USDOT Region V Regional University Transportation Center Final Report

NEXTRANS Project No. 078PY04

Exploring the Opportunities and Barriers to Intermodal Rail Freight

By

Yuntao Guo
PhD Student of Civil Engineering
Purdue University
guo187@purdue.edu

Srinivas Peeta
Professor of Civil Engineering
Purdue University
peeta@purdue.edu

Hong Zheng
Research Associate of NEXTRANS Center
Purdue University
zheng225@purdue.edu

and

Bruce Cox
Vice-President for Strategic Planning
TransWorks, Inc
Bruce.Cox@trnswrks.com

DISCLAIMER

Funding for this research was provided by the NEXTRANS Center, Purdue University under Grant No. DTRT07-G-0005 of the U.S. Department of Transportation, Research and Innovative Technology Administration (RITA), University Transportation Centers Program. The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.

USDOT Region V Regional University Transportation Center Final Report

TECHNICAL SUMMARY

NEXTRANS Project No. 078PY04 Final Report, April 30, 2014

Title

Exploring the Opportunities and Barriers to Intermodal Rail Freight

Introduction

Due to the effects of congestion and rising fuel costs, the need for green transportation and energy security, and the increasing revenue gaps to finance highway infrastructure construction and renewal, there is a critical need to explore the opportunities and barriers to rail-truck multimodal transportation paradigms involving all types of rail and truck assets in both modes. For truck freight carriers, the potential for the growing market also entails challenges such as increased highway congestion and energy consumption, and reduced operational safety, which can affect the reliability and competitiveness of truck freight carriers. In addition, truck driver shortage, high truck driver turnover rate, rising fuel cost, competition with rail freight carriers and third party logistics providers, and freight shippers' increasing focus on choosing eco-friendly carriers also limit the ability of truck freight carriers to seamlessly capture the steadily growing freight transportation market. For freight shippers, there is urgency for freight shippers to improve the reliability of their logistic system and reduce the supply chain costs. This project aims to explore freight shipper and truck freight carrier perspective in the United State (U.S.) on the factors that foster or impede their usage of rail-truck multimodal freight carriers.

Findings

Freight shippers and truck carriers have significant differences on the factors that foster or impede rail-truck multimodal freight collaboration. A freight shipper's primary mode of freight shipping and its primary shipping range have significant influence on the factors that foster and impede its usage of rail-truck multimodal freight carriers. The analysis suggests that a truck freight carrier's primary operational service range significantly affects its affiliation with the factors that foster or impede collaboration. Other significant characteristics on the operational side include the carrier's fleet size, cargo containerization level, and use of technology. Significant characteristics on the behavioral side include the carrier's confidence in rail freight carrier performance, and its attitude towards rail-truck multimodal freight collaboration.

Recommendations

The findings are useful for decision-makers to prepare a range of strategies to foster rail-truck multimodal freight collaboration based on freight shippers' operational and behavioral characteristics.

Also, the research provides new insights as previous related literature has not address the perspective differences between freight shippers and truck carriers and limited the collaboration to rail-truck intermodal freight collaboration.

Contacts

For more information:

Srinivas Peeta
Principal Investigator
Professor of Civil Engineering,
Purdue University
Ph: (765) 496 9726
Fax: (765) 807 3123
peeta@purdue.edu
www.cobweb.ecn.purdue.edu/~peeta/

NEXTRANS Center
Purdue University - Discovery Park
3000 Kent Ave
West Lafayette, IN 47906

nextrans@purdue.edu
(765) 496-9729
(765) 807-3123 Fax

www.purdue.edu/dp/nextrans

ACKNOWLEDGMENTS

The authors would like to thank the NEXTRANS Center, the USDOT Region V Regional University Transportation Center at Purdue University, for supporting this research.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. INTRODUCTION

1.1 Background and Motivation

The promise of economic growth and the trend of globalization have increased the demand of freight logistics. The estimated total U.S. business logistics costs were $1.33 trillion in year 2012, a 3.4 percent increase from year 2011, and accounting for 8.5% of the U.S. gross domestic product; and the freight transportation costs represented the largest costs (overall 60%) of the total logistics costs (Wilson, 2013). Truck-only freight transportation mode remains the primary freight transportation mode of freight shippers in U.S., and accounted for 68.5% share by weight of the freight market in year 2012 (ATA, 2013). And truck freight volume is expected to increase about 60% by 2040 compared to 2011 (United States Department of Transportation, 2013). However, the growing usage of truck-only carriers also entails challenges such as increased highway congestion and energy consumption, which can increase the cost of truck-only freight transportation and reduce its service reliability, thereby affect the competiveness of the freight shippers. Hence, the needs to improve transportation quality and reduce transportation costs are emerging focuses for freight shippers to expand their market coverage and strengthen their competitiveness in the market. In addition, truck driver shortage, the introduction of the new Federal Motor Carrier Safety Administration Hours of Services Rules in year 2013 (a theoretical 17% reduction in a standard work week), rising fuel cost, development of rail freight sector (capital spending for tracks and equipment increased 16.1% in year 2012) and freight forwarders, and increasing realization of social and environmental accountabilities also increase the need for freight shippers to leverage all modes of carriers to improve the service reliability and reduce the costs of transportation. One viable option for freight shippers is to consider an alternative freight transportation mode: rail-truck multimodal freight transportation. By doing so, freight shippers can potentially reduce shipping costs and improve service reliability. However, only 1% of the freight by weight is handled by rail-truck multimodal freight transportation (Bureau of Transportation Statistics, 2010), implying limited usage of rail-truck multimodal freight transportation by freight shippers.

1.2 Organization

This project is divided into four chapters. Chapter 2 describes the findings for the truck freight carriers. This study explores opportunities and barriers for truck freight carriers in the United States (U.S.) to enter the rail-truck multimodal freight transportation market, using stated preference survey data from truck freight carriers operating in the U.S. Midwest region. Based on the truck freight carrier perspectives on opportunities and barriers to rail-truck collaboration, three truck freight carrier market segments each are identified using cluster analysis that exhibit distinct factors that foster or impede collaboration. By understanding the operational and behavioral characteristics of the carriers in these segments, decision-makers can utilize their resources more efficiently and effectively by targeting different strategies for different segments to promote synergistic collaboration between rail and truck freight carriers. To do so, mixed logit models are developed to link a truck freight carrier's operational and behavioral characteristics to its factors that foster and impede rail-truck freight collaboration.

Chapter 3 presents the findings for the freight shippers. Due to the effects of congestion, rising fuel costs, truck driver shortage, and the need for green transportation, there is urgency for freight shippers to improve the reliability of their logistic system and reduce the supply chain costs. One viable option is to consider increasing the usage alternative freight shipping mode, naming rail-truck multimodal freight carriers. This paper aims to explore freight shipper perspective in the United State (U.S.) on the factors that foster or impede their usage of rail-truck multimodal freight carriers, while also comparing them with the perspective of truck carriers on the similar factors. This research provides an empirical analysis of freight shipper perspective of rail-truck multimodal freight collaboration from a survey of 169 freight shippers in U.S. while also comparing these findings to results from a survey towards truck carriers on similar factors.

In chapter 4, the policy insights for this project will be provided.

CHAPTER 2. FREIGHT CARRIER PERSPECTIVE

2.1 Introduction

Economic growth and globalization have led to dramatic increases in freight transportation demand, and the trend is expected to continue over the long term. The estimated total U.S. business logistics costs were $1.28 trillion in year 2011, a 6.6 percent increase from year 2010, and accounting for 8.5% of the U.S. gross domestic product; the freight transportation costs alone represented more than 60% of the total logistics costs (Burnson, 2012). The primary freight transportation mode is truck-only freight transportation, and accounted for 77% of the freight volume transported in year 2011 (Burnson, 2012). Truck freight by weight is projected to increase about 62% by 2040 compared to 2011 (United States Department of Transportation, 2013). Hence, the need to leverage opportunities to capture the increasing demand is an emerging focus for truck carriers. However, the potential for the growing market also entails challenges such as increased highway congestion and energy consumption, and reduced operational safety, which can affect the reliability and competitiveness of truck freight carriers. In addition, truck driver shortage, high truck driver turnover rate, rising fuel cost, competition with rail freight carriers (15.3% rail freight sector increase in 2011) and third party logistics providers, and freight shippers' increasing focus on choosing eco-friendly carriers (Fries et al., 2010) also limit the ability of truck freight carriers to seamlessly capture the steadily growing freight transportation market. One viable option to improve their competitiveness is to collaborate with rail freight carriers. By doing so, truck freight carriers can combine their accessibility, convenience and flexibility with the high volume and long haul economy of the rail freight carriers. However, only around 1% of the freight transportation market in terms of shipment value, tonnage and ton-miles was captured by rail-truck intermodal transportation in 2007 (Bureau of Transportation Statistics, 2008), implying limited collaboration between them.

Rail-truck multimodal freight collaboration, in a limited sense, exists in the form of rail-truck intermodal freight transportation collaboration, where rail freight carriers only collaborate with specialized drayage carriers handling containerized trailer on flatcar (TOFC) and container on flatcar (COFC). The intermodal freight transportation collaboration limits the service cargo types, truck freight carrier types and service range. There is a vast body of literature in the 1990s on improving the competitiveness of rail-truck intermodal freight collaboration in relation to other freight transportation modes, especially truck freight service, after the Stagger Rail Act (1980) and the railroad mega-mergers. Most of these studies focused on identifying the factors that influence freight shippers' mode choices. Fowkes et al. (1991), Harper and Evers (1993), Evers et al. (1996) and Ludvigsen (1999) used stated preference surveys to study the perception of shippers towards the performance of rail-truck intermodal freight transportation collaboration and other freight transportation modes. They found that shippers' perception of the shipping quality of rail-truck intermodal freight transportation is lower than that of the truck-only freight transportation in general, but higher than the rail-only freight transportation. Murphy and Hall (1995) analyzed 14 freight transportation mode choice studies between the 1970s and the 1990s and summarized the parameters affecting the mode choice into six categories: freight rate (costs, charges, rates), reliability (reliability, deliver time), transit time (time-in-transit, speed, delivery time), damage and loss claim (loss, damage, claims processing, and tracing), shipper market considerations (customer service, user satisfaction, market competitiveness, market influences) and carrier considerations (availability, capability, reputation, special equipment, financial stability). Murphy et al. (1997) studied the shipper and carrier perspectives on the importance of individual performance criteria (such as service quality, equipment availability, reliability, and flexibility) and concluded that shippers and carriers place the same relative importance on these criteria. Based on a study of the freight shipper decision-making process, Tsamboulas and Kapros (2000) concluded that the intensive users of rail-truck intermodal freight transportation chose the mode almost exclusively based on transportation cost, while shippers factoring both transportation cost and quality were less likely to use rail-truck intermodal freight transportation. Patterson et al. (2008) evaluated freight shipper attitudes for the transportation of intercity consignments using rail service in the Quebec City-Windsor corridor, and highlighted shippers’ mistrust towards using rail to move their consignments, and bias against rail use. They found that even with the same on-time performance, rail-truck intermodal freight carriers were less likely to be chosen compared to truck-only freight carriers. Despite their increasing awareness of the potential environmental benefits of using rail-truck intermodal freight transportation, freight shippers were less likely to make modal changes based only on carriers’ environmental performance (Fries et al., 2010).

