Competitive industry clusters and transportation in Minnesota

Lee W. Munnich
Hubert H. Humphrey School of Public Affairs, University of Minnesota, Minneapolis, Minnesota, USA, and
Michael Iacono
Department of Civil, Environmental and Geo-Engineering, University of Minnesota, Minneapolis, Minnesota, USA

Received 19 March 2015
Revised 5 June 2015
Accepted 7 August 2015

Abstract

Purpose – This study aims to advance the state of knowledge of the relationship between transportation and economic development by investigating how firms in competitive industry clusters use transportation networks and what role those networks play in the competitiveness of these clusters.

Design/methodology/approach – The approach combines quantitative and qualitative techniques to geographically identify competitive industry clusters and to investigate the role of transportation. The US Cluster Mapping tool is used to identify competitive clusters by employment location quotients in 25 Minnesota metropolitan and micropolitan regions. A total of 12 competitive clusters were selected for further study, and in-depth interviews and site visits were conducted with businesses in each cluster to explore the competitive importance of different modes of transportation.

Findings – Minnesota's economic competitiveness is dependent on a well-functioning transportation system in all modes – truck, air, rail, and water. Access to global markets requires rail and truck to reach coastal ports. Air transportation is critical for high-value, low-weight, time-sensitive products such as medical devices or Mayo lab testing samples. Air service is important for customers at Minneapolis – St. Paul, St. Cloud, and Rochester, Duluth, as well as other Minnesota cities. Highway access and reliability is critical for key statewide clusters such as processed food and heavy machinery.

Research limitations/implications – Study limitations include the representativeness of company interviews in generalizing for a cluster and industry employment as a measure of competitiveness.

Practical implications – These methods can yield valuable insights into how transportation functions as an input within competitive industry clusters and how it can inform economic development strategies tailored to certain locations and industries.

Originality/value – This is a first-of-its kind study using industry clusters as a framework for examining the role that transportation plays in economic competitiveness.

Keywords Competitiveness, Economic, Transportation, Clusters, Industry, Minnesota

Paper type Research paper

Introduction

Traditional policies oriented toward the use of transportation infrastructure to promote economic development have focused on infrastructure as a magnet for firm location, often with little regard for the characteristics of specific industries. This study has sought to advance the state of knowledge of the relationship between transportation and

This study was funded with a grant from the Minnesota Department of Transportation through the University of Minnesota's Center for Transportation Studies.

Competitiveness Review
Vol. 26 No. 1, 2016
pp. 25-40

1059-5422
DOI 10.1108/CR-03-2015-0018

economic development by investigating how firms in specific industry clusters use transportation networks and what role those networks play in the competitiveness of industry clusters. The approach combines quantitative and qualitative techniques to geographically identify competitive industry clusters in Minnesota's metropolitan and micropolitan regions and to further investigate the role of transportation in these industry clusters through in-depth interviews and site visits with representatives of firms in specific industry clusters. These methods can yield valuable insights into how transportation functions as an input within industry clusters and how it can inform economic development strategies tailored to certain locations and industries.

This study helps to understand both the complexity of the Minnesota economy and the role that transportation plays in the state's economic competitiveness. The competitive clusters examined provide a snapshot of how Minnesota companies in various metropolitan and micropolitan regions of the state are handling transportation costs, managing their supply chains and meeting the expectations of their customers. In addition, the study provides some insights into how the transportation system affects the workforce recruitment and accessibility for some highly competitive industry clusters such as health care in Rochester, MN (the Mayo Clinic) and recreational vehicles in northwest Minnesota (Polaris, Arctic Cat).

Transportation, agglomeration and industry clusters

A critical way in which transportation infrastructure may foster economic development is through its ability to foster agglomerations, that is, clusters of firms in related industries. Improved transportation networks can provide an environment in which firms can take advantage of proximity to other firms in the same industry (localization effects), as well as access to larger and more diverse markets (urbanization effects). Especially within urban areas, transportation infrastructure may represent a shared input that can be used by large numbers of firms in their respective production processes. This same infrastructure may increase access to skilled labor, thus increasing the returns to firms in a given location. While there has been a large amount of empirical research conducted on the relationship between public infrastructure (including transportation) and economic growth (Eberts and McMillen, 1999; Weisbrod, 2008), much of this research has been conducted using data aggregated to large spatial units, such as counties, metropolitan areas or even entire states, and thus can offer only limited insights into how transportation is actually used by firms in various industries. Indeed, in the field of urban economics, the nature and sources of agglomeration economies, including low transportation costs, are a major focus of ongoing research (Venables, 2007; Graham, 2007a, 2007b; Rosenthal and Strange, 2004; Puga, 2010).

The parallel concept to agglomeration in urban economics is the concept of industry clusters in the fields of economic development and public policy. There remains much to be known about how comparative advantage across locations, along with complementary factors, translates into the formation of successful, competitive industry clusters. Textbook-length treatments of the subject, including the work of Michael Porter (Porter, 1996, 1998), have sought to frame the topic in terms of core aspects of competitiveness in private industry, industrial location and solutions to societal problems as a source of competitiveness. Porter's work on industry clusters proposes a framework for describing the elements of competitive advantage by grouping them into four sets of factors:

(1) demand conditions;
(2) related and supporting industries;
(3) context for firm strategy and rivalry; and
(4) factor (input) conditions.

