailer and is widely recognized as a leader in supply chain planning and management (Traub 2012). Effective supply chains have enabled its enormous growth even while efficient supply chains have allowed it to remain cost competitive. Its success have also made it a model for private-sector and military supply chain managers (Traub 2012).

One of Walmart's innovations is cross docking, which is the direct transfer of shipments from inbound to outbound trailers without intermediate storage. Cross docking still allows distribution centers to consolidate shipments into more efficient sizes while eliminating the cost of extra storage at the warehouse. Walmart's dedicated truck and driver fleet make warehouse and store deliveries (Traub 2012)

Walmart operates a series of 157 distribution centers (some in conjunction with Sam's Club) around the country supporting 4,130 U.S. handling 81% of merchandise in Walmart stores (MWPVL International Inc. 2013), with the remainder shipping directly to stores (Walmart 2014). These distribution centers are of different types (e.g., general merchandise, groceries). Despite using its own warehouses to process shipments, Walmart integrates stores and suppliers very tightly into its logistics network. Walmart's initiative called "vendor-managed inventory" makes suppliers responsible for managing their inventory in Walmart warehouses, which reduces Walmart's costs and helps ensure timely order fulfillment to warehouses (Traub 2012). The operational integration among suppliers, warehouses, and stores is sometimes so tight that they are said to behave similarly to a single company despite their size and organizational divisions (Traub 2012).

Walmart also operates a supply chain network for the Sam's Club chain with some separate distribution channels. This analysis focus' on distribution centers supporting Walmart stores as identified by MWPVL Supply Chain Consultants.

Walmart operates several types of distribution centers, which are described below.

Regional General Merchandise Distribution Centers

Walmart has 42 regional general merchandise distribution centers totaling 50.1 million square feet. Each distribution center employs approximately 1,000 people. Regional distribution centers serve stores in a designated region, and distribution centers are on average 124 miles from their stores. Each distribution center serves between 90 and 170 stores. Regional general merchandise DCs have a very standard design that has been heavily automated with conveyors and other labor-saving devices throughout in most cases (MWPVL International Inc. 2013)

Grocery and Perishable Food Distribution Centers

Walmart operates 42 grocery and perishable food distribution centers totaling 34.7 million square feet and each employing about 740 people. The average store is 134 miles away. At least 17 of the 42 distribution centers supply both Walmart and Sam's Club stores. Most Grocery and Perishable Food DCs are L-shaped buildings, with a long, rectangular building

housing perishables and a connected square building housing dry goods. The perishables building has inbound and outbound docks on opposite long sides, and the dry goods building has truck docks on three sides (MWPVL International Inc. 2013).

Import Distribution Centers

Walmart operates 10 import distribution center buildings in five different locations near the Pacific, Atlantic, and Gulf coast ports, as well as near Chicago. Import DC locations are near Los Angeles, Houston, Savannah, Norfolk, and Chicago. Import distribution centers receive imports from abroad and reship them to other Walmart grocery or general merchandise distribution centers. They do not ship directly to stores, but instead are pass-through locations to the rest of the distribution network. Walmart has contracted operations in most import distribution centers to third party logistics providers (MWPVL International Inc. 2013).

Fashion Distribution Centers

Walmart operates seven fashion distribution centers and one footwear distribution center. The fashion distribution centers are normally heavily automated, rectangular buildings between 0.6 million and 1.6 million square feet, while the footwear distribution center is much smaller. Most fashion distribution centers supply over 1,000 Walmart stores (MWPVL International Inc. 2013).

Specialty Distribution Centers

Walmart operates specialty distribution centers for select merchandise types not appropriate for handling in other distribution centers. They include optical labs (x3); pharmacy (x5); print and mail (x1); returns, consolidations, and refurbishing (x22); tires (x2), and e-commerce (x2). This research does not include specialty distribution centers because its scope concentrates on traditional 'big-box' retail distribution (MWPVL International Inc. 2013).

Center Point Distribution Centers

Walmart operates 11 center point distribution centers. Like import distribution centers, center point distribution centers do not make deliveries to stores. Rather, center point distribution centers are intermediates between suppliers and other DCs. They receive less-than-truckload (LTL) shipments from suppliers, which are then consolidated into truckload shipments to a given DC. The goal is to reduce shipment and receiving costs by ensuring that DCs receive fewer truckload shipments rather than more LTL shipments. Center point DCs are long, thin buildings with truck docks on both long side to facilitate cross docking. This research does not include center point distribution centers (MWPVL).

Methodology

The researcher analyzed Walmart distribution center locations through descriptive statistics. The first step was to spatially locate the warehouses provided by MWPVL by geocoding each address in the Google Map Engine (Google 2014). Google Map Engine identified each address location on a map, which was organized according to layers named after the distribution center type. Google Map Engine files can be exported into '.kml' format and converted to point shapefiles using the conversion toolkit in the ArcGIS toolbox. Overlaying distribution center locations with a country-level megaregion map (Ross et al. 2009) allows for descriptive

megaregion-level statistics. The researching selected warehouses by spatial location when they were entirely within megaregions, and the researcher transferred summary statistics into a summary spreadsheet using Microsoft Excel.

Findings

Figure 44 below shows Walmart distribution center locations overlaid with U.S. megaregions. Visual inspection shows that Walmart distribution centers to exist in all parts of the country, both in and around megaregions. Distribution centers exist in and around all megaregions. Distribution centers do not appear to be noticeably more concentrated in megaregions than population concentrations would suggest. Statistical and visual analysis provided the following conclusions.