Other studies consider rail-truck intermodal freight collaboration as multi-actor chain management. Taylor and Jackson (2000) analyzed the market power of different players in the intermodal freight transportation system. They found that the ocean carrier, as a multi-actor chain leader, has the most market power in both the ocean-rail and ocean-truck intermodal freight transportation chains to generate overall chain steering. They concluded that neither the rail carrier nor the truck carrier has the market power to promote standardization and multi-actor collaboration in rail-truck intermodal freight transportation chain. They argue that the development of rail-truck intermodal freight transportation would be limited unless some players can assert a leadership role in the rail-truck intermodal freight transportation chain. Bontekoning et al. (2004) reviewed past literature related to the chain management of rail-truck intermodal freight transportation and summarized that information sharing, communication, and liability sharing are the major issues. Motraghi (2013) conducted a review of government policies related to intermodal freight transportation in the European Union (EU) so as to identify relevant barriers. However, the associated methodology is not clearly articulated and the results cannot be applied to the U.S. conditions due to the differences in the planning aspects between the EU and the U.S. In the EU, it is a common practice to evaluate a new intermodal terminal based not only on its economic merit but also in terms of its contribution to the regional economic development, unlike in the U.S. where it is based primarily on the economics (Slack, 1996). Some other studies consider only specific policies benefiting truck or rail freight carriers, as opposed to policies that improve the overall freight transportation service quality by fostering the potential win-win collaboration of rail and truck freight carriers. Golob and Regan (2001) conducted surveys in California to evaluate potential policies to address the operational issues faced by truck carriers, but focused only on policies benefiting truck freight carriers and did not consider the impacts on freight shippers or rail freight carriers.

Few studies address the potential for rail-truck multimodal freight collaboration in a broader sense, where general truck freight carriers collaborate with rail freight carriers without permanently converting to specialized short-range drayage companies and the cargo types are not limited to TOFC and COFC. Van Schijndel and Dinwoodie (2000) analyzed the willingness of Dutch truck freight carriers to collaborate with rail freight carriers under the burden of traffic congestion. They found that despite having the ability to collaborate with rail freight carriers, most truck carriers prefer alternatives such as adding night shifts and dedicated truck lanes. Dewan et al. (2006) proposed the idea of developing multimodal freight transportation to promote economy of Bangladesh. They identified that complex and inflexible customs procedures presented a greater barrier to multimodal freight development than the shortcomings in the transportation infrastructure for the local government agency. However, these findings are not applicable to U.S. due to its unique planning aspects, as discussed heretofore (Slack, 1996).

Emergent factors such as truck driver shortage and the role of technology can potentially influence rail-truck multimodal freight collaboration. While the studies in the 1990s and early 2000s do not factor truck driver shortage, the expected shortage of drivers could reach 239,000 by 2022 and 90% of truckload (TL) carriers are unable to find enough qualified drivers (Costello, 2012). Also, driven by advances in information and communication technologies over the past decade or so, the level of technology usage by a truck carrier can influence its capability and willingness to collaborate with rail freight carriers. However, these aspects have not been addressed in the previous studies.

The limited perspectives to understanding the broader rail-truck multimodal freight carrier collaboration problem motivates the need for an in-depth and contemporary study to explore the opportunities and barriers for U.S. truck freight carriers to enter the rail-truck multimodal freight transportation market. The key to understanding these opportunities and barriers lies in analyzing the profiles of truck freight carrier segments based on their operational and behavioral characteristics. It manifests in terms of two fundamental questions: (i) what are the factors that foster and impede rail-truck freight collaboration? and (ii) how are the operational and behavioral characteristics of a truck freight carrier related to these factors? This study fills this gap by exploring truck freight carrier perspectives in terms of the factors that foster and impede rail-truck multimodal freight collaboration, and their linkages to the operational and behavioral characteristics of the carriers in these segments. By doing so, decision-makers can utilize their resources more efficiently and effectively by targeting different strategies for different segments to promote synergistic collaboration between rail and truck freight carriers. Cluster analysis is used to identify the specific segments of truck carriers with similar factors that foster and impede rail-truck multimodal freight collaboration. Econometric models are then used to uncover the operational and behavioral characteristics of truck freight carriers with similar factors that foster and impede such collaboration. To do so, a survey is conducted for truck freight carriers located in the U.S. Midwest region (Indiana, Illinois, Iowa, Ohio, Michigan, Kansas, Minnesota, Wisconsin, and Nebraska).

The remainder of this paper is organized as follows. Section 2 describes the survey mechanism, design, implementation, and the descriptive statistics of the raw survey data. Section 3 discusses the cluster analysis to identify truck freight carrier market segments based on factors that foster and impede rail-truck multimodal freight collaboration. It then develops econometric models to link the operational and behavioral characteristics of truck freight carriers to these market segments. Section 4 analyzes insights from the econometric models to generate an understanding of the relationship between the behavioral and operational characteristics of the truck freight carriers and the factors that foster and impede rail-truck multimodal freight collaboration. Section 5 provides some concluding comments.

2.2 Survey description and data characteristics

The relationship between the operational and behavioral characteristics of a truck freight carrier and its factors that foster and impede rail-truck multimodal freight collaboration is investigated using a stated preference survey of truck freight carriers based in the Midwest region[1]. As rail-truck multimodal freight collaboration in the broader sense is currently in its infancy, and most of the collaboration is limited to traditional rail-truck intermodal freight collaboration, a revealed preference survey approach is not a viable option. The stated preference survey of the truck carriers seeks information related to operational characteristics, performance assessment of rail service, and perceptions of rail-truck collaboration. The survey questionnaire was designed based on an exhaustive review of truck freight operations and rail-truck multimodal freight collaboration.

2.2.1 Survey setup description

The multimodal rail-truck freight shipment survey was conducted by providing questionnaires to operational managers and owners of some freight truck carriers in the Midwest region. It involved telephone interviews and online questionnaires distributed via email. It focuses on studying truck freight carriers' operational and behavioral characteristics, and the factors that foster and impede rail-truck multimodal freight collaboration.

2.2.2 Survey questionnaire design

The survey consisted of a cover page and three sections of questions. The cover page described the definition of rail-truck multimodal freight collaboration in terms of its service characteristics, and the differences relative to rail-truck intermodal freight service. The questions were classified into three parts: (i) operational characteristics, (ii) performance assessment of rail service, and (iii) perceptions of rail-truck collaboration.

The first part of the survey was used to capture the respondents' operational characteristics. Of interest are the types of service offered, percentage of haul movement

---

[1] The survey details can be accessed via: https://purdue.qualtrics.com/SE/?SID=SV_ezePrKzdYfxitqR

in each distance range, annual revenue range, fleet size, primary and secondary commodities types and their origin-destination information, level of concern towards some operational issues, and whether these issues will be resolved in the long term. A five-point Likert scale ranging from “Extreme concern” (=5) to “No concern” (=1) is used for this purpose. Questions were also asked related to carriers’ use of technologies, including mobile communication devices, electronic data interchange (EDI), automatic vehicle location (AVL) and electronic clearance system, as well as publicly available traffic information updates (Internet, television or radio). Tables 1 and 2 and Figure 1 in Section 2.3 illustrate the breakdown of respondents by some of their operational characteristics. The objective of this part of the questionnaire is to understand the operational characteristics of truck freight carriers that impact the factors that foster and impede rail-truck multimodal freight collaboration.

The second part explores a truck freight carrier’s assessment of rail freight carriers’ performance based on their experiences or expectations, including the rail freight carriers’ overall performance and thirteen individual performance criteria. Table 3 in Section 2.3 presents the rail service assessment by the respondents, classified based on their frequency of freight shipment collaboration with rail freight carriers. A five-point Likert scale ranging from “Excellent” (=5) to “Poor” (=1) is used for this purpose. In addition, respondents were asked to identify the Class I rail carriers in the U.S. they had worked with and the ones they would like to work with in the future. This part seeks to understand the truck carriers’ current and potential future partners, and their perspective of rail freight carriers’ services.

The last part of the survey elicits the factors that foster and impede rail-truck multimodal freight collaboration. Respondents were requested to rate the importance of various factors that might lead them to consider collaboration or expand their current collaborations with rail carriers on a scale of 1 to 5, where 1 indicates not at all important and 5 indicates extreme importance. Table 4 in Section 2.5 illustrates the factors aiding a truck freight carrier’s willingness to collaborate with rail freight carriers. Respondents were also asked to identify the barriers to such collaboration. A five-point Likert scale ranging from “Extreme concern” (=5) to “No concern” (=1) is used for this purpose. Table 5 in Section 2.5 identifies the factors that impede rail-truck multimodal freight collaboration.

2.2.3 Survey sample operational characteristics

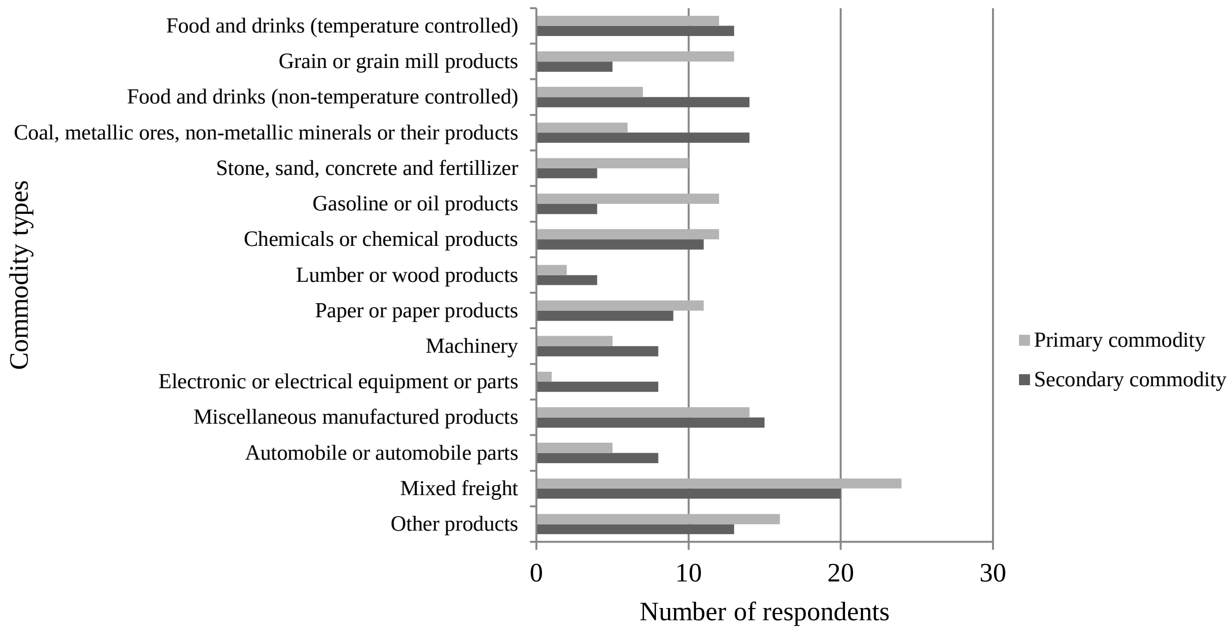
1350 truck freight carriers were contacted for the stated preference survey, including: (i) 627 truck freight carriers offering truckload (TL) service only, (ii) 296 truck freight carriers offering less than truckload (LTL) service only, and (iii) 427 truck freight carriers offering both TL and LTL services. 150 completed surveys were obtained for an overall response rate of 11.1%. Non-response analyses were performed based on operation type and fleet size. A Chi-square test, with $\alpha=0.05$, was used to assess the differences between respondents and non-respondents; there was no significant statistical difference on any criteria for the TL service only carriers (p-value=0.665, 0.446, respectively), the LTL service only carriers (p-value=0.570, 0.517, respectively), and those with both TL and LTL service (p-value=0.687, 0.628, respectively).