While the framework makes reference to a "common innovation infrastructure" (Porter, 2001), there is no explicit reference to the role of transportation infrastructure and hence little guidance as to how transportation policy might support cluster development. This characteristic vagueness is a common criticism of Porter's framework and of industry cluster policies more broadly (Martin and Sunley, 2003; Duranton, 2011; Ketels, 2013).

The nature of the literature on industry clusters, with some notable exceptions (Delgado *et al.*, 2010; Sasson and Reve, 2015) tends toward a more qualitative approach, emphasizing a more in-depth understanding of industry linkages (Titze *et al.*, 2011), the behavior of individual firms within competitive industry clusters, and elements of industrial organization (Kubis *et al.*, 2012). Thus, it seems reasonable to investigate the role of transportation networks and transportation policy in supporting the growth of clusters in the same fashion. Similar qualitative approaches have also been applied to other types of industry-specific studies, such as those investigating the transportation needs of high-technology industrial development (Toft and Mahmassani, 1984; Mahmassani and Toft, 1985; Button, 1988a, 1988b). Focusing on specific representative firms may be necessary, as it is often difficult to find data on firm- or industry-level interactions at anything other than an aggregate level (as is the case with regional input-output tables), but also because it allows for a deeper level of response to questions about firms' behavior and greater context than is available through survey methods.

Industry clusters have taken on a new life in the USA since the housing and financial collapse in 2008 and the subsequent deep recession. This has led to an increased interest in "the more grounded, day-to-day interactions by which real companies in real places complete transactions, share technologies, develop innovations, start new businesses and locate employees" (Muro and Katz, 2011).

Selection of industry clusters

For this analysis, the University of Minnesota team produced a matrix showing cluster employment location quotients for the 8 metropolitan and 17 micropolitan regions located within or partially within Minnesota. The cluster matrix included 66 traded and local clusters using 2011 US Cluster Mapping data developed by the Harvard Business School's Institute for Strategy and Competitiveness led by Professor Michael Porter for the US Economic Development Administration (Economic Development Administration, 2014).

A location quotient measures the share of an industry cluster's employment in a region as a ratio of the share of the cluster's employment in the USA as a whole. This generates an indicator of industry concentration or specialization within a region. A higher location quotient significantly exceeding one can be an indicator of that an industry cluster is exporting its products or services outside of the region and is referred to as a traded cluster. Local industry clusters that serve a regional market such as restaurants or retail stores tend to have location quotients close to one. A high location quotient may also be an indicator of the competitiveness of a regional industry cluster, and a rising or declining location quotient may indicate that a regional cluster is

becoming more or less competitive within the US economy. However, more information is required about productivity and innovation within the cluster to confirm the competitiveness of a regional cluster.

Other, more sophisticated cluster identification techniques have been proposed, such as a three-step method outlined by Spencer *et al.* (2010) which emphasizes cluster characteristics such as specialization, co-location, scale, scope and concentration. However, this approach uses a more detailed industry-level disaggregation and thus is targeted toward larger metropolitan areas. In light of our analysis including several smaller micropolitan regions within the state, a simpler definition was used that would allow for greater data availability and consistency.

The matrix with 25 regions and 66 clusters resulted in a total of 1,650 cells, each indicating a regional/cluster pair. A location quotient threshold of 1.3 was used as an indicator of whether a cluster is competitive within its region. Based on this approach, the study team identified 401 regional clusters that met this criterion.

A technical advisory panel (TAP) made up of Minnesota Department of Transportation (MnDOT) and Minnesota Department of Employment and Economic Development staff identified 12 regional cluster pairs for interviews and further analysis. The TAP chose to select 12 different clusters throughout the state, rather than selecting the same cluster for multiple regions or many clusters for the same region. In addition, three additional clusters were studied by students as team projects for a Humphrey School course on Economic Competitiveness during the 2013 fall semester. The selected clusters and locations are shown on the map in Figure 1.

The clusters differed in that some were statewide with high location quotients in most of the 25 Minnesota regions; other clusters were strong in a multiple regions but not most regions; and some were strong clusters in single regions.

Statewide clusters: processed food, heavy machinery

Processed food is a statewide cluster with 21 of 25 Minnesota metropolitan and micropolitan regions having location quotients of 1.3 or higher. The state employed 30,098 in the processed food cluster in 2011 with an average annual wages of $48,221. The statewide location quotient for processed food is 1.52. The processed food industry in Minnesota includes major food industry leaders such as Cargill, Hormel, General Mills, Jennie-O and Schwans. The processed food cluster is highly dependent on a reliable and smooth road system to move live animals for processing and to move perishable processed food by truck on a timely basis. The cluster also relies on rail transport to reach coastal and international markets.

Heavy machinery has strong concentrations in 19 of the 25 Minnesota regions. Production technology and heavy machinery provided 28,672 jobs with an average annual wage of $56,491 in 2011. The statewide location quotient for this cluster was 1.53 in 2011. An example of a Minnesota heavy machinery company is AGCO, an agricultural equipment manufacturer. AGCO's plant in Jackson, Minnesota, near I-90, employs 1,350 to 1,400 people and assembles farm equipment – tractors, sprayers and spreaders. AGCO relies on good access to the interstate system to move supplies for the assembly of equipment and to move assembled equipment to markets throughout the USA.