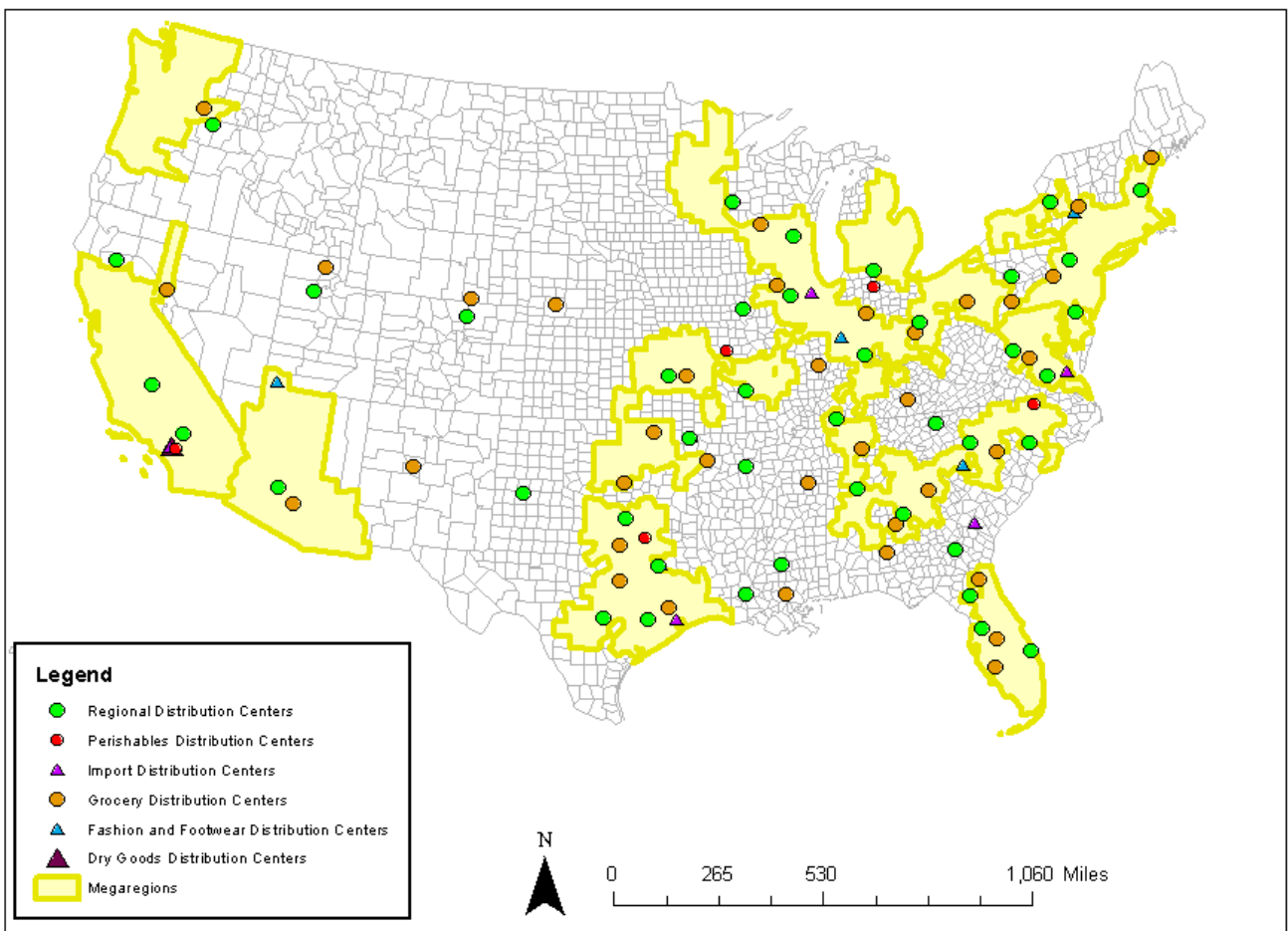


Figure 44: Walmart Distribution Centers

Walmart distribution centers do not significantly cluster in megaregions. A slight majority of the most common warehouses are in megaregions as opposed to non-megaregions. 24 out of 41 (56%) regional distribution centers and 21 out of 36 (58%) grocery distribution centers are in megaregions. While this is a clear majority of distribution centers, it is not greater than the percentage of the U.S. population that lives in megaregions, suggesting that operational

considerations do not cause Walmart to favor megaregions in siting distribution centers. Table 4 below shows Walmart's warehouse type by megaregion.

Table 4: Walmart Warehouse Type by Megaregion

Distribution Center Type	Arizona	California	Cascadia	Central Plains	DC-Virginia	Florida	Midwest	Northeast	Piedmont Atlantic	Texas Triangle	Megaregion Total	Non-Megaregion	Total
<i>Regional</i>	1	2	0	0	3	3	4	3	5	3	24	17	41
<i>Perishables</i>	0	1	0	1	0	0	0	0	1	1	4	2	6
<i>Grocery</i>	1	1	1	3	1	3	3	2	3	3	21	15	36
<i>Fashion and Footwear</i>	1	0	0	0	0	0	1	1	1	0	4	3	7
<i>Dry Goods</i>	0	1	0	0	0	0	0	0	0	0	1	0	1
<i>Import</i>	0	3	0	0	0	0	1	0	0	1	5	1	6
Total	3	8	1	4	4	6	9	6	10	8	59	38	97

By 2050, 67% of the U.S. population is expected to live in megaregions (Ross 2008). While it is impossible to foresee Walmart's supply chain configuration in 2050, the fact that only 61% of today's warehouses are in megaregions suggest that Walmart disproportionately favors non-megaregions in siting warehouses (Table 5).

Table 5: Walmart Distribution Center Types

Distribution Center Type	Total	Percent of Total in—	
		Megaregion	Non-Megaregion
<i>Regional</i>	41	59%	41%
<i>Perishables</i>	6	67%	33%
<i>Grocery</i>	36	58%	42%
<i>Fashion and Footwear</i>	7	57%	43%
<i>Dry Goods</i>	1	100%	0%
<i>Import</i>	6	83%	17%
Total	97	61%	39%

There are several possible reasons why Walmart may locate warehouses in non-megaregions. First, locations outside of megaregions may allow it to gain adequate territorial coverage for its stores throughout the United States. The majority of the U.S. territory is non-megaregion area, so it is possible that megaregion DCs may serve larger populations or more stores than non-megaregion DCs. However, it is also true that Walmart began in a rural area and has traditionally been locked out of some major cities including New York and Atlanta that anchor

their megaregions. Future analysis should also consider alignment with the proportion of Walmart sales that occur inside megaregions if Walmart releases geographically specific sales data.

Amazon.com

Amazon.com is the largest online retailer in the world (O'Connor 2013) and one of the fastest growing with an annual growth rate of 30% in revenues between 2011 and 2012 (Shultz 2013). Amazon's sales presence is entirely digital. It has expanded from its origins in 1994 as a book seller to sell a wide variety of non-perishable goods and—more recently—some web-based services including digital books, cloud computing, and storage (CrunchBase 2014).

Although Amazon's sales presence is digital, most products are physical. This means that Amazon must ship its products to customers, which it does from a growing number of dedicated distribution centers (MWPVL International Inc. 2013). Amazon is working to better compete with physical retailers by offering free shipping in some cases and reducing shipping time. Amazon is planning to offer same-day shipping in some large markets (McKinsey & Company 2013). Having warehouses that are closer to consumers may help it reduce both shipping cost and time. Amazon's well-developed warehouse network also gives it an advantage over other smaller online retailers by allowing its products to more easily and quickly reach consumers (McKinsey & Company 2013).

Amazon currently has 50 distribution centers in the United States with nine new DCs planned. It also has dedicated distribution centers in Canada, Europe, and Asia. Unlike Walmart, which has grown its distribution network slowly over several decades, most of Amazon's distribution center growth has occurred since 2005. In 2011 alone, Amazon opened 10 U.S. distribution centers, five in 2012, and another six in 2013. Nine new U.S. distribution centers are planned to open in 2014 alone (MWPVL International Inc. 2013). Amazon's warehouses are named and numbered for a nearby airport based on the International Air Transport Association's three-digit airport codes (such as 'PHL' for distribution centers near Philadelphia and 'SDF' for distribution centers near Louisville).

According to the MWPVL, until recently Amazon reached customers in major population centers without having to charge state sales tax by locating in states with favorable tax laws and omit some states with large population centers (e.g., California). However, Amazon's recent focus on faster deliveries and its decision to charge most customers state income tax has caused it to increasingly locate its new warehouses near major population centers (MWPVL International Inc. 2013).

Methodology

The same methodology was used to analyze Amazon's distribution center locations as for Walmart. Please reference the Walmart methodology.

Findings

Amazon's distribution centers form several compact clusters. Establishing the greatest geographical coverage does not appear to be the primary concern in locating distribution centers, but rather other considerations, such as growing in propitious locations. Distribution centers cluster in states such as Arizona, Tennessee, Kentucky, Indiana, and Pennsylvania while omitting major areas such as Florida, New England, and most of the center west of the country. Recent openings have expanded small clusters and brought Amazon into new areas, like California and Texas Triangle. Moreover, planned openings will bring Amazon's DCs into Florida, New England, and Illinois. Figure 45 and Table 6 show Amazon's warehouse locations overlaid with U.S. megaregions.