Table 1 illustrates the aggregated operational characteristics of the 150 survey respondents. A key observation is that the majority of the respondents are small- to medium-size companies in terms of fleet size and annual revenue, and focus on short-range freight service in the Midwest region. More than 55% of the respondents are truck carriers with less than 50 trucks, and over 50% of the respondents generate less than 5 million dollars in annual revenue. Over 40% of the respondents' primary service range was within 50 miles, while only less than 10% had a primary service range of over 500 miles. The majority of primary and secondary commodities (60 and 67, respectively) carried by the respondents are not containerized. Lumber or wood products (83.3%) and paper or paper products (55.0%) are the two highest non-containerized commodities by percentage. About a third of the respondents suggested that primary and secondary commodities types (51 and 51, respectively) carried by them are containerized only. Electronic or electrical equipment or parts (55.6%) and machinery (53.8%) are the two highest containerized commodities by percentage. The remaining respondents stated that the primary and secondary commodities types (39 and 32, respectively) carried by them include both containerized and non-containerized cargo.

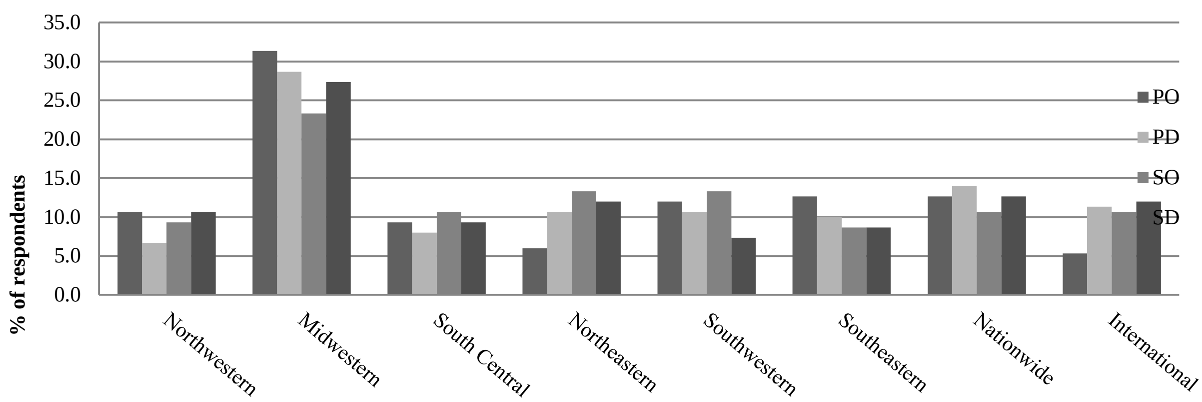
The most common freight service origin and destination were within the Midwest region (Figure 1). Around 30% of the respondents' primary commodity's shipping origin (PO) and destination (PD) were in the Midwest region, and over 25% of the respondents' secondary commodity's shipping origin (SO) and destination (SD) were in the Midwest region. A sizeable number of respondents (24) had the greatest percentage of freight service for both primary and secondary commodities originating from and destined to the Midwest region. Other than the Midwest traffic, the origins and destinations of the respondents' freight service were distributed evenly among the other regions. The survey results also suggest that the respondents carried a wide range of commodities (Figure 1). About 90% of the respondents do not limit their service to only a single commodity. Only 17 respondents (11.3%) selected the same primary and secondary commodities. Among them, 9 (6.0%) respondents selected either chemicals or chemical products, or gasoline or oil products.

Table 1 Operational characteristics of truck freight carriers

Attribute	%
Primary service type	
Truckload	44.7
Less than truckload (LTL)	24.7
Both truckload and LTL	30.6
Primary operation type	
Private fleet	16.7
Common carrier	24.0
Contract carrier	25.3
Common and contract carrier	34.0
Primary haul length movement	
< 50 miles	42.4
50-500 miles	46.9
>500 miles	10.7
Annual revenue	
Less than $1,000,000	35.3
$1,000,000-$4,999,999	22.7
$5,000,000-$9,999,999	22.7
$10,000,000-$49,999,999	12.6
Over $50,000,000	6.7
Fleet size	
0-15	34.7
16-50	24.0
51-100	15.3
101-151	12.0
151-200	12.0
>200	2.0
Containerization of cargo (primary commodity)	
All containerized	34.2
No containerization	39.3
Mix of both	26.5
Containerization of cargo (secondary commodity)	
All containerized	34.2
No containerization	44.0
Mix of both	21.8
Technology usage	
Mobile communication device	82.7
Electronic data interchange	52.7
Automatic vehicle location	52.0
Electronic clearance system	35.3
Publicly available traffic information	22.7



1(a) Primary and secondary commodities of respondents



1(b) Origins and destinations of the majority of primary and secondary commodities

Figure 1(a) Primary and secondary commodities types, and (b) the shipping origins and destinations of survey respondents.

The next question in this section addresses the use of technologies in the daily operations of truck carriers. As shown in Table 1, mobile communication devices (82.7%) are the most common technology applied in the respondent operations, while publicly available traffic information (22.7%) is the least applied technology. The statistics illustrate an increased usage of technologies compared to the 1990s (Golob and Regan, 2001); for example, the usages of mobile communication device, EDI and AVL were 80%, 32% and 28%, respectively, in 1998. Publicly available traffic information has presumably not been widely used for daily operations due to the non-availability of the relevant technological hardware to the carrier dispatchers (Golob and Regan, 2001), the truck driver behaviors, and the usefulness of the information for truck routing. That is, publicly available traffic information often contains alternate routes that are not feasible for trucks, and this issue is especially important in commercial highway corridors (Peeta et al., 2000).

The final two questions in this section address the level of concern related to the thirteen operational issues in terms of their potential effects on the respondents' current and future business. A five-point Likert scale ranging from "Extreme concern" (=5) to "No concern" (=1) is used for this purpose. As shown in Table 2, the respondents ranked operational safety (4.31) and rising fuel costs (4.01) as the top two issues affecting their business, and competition with other modes of freight transportation (rail excluded) (2.97) and traffic congestion (3.03) as their two least concerns. Compared to earlier studies (in the 1990s and early 2000s), the results show that truck driver shortage has become a major challenge for the truck carriers and the expected shortage of drivers could reach 239,000 by 2022 (Costello, 2012). Operational safety remains the primary concern for truck freight carrier operations despite the decline in crashes related to large trucks since the 1970s (USDOT, 2012). By contrast, truck carriers were optimistic about the truck freight market and did not have a high level of concern towards business competition. Apart from the issues queried in the questionnaire, 8 respondents (5.3%) mention (as an optional comment) that they are also concerned about competition from freight brokers. The competition between freight brokers and truck carriers was addressed from the freight broker perspective in a previous study (Brown, 1984).

Respondents were asked a follow up question on whether they expected these operational issues to become worse or better in the long term, with 1 implying much worse and 5 implying much better on a 5-point Likert scale. As illustrated in Table 2, they felt that most of the issues would affect their operations more in the future, except for competition with other modes of transportation, and rising labor and management costs.

Table 2 Operational issues for truck carriers

Operational issues	Level of concern	Worse or better in the long term
Rising fuel costs	3.92	2.57
High truck driver turnover rate	3.31	2.55
Truck driver shortage	4.01	2.47
Traffic congestion	3.03	2.67
Rising environmental concerns	3.21	2.59
High empty haul costs	3.37	2.65
Rising labor and management costs	3.24	3.16
Operational safety	4.31	2.27
Limited truck freight market	3.14	2.59
High investment costs	3.30	2.97
Competition among truck freight carriers	3.67	2.68
Competition with rail freight carriers	3.29	2.93
Competition with other modes of freight transportation (rail excluded)	2.97	3.17

2.2.4 Performance assessment of rail freight service

To assess their perception of the performance of rail service, the respondents were asked to rate the overall performance of rail freight carriers as well as their performance on thirteen individual criteria using a Likert scale from 1 to 5, where 1 implied poor service and 5 implied excellent service on that criterion. Only about 28% of the respondents indicated that they often or very often collaborated with rail freight carriers on freight delivery, suggesting that collaboration between rail and truck freight carriers remains relatively limited. Table 3 illustrates the rail service assessment by the respondents, classified based on their frequency of freight shipment collaboration with rail freight carriers.

Table 3 Truck carriers' assessment of rail carrier performance based on their frequency of freight shipment collaboration with rail freight carriers

	Freight shipment collaboration frequency			
Performance criteria	Never	Sometimes	Often	Very Often
Price competitiveness	2.93	2.59	2.91	2.39
Service reliability	2.11	2.35	2.18	2.06
Transit time	2.62	2.43	2.91	3.00
Equipment availability	2.48	2.49	3.27	2.94
Service availability	2.63	2.68	2.00	2.77
Punctuality	2.58	2.32	3.18	2.26
Communication	2.59	2.70	3.73	2.32
After sale service	2.92	2.35	3.45	2.90
Flexibility	2.34	2.49	2.18	2.13
Loss and damage claims	2.69	2.59	2.36	2.94
Safety and security	2.80	2.92	3.64	2.71
Service frequency	2.38	2.57	2.64	2.52
Terminal operations	3.03	2.41	2.64	2.94
Overall performance	2.54	2.29	2.81	2.61

Table 4Factors that foster rail-truck multimodal freight collaboration

Factors that foster collaboration	Level of importance
Rising fuel costs	2.87
High truck driver turnover rate	3.06
Truck driver shortage	3.13
Traffic congestion	2.83
Rising environmental concerns	2.79
High empty haul costs	2.78
Shrinking of current truck freight market	2.87
Rising labor and management costs	2.58
Improving operational safety	2.97
Large multimodal transportation market potential	3.03
Competition among truck freight carriers	2.95
Competition with rail freight carriers	2.55
Competition with other modes of freight transportation (rail excluded)	2.81

2.2.5 Perceptions of rail-truck multimodal freight collaboration

In the third part of the survey, respondents were requested to rate the importance of various factors that might lead them to consider multimodal freight collaboration or expand their current multimodal freight collaborations with rail carriers on a scale of 1 to 5, where 1 indicates not at all important and 5 indicates extreme importance. Table 4 illustrates the associated outcomes. Truck driver shortage (3.13), high truck driver turnover rate (3.06), and large market potential (3.03) are the top three factors that would lead the respondents to consider collaboration or expanding their multimodal freight collaborations with rail freight carriers. Table 5 illustrates potential factors that impede collaboration and indicates that unreliable rail transport times (3.49), rail service flexibility (3.35), and transshipment delays (3.29) are rated as the top three challenges that truck carriers face or expect to face related to collaboration with the rail carriers.