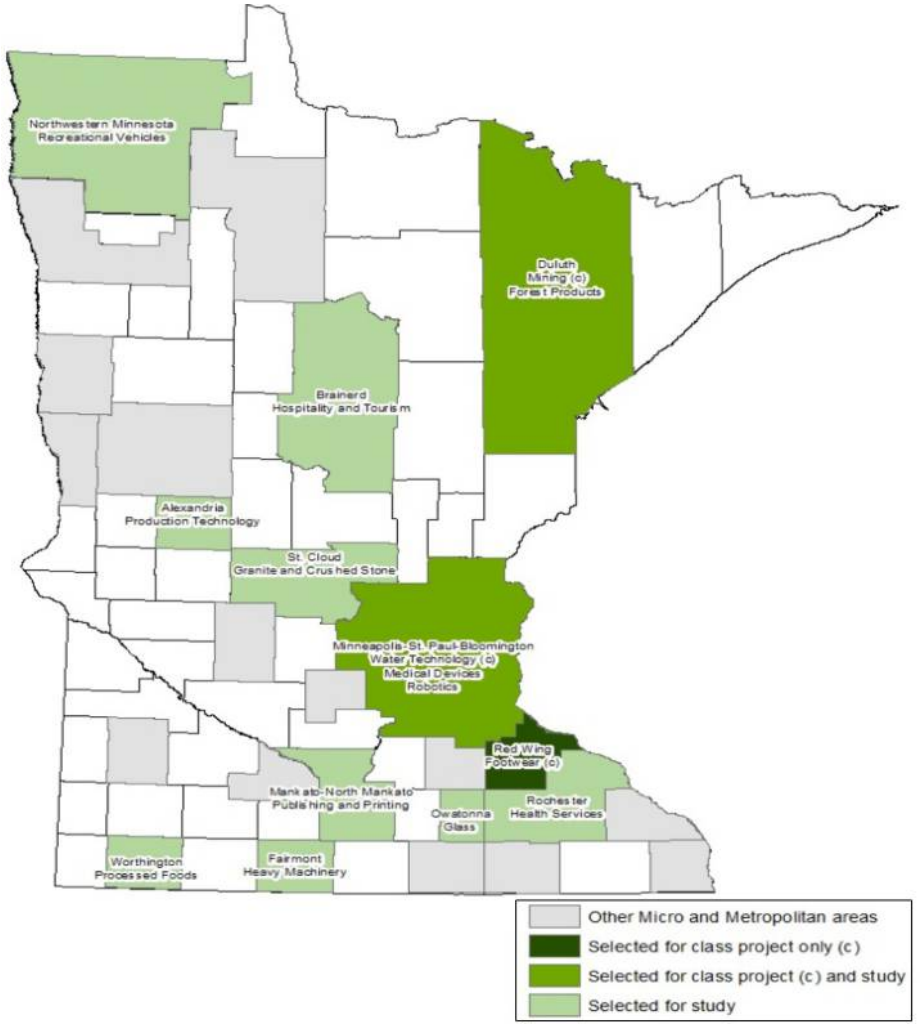

Figure 1.
Selected industry clusters

Multi-region clusters: health services, forest products, hospitality and tourism, medical devices

Health services are usually considered a local cluster, as they serve the local population. However, 13 of Minnesota's 25 regions have location quotients of 1.3 or higher, indicating that the health service industry in these regions is serving populations beyond the region and could be considered a traded cluster. One Minnesota region in particular, Rochester, Minnesota, is the home of the Mayo Clinic, which serves much of southern Minnesota and southwest Wisconsin, but also is a tertiary health provider for the US and international patients. Rochester is a small metropolitan region located about 80 miles south of the Minneapolis – St. Paul (MSP) region. The Mayo Clinic faces transportation challenges in terms of bringing in patients, employee transportation,

emergency response, supply chain management and daily air transport of samples for lab testing. The State of Minnesota is making a $500 million investment in Rochester to improve its downtown and make it a more competitive location. The Mayo Clinic itself is planning a $5 billion investment in its Rochester location.

Forest products have a strong employment concentration in ten of Minnesota's 25 regions. NewPage is a paper manufacturer in Duluth that produces supercalendered paper used for catalogs, magazines, advertising inserts, flyers and other commercial printing. The company located this plant in Duluth in 1987 in part to take advantage of rail service but has had to reduce its reliance on rail from 80 to 50 per cent due to availability of the types of rail cars needed for moving large rolls of paper. The company is interested in future intermodal opportunities for transporting paper from Duluth.

Publishing and printing is a strong industry in Minnesota although the printing industry continues to be challenged by digital media alternatives. In 2011, there were 23,638 employees in Minnesota's printing industry with annual wages of $48,236 and a location quotient of 2.29. Ten of Minnesota's 25 regions have location quotients of 1.3 or higher for publishing and printing. Taylor Corporation is a family of companies headquartered in Mankato with over 80 subsidiaries located throughout the USA, Canada, Mexico and parts of Europe and Asia. While the company has expanded over time into areas such as marketing, packaging and retail solutions, the bulk of its sales tends to be concentrated among published and printed products, including business cards, children's books and wedding invitations. Timeliness of shipments is a critical transportation issue for Taylor, as it allows them to maintain lower inventory levels. Shorter lead times made possible by this and other logistics improvements gives them an advantage over their competitors.