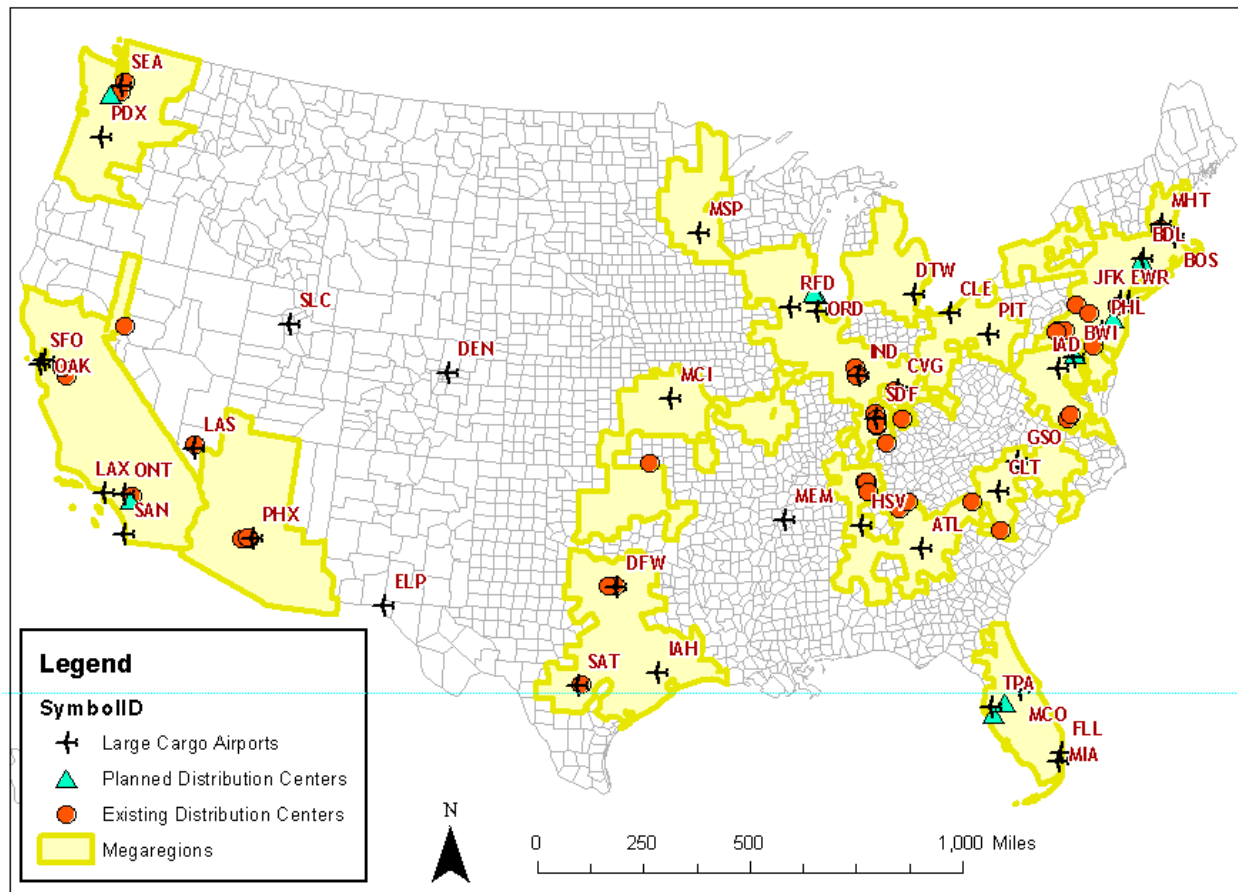


Figure 45: Amazon Distribution Centers and the Largest U.S. Cargo Airports

Table 6: Amazon Warehouses by Megaregion

Distribution Center Type	Arizona	California	Cascadia	Central Plains	DC-Virginia	Florida	Midwest	Northeast	Piedmont Atlantic	Texas Triangle	Total Megaregion	Non-Megaregion	Total
<i>Existing</i>	4	3	2	0	2	0	15	10	6	3	45	5	50
<i>Planned</i>	0	1	1	0	1	2	2	2	0	0	9	0	9
Total	4	4	3	0	3	2	17	12	6	3	54	5	59

The following are major characteristics from Amazon's warehouse locations—

Warehouses cluster in just a few megaregions. Some megaregions, including the Midwest, Piedmont-Atlantic, and the Northeast contain multiple distribution centers in very close proximity while Florida has no operational DCs and Texas Triangle had none until 2013. The reasons may relate to state sales tax laws and infrastructure availability since the distribution configuration is changing rapidly when Amazon decided to charge sales tax and minimize delivery times.

Megaregions are very important for Amazon's distribution centers. Ninety-five percent of existing distribution centers and 100% of new distribution centers are located in megaregions. This contrasts with Walmart, where just 61% of distribution centers were in megaregions. Megaregions may be attractive to Amazon supply chain planners because of the proximity to population, labor availability, and the availability of high quality transportation infrastructure.

Airports may influence Amazon siting decisions. It is likely not coincidental that the warehouse names reported by MWPVL derive their names from three digit airport codes. Visual inspection shows many warehouses to be located near large cargo airports. Air delivery may be important to Amazon to allow faster delivery to customers, particularly in the large parts of the country that are not near Amazon distribution centers. Its uneven distribution center placement may make the air delivery option more important than it would have been otherwise.

Megaregions align more closely with the distribution center locations in Amazon's e-commerce than Walmart's brick-and-mortar model. This is particularly true for Amazon's planned warehouses, which are all in megaregions to reduce delivery times. Amazon's role as an e-commerce leader may reduce acceptable delivery times across the industry and ultimately require its competitors to adopt similar strategies maximizing proximity between warehouses and consumers. The development could cause more e-commerce warehouses to locate in megaregions across brands.

Airports' Effects on Distribution Center Siting

Initial review revealed that airport locations may influence Amazon's distribution center locations. The following section examines the distance between the country's largest freight airports and distribution centers for Walmart and Amazon to see how the two companies' distribution center locations are affected by cargo airports.

Methodology

The researcher collected the 50 busiest cargo airports in North America from the Airports Council International (Airports Council International - North America 2014). It is assumed that busier cargo airports would be much more attractive to distributors than small airports because they would offer more competition, more frequent delivery options, and more direct connections. Small airports may not meet a large distributor's needs. Using only the 50 busiest airports does omit some small airports for which Amazon DCs are named, such as Chattanooga (CHA).

The researcher geocoded each airport and spatially joined airports to distribution centers based on proximity. In other words, each airport was joined with the distribution centers closest to it for both Walmart and Amazon. Descriptive statistical analysis was performed in Excel.

Findings

Walmart warehouses are an average of 112 miles from the nearest large cargo airport versus only 50 miles for Amazon.com warehouses. The difference reinforces Walmart's emphasis on truck transportation versus Amazon's use of multiple air and ground modes to reach customers. Table 7 below shows the average distance between the nearest cargo airport and Walmart warehouse categories.

Table 7: Distance between Large Cargo Airports and Walmart Warehouses

	Distribution Centers						
	All	Regional	Perishables	Imports	Groceries	Fashion	Dry Goods
<i>Mean Distance (Miles)</i>	112	115	94	61	117	135	5.8
<i>Standard Deviation</i>	73	74	58	76	74	61	N/A
<i>Maximum Distance (Miles)</i>	336	336	159	199	314	206	5.8
<i>Minimum Distance (Miles)</i>	4.4	21.0	18.7	4.4	13.4	37.2	5.8

Amazon's DCs are on average closer to large cargo airports than Walmart's. The closest existing DC is 2.8 miles from the nearest cargo airport. Moreover, planned DCs are even closer, just 29 miles from large cargo airports versus 50 miles for existing Amazon DCs. Table 8 below shows Amazon's average warehouse distance to a large cargo airport.