Table 5 Factors that impede rail-truck multimodal freight collaboration

Factors that impede collaboration	Level of concern
High investment costs	3.17
Low investment return rate	2.79
Customer willingness to accept transshipment handling	3.03
Scope of operation	2.89
Security of information shared with rail freight carriers	2.79
Lack of multimodal market potential	2.96
Transshipment delays	3.29
Unreliable rail transport times	3.49
Reduction of overall service quality	3.21
Transshipment safety and security	2.83
Rail service flexibility	3.35
Handling equipment availability	3.17
Lack of fair allocation mechanism for collaboration revenues	2.97

2.3 <u>Data analysis and model development</u>

This section describes the model structure development process to analyze the survey data. Presumably, truck freight carriers with similar operational and behavioral characteristics may entail similar factors that foster and impede rail-truck multimodal freight collaboration from their perspective. Thereby, groups of similar truck freight carriers can potentially be profiled into different market segments. The process to identify these market segments and their characteristics is done through two sequential steps. In the first step, cluster analysis (Anderberg, 1973) is used to identify the existence of embedded truck freight carrier market segments with similar factors that foster and impede rail-truck multimodal freight collaboration. In the second step, mixed logit models (Hensher and Greene, 2003) are used to uncover the operational and behavioral characteristics within each market segment. Thereby, the procedure seeks to link a truck freight carrier's operational and behavioral characteristics to the factors that foster and impede collaboration from the truck freight carrier perspective.

2.3.1 Cluster analysis

Cluster analysis is a multivariate technique widely used to identify structures within a data set (Anderberg, 1973). Its objective is to group (cluster) data based only on the information found in the data such that the elements within these groups have a high degree of association (Tan, 2006). Cluster analysis has been used as an exploratory technique to uncover the different segments within a market so as to derive insights on the decision-making process of business entities. For example, Ketchen and Shook (1996) addressed the application of cluster analysis in strategic management research, while Okazaki (2006) applied cluster analysis to profile mobile Internet adopters in Japan. However, the number of variables that can be used to conduct cluster analysis is limited by the sample size, though the number of cluster variables should be maximized to discover meaningful differences (McKelvey, 1975).

There are three major types of clustering methods: hierarchical, partitioning and two-step cluster analysis. The two-step cluster analysis combines the principles of the other two methods, and is implemented here. It can handle categorical and continuous variables simultaneously and offers users the flexibility to specify the cluster numbers as well as the maximum number of clusters (Chui et al., 2001). The Silhouette measure of cohesion and separation, a value between -1 and 1, is used to assess the quality of a cluster whereby values higher than 0.50 indicate a good solution. In general, the two-step cluster analysis is computationally efficient without sacrificing the cluster quality. Hence, the two-step cluster analysis is used in this study to identify relevant market segments among the truck freight carriers. Consistent with the study objectives, cluster analyses are performed corresponding to factors that foster (opportunities cluster analysis) and impede (barriers cluster analysis) rail-truck multimodal freight collaboration, as discussed hereafter. The SPSS Statistics 21 (IBM, 2012) is used to identify the truck freight carrier market segments.

2.3.2 Opportunities cluster analysis

The opportunities cluster analysis identifies truck freight carrier market segments based on the factors that foster collaboration. Based on the survey data, the four factors are rising fuel costs (RFC), truck driver shortage (TDS), increasing traffic congestion (TCG), and large rail-truck multimodal freight transportation market potential (LMT), and are labeled as "opportunities" factors. Nine other factors from the survey questionnaire were omitted in the analysis after performing a Pearson product-moment correlation coefficient test. Another incentive to reduce the number of factors under consideration is that the recommended minimum sample size is 2m, where m is the number of cluster variables (Anderberg, 1973). So the variables (factors) included should be limited to 7 for a sample size of 150.

Examining the importance truck freight carriers placed on each opportunities factor helped determine the major characteristics for each market segment. Responses to the opportunities factors were categorized into two groups. If a carrier selected "important", "very important" or "extremely important" for an opportunities factor, it indicates that this factor would foster collaboration; otherwise it is deemed indifferent. Then, Chi-square tests, with α=0.05, were performed to determine if significant differences existed between the frequency of responses for important opportunities factors and unimportant ones in each group. Three distinct truck freight carrier market segments (segments 1, 2 and 3) related to factors fostering collaboration were observed based on the opportunities cluster analysis. Table 6 shows percentages corresponding to the factors that foster collaboration within each market segment.

Table 6 Factors that foster collaboration for each market segment of truck freight carriers (n=150)

Opportunities factors (Mnemonics)	Total	Segment 1 (n = 81)	Segment 2 (n = 17)	Segment 3 (n = 52)
Rising fuel costs foster collaboration (RFC)				
Yes	47.3	46.9	70.6	40.4
No	52.7	53.1	29.4	59.6
Truck driver shortage fosters collaboration (TDS)				
Yes	68.0	85.2	82.4	36.5
No	32.0	14.8	17.6	63.5
Increasing traffic congestion fosters collaboration (TCG)				
Yes	53.3	70.4	35.3	32.7
No	46.7	29.6	64.7	67.3
Rail-truck multimodal freight market potential fosters collaboration (LMT)				
Yes	49.3	43.2	47.1	59.6
No	52.7	56.8	52.9	40.4

Note: The numbers in the last four columns indicate percentages that vertically sum to 100% for each factor.

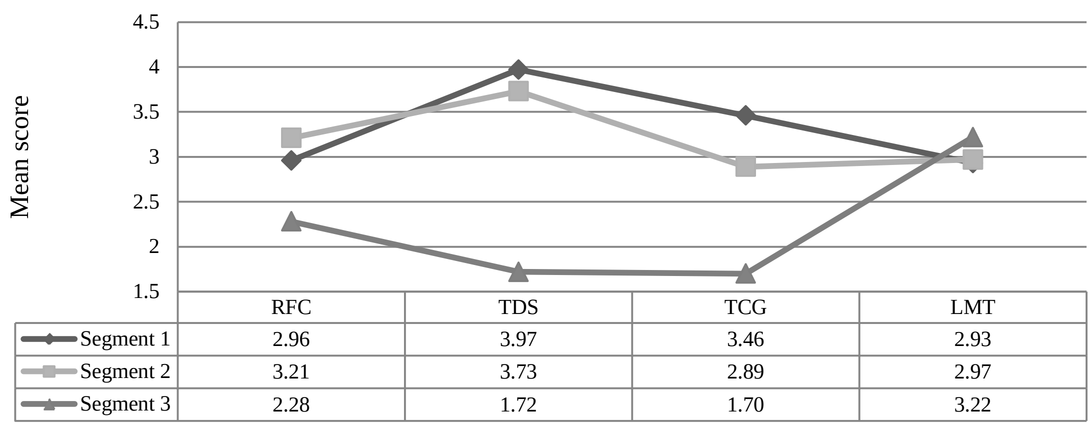


Figure 2 Mean values of opportunities factors for different truck freight carrier market segments

Figure 2 illustrates the characteristics from Table 6 using the mean values of the opportunities factors, with scores greater than 3 illustrating significance for a factor for that market segment, and implying values greater than 50% for the "Yes" in Table 6.

The truck freight carrier market can be divided into three segments exhibiting different opportunities factors that foster collaboration. The largest market segment, segment 1 (n=81, 54% of the sample), represents the truck freight carriers who will consider rail-truck collaboration under truck driver shortage (TDS) and increasing traffic congestion (TCG). Segment 2 (n=17, 11.3% of the sample), the smallest market segment, includes truck freight carriers who will consider rail-truck multimodal freight collaboration under truck driver shortage (TDS) and rising fuel costs (RFC). Carriers in segment 2 share the opportunities factor, TDS, with the carriers in segment 1. Carriers in segment 3 (n=52, 34.7% of the sample) will consider rail-truck multimodal freight collaboration based on the optimism for rail-truck multimodal freight market potential (LMT). As can be noted from Figure 2, TDS and TCG (1.72 and 1.70, respectively) have low values for segment 3 implying that many carriers chose "not at all important" for these factors for this market segment.

Table 7 Factors that impede collaboration for each market segment (n=150)

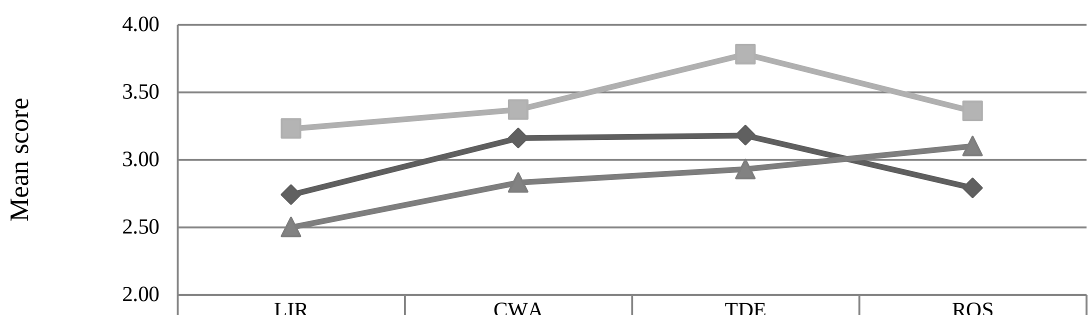
Barriers factors (Mnemonics)	Total	Segment 4 (n = 31)	Segment 5 (n = 73)	Segment 6 (n = 46)
Low investment return rate is a barrier to collaboration (LIR)				
Yes	46.0	41.9	54.8	35.0
No	54.0	58.1	45.2	65.0
Customer willingness to accept transshipment handling is a barrier to collaboration (CWA)				
Yes	64.7	61.3	78.1	45.7
No	35.3	38.7	21.9	54.3
Transshipment delays are a barrier to collaboration (TDE)				
Yes	54.0	54.8	58.9	43.5
No	46.0	45.2	41.1	56.5
Reduction in overall service quality is a barrier to collaboration (ROS)				
Yes	54.7	48.2	57.5	54.3
No	45.3	51.6	42.5	45.7

Note: The numbers in the last four columns indicate percentages that vertically sum to 100% for each factor.

2.3.3 Barriers cluster analysis

The barriers cluster analysis identifies truck freight carrier market segments based on the factors that impede collaboration. Akin to the opportunities cluster analysis, a barriers cluster analysis was performed using the four "barriers" factors identified from the survey data: low investment return rate (LIR), customer willingness to accept transshipment handling (CWA), transshipment delays (TDE), and reduction in overall service quality (ROS). If a carrier selected "very concerned" or "extremely concerned" for a barriers factor, it indicates that this barrier factor would impede collaboration; otherwise it is deemed indifferent. The analysis resulted in three truck freight carrier market segments (segments 4, 5 and 6) related to factors that impede rail-truck multimodal freight collaboration, as shown in Table 7.

As illustrated in Figure 3, the truck freight market can be divided into three segments exhibiting different barriers factors that impede collaboration. The smallest market segment, segment 4 (n=31, 20.7% of the sample), represents the truck freight carriers for whom transshipment delays (TDE) and the lack of customer willingness to accept transshipment handling (CWA) would impede their collaboration with rail freight carriers. Segment 5 (n=73, 48.7% of the sample), the largest market segment, includes truck freight carriers for whom all four barriers factors would impede rail-truck freight collaboration. The truck freight carriers in this market segment share the barriers factors, TDE and CWA, with the carriers in market segment 4. Carriers in segment 6 (n=46, 30.6% of the sample) consider reduction in overall service quality (ROS) as the only barriers factor. They share this barriers factor with the carriers in segment 5.



	LIR	CWA	TDE	ROS
Segment 4	2.74	3.16	3.18	2.79
Segment 5	3.23	3.37	3.78	3.36
Segment 6	2.50	2.83	2.93	3.10

Figure 3 Mean values of barriers factors for different truck freight carrier market segments.