Hospitality and tourism employs 52,779 in Minnesota with average annual wages of $32,091. While the statewide location quotient is 0.84, six of Minnesota's regions have location quotients of 1.3 or higher. The Brainerd Lake region is a popular summer tourist destination with 2,378 jobs and a location quotient of 2.64 in 2011. The Brainerd area is known for its resorts – Grand View Lodge, Madden's Resort and Cragun's Resort. These resorts rely on good road access for customers as well as suppliers of food and other hospitality essentials. Grand View lodge sees opportunities for attracting more customers from North Dakota with the increased wealth from the oil boom.

Minnesota has 22,637 jobs in the *medical device* cluster with average annual wages of $73,624 and a location quotient of 2.48. Five of the 25 regions in Minnesota have location quotients of 1.3 or higher. Medical devices are perhaps the premier industry cluster in the MSP region, with a location quotient of 3.96. Medtronics, Boston Scientific, St. Jude, Starkey Labs, among others, have major operations in the region. The medical device cluster relies heavily on air transportation for shipping its products.

Single-region clusters: granite, glass, shoes, recreational vehicles, mining

Five clusters had high employment concentrations in a single region of the state. The *granite* industry in St. Cloud is part of the cut and crushed stone subcluster of construction materials, with a location quotient of 10.32. Cold Spring Granite provided the granite for major monuments such as the Franklin Delano Roosevelt and Martin Luther King memorials in Washington, DC, as well as for the World Trade Center in New York City. Fuel costs and reliable shipping are critical for Cold Spring Granite. I-94 is the primary route for moving granite to Cold Spring for production and finished

product to customers. Cold Spring and other granite companies in the St. Cloud use black granite from China and laser-etched headstones from India. This granite is shipped by boat to Tacoma, Washington, by rail to the Twin Cities and by truck to St. Cloud. Rail delays due to the Williston oil boom and bad weather have slowed these shipments recently.

The *glass* industry in the Owatonna-Faribault-Northfield region in southeast Minnesota employs 1,925 people and has a location quotient of 124.62. Several firms provide a variety of high-value glass treatments that are marketed primarily to commercial clients around the USA and overseas. These operations account for a significant share of regional employment in the USA, with the industry directly employing over 10 per cent of the region's total employees. The largest single company in the glass cluster is Viracon, an Owatonna-based architectural glass fabricator which is the city's second-largest employer with 1,446 local employees. Timely delivery of its finished product is a major issue for Viracon. As many of its customers are developers of commercial properties and general contractors, delays in the delivery of its product can result in delays for construction projects as a whole and higher construction costs.

The *recreational vehicle* industry in northwest Minnesota is a very competitive industry with a location quotient of 17.22. The snowmobile industry led by Polaris and Arctic Cat has moved into other recreational vehicles and has experienced rapid growth in recent years. The sparsely populated area of the state relies on a high-quality workforce and a strong transportation and logistics system to respond to customer demand in a global market. Workforce shortages as well as capacity constraints in transportation and logistics are becoming challenges for the two companies, as they experience growth and increased global demand.

Red Wing Shoe Company is unique to the *footwear* industry because it is one of the few companies that still manufactures shoes in the USA. Although the future competitive vision involves expanding to global markets, domestically, Red Wing Shoes is still the preferred boot for many workers in the construction, manufacturing and transportation industries. Unlike other US-based companies that manufacture their product abroad, Red Wing Shoes follows OSHA (Occupational Health and Safety Administration) standards for safety (steel toes, leather and sole thickness), and its boots are the preferred brand for many laborers. Many union contracts, for example, stipulate that Union Laborers are allowed two new Red Wing Shoes boots each year, paid for by the company they work for. These contracts make up the majority of business for the shoe company.

The iron deposits in the Duluth Complex along the Mesabi Iron Range in northeastern Minnesota are rich with high-quality deposits of iron ore. This abundance of material underpins the competitive advantage of the *mining* industry in Minnesota, creating opportunities for the development of an economy for an entire quadrant of the state based on the ability to extract minerals from a relatively narrow scratch of the earth's surface. Rail and water transportation are critical components for the mining industry in northern Minnesota and will continue to be important, as new mining activities are developed in the region.

Transportation and logistics cluster

As a major hub for transportation networks in the Upper Midwest, the MSP MSA has developed a significant industry cluster focused on *transportation and logistics*

activities. A large component of this industry cluster (63 per cent, as measured by employment) is a subcluster focused on air transportation, owing to the region being home to a major international airport and a hub for Delta Airlines. Another significant subcluster encompasses activities related to transportation arrangement and warehousing. The transportation and logistics industry cluster employed over 28,000 workers in the Twin Cities region alone in 2011, with average wages exceeding $54,000.

Two major firm involved in transportation and logistics are C.H. Robinson and FedEx. C.H. Robinson Worldwide, Incorporated, is a major third-party logistics provider, offering freight transportation and logistics, outsourcing services, produce sourcing and information services to customers through a network of offices on five continents. The services offered to clients range from traditional brokerage services (e.g. spot market and surge capacity services) to more integrated logistics and information services.

FedEx Corporation is one of the world's largest integrated transportation and logistics companies, providing services to shippers, ranging from express courier services to ground transport and supply chain services. FedEx actively attempts to improve its competitiveness by expanding the reach of its networks and the variety of services it provides. This can also include identifying potential customers within existing markets. For example, in the Twin Cities region, FedEx works with companies in the Life Sciences and Medical Devices industries to provide transportation and related services.