Table 8: Distance between Large Cargo Airports and Amazon Warehouses

	Existing	Planned	Difference
Mean Distance (Miles)	50	29	20
Standard Deviation	50	16	34
Maximum Distance (Miles)	245	46	199
Minimum Distance (Miles)	2.8	4.5	-1.7

There appears to be a positive correlation between a cargo airport's size and the number of nearby Amazon DCs. Some of the country's busiest cargo airports have some of the most and closest distribution centers. For example, Louisville (SDF) has seven paired distribution centers. Louisville is also the primary hub for UPS, which would offer Amazon very high levels of connectivity from its airport hub.

Even though Amazon DCs are much closer to airports on average than Walmart DCs, there are also some that are quite far from large cargo airports. The minimum distance to an airport is 2.8 miles while the maximum distance is nearly 250 miles.

Non-publicly available information on Amazon's distribution strategy might explain why some DCs are so far from large airports. One plausible explanation is that Amazon DCs may specialize in different products or different modes. Those closer to the best connected cargo airports would be most appropriate to specialize in high-speed, long-distance deliveries. Amazon might also be able to ship air freight through small airports not captured in this analysis. Moreover Amazon may still use air freight to reach remote (e.g., non-megaregion areas) where it does not have a DC while using ground for closer population centers (in megaregions). Amazon's air-mode deliveries are assumed to be primarily for outbound logistics (distribution center to consumer) because outbound shipments are more time-pressed than inbound shipments (i.e., supplier to distribution center). Future research should examine detailed e-commerce distribution strategies to confirm DC specialization and the connectivity offered by small airports.

The comparison between Walmart and Amazon is telling. Amazon DCs' megaregion locations suggests that e-commerce distributors (who shipping directly to customers rather than to stores) need to be closer to customers to achieve acceptable delivery times. Megaregions are natural e-commerce distribution sites because of their high populations and high connectivity. Moreover, Amazon DCs' airport proximity also speaks to the need for omni-modal e-commerce delivery. E-commerce distribution contrasts with brick-and-mortar retailers, who can predict store replenishment needs far enough in advance to use ground delivery.

E-commerce distribution appears to operate under a different model than traditional retail, and it may feature megaregions more heavily. Future research should seek to use interviews and company documents to more thoroughly examine companies' distribution strategies for

megaregion impacts. Future research should also examine how traditional retailers may need to change their supply chain strategies under the pressure of online retailers, particularly if they seek to imitate e-commerce distribution channels.

Section IV: Megaregion Survey

The past two sections have examined logistics distribution physical locations as they relate to megaregions. They provide an understanding of megaregion's role in private sector supply chains to inform transportation planning practice and national transportation policymaking. Supply chain's existence at the megaregion scale means that isolating transportation planning to local, regional, and state scales will cause externalities in the form of traffic congestion, environmental impacts, infrastructure duplication, or other inefficiencies that megaregion-level coordination could avoid. This section does not comprehensively analyze the governance structures that could contribute to megaregion-level transportation planning. Rather, it draws insights about the form that practitioners believe that megaregion-level planning should take based on fall 2012 survey results.

Researchers at the Center for Quality Growth and Regional Development (CQGRD) at the Georgia Institute of Technology conducted a survey on "the Architecture of the Megaregion" in fall 2012 that can help policymakers gauge the state of planning practice. The research was part of the multi-phase project to examine megaregion structure and implementation supported by the Federal Highway Administration. Researchers compiled a database of contacts at the country's 384 metropolitan planning organizations (MPOs) from the U.S. Department of Transportation's MPO database (<http://www.planning.dot.gov/mpo.asp>) and individual MPO websites. When possible, researchers included one MPO director or senior manager with a strategic perspective. The database also included one or more planning officials from state departments of transportation (DOT) who were selected based on state website listings and position. The very different structures and available information prevented researchers from always reaching identical positions in each organization. State DOT respondents included planning directors, deputy planning directors, policy managers, and principal planners. The survey asked both DOT and MPO contacts to forward the survey if there was a more appropriate respondent.

The survey was sent via email. An initial message introduced the project, explained the megaregions concept, and provided the survey link. Two follow-up emails at several-week intervals and a follow-up phone call to non-respondent MPOs occurred in that order, and the Federal Highway Administration also sent an email explaining the survey to state DOT contacts. The survey was hosted on the online platform called Survey Monkey, and it included selection and free-response questions.

The survey received 194 responses from 191 different MPOs for a unique response rate of 49.7%, and 24 responses from 22 different state DOTs for a unique response rate of 43.1%. Seventy percent of state DOTs and 75% of MPOs were in megaregions, and responses represented all megaregions and non-megaregion areas. Respondent MPO population sizes represent the MPO universe very closely. DOT responses are slightly more representative of non-megaregion areas than DOTs as a whole, and they have slightly smaller state populations than DOTs as a whole. The high response rate allows a high degree of certainty about transportation planning state and preferences regarding megaregions among MPOs and state DOTs.

Findings

The survey revealed many characteristics about planning practice in megaregions. A selection of the most relevant findings to this research is included below.

Passenger modes continue to dominate transportation planning discussions in and out of megaregions. While freight has received increasing attention in the transportation planning community in recent years, passenger travel remains the focus of most MPOs and DOTs in viewing the role of megaregions. When asked about the project types needing a megaregion approach 72% of respondents cited explicitly passenger modes. Only 38% percent cited explicitly freight initiatives, which included truck, air, rail, and waterborne freight modes. 61% cited initiatives that could refer to freight or passenger travel.

Many transportation planners perceive a role for freight planning in megaregion initiatives. Even though current projects focus heavily on passenger travel, state and regional transportation planners perceive a role for freight across modes in megaregion planning. Figure 46 below illustrates the number of times that respondents suggested different modes and project types as requiring attention in a megaregion perspective. It shows that rail is the most frequently cited mode or infrastructure type that planners believe need to be addressed. This is despite or perhaps because of the fact that rail carries a much smaller percentage of passengers and freight value than other modes.