2.3.4 Logit model structure

To model the correlation between a truck freight carrier's operational and behavioral characteristics and its propensity for rail-truck multimodal collaboration, multinomial logit (MNL) and mixed logit (MMNL) models were considered. The MNL model can be written as (Train, 2009):

$$P_{in} = \frac{e^{\beta_i x_{in}}}{\sum_{j \in J} e^{\beta_j x_{jn}}} \qquad (1)$$

where J is the set of possible market segments, xin is a vector of explanatory variables (carrier n operational and behavioral characteristics) for market segment i, and □□ is a vector of estimable parameters for market segment i. Pin is the probability of carrier n belonging to market segment i.

Sections 3.1.1 and 3.1.2 indicate that some market segments share one or more common factors that foster or impede rail-truck multimodal freight collaboration. Thus, the independence from irrelevant alternatives (IIA) property of the MNL model can be limiting and result in specification errors. In addition, the MNL model assumes that the estimated parameters are the same for all carriers. This fails to consider the potential heterogeneity among the carriers, especially in the context of the explanatory variables representing the behavioral characteristics of the truck freight carriers. To circumvent these potential sources of specification errors for the MNL model, an MMNL model is also specified. The MMNL model (McFadden and Train, 2000) is a flexible discrete choice model that circumvents key limitations of the MNL model, and allows for non-IIA cases and random taste variations. The mixed logit model can be written as (Train, 2009):

$$P_{in} = \int \left(\frac{e^{\beta_i x_{in}}}{\sum_{j \in J} e^{\beta_j x_{jn}}} \right) f(\beta) d\,\beta \qquad (2)$$

where βi is a vector of estimable random parameters for market segment i, f(β) is the probability density function of β, and all other terms are as defined in Equation (1).

Table 8 Explanatory variables (carrier operational and behavioral characteristics) for the mixed logit models

Explanatory variables	Mnemonics
Alternative constant	ONE
Truck freight carrier fleet size	FLS
= 1, if fleet size □50	
= 0, if fleet size < 50	
Truck freight carrier’s primary service distance over 500 miles	LGH
= 1, if yes	
= 0, if no	
Truck freight carrier’s primary service distance under 50 miles	SHH
= 1, if yes	
= 0, if no	
Truck freight carrier’s primary or secondary commodities shipped by the carrier is containerized	CTL
= 1, if yes	
= 0, if no	
Truck freight carrier applied at least two technologies identified in Table 1	UOT
= 1, if yes	
= 0, if no	
Truck freight carrier is “very concerned” or “extremely concerned” of increasing traffic congestion affecting operations	TCA
= 1, if yes	
= 0, if no	
Truck freight carrier is “very concerned” or “extremely concerned” of truck driver shortage affecting operations	TSA
= 1, if yes	
= 0, if no	
Truck freight carrier collaborates “often” or “very often” with rail freight carriers	WFR
= 1, if yes	
= 0, if no	
Truck freight carrier rated rail freight carrier overall performance higher than 3	RCO
= 1, if yes	
= 0, if no	
Truck freight carrier “likely” or “definitely” will collaborate with rail freight carriers in the future	FCW
= 1, if yes	
= 0, if no	

Table 9 Goodness-of-fit measures for the MNL and MMNL

	Opportunities models		Barriers models	
	MMNL	MNL	MMNL	MNL
Number of parameters	14	13	15	13
Log-likelihood at zero, LL(0)	-156.27	-156.27	-190.59	-190.59
Log-likelihood at convergence, LL(β)	-95.15	-99.39	-114.87	-119.74
McFadden ρ^2 statistic	0.391	0.364	0.397	0.372
Corrected ρ^2	0.301	0.281	0.319	0.304
Likelihood ratio test				
$x^2 = -2[\text{LL}(\beta_{MNL}) - \text{LL}(\beta_{MMNL})]$	8.48		9.74	
Degree of freedom	1		2	
Critical x^2 (0.99 level of confidence)	6.63		9.21	

Table 10 Operational and behavioral characteristics that foster rail-truck multimodal freight collaboration (All random parameters are normally distributed)

	Segment 1		Segment 2		Segment 3	
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
ONE	—[2]	—	-0.27	-2.00	0.50	2.03
LGH	—	—	0.79	2.45	—	—
SHH	-0.39	-2.73	-0.43	-2.14	0.79	3.24
UOT	—	—	—	—	0.47	2.31
TCA	0.63	2.62	0.25	1.99	—	—
TSA	0.38	2.44	—	—	—	—
RCO	0.69	2.53	—	—	0.62	2.61
FCW	0.42 (0.24)[3]	1.98 (3.17)	—	—	—	—
Sample size						150
Log-likelihood at zero						-156.27
Log-likelihood at convergence						-95.15

Due to the analytical intractability in computing the MMNL probabilities through maximum likelihood estimation, simulation-based approaches were explored. Based on this, 300 Halton draws (Train, 2009) are used in a simulation-based approach to determine the Pin values. Four types of distributions (normal, lognormal, triangular

[2] Dash (—) in Tables 10 and 11 indicates that the variable is not statistically significant for that market segment.
[3] The number inside the parenthesis in Tables 10 and 11 is the standard deviation of the parameter distribution.

and uniform) were analyzed for the random parameters; of these, only the normal distribution was significant and hence used in the analysis. The LIMDEP software (Greene, 1998) was used to estimate the parameters of the MNL and MMNL models. Table 8 specifies the truck freight carrier operational and behavioral characteristics that were found to be significant in the MNL and MMNL models. The MMNL models provide a statistically superior fit relative to the MNL models (with 99% level of confidence) as indicated by the likelihood ratio test in Table 9. It indicates the possibility that heterogeneity may exist; this is confirmed in Table 10 where the parameter for FCW in the segment 1 model has random taste variations, and Table 11 illustrating one parameter each for segments 4 and 5 with random taste variations. It confirms the notion that heterogeneity exists in the context of the behavioral characteristics of truck freight carriers. Even for models (such as for segments 2 and 6) in Tables 10 and 11 with no random taste variations, MMNL can eliminate the IIA issues arising from shared common opportunities/barriers factors across subsets of market segments as discussed in Sections 3.1.1 and 3.1.2. Considering the statistically superiority of MMNL, only the results for the MMNL models are provided hereafter. Tables 10 and 11 illustrate the MMNL models for three market segments each for the opportunities and barriers cases, respectively. The estimated parameters illustrated are statistically significant ($\|t\| \geqslant 1.96$). Since all variables other than ONE are 0-1 binary variables, their parameters can be compared to illustrate their relative importance for a market segment. Based on the six MMNL models, Section 4.1 provides a detailed analysis and insights on the linkages between the operational and behavioral characteristics of the carriers and the various market segments.

Table 11 Operational and behavioral characteristics that impede rail-truck multimodal freight collaboration (All random parameters are normally distributed)

	Segment 4		Segment 5		Segment 6	
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
ONE	—	—	—	—	0.64	1.99
FLS	—	—	0.90	2.40	-0.72	-2.19
SHH	0.38	2.31	—	—	—	—
CTL	0.22	2.56	-0.75	-2.62	—	—
UOT	—	—	—	—	0.68	2.42
WFR	-0.64 (0.54)	-2.67 (3.97)	—	—	0.51	2.03
RCO	—	—	-0.27 (0.32)	-1.98 (2.69)	—	—
FCW	0.30	2.97	-0.38	-2.10	—	—
Sample size						150
Log-likelihood at zero						-190.59
Log-likelihood at convergence						-114.87

2.4 <u>*Model analysis and insights*</u>

2.4.1 *Operational characteristics of different market segments*

The MMNL models suggest that a truck freight carrier's primary service range (LGH or SHH) is an important explanatory variable for determining its likelihood of belonging to a market segment, and can thereby be linked to the market segment factors (in Section 3.1) identified as fostering or impeding collaboration. Based on this, SHH with a negative parameter for segment 1 implies that a truck freight carrier with primarily short-range (under 50 miles) service is less likely to collaborate with rail freight carriers under truck driver shortage (TDS) and increasing traffic congestion (TCG). SHH also has a negative parameter for segment 2, indicating that a truck freight carrier with short-range (under 50 miles) service is less likely to collaborate under rising fuel costs (RFC) and truck driver shortage (TDS). Since a majority of SHH carriers' shipments are short-ranged, they can be viewed as localized truck freight carriers. Despite the overall impact of truck driver shortage on truck freight carriers, the impact on short-range truck freight service is limited. The American Trucking Associations (ATA) estimate the current shortage of drivers to be in the 20,000 to 25,000 range on a base of roughly 750,000 trucks in the over-the-road (i.e., non-local) TL market, while the impact of truck driver shortage is much less for localized truck services (Costello, 2012). In addition, localized truck freight carriers are less likely to be burdened by rising fuel costs. Past studies (Spychalski and Swan, 2004; Larson, 2013) have indicated that fuel consumption for long-haul truck operation can represent up to 60% of the total operational cost. This also implies that truck freight carriers with primarily long-range service (over 500 miles) are likely to collaborate with rail freight carriers under rising fuel costs (RFC) and truck driver shortage (TDS); this is confirmed by the positive coefficient for LGH for segment 2. For segment 3, SHH has a positive parameter, suggesting that truck freight carriers with primarily short-range service are likely be attracted to rail-truck multimodal freight collaboration by the market potential of such collaboration. Localized truck freight carriers are less likely to offer long-haul services due to limitations including company size, operation scale, and price competitiveness, etc. By collaborating with rail freight carriers, local truck freight carriers can offer competitive long-range freight transportation services without losing their current customer base. SHH has a positive parameter for market segment 4 (Table 11), implying that truck freight carriers with primarily short-range service (under 50 miles) are likely to have concerns with customer willingness to accept transshipment handling (CWA) and transshipment delay (TDE) when collaborating with rail freight carriers. Since a majority of their shipments are short-ranged, their primary customers are likely to local. Thereby, the additional time spent on transshipment at the terminal may not be meaningful for the relatively short range of shipments. Also, their customers are less likely to accept the potential loss of time and reliability arising from the additional handling processes for the relatively short range of shipment.

The level of technology usage (UOT) is also a key operational characteristic for a carrier’s likelihood of belonging to a market segment. Truck freight carriers using at least two of the technologies (Table 1) are likely to consider rail-truck multimodal freight collaboration when they find the market potential of rail-truck multimodal collaboration to be large, as indicated by the positive parameter for UOT for the market segment 3 (Table 10). It may suggest that truck freight carriers that are more amenable to the use of various technologies may identify it as a mechanism to leverage collaboration when such market potential is large. By contrast, the positive parameter of UOT for the segment 6 barriers model (Table 11) suggests that truck freight carriers using at least two of the technologies (Table 1) are likely to be concerned with the reduction of overall service quality (ROS) when collaborating with rail freight carriers.

Fleet size of truck freight carriers (FLS) and cargo containerization level (CTL) are largely insignificant operational characteristics related to the market segment factors that foster collaboration, but are associated with market segment factors that impede collaboration. Truck freight carriers with large fleet size (larger than 50) are likely to consider all four barriers factors that impede collaboration, as implied by the positive parameter of FLS in segment 5 (Table 11). It illustrates that larger truck freight carriers are likely to experience more barriers due to their relatively large operational scales and the consequent challenges in terms of adjusting to such collaboration. The negative parameter of CTL in segment 5 indicates that truck freight carriers with low containerization levels are also likely to consider all barrier factors that impede collaboration. These carriers may perceive that rail carriers do not have the ability to handle non-containerized cargo as most of the current collaboration is limited to containerized cargo only.