Findings from industry cluster firm interviews

Having identified competitive clusters in metropolitan and micropolitan regions, the next phase of the study involved face-to-face interviews with representative firms in each regional industry cluster. For each cluster, the larger, more dominant firms were contacted first and made a priority for interviews. Subject to the willingness of larger firms to participate, two or more firms from each cluster were chosen for interviews. The one exception to this practice was the Mayo Clinic in Rochester, MN, which comprises most of the health services cluster in that region. Mayo is such a large organization that separate interviews were conducted with each of five operating divisions within the organization.

The purpose of the interviews was to ask in-depth questions about each firm's location decisions and its operations, specifically as they relate to its transportation and supply chain functions. The questions were grouped under broad themes, including general questions about the firm's size and primary products, current and previous location considerations, the locations of customers and suppliers, competitors and use of transportation in its operations.

Critical questions were those relating to the firms' use of transportation services and the unique transportation issues encountered on an ongoing basis. Table I provides a summary of responses to several of the transportation-related questions from firms in each industry cluster. In addition to highlighting critical transportation issues found in each industry cluster, the table contains information about the primary freight modes used by firms in that cluster, service characteristics prioritized by firms in choosing carriers and modes, along with the number of regions within the state where the cluster is specialized (using the criterion of a location quotient greater than 1.3 as discussed earlier).

Table I. Summary of transportation characteristics of firms in competitive industry clusters

Industry cluster	Transportation issues	Primary freight modes used	Important service characteristics	No. of MN regions in which cluster is specialized
Construction materials (granite)	Varying state regulations, customs delays and fuel costs	Truck (flatbed), rail, water	Reliability, safety	1
Forest products	Rail capacity and equipment, need for intermodal facilities	Truck, rail	Cost, transit time, reliability	10
Glass	Specialized carrier availability, labor access and weather delays	Truck, water, air	Cost, reliability, transit time	1
Health services	Regional air access, reliability of shipments and improved air navigation	Air, truck	Reliability, safety	13
Heavy machinery	Road conditions, truck availability and weather-related delays	Truck, water, rail	Cost, reliability	19
Hospitality and tourism	Regional air access and highway access from points west	Truck	Reliability, transit time	6
Medical devices	Airport access, congestion delays and shipment reliability	Air, truck	Safety, reliability, cost	5
Printing and publishing	Weather-related delays and customs delays	Truck (LTL and small parcel), water	Cost, reliability, transit time	10
Processed food	Carrier availability, shipment reliability and regulatory consistency	Truck (truckload), rail, water	Safety, transit time	21
Recreational vehicles	Weather-related delays, infrastructure condition and carrier availability	Truck, water, rail	Cost, reliability, safety	1
Robotics	Speed of shipments	Truck (LTL and small parcel), air, water	Cost, transit time	1
Transportation and logistics	Congestion delays, infrastructure condition and carrier availability	Truck, air, rail, water	Safety, reliability	4

Some of the transportation issues identified among the different clusters in Table I are not within the control of organizations responsible for the provision and maintenance of transportation infrastructure. For example, the availability of freight carrier capacity, whether due to geographic isolation or to seasonal variations in output levels, is an issue that is typically resolved between private carriers, shippers and any third-party logistics firms. Other issues like severe weather, which can impair or result in complete closure of some parts of transportation networks, are essentially exogenous events, though transportation organizations can respond by increasing maintenance efforts and providing up-to-date information about the condition of the network.

Weather-related delays are one type of issue that relates more broadly to concerns about reliability of shipments. Other factors affecting reliability include short-term events like recurrent congestion on urban highway networks or at major freight facilities, construction-related delays and, for international shipments, delays in clearing customs at major port facilities.

Several firms also cited condition of infrastructure, particularly roadways, as an area of concern. Apart from concerns about higher operating costs for carriers due to pavement roughness, some of the firms interviewed noted that products they shipped were fragile (for example, treated glass) and required special packaging or handling to avoid costly damage.

Information about the modes used most frequently by firms in each cluster to ship and receive products largely reflects patterns of freight mode use at the national level. Nearly, every firm interviewed makes relatively intensive use of truck freight carriers to ship their products, though there is some variability in the types of truck services used. Only a couple of larger firms made frequent use of truckload services, while smaller firms typically used either less-than-truckload carriers, small parcel services or some combination of each. Many of the firms interviewed ship to overseas customers via ocean freight carriers, with air shipments reserved for time-sensitive express shipments or higher-valued goods. The medical devices and health services industries are examples of industries that rely more heavily on air freight. Industries making greater use of rail freight services include industries that rely on shipments of bulky raw materials, such as the forest products and construction materials clusters, along with industries with relatively heavy finished goods such as the heavy machinery and recreational vehicles industries.

Finally, the interviewed firms were asked to prioritize several characteristics of freight services to get a sense of the relative importance of different characteristics to shippers in each industry. Reliability and cost of shipments were the two characteristics cited most frequently as the most important shipping consideration across a variety of industries. Safety was also cited by several industries whose products were more vulnerable to damage or perishability, including medical devices, health services, processed food, and construction materials and glass. The relative rankings of these characteristics seemed to largely reflect the nature of the product or service being provided.

Minnesota transportation issues and economic competitiveness

Minnesota is centrally located within the USA, with rich natural resources of water, minerals, agriculture and forest products, but with a relatively small market with 2 per cent of the US population. The region is a global business hub with a high concentration

of corporate headquarters and managerial and professional talent located in the MSP region.