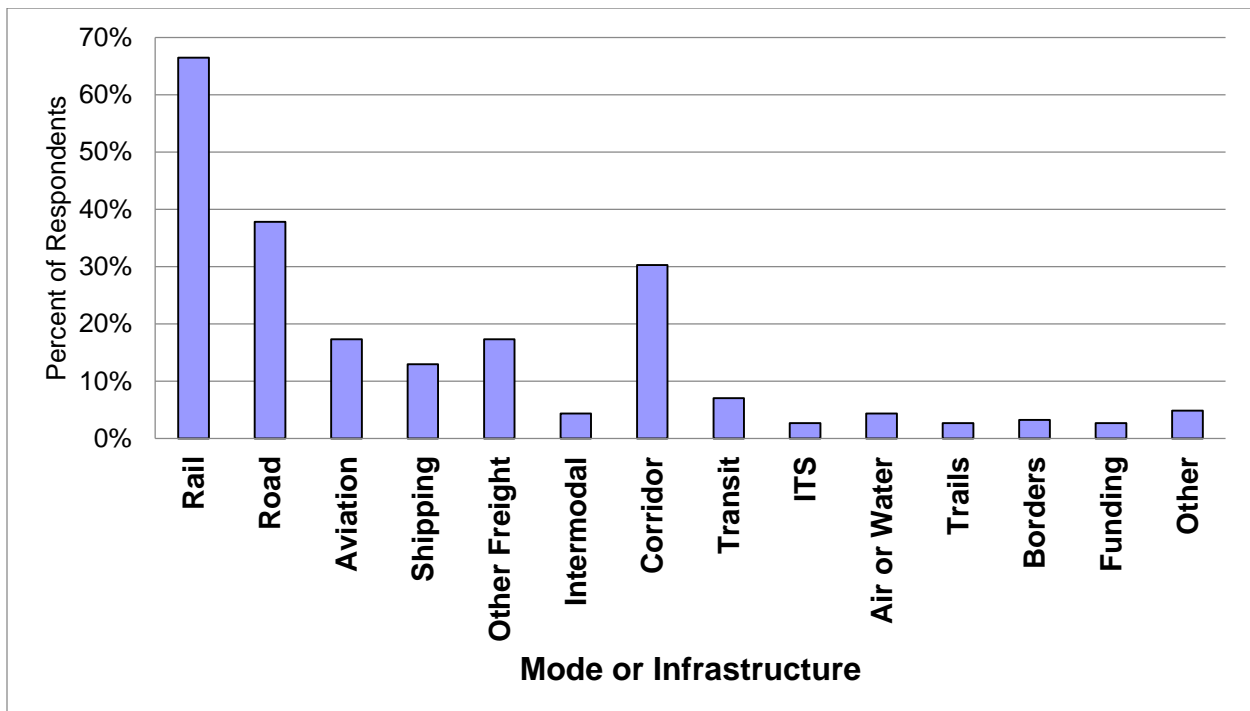


Figure 46: What Infrastructure needs to be addressed at a Megaregion scale?

Moreover, many respondents reported that they are already addressing freight initiatives as part of collaborative initiatives outside of their jurisdiction. Figure 47 below shows the percentages of respondents who reported that their organization was already involved in a given type of

inter-jurisdictional initiative involving freight. Many types of multi-jurisdictional freight planning are occurring, albeit at lower rates than what planners consider is needed based on the responses in Figure 46 above.

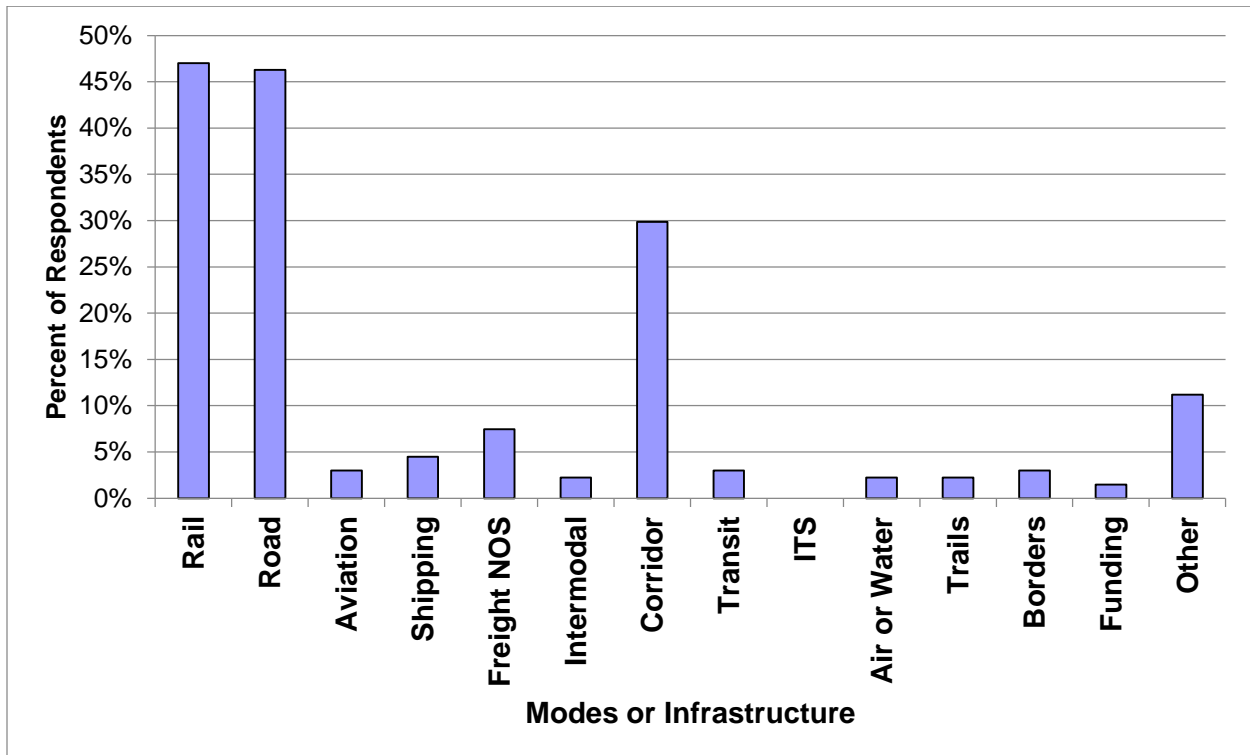


Figure 47: Are There Any Existing Megaregion-Scale Transportation Efforts Currently Underway Within or Around the Planning Boundaries of Your Organization?

Practicing planners believe that a mix of corridor-, function-, and project-based approaches are needed for successful megaregion planning. Figure 48 below shows that similar percentages of respondents expressed a belief in each of the spatial organization types' efficacy in megaregion transportation planning. Corridor-based approaches are oriented to linear infrastructure spanning multiple jurisdictions, often along highways. Function-based approaches create enduring structures that coordinate planning functions among organizations inside a 'natural' boundary that corresponds with phenomena characteristics. Project- or initiative-based approaches are short-term or medium-term collaborations that are limited to organizations involved in a specific project. They are often of shorter duration and narrower geographic area than corridor- or function-based approaches. The fact that respondents assess each approach's feasibility suggests that each may be possible and needed in difference circumstances.

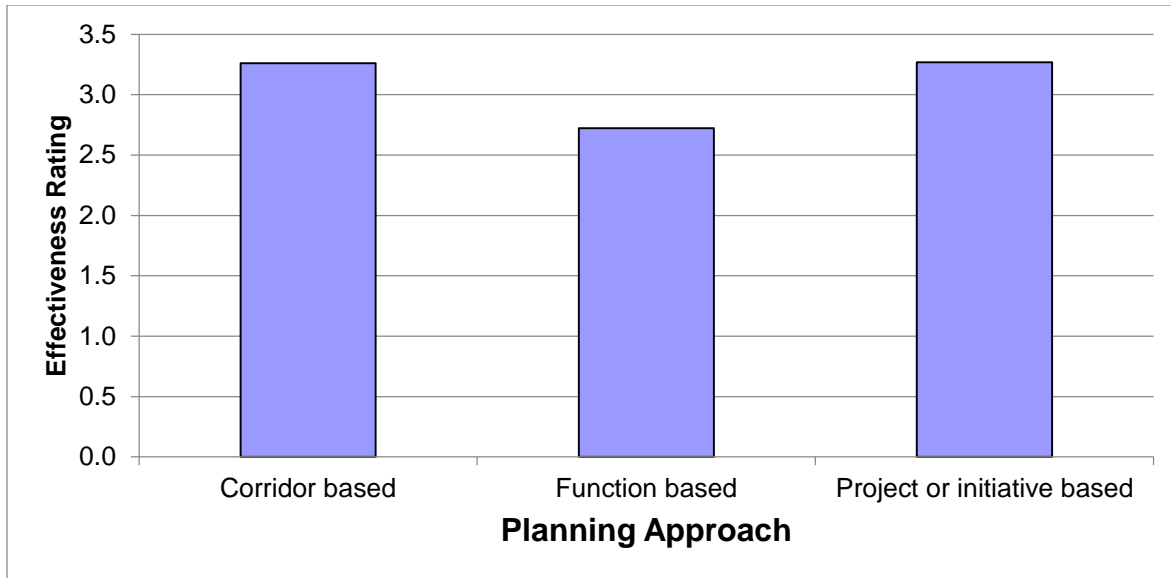


Figure 48: Which Approach Would Be More Feasible in Terms of Implementation of Megaregion Planning?