2.4.2 Behavioral characteristics of different market segments

The MMNL models suggest that a truck freight carrier’s rating of rail freight carriers’ overall performance (RCO) is an important behavioral characteristic for determining its factors that foster or impede collaboration. Truck freight carriers who positively rated rail freight carriers’ overall performance (good, very good or extremely good) are likely to consider rail-truck multimodal freight collaboration under truck driver shortage (TDS) and increasing traffic congestion (TCG), as indicated by the positive parameter of RCO for segment 1. Similarly, the positive RCO parameter for segment 3 suggests that truck freight carriers who rate rail freight carrier performance positively are likely to consider collaboration based on the rail-truck multimodal freight market potential (LMT). In segment 5, the RCO has a normally distributed parameter with a mean of -0.27 and a standard deviation of 0.32. Based on this distribution, the probability of this parameter being negative is 80.1%. It illustrates that the majority of truck freight carriers (80.1%) are less likely to consider all four barriers (but may consider a few of them) that impede collaboration when their assessment of rail freight carriers' overall performance is relatively good. However, about 19.9% would consider all of these barriers despite rating rail freight carriers' overall performance high, implying that a positive perception of rail freight carriers' performance may not necessarily indicate by itself an inclination for collaboration.

The collaboration willingness (FCW) is also an important behavioral characteristic for a carrier's likelihood of belonging to a market segment. For segment 1, FCW has a normally distributed random parameter with a mean of 0.42 and a standard deviation of 0.24. It suggests that truck freight carriers (96.0%) with higher collaboration willingness are very likely to consider rail-truck multimodal freight collaboration under truck driver shortage (TDS) and increasing traffic congestion (TCG). Only a small portion (4.0%) of truck freight carriers with high collaboration willingness would not do so under TDS and TCG. It may suggest that based on the current trend of increasing truck driver shortage and increasing traffic congestion, truck freight carriers with high collaboration willingness are very likely to consider rail-truck multimodal collaboration. For segment 4, FCW has a positive parameter, suggesting that truck freight carriers with high collaboration willingness are likely to have concerns with customer willingness to accept transshipment handling (CWA) and transshipment delay (TDE) in such collaboration. FCW has a negative parameter for market segment 5, implying that truck freight carriers with high collaboration willingness are less likely to consider all of the four barriers factors, but may consider a few of them.

Work frequency with rail freight carriers (WFR) is largely an insignificant behavioral characteristic relative to a truck freight carrier's factors that foster collaboration, but links to the truck freight carrier's factors that impede collaboration. For segment 4, WFR has a normally distributed random parameter with a mean of -0.64 and a standard deviation of 0.54 (Table 11). It implies that the majority of truck freight carriers (88.2%) who work frequently with rail freight carriers (often or very often) are less concerned about customer willingness to accept transshipment handling (CWA) and transshipment delay (TDE) when collaborating with rail freight carriers. Only a small portion (11.8%) of such truck freight carriers are concerned with CWA and TDE. The WFR has a positive parameter for segment 6, suggesting that truck freight carriers who work frequently with rail carriers are likely to be concerned with the reduction of overall service quality (ROS) in the context of collaboration.

Truck driver shortage affecting operations (TSA) and truck congestion affecting operations (TCA) are largely insignificant behavioral characteristics related to impeding collaboration, but are associated with the market segment factors that foster collaboration. Truck freight carriers with high concerns ("very concerned" or extremely concerned") over truck driver shortage are likely to consider collaboration under truck driver shortage (TDS) and increasing traffic congestion (TCG), as implied by the positive parameter of TSA in segment 1 (Table 11). The positive parameter of TCA in segment 1 indicates that truck freight carriers with high concerns related to traffic congestion are also likely to consider collaboration under TDS and TCG. For segment 2, TCA has a positive parameter, suggesting that truck freight carriers with high concerns related to traffic congestion are likely to consider collaboration under rising fuel costs (RFC) and TDS.

CHAPTER 3. FREIGHT SHIPPER PERSPECTIVE

3.1 Introduction

Few studies address the perceptional differences between freight shippers and carriers on carrier selection criteria, involving IFC and rail-truck multimodal freight carriers. Murphy, et al. (1997) used the within-group rankings given by shippers and truckload carriers in U.S. on the importance of 18 individual truckload carrier selection criteria (service quality, equipment availability, reliability, and flexibility, etc.). They concluded that despite the differences of mean rating given by shippers and carriers on individual criteria that they both place the similar within group rating on these selection criteria. Premeaux (2002) provides longitudinal assessment of shipper-to-shipper perceptions, carrier-to-carrier perceptions, and shipper-to-carrier perceptions using stated preference survey conducted in year 1991 and year 2001 for shippers and truck carriers on carrier selection. The study reveals that eleven of the thirty-six selection criteria have statistically significant differences between shipper and truck carrier in year 2001. However, none of these studies addresses the perceptual different between shippers and carriers on carrier selection criteria involving IFC or rail-truck multimodal freight carriers, as well as the potential of rail-truck multimodal freight collaboration.

Some of the emergent factors, such as demand for in-transit visibility, and heterogeneity among freight shippers can potentially influence the development of rail-truck multimodal freight collaboration. However, these aspects have not been addressed in the previous studies. Driven by increasing demand of the in-transit visibility of the overall supply chain, the level of in-transit visibility by a shipper can influence its willingness to choose rail-truck multimodal freight carriers. Many studies (i.e. Moberg et al., 2002) suggest that information in-transit visibility is critical for shippers to manage end inventory and back-order quantities, and distributors and wholesalers gain significantly from the improved in-transit visibility. And in-transit visibility is significantly reduced during the transshipment process for IFC (Francis, 2008; Goel, 2010), and it is very likely exists in the rail-truck multimodal freight carriers. As of heterogeneity among freight shippers, most of the previous studies assumed homogeneity of behaviour within given industrial or commodity segments. Arunotayanun and Polak (2011) attempted to use mixed logit models to investigate the heterogeneity among freight shippers of different commodity segments on mode choice in Indonesia. Their results indicate that there is heterogeneity within each commodity-type based shipper market segment. Bergantino et al. (2013) studied the truck carriers' mode choice behavior in Sicily, Italy, and they factored the heterogeneity among truck freight carriers. However, previous studies do not consider IFC among the mode choice and their results cannot be applied to the U.S. conditions due to the potential differences in planning aspects of different countries (Bontekoning, et al., 2004).

The limited perspective to understand the broader rail-truck multimodal freight collaboration motivates the need for an in-depth and contemporary study to explore the opportunities and barriers for U.S. shippers to use the rail-truck multimodal freight carriers. The key to understand these opportunities and barriers lies in analyzing the profiles of freight shipper market segments based on the factors that foster or impede their usage of rail-truck multimodal freight carriers. It embodies in terms of three fundamental questions: (i) what are the factors related freight shippers that foster and impede their usage of rail-truck freight carriers? (ii) are there any perceptional differences between freight shippers and truck freight carriers regarding to factors that foster and impede rail-truck freight collaboration? and (iii) how are the operational and behavioral characteristics of a freight shippers related to these factors? This study fills this gap by exploring freight shipper perspectives in terms of the factors that foster and impede their usage of rail-truck multimodal freight carriers, their linkage to the operational and behavioral characteristics of the carriers in these segments, and the differences of freight shippers and truck carriers on rail-truck multimodal freight collaboration. By doing so, decision-makers can utilize their resources more efficiently and effectively by employing different strategies for different segments to promote synergistic collaboration between rail and truck freight carriers. Univariate t tests and Spearman's rank correlation coefficients are used to capture the perceptional differences between freight shippers and truck freight carriers on factors that foster and impede rail-truck freight collaboration. Cluster analysis is used to identify segments of freight shippers with similar factors that foster or impede their usage of rail-truck multimodal freight carriers. Econometric models are then used to uncover the operational and behavioral characteristics in each segment. To enable these, a survey is conducted for freight shippers located in the U.S. Midwest region (Indiana, Illinois, Iowa, Ohio, Michigan, Kansas, Minnesota, Wisconsin, and Nebraska).

3.2 Survey description and outcome

The relationship between operational and behavioral characteristic of a freight shipper and its factors that foster or impede its usage of rail-truck multimodal freight collaboration is investigated in this paper using a stated preference survey data from freight shippers located in Midwest region[4]. As the rail-truck multimodal freight carrier is currently in its infancy, a revealed preference survey approach is not an option. The stated preference survey seeks information related to freight shippers' operational characteristics, performance assessment of different modes of freight carriers, and perceptions of rail-truck multimodal freight collaboration from a sample of freight shippers. The survey questionnaire was designed based on an exhaustive review of freight shipper mode choice and rail-truck multimodal freight collaboration.

3.2.1 Survey sample operational characteristics

The multimodal rail-truck freight shipment survey is conducted by providing questionnaires to logistic managers and owners of some freight shippers in the Midwest region. The survey was conducted through telephone interviews and online questionnaires distributed via emails. It focuses on studying freight shippers' operational and behavioral characteristics, and the factors that foster or impede their usages of rail-truck multimodal freight transportation service. The questions resided in two sections: (i)

[4] The survey details can be accessed via: https://purdue.qualtrics.com/SE/?SID=SV_beamuYNTWljdVFr

operational characteristics, (ii) performance assessment of freight transportation service and perceptions of rail-truck multimodal freight collaboration.

The first part of the survey was used to capture the respondents' operational characteristics. Of interest are the company type, annual revenue, percentage of annual revenue attribute to freight transportation, primary and secondary mode of transportation, cargo shipping range, primary and secondary commodities types and their origin-destination information, and cargo containerization level. Question was also asked related to their expectation of in-transit visibility, including no visibility, daily snapshot, departure/arrival updates, and checkpoint update. Table 1 present the breakdown of respondents by some of their operational characteristics. This part seeks to understand the operational characteristics of freight shippers that impact the factors that foster or impede their usage of rail-truck multimodal freight carriers.

The second part of the survey explores freight shippers' assessment of different freight transportation modes, including truck-only, rail-only, intermodal, and ocean/barge. The assessment involves freight carriers' overall performance and thirteen individual performance criteria. A five-point Likert scale ranging from "Excellent" (=5) to "Poor" (=1) is used for this purpose. In addition, it also elicits the factors that foster and impede the usage of rail-truck multimodal freight carriers. Respondents were requested to rate the importance of various factors that might foster their usage of rail-truck multimodal freight carriers on a scale of 1 to 5, where 1 indicates not at all important and 5 indicates extreme importance. Table 2 illustrates the factors aiding a freight shipper's willingness to choose rail-truck multimodal freight carriers. Respondents were also asked to identify the factors that impede their usage of rail-truck multimodal freight carriers. A five-point Likert scale ranging from "Extreme concern" (=5) to "No concern" (=1) is used for this purpose. Table 3 identifies the barriers to such collaboration.

3.2.2 Survey sample operational characteristics

1400 freight carriers were contacted for the stated preference survey, with 200 freight shippers each from seven different business sectors, including agriculture, forestry, finishing and hunting; mining, quarrying and oil and gas extraction; utilities;

construction; manufacturing; wholesale trade; accommodation and food service. 169 completed surveys were obtained for an overall response rate of 12.1%. Non-response analyses were performed based on business sectors. A Chi-square test, with $\alpha=0.05$, was used to assess the differences between respondents and non-respondents. There was no significant statistical difference for each business sectors.