The competitiveness of the Minnesota economy in a global marketplace is dependent on a well-functioning transportation system in all modes – truck, air, rail and water:

- Access to global markets requires rail and truck to reach coastal ports.
- Air transportation is critical for high-value, low-weight, time-sensitive products such as medical devices or Mayo lab testing samples.
- Air service is important for customers at MSP, St. Cloud, and Rochester, Duluth, as well as other Minnesota cities.
- Highway access and reliability is critical for key statewide clusters such as processed food and heavy machinery.

Minnesota has a diverse set of talent-driven traded industry clusters that provide products and services nationally and globally. The state's central location in the continental USA requires a robust multimodal transportation system, including trucks, air, rail and water freight modes. All of these clusters rely on trucks for "last mile" as well as long-distance deliveries of supplies and customer products on a reliable, timely and cost-effective basis. By and large the Minnesota system of roads is working well for Minnesota companies, but the system needs to be consistently maintained and improved to assure the future competiveness of these companies.

For future competitiveness, Minnesota's transportation system will require new and ongoing investments to assure reliable, safe and quality road access for Minnesota companies and their employees, to establish new intermodal connections and to maintain, replace and make needed improvements in existing transportation. In addition, Minnesota's special winter weather challenges require continuous improvements in MnDOT's 511 weather information and operational systems, as well as public and private technology and system improvements.

Minnesota's economy is more dependent on rail than other states.

Minnesota's rail transportation share of gross state product (GSP) has been about 40 per cent higher than the USA rail share of gross domestic product from 1997 to 2011 (Figure 2). With US population more concentrated in the east and major ocean ports providing access to global markets on the east and west coast, rail is a particularly important transportation mode for key Minnesota industries such as agriculture, processed food, mining, and paper and forest products.

Air transportation is relatively more important to Minnesota's economy than other states, with a 40 per cent higher GDP share than the USA as a whole. Minnesota's air transportation GSP share has declined significantly since 2001 when it was 140 per cent higher than the US average, perhaps in part because of the Northwest Airlines/Delta merger and shift of the company headquarters to Atlanta. Minnesota clusters, where air transportation is particularly important, are the medical devices cluster in the MSP region and health care (Mayo Clinic) in Rochester. However, the MSP international airport and regional air transportation systems are important to other industry clusters as well. The MSP region has a large concentration of corporate headquarters, with 19 of the Fortune 500 firms located in the region, including 3M, Target, General Mills, United Health, among others. These international firms require access to a strong international airport.

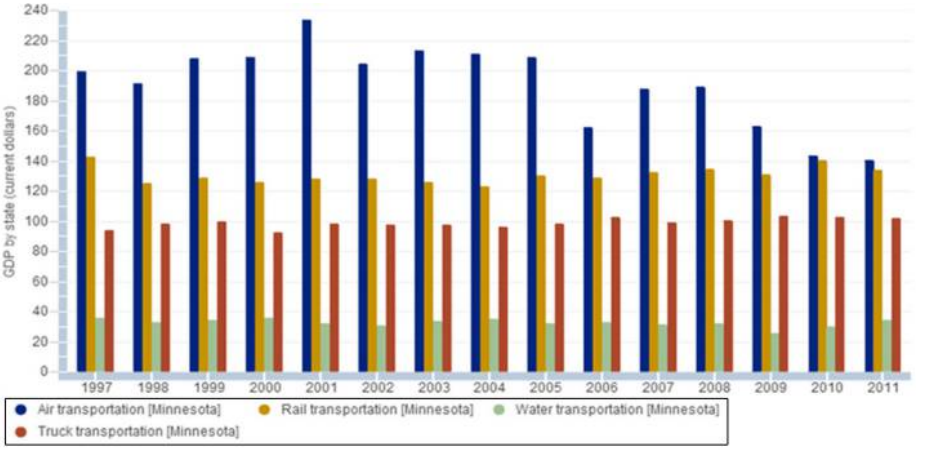

Figure 2.
Minnesota's GDP share specialization by transportation mode, 1997 to 2011

Source: US Bureau of Economic Analysis

Water transportation is limited in Minnesota, although the state has significant ports in Duluth and on the Mississippi River. Minnesota's water transportation share is 40 per cent of the national average. As water transportation is the most cost effective mode in transporting products globally, Minnesota depends on rail, trucks and intermodal transportation to reach global markets and suppliers. Mining in northeastern Minnesota relies on the Duluth port in exporting through the Great Lakes.

Winter weather poses special challenges for Minnesota economic competitiveness. Rail delays during severe winter adversely affect the granite industry cluster in St. Cloud and the paper cluster in Duluth. Air transport disruptions due to weather at the Rochester airport have imposed significant delays and costs to Mayo Clinic in timely delivery of lab samples from throughout the US Road network disruptions and delays due to weather adversely affect processed food, recreational vehicles and other clusters critical to the Minnesota economy.

Implications for transportation policy, planning and implementation

Industry cluster mapping and analysis can be a useful tool for transportation planners and policymakers. These are a few areas where a cluster-based approach could enhance transportation planning.

Statewide freight planning

As states update their freight plans, information about which industry clusters are most important to the state economy and specific information about how transportation costs influence cluster competitiveness could help in framing these plans. This information can deepen the analysis that goes into developing the freight plans and provide a more specific set of priorities based on ensuring that transportation investments support future cluster competitiveness.