Multiple approaches are likely to be necessary to respond to different conditions; it may also be helpful to have overarching planning initiatives that correspond more closely with supply chain's physical structures. Supply chains and distribution networks are not confined to project boundaries or specific corridors. Rather, they form complex activity webs across corridors and jurisdictions that are anchored in specific locations by distribution centers, intermodal centers (e.g., seaports, airports, rail-truck intermodal centers), supplier locations, and factories. Some planning structures may benefit from being large enough to encompass key connections among nodes, such as seaports and distribution centers, or common distribution center location and store radii. Project- and corridor-based approaches are likely to omit these connections.

Transportation planners are ready to incorporate limited private-sector participation into megaregion transportation planning. Outside of military transportation, the private sector is almost entirely responsible for freight movement whether they occur on rails, roads, sea, or in the air. At most, the public sector operates infrastructure, but the private sector nearly always manages freight flows. When asked about their preferred megaregion governance structure, the plurality of respondents (Figure 49) selected a hybrid structure, which is described as “cross-sectoral alliances of public and private-sector partnerships with federal leadership” that posits that “there should be very strong leadership to facilitate cooperation among different interests.” Notably, the hybrid structure includes private-sector participation along with regional, state, and federal roles. The selection suggests that there may be an accepted role, such as logistics advisory councils, for transportation planning mechanisms.

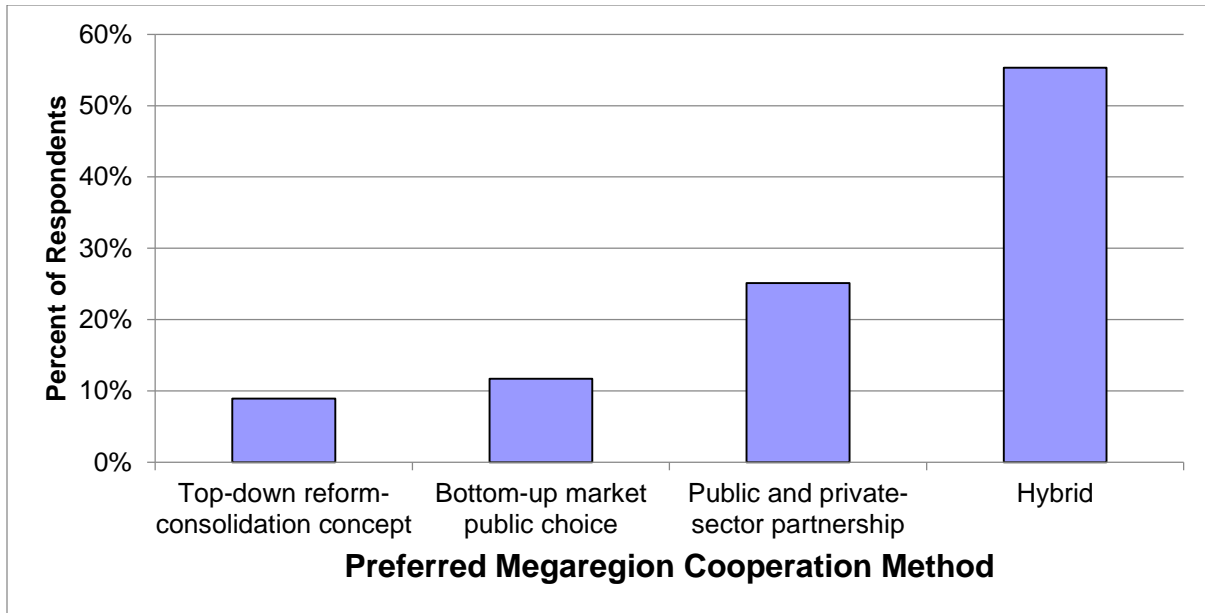


Figure 49: Which Conception of Regional Planning Do You Think Is Most Feasible for Megaregion Planning?

Practicing planners generally believe that the transportation network may benefit by planning freight at the megaregion level. Many different modes and project types may be appropriate. Moreover, corridor-, function-, and project-based approaches may each be feasible and desirable in different situations. Finally, local, state, regional, federal, and private organizations may need to be involved in megaregion-level solutions. On the one hand, the results reveal that practice has not yet settled on a specific megaregion-planning paradigm since megaregion-planning remains in its infancy. The largest finding is that planning approaches need to remain inclusive and open-minded. This opens planning practice to include private-sector supply chain partners as freight advisors. Both government planners and private business may benefit from the alliance. Ideally, the collaboration which may result in more efficient transportation network expenditures and faster, more reliable freight distribution.

Section V: Conclusion

This report's single most important lesson is that public-sector freight planners and private-sector supply chain managers can best achieve a well-functioning transportation network, economic competitiveness, and business profits by working together. The two fields have traditionally coexisted in an uneasy partnership that has not always acknowledged their interdependencies and potential synergies. The separation comes from the fact that the planning function has typically resided in the public sector, while the private sector has handled freight operations,

Both transportation planning and supply chain management have discovered that supra-regional thinking can help achieve their goals. Transportation planning has conceived of this supra-regionalism as "megaregions." Conversely, supply chain managers have built large supply chains connecting suppliers, ports, distribution centers, and stores at multiple geographic scales, some of which approximate megaregions. The two case studies revealed the convergence between freight planning and supply chain management. Walmart builds distribution centers to connect stores in a large region, and Amazon has very heavily concentrated its distribution centers in megaregions to benefit from the access, infrastructure, connectivity, and markets that they contain. Megaregions offer opportunities for synergistic public-private approaches.

Section I reviewed literature relating to megaregions, supply chain management, and supply chain trends. Many freight impediments cannot be solved at local or even state scales, but instead call for spatially and temporally broad megaregion definitions (Amekudzi, Thomas-Mobley, and Ross 2007; Seedah and Harrison 2011). However, it is not sufficient to understand how freight moves within regions and megaregions, or even nationally. Planning must address supply chain dynamics to accurately frame observed freight movements. Freight movements are linked with much larger production, consumption, reuse and disposal processes that cross state and national boundaries. Supply chain management describes and improves the processes that drive freight demand (Bowen 2008; Rodrigue 2006b). Several researchers such as Dablanc and Ross (2012) have recognized that freight facilities are embedded in global supply chain dynamics and have studied megaregion freight from that perspective (Christopherson and Belzer 2009). This report builds on their work and explicitly expands analysis into emerging trends, including e-commerce.

Section II explored megaregion logistics characteristics by analyzing aggregate logistics data contained in logistics NAICS categories. The analysis revealed that megaregions house logistics clusters. These clusters connect the national transportation infrastructure across modes and logistics support services. The analysis also showed the several megaregions dominate the national logistics, namely the Midwest, the Northeast, and California. Nevertheless, each megaregion is fairly unique, both in the amount of logistics activity, the dominant activities, and spatial arrangements. There are clear contrasts between bipolar and multipolar systems, concentrated and diffuse establishments, corridors and galaxy-type arrangements. The megaregion profiles and comparisons can guide policy makers and transportation planners to understand each megaregion's needs and relative sizes.