Table 12 Operational characteristics of truck freight carriers

Attribute	%
Primary mode of transportation	
Truck-only	71.6
Rail-only	10.7
Intermodal (truck-rail)	16.0
Ocean/barge	1.70
Others	0.00
Secondary mode of transportation	
Truck-only	23.1
Rail-only	24.0
Intermodal (truck-rail)	46.7
Ocean/barge	3.55
Others	2.65
Primary shipping length movement	
< 100 miles	46.2
99-500 miles	50.2
>500 miles	3.60
Annual revenue	
Less than $10,000,000	61.5
$10,000,000-$49,999,999	20.7
$50,000,000-$499,999,999	16.6
Over $500,000,000	1.20
Containerization of cargo (primary commodity)	
All containerized	32.0
No containerization	36.7
Mix of both	31.3
Containerization of cargo (secondary commodity)	
All containerized	39.6
No containerization	24.9
Mix of both	35.5
Expected in-transit visibility	
No visibility	0.00
Daily snapshot	21.9
Departure/arrival update	43.2
Checkpoint update	34.9

Table 12 illustrates some of the aggregated operational characteristics of the respondents. A key observation is that the majority of the respondents are small- to medium-size shippers in terms of annual revenue, and use primarily truck-only carriers to ship their products in short- to medium-distance. More than 60% of the respondents are freight shippers generate less than 10 million U.S. dollars in annual revenue. Over 70% of the respondents' primary freight shipping mode is truck-only mode. Less than 5% of the respondents' primary haul length is over 500 miles. Only a relatively small portion of the respondents indicate the primary and secondary (32.0% and 39.6%, respectively) shipped are fully containerized. The most common freight shipping origin and destination were within the Midwest region. Over 50% of the respondents' primary commodity's shipping origin and shipping destination were Midwest region, and over 60% of the respondents' secondary commodity's shipping origin and shipping destination were in the Midwest region. Other than the Midwest traffic, the origins and destinations of the respondents' freight service were evenly distributed.

The final question in this section is related to the level of in-transit visibility freight shippers expected when they were choosing freight carriers. Four different levels of in-transit visibility (Goel, 2008) were included in the survey, including no visibility (level 0), daily snapshot (level 1), departure/arrival (level 2), and checkpoint (level 3). Checkpoint represents the highest level of in-transit visibility that a shipper can request and receive information at each checkpoint including scheduled time of departure or arrival at a node. Departure/arrival is the second highest in-transit visibility level that the shipper can request and receive information at each scheduled time of departure or arrival at a node. The second lowest level of in-transit visibility is the daily snapshot that the shipper receives a daily update containing information about all departure and arrivals scheduled on the previous day. In the no visibility case, the shipper does not receive any information related to the freight transportation. The information related to the delayed departures and arrivals can give the freight shippers flexibility of planning mitigation action and reduce the risk of stockout. The results in Table 1 illustrates that over 70% of our respondents (125) expect at least level 2 (departure/arrival) in-transit visibility, and none of the respondent selected no in-transit visibility.

3.2.3 Performance assessment of different modes of freight service

To assess their perception of different modes of freight service performance, the respondents were asked to rate the overall performance of different modes of freight carriers as well as the performance on thirteen individual criteria using a Likert scale from 1 to 5, where 1 implied poor service and 5 implied excellent service on that criterion. Price competitiveness of rail-truck intermodal is the only performance criteria rated higher than the truck-only freight transportation mode. In addition, freight shippers also consider the performance of the rail-truck intermodal carrier is higher than the rail-only carrier. These results are consistent with previous studies (Evers et al., 1996; Evers and Johnson, 2000).

Table 13 Factors that foster freight shipper usage of rail-truck multimodal freight collaboration carriers (the number in the brackets is the within-group ranking)

Factors that foster collaboration	Mean rating		
	Shippers	Truck carriers	t-value
Rising fuel costs	3.54 (1)	2.87 (6.5)	4.08*[5]
High truck driver turnover rate	3.11 (6)	3.06 (2)	0.51
Truck driver shortage	3.28 (3)	3.13 (1)	0.92
Traffic congestion	3.35 (2)	2.83 (8)	2.57*
Rising environmental concerns	3.17 (5)	2.79 (10)	2.02*
High empty haul costs	2.65 (12)	2.78 (11)	4.63*
Shrinking of current truck freight market	2.58 (13)	2.87 (6.5)	1.17
Rising labor and management costs	3.23 (4)	2.58 (12)	1.61
Improving operational safety	3.02 (8)	2.97 (4)	0.48
Large multimodal transportation market potential	3.07 (7)	3.03 (3)	0.43
Competition among truck freight carriers	2.85 (10)	2.95 (5)	1.34
Competition with rail freight carriers	2.97 (9)	2.55 (13)	2.48*
Competition with other modes of freight transportation (rail excluded)	2.78 (11)	2.81 (9)	-0.38
Grand mean	3.05	2.86	2.45*

[5] *Significant at the 0.05 level (two-tail test) for Table 2 and 3.

Respondents were requested to rate the importance of individual performance criteria of rail-truck multimodal freight carriers that might foster their usage of rail-truck multimodal freight transportation carriers from their current mode of carriers on a 5-point Likert scale of 1 to 5, where 1 indicates not at all important and 5 indicates extreme importance. Table 2 illustrates the associated outcomes. Rising fuel costs (3.54) and traffic congestion (3.35) are the top two factors that would foster rail-truck multimodal freight collaboration. Table 3 presents potential factors that impede collaboration and illustrates that transshipment delay (3.42) and scope of operation (3.31) are rated as the top two challenges that shippers consider related to rail-truck multimodal freight collaboration.

Table 14 Factors that impede their usage of rail-truck multimodal freight collaboration carriers (the number in the brackets is the within-group ranking)

Factors that impede collaboration	Level of concern (mean rating)		
	Shippers	Truck carriers	t-value
High investment costs	2.58 (9)	3.17 (5.5)	-2.57*
Low investment return rate	2.32 (13)	2.79 (12.5)	-2.14*
Shipper willingness to accept transshipment handling	3.20 (3)	3.03 (7)	0.98
Scope of operation	3.31 (2)	2.89 (10)	1.93
Security of information sharing	2.66 (8)	2.79 (12.5)	0.86
Lack of multimodal market potential	2.42 (11)	2.96 (9)	-2.51*
Transshipment delays	3.42 (1)	3.29 (3)	0.87
Unreliable rail transport times	2.86 (6)	3.49 (1)	-2.89*
Reduction of overall service quality	3.08 (4)	3.21 (4)	0.83
Transshipment safety and security	2.53 (10)	2.83 (11)	-1.92
Rail service flexibility	3.03 (5)	3.35 (2)	-2.03*
Handling equipment availability	2.39 (12)	3.17 (5.5)	-4.05*
Lack of fair allocation mechanism for collaboration revenues	2.74 (7)	2.97 (8)	-1.82
Grand mean	2.81	3.07	-2.69*

To compare the difference between shippers and carriers on factors that foster and impede collaboration, two different methods are used and the results are presented in Table 2 and Table 3. The t-test involving the grand mean (the average score rated by shippers or truck carriers for all 13 factors) given by shippers and carriers is used to discover the factors exhibiting statistically significant differences (at the 0.05 level) in mean scores. From t-tests of the individual factors that foster collaboration, 5 out of 13 factors statistically significant difference were revealed, while 6 out of 13 factors statistically significant different for the factors impede collaboration between shippers and truck carriers.

In addition to the comparison of mean ratings given to factors foster or impede collaboration, Spearman's rank correlation coefficients are used to analyze the significant within group ranking differences between freight shippers and truck carriers on these factors. The data of truck carriers is provided by Guo and Peeta (2014). They are found to be insignificant for both factors foster and impede rail-truck multimodal freight collaboration (0.154 and 0.452 respectively) at the 0.05 level (0.618). Both of the measurements indicates a high degree of dissimilarity between shipper and carrier on the factors that foster or impede rail-truck multimodal freight collaboration.

Regarding to future willingness to use rail-truck multimodal freight carriers, more than 20% of the freight shippers (n=35) indicate that they definitely will use rail-truck multimodal freight carriers in the future if the service is available. Less than 25% of the freight shippers (n=41) indicate that they definitely will not use rail-truck multimodal freight carriers.

3.3 Data analysis and model development

This section describes the model structure development process to analyze the survey data. As stated in section 2, shippers and truck carriers have high degree of dissimilarity on the factors that foster or impede rail-truck multimodal freight collaboration. Thereby, it is critical to understand the freight shipper market's response towards rail-truck multimodal freight collaboration. Presumably, freight shippers with similar operational and behavioral characteristics (freight shipper market segments) may entail similar factors that foster and impede their usage of rail-truck multimodal freight carriers. Two sequential steps are employed to identify these segments. Cluster analysis is used to identify the existence of embedded freight shipper market segments with similar factors that foster and impede rail-truck multimodal freight collaboration in the first step. In the second step, mixed logit models are used to uncover the operational, freight shipment and behavioral characteristics within each market segment. In addition, heterogeneity among the freight shippers is also identified using mixed logit models.

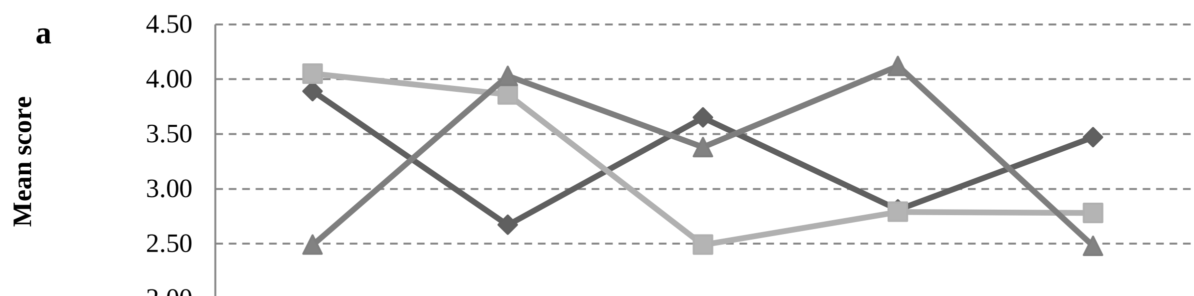
The opportunities cluster analysis identifies freight carrier market segments based on the factors that foster their usage of rail-truck multimodal freight carriers. Eight factors are omitted after performing Pearson product-moment correlation coefficient test. The remaining five factors are rising fuel cost (RFC), traffic congestion (TRC), truck driver shortage (TDS), rising environmental concerns (REC), and improving operational safety (IOS). And these factors are labeled as opportunities factors. Three distinct freight shipper market segments are found based on rating to these opportunities factors. Figure 1a illustrates the characteristics using the mean value of the opportunities factors in these segments. The mean value of an opportunity factor over 3 indicating that the majority of the freight shippers in that segment consider the opportunity factor important, very important or extremely important factor that foster their usage of rail-truck multimodal freight carriers.