Regional transportation strategies

While a few competitive clusters are statewide in scope, many of the clusters analyzed in this study were competitive in just one or a few regions of the state. Regional transportation leaders may find the cluster approach useful in developing regional transportation plans and in improving transportation services to support the competitiveness of regional businesses. Metropolitan planning organizations could also use a cluster approach in prioritizing transportation investments to address workforce-related transportation issues and freight issues. These regional organizations may also influence the land-use/transportation issues that could affect the competitiveness of regional clusters.

Transportation investments to promote economic competitiveness

States could use a cluster mapping and an industry cluster approach as a means of identifying and prioritizing targeted investments to promote economic competitiveness. For example, Minnesota has a collaborative Transportation Economic Development program which provides state funding to close financing gaps for transportation infrastructure improvement construction costs. Criteria for funding under this program might include a demonstration that the funding will improve the competitiveness of a critical statewide or regional cluster or clusters.

Intermodal connections and investments

Cluster mapping and interviews may help in surfacing opportunities to reduce transportation costs and expand capacity to support competitive clusters through improved intermodal connections between roads, rail, water and air. Strategic investments or policy decisions to make rail, water or air transportation more accessible, less costly or more reliable could enhance the competitiveness of important clusters to a region.

Public-private partnerships and collaboration

A systematic approach to analyzing and reaching out to competitive regional clusters may lead to new collaborations among transportation professionals and industry cluster leaders, improving the effectiveness of transportation services and making more strategic transportation investments. The increased public-private collaboration may also encourage greater collaboration among public agencies that is necessary in addressing the transportation challenges identified through the cluster-based process.

Transportation networks and cluster policy

As the preceding set of case studies from industry clusters in Minnesota illustrates, transportation networks play a critical role in the competitiveness of clusters of a variety of sizes and industrial bases. The evidence that emerged from the interviews with firms in competitive clusters suggested a heterogeneous set of needs among different clusters in terms of their use of different modes, freight services and information about system performance. There were also some common themes across clusters, such as the importance of network reliability and the provision of advance information in the event of potentially disruptive events such as construction projects or severe weather.

The approach taken in this study was necessarily somewhat exploratory due to the limited amount of previous research linking transportation with industry cluster policy. Indeed, the relative newness of the latter and the considerable debate that has followed

regarding its direction and purpose seem to have precluded its extension into related areas such as transportation planning and infrastructure policy more broadly.

Thus, there are opportunities to expand the base of knowledge regarding transportation networks and cluster policy. Among the most urgent needs in this area is a more thorough articulation of how transportation infrastructure fits within a broader conceptual framework of cluster emergence. Is it merely to be treated as a common production factor, or are there ways in which networks and services can be configured so as to confer advantages on firms in specific clusters? What role do freight systems play relative to passenger travel?

Another issue which might be further explored is the role of transportation in the linkages between industries. While our study focused solely on firms within clusters of a single industry, an important concept in the measurement and identification of clusters is the co-location of firms in related industries and the linkages between them. Can transportation networks facilitate these kinds of linkages? Are there thresholds of transportation cost below which they might emerge? Are there common patterns of transportation demand among co-locating firms or industries within a cluster?

Finally, once a basic framework is established through which transportation networks can be conceptualized as a factor in the growth of clusters, empirical tests of several of these questions should proceed. Improvements in the quality of data, especially the availability of firm-level microdata, along with better, more rigorous techniques for defining clusters should facilitate this process. As noted before, empirical examinations of other aspects of cluster policy (such as entrepreneurship) have begun to emerge, along with some direct tests of the effectiveness of extant cluster policies (Falck *et al.*, 2010).

Conclusion

This study demonstrates the potential for practical applications of an industry cluster approach in both understanding the transportation needs of firms within competitive industry clusters and in understanding the role that transportation networks and services play in supporting the development of such clusters.

The study approach of looking at industry clusters in different regions of the state and differentiating between single-industry clusters, multi-region clusters and statewide clusters indicates that different lessons may be drawn from each. For example, the transportation needs of firms in competitive industry clusters found throughout a state may help transportation planners develop broad-based policies relating to freight movement or maintenance operations. On the other end of the spectrum, examination of firms in single-industry clusters may yield insights about policies which are highly specialized and locally targeted, such as efforts to improve regional airline service. The study also highlights other policy areas that might be informed by an industry cluster-based approach, including intermodal freight connections and opportunities for collaboration between transportation agencies and local industry stakeholders on funding and investment decisions.

Despite its promise, the industry cluster approach is not without limitations, and any prospective user of this approach should be aware of them. First, the industry cluster approach, as originally conceived, focused on countries, states and larger urban areas with generally more diverse economies. As adopted in this study, a cluster approach is applied not only to larger urban areas but also to regions that meet the US Census

definition of a micropolitan area. This increases the chances that a competitive industry cluster, as defined here, may be dominated by a single large firm or very small number of firms, rather than the larger, more robust clusters of firms found in metropolitan economies.

Second, the approach of interviewing firms in competitive industry clusters is limited in terms of its generalizability. Due to resource constraints and the time and labor-intensive process of conducting interviews, it is often not possible to interview more than a couple of firms in a given industry cluster. This raises concerns about the representativeness of the firms chosen relative to their industry as a whole. The firms that are ultimately chosen may vary considerably from others classified within the same cluster in size of operation or type of product being produced.