Section III took up two case studies of large retailers that have set trends for traditional retail distribution and e-commerce distribution: Walmart and Amazon. The case studies found important differences in the two retailers' distribution center locations. Compared with the U.S. population, Walmart distribution centers focus slightly on non-megaregions, while Amazon DCs are almost entirely contained in megaregions. Walmart DCs are fairly evenly dispersed around the entire country, while Amazon DCs cluster close to each other in just a few megaregions. Cargo airports are much more heavily correlated with Amazon distribution center locations than Walmart DCs. The comparisons suggest different distribution models for traditional retail and the growing e-commerce industry. Megaregions' markets and connectivity appear especially important for e-commerce success.

Section IV examined the results of a late-2012 survey performed by the Center for Quality Growth and Regional Development of planners in metropolitan planning organizations (MPO) and state departments of transportation (DOT). The survey found that the planning community does believe that megaregion-scale cooperation can improve freight planning, and that some multi-jurisdictional efforts are already addressing freight transportation. However, passenger initiatives continue to take the limelight in megaregions. Moreover, the planning community's preferences for megaregion decision making may leave room for both private-sector participation perhaps in an advisory council and for freight-based approaches that would encompass the geographies at which supply chains exist.

The four sections provide an overview of supply chain management's relationship with transportation planning and megaregions. They allow for several overarching lessons that can inform transportation and policy making regarding freight. The lessons improve upon past research by explicitly incorporating supply chain management.

Freight movement aligns well with the megaregion scale. Aggregate NAICS code analysis showed that most kinds of freight movement concentrate in megaregions, particularly hub and support activities. Moreover, based on Amazon's example, the emerging e-commerce industry appears particularly suited to the megaregion scale. The connections between ports, distribution centers, stores, and customers span local and state boundaries to approximate megaregion-scale patterns of the sort observed in passenger and freight movement.

Megaregions have unequal amounts of logistics activity. The aggregate analysis of logistics activities showed that America's 10 megaregions were home to vastly different amounts of logistics activity. The Midwest, the Northwest, and the California Megaregions emerged as some of the most important national freight and logistics centers. The divergence among megaregions holds at the firm level. The case studies revealed that Amazon has built numerous megaregions in the Midwest and the Northeast while almost entirely omitting Florida and the Texas Triangle. It is less clear how traditional retailers may focus on different megaregions, since Walmart showed a fairly even nationwide distribution, possibly to gain better access to its nationwide stores. Moreover, e-commerce retailers may need to build new distribution centers to meet short delivery times currently being tested.

Policy should allow for project prioritization within and among megaregions based on the megaregion's supply chain size and strengths. Prioritization must also account for future potential. Macro-scale supply chain configurations may channel freight flows into megaregions that are less important today. The largest megaregions will merit large amounts of freight-related transportation investment, but investment decisions should also consider megaregion growth potential so as to not unduly skew funding towards the largest megaregions. Comparing supply chain operations in each megaregion allows planners to gauge relative sizes.

Logistics activities are unevenly distributed around megaregions. Each megaregion offers a very different profile. Megaregions differ not only in logistics activity scale, but also by the mode and presence of support activities. Arizona illustrates how modal presence differs. Trucking is the largest mode nationwide, but the Arizona Megaregion has relatively few truck establishments. However, one of the Arizona Megaregion's relative strength is in passenger and freight air transportation establishments. Different project types will be most appropriate in different locations corresponding to the modes and freight types most dominant there.

Supply chains are layered. The literature review and the Walmart case study reveal that many distribution systems have a hierarchical organization that involves not just distribution centers between suppliers and stores, but also secondary distribution centers that mediate flows between supply chain nodes. The hierarchical system tends to be organized like a pyramid, with fewer higher level distribution centers, and air or sea gateways (e.g., ports). While the high-level infrastructure may be more concentrated, trucking establishments are a low-level connector between distribution centers and stores/consumers nationwide. Trucking is the national *lingua franca*, accessible everywhere and understood everywhere.

Distribution centers are located to provide the fastest and cheapest connections to customers. The fact that distribution centers follow customers is evidenced in both the Walmart and Amazon case studies, albeit differently. Walmart builds distribution centers to serve large numbers of stores in a radius of approximately 130 miles. Distribution centers' location requires proximity to stores to achieve quick truckload deliveries. Amazon's traditional strategy has concentrated its distribution facilities in just a few locations based on access to transportation infrastructure and favorable tax laws. However, its new strategy is bringing it closer to its largest customer groups—often in megaregions—to achieve faster delivery times. Thus, distribution centers are not only trip generators as conceived in travel demand models, but also long-term installations that channel traffic based on economic demand.

Gateways are bottlenecks that could delay freight flows through the rest of the freight network if not adequately supported. Even though trucks carry the majority of goods and can reach nearly any location, they often interface with other modes at key gateways. They may transport freight to and from large cargo airports. Airport delays reduce the truck network efficiency. Seaports act similarly. Distribution centers cluster near gateways to process and distribute freight. Megaregion transportation planning should ensure that gateways process freight efficiently and reliably for the rest of the network.

E-commerce and traditional retail distribution may configure supply chains differently.

The Walmart and Amazon case studies revealed important differences between the two companies' distribution systems, which may be at least partially attributable to the distinctions between deliveries to stores in traditional retail and small parcel deliveries direct to customers in e-commerce. E-commerce distribution appears to allow distribution centers to cluster more heavily in megaregions to be near population centers and access air and ground transportation hubs. This allows the distributors to reduce delivery time and cost in megaregions and provide options for fast delivery by air or other fast modes to customers outside of megaregions. The spatial differences between traditional retail distribution and e-commerce merit further research to understand the cases' nuances and generalizability.

Megaregions offer an exciting opportunity to align transportation planning and supply chain management in ways heretofore untested. The major challenge will be to formulate a national system to address megaregion planning in ways that encourages public-private synergies. This report provides a starting point for policy discussion by integrating supply chain concepts into the planning forum. The policy discussion will be challenging because of the number of partners involved, their different cultures, and their operational paradigms. However, a successful policy may improve freight planning's effectiveness as well as private companies' ability to meet their goals through efficient and effective logistics.

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Appendix 1: Distribution Center Statistics

Table 9: Walmart Distribution Centers by Nearest Major Cargo Airports

Airport Code	City	Number of Warehouses	Average Distance (Miles)
ATL	Atlanta, GA	6	124
BDL	Hartford, CT	2	142
CLT	Charlotte, NC	4	84
CVG	Cincinnati, OH	2	108
DEN	Denver, CO	3	140
DFW	Dallas, TX	6	119
DTW	Detroit, MI	2	124
ELP	El Paso, TX	1	211
EWR	Newark, NJ	1	214
FLL	Fort Lauderdale, FL	1	93
GSO	Greensboro, NC	2	108
HSV	Huntsville, AL	3	85
IAD	Washington, DC	5	112
IAH	Houston, TX	6	98
IND	Indianapolis, IN	3	84
LAS	Las Vegas, NV	1	140
LAX	Los Angeles, CA	1	151
MCI	Kansas City, MO	8	166
MCO	Orlando, FL	2	88
MEM	Memphis, TN	5	199
MHT	Manchester, NH	2	69
MSP	Minneapolis-St. Paul, MN	1	94
OAK	Oakland, CA	2	193
ONT	Ontario, CA	6	14
ORD	Chicago, IL	1	43
PDX	Portland, OR	1	231
PHL	Philadelphia, PA	3	77
PHX	Phoenix, AZ	2	41
PIT	Pittsburgh, PA	2	84
RFD	Rockford, IL	5	110
SAT	San Antonio, TX	1	32
SDF	Louisville, KY	2	93
SEA	Seattle, WA	1	183
SLC	Salt Lake City, UT	2	46

Airport Code	City	Number of Warehouses	Average Distance (Miles)
TPA	Tampa, FL	3	80
Average		2.8	114
35	Count	98	

Table 10: Amazon Distribution Centers by Nearest Major Cargo Airport

Airport Code	City	Existing Warehouses		Planned Warehouses	
		Number of Warehouses	Average Distance (Miles)	Number of Warehouses	Average Distance (Miles)
ATL	Atlanta, GA	2	113	-	
BDL	Harford, CT			1	4
BWI	Baltimore, MD	3	76	1	8
CLT	Charlotte, NC	2	84		
CVG	Cincinnati, OH	5	30		
DFW	Dallas, TX	2	13		
EWR	Newark, NJ	1	11	1	46
HSV	Huntsville, AL	3	98		
IAD	Washington, DC	2	116		
IND	Indianapolis, IN	4	7		
LAS	Las Vegas, NV	1	10		
MCI	Kansas City, MO	1	163		
MHT	Manchester, NH	1	11		
OAK	Oakland, CA	3	128		
ONT	Ontario, CA	1		1	26
ORD	Chicago, IL			2	43
PHL	Philadelphia, PA	5	54		
PHX	Phoenix, AZ	4	17		
SAT	San Antonio, TX	1	14		
SDF	Louisville, KY	7	20		
SEA	Seattle, WA	2	15	1	34
TPA	Tampa, FL			2	30
Average		2.6	54	1.1	27
22	Count	50		9	

Appendix 2: Description of NAICS Codes

The following section provides a complete description of NAICS codes from the U.S. Census Bureau (2014)

481 Air Transportation

Industries in the Air Transportation subsector provide air transportation of passengers and/or cargo using aircraft, such as airplanes and helicopters. The subsector distinguishes scheduled from nonscheduled air transportation. Scheduled air carriers fly regular routes on regular schedules and operate even if flights are only partially loaded. Nonscheduled carriers often operate during nonpeak time slots at busy airports. These establishments have more flexibility with respect to choice of airport, hours of operation, load factors, and similar operational characteristics. Nonscheduled carriers provide chartered air transportation of passengers, cargo, or specialty flying services. Specialty flying services establishments use general-purpose aircraft to provide a variety of specialized flying services.

Scenic and sightseeing air transportation and air courier services are not included in this subsector but are included in Subsector 487, Scenic and Sightseeing Transportation and in Subsector 492, Couriers and Messengers. Although these activities may use aircraft, they are different from the activities included in air transportation. Air sightseeing does not usually involve place-to-place transportation; the passenger's flight (e.g., balloon ride, aerial sightseeing) typically starts and ends at the same location. Courier services (individual package or cargo delivery) include more than air transportation; road transportation is usually required to deliver the cargo to the intended recipient.

483111 Deep Sea Freight Transportation

This U.S. industry comprises establishments primarily engaged in providing deep sea transportation of cargo to or from foreign ports.

483113 Coastal and Great Lakes Freight Transportation

This U.S. industry comprises establishments primarily engaged in providing water transportation of cargo in coastal waters, on the Great Lakes System, or deep seas between ports of the United States, Puerto Rico, and United States island possessions or protectorates. Marine transportation establishments using the facilities of the St. Lawrence Seaway Authority Commission are considered to be using the Great Lakes Water Transportation System. Establishments primarily engaged in providing coastal and/or Great Lakes barge transportation services are included in this industry.

483211 Inland Water Freight Transportation

This U.S. industry comprises establishments primarily engaged in providing inland water transportation of cargo on lakes, rivers, or intra-coastal waterways (except on the Great Lakes System).

484 Truck Transportation

Industries in the Truck Transportation subsector provide over-the-road transportation of cargo using motor vehicles, such as trucks and tractor trailers. The subsector is subdivided into general freight trucking and specialized freight trucking. This distinction reflects differences in equipment used, type of load carried, scheduling, terminal, and other networking services. General freight transportation establishments handle a wide variety of general commodities, generally palletized, and transported in a container or van trailer. Specialized freight transportation is the transportation of cargo that, because of size, weight, shape, or other inherent characteristics require specialized equipment for transportation.

Each of these industry groups is further subdivided based on distance traveled. Local trucking establishments primarily carry goods within a single metropolitan area and its adjacent nonurban areas. Long distance trucking establishments carry goods between metropolitan areas.

The Specialized Freight Trucking industry group includes a separate industry for Used Household and Office Goods Moving. The household and office goods movers are separated because of the substantial network of establishments that has developed to deal with local and long-distance moving and the associated storage. In this area, the same establishment provides both local and long-distance services, while other specialized freight establishments generally limit their services to either local or long-distance hauling.

484121 General Freight Trucking, Long-Distance, Truckload

This U.S. industry comprises establishments primarily engaged in providing long-distance general freight truckload (TL) trucking. These long-distance general freight truckload carrier establishments provide full truck movement of freight from origin to destination. The shipment of freight on a truck is characterized as a full single load not combined with other shipments.

484122 General Freight Trucking, Long-Distance, Less Than Truckload

This U.S. industry comprises establishments primarily engaged in providing long-distance, general freight, less than truckload (LTL) trucking. LTL carriage is characterized as multiple shipments combined onto a single truck for multiple deliveries within a network. These establishments are generally characterized by the following network activities: local pickup, local sorting and terminal operations, line-haul, destination sorting and terminal operations, and local delivery.

488 Support Activities for Transportation

Industries in the Support Activities for Transportation subsector provide services which support transportation. These services may be provided to transportation carrier establishments or to the general public. This subsector includes a wide array of establishments, including air traffic control services, marine cargo handling, and motor vehicle towing.

The Support Activities for Transportation subsector includes services to transportation but is separated by type of mode serviced. The Support Activities for Rail Transportation industry includes services to the rail industry (e.g., railroad switching and terminal establishments).

Ship repair and maintenance not done in a shipyard are included in Other Support Activities for Water Transportation. An example would be floating dry dock services in a harbor.

Excluded from this subsector are establishments primarily engaged in providing factory conversion and overhaul of transportation equipment, which are classified in Subsector 336, Transportation Equipment Manufacturing. Also, establishments primarily engaged in providing rental and leasing of transportation equipment without operator are classified in Subsector 532, Rental and Leasing Services.

488510 Freight Transportation Arrangement

This industry comprises establishments primarily engaged in arranging transportation of freight between shippers and carriers. These establishments are usually known as freight forwarders, marine shipping agents, or customs brokers and offer a combination of services spanning transportation modes.

493 Warehousing and Storage

Industries in the Warehousing and Storage subsector are primarily engaged in operating warehousing and storage facilities for general merchandise, refrigerated goods, and other warehouse products. These establishments provide facilities to store goods. They do not sell the goods they handle. These establishments take responsibility for storing the goods and keeping them secure. They may also provide a range of services, often referred to as logistics services, related to the distribution of goods. Logistics services can include labeling, breaking bulk, inventory control and management, light assembly, order entry and fulfillment, packaging, pick and pack, price marking and ticketing, and transportation arrangement. However, establishments in this industry group always provide warehousing or storage services in addition to any logistic services. Furthermore, the warehousing or storage of goods must be more than incidental to the performance of services, such as price marking.

Bonded warehousing and storage services and warehouses located in free trade zones are included in the industries of this subsector.