Third, this study uses industry employment as a basis for identifying clusters as competitive. While employment generally tends to correlate reasonably well with other measures of economic activity, there may be some industries for which other types of measures are preferable. Examples include manufacturing industries that have increased their productivity and become relatively less labor-intensive over time. Employment as a measure of activity might overstate the decline in competitiveness in the industry over time, relative to another measure such as industry earnings which might give a better sense of the industry's degree of export orientation and overall competitiveness.

References

Button, K.J. (1988a), "High-technology companies: an examination of their transport needs", *Progress in Planning*, Vol. 29 No. 2, pp. 77-146.

Button, K.J. (1988b), "Transport demands of Scotland's high-technology industries", *Journal of the Transportation Research Board*, No. 1197, pp. 35-44.

Delgado, M., Porter, M.E. and Stern, S. (2010), "Clusters and entrepreneurship", *Journal of Economic Geography*, Vol. 10 No. 4, pp. 495-518.

Duranton, G. (2011), "California dreamin': the feeble case for cluster policies", *Review of Economic Analysis*, Vol. 3 No. 1, pp. 3-45.

Eberts, R.W. and McMillen, D.P. (1999), "Chapter 38: agglomeration economies and urban public infrastructure", in Mills, E.S. and Cheshire, P. (Eds), *Handbook of Regional and Urban Economics*, Elsevier, Amsterdam, Netherlands, Vol. 3, pp. 1455-1495.

Economic Development Administration (2014), *US Cluster Mapping Project*, Led by Harvard Business School's Institute for Strategy and Competitiveness, available at: http://clustermapping.us/ (accessed 19 March 2015).

Falck, O., Heblich, S. and Kipar, S. (2010), "Industrial innovation: direct evidence from a cluster-oriented policy", *Regional Science and Urban Economics*, Vol. 40 No. 6, pp. 574-582.

Graham, D. (2007a), "Agglomeration, productivity, and transport investment", *Journal of Transport Economics and Policy*, Vol. 41 No. 3, pp. 317-343.

Graham, D. (2007b), "Variable returns to urbanization and the effect of road traffic congestion", *Journal of Urban Economics*, Vol. 62 No. 1, pp. 103-120.

Ketels, C. (2013), "Recent research on competitiveness and clusters: what are the implications for regional policy?", *Cambridge Journal of Regions, Economy and Society*, Vol. 6 No. 2, pp. 269-284.

Kubis, A., Brachert, M. and Titze, M. (2012), "Economic structure and regional performance in Germany, 2002-2007", *European Planning Studies*, Vol. 20 No. 2, pp. 213-229.

Mahmassani, H.S. and Toft, G.S. (1985), "Transportation requirements for high technology industrial development", *ASCE Journal of Transportation Engineering*, Vol. 111 No. 5, pp. 473-484.

Martin, R. and Sunley, P. (2003), "Deconstructing clusters: chaotic concept or policy panacea?", *Journal of Economic Geography*, Vol. 3 No. 1, pp. 5-35.

Muro, M. and Katz, B. (2011), "Chapter 5: The new 'cluster moment': how regional innovation can foster the next economy", in Libecap, G.D. and Hoskinson, S. (Eds), *Entrepreneurship and Global Competitiveness in Regional Economies: Determinants and Policy Implications*, Advances in the Study of Entrepreneurship, Innovation and Economic Growth, Vol. 22, Emerald, Bingley, pp. 93-140.

Porter, M.E. (1996), "competitive advantage, agglomeration economies, and regional policy", *International Regional Science Review*, Vol. 19 No. 1, pp. 85-94.

Porter, M.E. (2001), "Innovation: location matters", *MIT Sloan Management Review*, Vol. 42 No. 4, pp. 28-36.

Porter, M.E. (1998), *On Competition*, Harvard Business School Press, Boston, MA.

Puga, D. (2010), "The magnitude and causes of agglomeration economies", *Journal of Regional Science*, Vol. 50 No. 1, pp. 203-219.

Rosenthal, S.S. and Strange, W.C. (2004), "Chapter 49: evidence on the nature and sources of agglomeration economies", in Henderson, J.V. and Thisse, J.F. (Eds), *Handbook of Regional and Urban Economics*, Elsevier, Amsterdam, Netherlands, Vol. 4, pp. 2119-2171.

Sasson, A. and Reve, T. (2015), "Complementing clusters: a competitiveness rationale for infrastructure investments", *Competitiveness Review*, Vol. 25 No. 3, pp. 242-257.

Spencer, G.M., Vinodrai, T., Gertler, M.S. and Wolfe, D.A. (2010), "Do clusters make a difference? Defining and assessing their economic performance", *Regional Studies*, Vol. 44 No. 6, pp. 697-715.

Titze, M., Brachert, M. and Kubis, A. (2011), "The identification of regional industrial clusters using qualitative input-output analysis (QOIA)", *Regional Studies*, Vol. 45 No. 1, pp. 89-102.

Toft, G.S. and Mahmassani, H.S. (1984), "Transportation and high technology economic development", *Journal of the Transportation Research Board*, No. 984, pp. 22-29.

Venables, A. (2007), "Evaluating urban transport improvements: cost-benefit analysis in the presence of agglomeration and income taxation", *Journal of Transport Economics and Policy*, Vol. 41 No. 2, pp. 173-188.

Weisbrod, G. (2008), "Models to predict the economic development impact of transportation projects", *Annals of Regional Science*, Vol. 42 No. 3, pp. 519-543.

Corresponding author
Lee W. Munnich can be contacted at: lmunnich@umn.edu