Table 15 Explanatory variables (carrier operational and behavioral characteristics) for the mixed logit models

Explanatory variables	Mnemonics
Alternative constant	ONE
Freight shippers’ primary mode of freight transportation as truck carriers = 1, if yes = 0, if no	TCP
Freight shippers’ primary shipping length lower than 100 miles = 1, if yes = 0, if no	LHL
Freight shippers’ primary or secondary commodities shipped is containerized = 1, if yes = 0, if no	CTL
Fright shippers expect in-transit visibility equal or higher than level 2 (departure/arrival update) = 1, if yes = 0, if no	HIT
Fright shippers with relatively small business size in terms of annual revenue = 1, if annual revenue < $10,000,000 = 0, if no	SBS

Freight shippers "likely" or "definitely" will use rail-truck multimodal freight carriers if such service available = 1, if yes = 0, if no	FUW
Freight shippers rated rail freight carrier overall performance higher than 3 = 1, if yes = 0, if no	HRP

The largest market segment, segment 1(n=79, 46.7%), includes the freight shippers who will increase the usage of rail-truck multimodal freight carriers under rising fuel costs (RFC), truck driver shortage (TDS) and improving operational safety (IOS). Segment 2 (n=43, 25.4%), the smallest market segments, represents the freight shippers who will increase the usage of rail-truck multimodal freight carriers under rising fuel costs (RFC) and traffic congestion (TRC). Freight shippers in segment 3 will increase their usage of rail-truck multimodal freight carriers under traffic congestion (TRC), truck driver shortage (TDS) and rising environmental concerns (REC). As can be noted in the Figure 1, freight shippers in segment 1 share the opportunities factor, RFC, with shippers in segment 2 and TDS with shippers in segment 3. For freight shippers in segment 2, they share the opportunities factor TRC with segment 3.



	RFC	TRC	TDS	REC	IOS
Segement 1	3.89	2.67	3.65	2.81	3.47
Segement 2	4.05	3.86	2.49	2.79	2.78
Segement 3	2.49	4.03	3.38	4.12	2.48

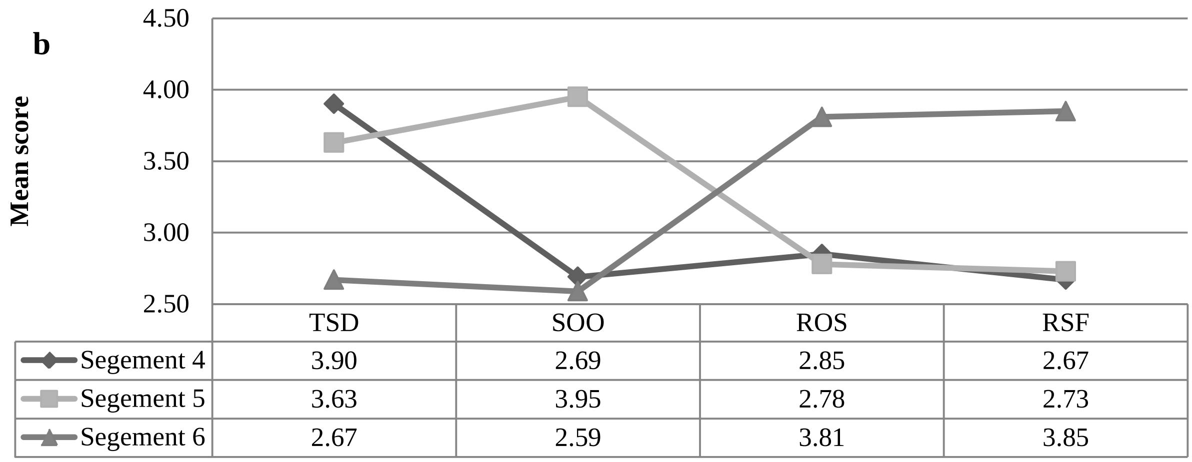


Figure 4 Mean values of opportunities factors (4a) and barriers factors (4b) for different freight shipper market segments

Akin to the opportunities cluster analysis, the barriers cluster analysis identifies freight shipper market segment based on the factors (barriers factors) that impede their usage of rail-truck multimodal freight carriers. Transshipment delay (TSD), scope of operation (SOO), reduction of overall service quality (ROS) and rail service flexibility (RSF).

As illustrated in Figure 4b, the freight shipper market can be divided into three segments exhibiting different barriers factors. Segment 4, the smallest market segment (n=35, 20.7%), represents the freight shippers for whom transshipment delay (TSD) would impede their using of rail-truck multimodal freight carriers. For the largest segment, segment 5 (n=87, 51.5%) includes freight shippers for whom transshipment delay (TSD) and scope of operation (SOO) would impede their using of rail-truck multimodal freight carriers. Freight shippers in segment 5 share the opportunities factor, TSD, with the freight shippers in segment 4. Freight shippers in segment 6 consider reduction of overall service quality (ROS) and rail service flexibility (RSF) would impede their using of rail-truck multimodal freight carriers.

Table 16 Goodness-of-fit measures for the MNL and MMNL

	Opportunities models		Barriers models	
	MMNL	MNL	MMNL	MNL
Number of parameters	13	12	13	11
Log-likelihood at zero, LL(0)	-147.63	-147.63	-150.30	-150.30
Log-likelihood at convergence, LL(β)	-92.38	-99.61	-92.62	-103.58
McFadden ρ^2 statistic	0.374	0.325	0.384	0.311
Corrected ρ^2	0.286	0.243	0.297	0.238
Likelihood ratio test				
$x^2 = -2[\text{LL}(\beta_{MNL}) - \text{LL}(\beta_{MMNL})]$	7.23		10.96	
Degree of freedom	1		2	
Critical x^2 (0.99 level of confidence)	6.63		9.21	

Table 17 Operational and behavioral characteristics that foster and impede rail-truck multimodal freight collaboration in each freight shipper market segment (All random parameters are normally distributed)

	Opportunities models			Barriers models		
	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6
Variable	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
ONE	0.23*	-0.20*	0.41**	0.20*	0.62*	—
TCP	0.46**	0.32**	—	—	—	0.31*
LHL	-0.30**	—	—	0.41**	—	—
CTL	—[6]	—	—	—	—	0.28**
HIT	—	—	0.42**	0.57**	—	—
SBS	—	0.23* (0.25**)	—	0.19*	-0.27**	—
FUW	0.35**	—	—	0.16*	0.35** (0.28**)	—
HRP	0.16*	—	-0.19**	—	—	-0.23** (0.25**)
Log-likelihood at zero			-147.63	Log-likelihood at zero		-150.30
Log-likelihood at convergence			-92.38	Log-likelihood at convergence		-96.62

Note: Significant at : *p<0.05 and **p<0.01; n=169 for sample size

[6] Dash (—) in Tables 6 indicates that the variable is not statistically significant for that market segment.

3.4 Model analysis and insights

3.4.1 Operational characteristics of different market segments and policy insights

The MMNL models indicate that a freight shipper's primary mode of freight transportation (TCP) is an important explanatory variable for determining its likelihood of belonging to a market segment, and can thereby be linked to the factors that foster or impede the usage of rail-truck multimodal freight carriers. As TCP with a positive parameter for segment 1, freight shippers, with truck freight shipping mode as their primary shipping mode, consider rising fuel costs (RFC), truck driver shortage (TDS) and improving operational safety (IOS) as the factors that foster their usage of rail-truck multimodal freight carriers. TCP also has a positive parameter for segment 2, suggesting that freight shippers, with truck freight shipping mode as their primary shipping mode, are also likely traffic congestion (TRC) as a factor that foster their usage of rail-truck multimodal freight carriers. Since the freight shippers use truck carriers as their primary freight shipping mode, RFC and TDS could increase the operation costs for truck freight carriers thereby freight shippers are likely to expect the potential increase in the shipping rate. Previous studies (Spychalski and Swan, 2004; Larson, 2013) have shown that fuel consumption cost can greatly impact the shipping rate offered by truck carriers. And the expected truck driver shortage could reach 239,000 by 2020 (ATA, 2013) and the effected HOS regulation would further drive up the needs of truck drivers. Due to the potential shortages, truck carriers have to provide more new drivers with driver training programs, higher sign on bonuses and productivity or performance bonuses to attract truck drivers (Wilson, 2013). Comparing to the working hours and working condition of main stream truck carriers, truck drivers in rail-truck multimodal freight carriers can be offered with shorter working hours and better working condition (i.e. work close home not away from family) similar to truck drivers in drayage carriers for IFC. The impacts of RFC and TDS are smaller for rail-truck multimodal freight carriers so they can offer relative competitive rate to freight shippers. TCP could also lead to the potential cost increase of truck carriers (i.e. night time shipping to avoid congestion), and may reduce the potential of reliability. Despite the safety precautions employed by truck carriers, the operational safety is still a major concern for freight shippers. These factors (RFC, TDS, IOS and TRC) would foster the usage of rail-truck multimodal carriers for freight shippers using primarily truck freight service. TCP has a positive parameter for freight shippers in segment 6, indicating that freight shippers using primarily truck freight service consider reduction of overall service quality (ROS) and rail service flexibility (RSF) would impede their usage of rail-truck multimodal freight carriers. Freight shippers rated very high on overall performance and service flexibility for truck freight carriers comparing to rail carriers and intermodal carriers. It suggests that freight shippers using primarily truck carriers consider the involvement of rail carriers would reduce the service quality and flexibility.

Primary freight shipping distance (LHL) is also a key freight shipping characteristics for a freight shipper's likelihood of belonging to a market segment. Freight shippers with a relatively shorter primary shipping range (less than 100 miles) are less likely to consider rising fuel costs (RFC), truck driver shortage (TDS) and improving operational safety (IOS) as the factors that foster their usage of rail-truck multimodal freight carriers, indicated by the negative parameter of LHL in segment 1. For short range freight shipping, the shipping rate is relatively stable despite the fuel costs increase as the portion of fuel costs is relatively small compare with long range freight shipping and it also reduce the competitiveness of rail-truck multimodal freight shipping due to the delay of transshipment process. Despite the truck driver shortage, the impact to the short-range freight carriers is smaller and the majority of the shortage exists for long-range truck carriers (ATA, 2013). And the majority of the safety issues related to truck carriers also exist in long-range truck carriers due to long working hours of drivers. These indicate that RFC and TDS would not bring significant impact on the service offered by the truck carriers and the freight shippers would less likely to make any freight shipping changes. Freight shippers (segment 4) with primarily short-range freight shipping are likely to find transshipment delay (TSD) is the factor that impedes their usage of rail-truck multimodal freight carriers. Short-range freight shippers consider the transshipment process may not be meaningful for short-range shipping.

The freight shipper's business size (SBS) is also found to be important operational characteristics for a freight shipper's likelihood of belonging to a market segment. For segment 2, SBS has a normally distributed random parameter with a mean of 0.23 and a standard deviation of 0.25. It suggests that freight shippers with relatively small business size in terms of annual revenue are very likely (82.1%) to consider rising fuel costs (RFC) and traffic congestion (TRC) as the factors that foster their usage of rail-truck multimodal freight carriers. Only a small portion (17.9%) of freight shippers with small business size would not consider RFC and TRC would foster their usage of rail-truck multimodal freight carriers. It may suggest that based on the current trend of rising fuel costs and traffic congestions freight shippers with small business size might be more likely to consider using rail-truck multimodal freight carriers. For segment 4, SBS has a positive parameter, suggesting that freight shippers with relatively small business size in terms of annual revenue consider transshipment delay (TSD), reduction of service quality (ROS) and rail service flexibility (RSF) would impede their usage of rail-truck multimodal freight carriers. SBS has a negative parameter in segment 5, suggesting that freight shippers with relatively small business size in terms of annual revenue are less likely to consider scope of operation (SOO) would impede their usage of rail-truck multimodal freight carriers. It indicates that larger freight shippers are likely to worry about using rail-truck multimodal freight carriers, because they may need to make major operation changes in order to use rail-truck multimodal freight carriers.

Cargo containerization level (CTL) is insignificant operational characteristics related to the market segment factor that foster their usage of rail-truck multimodal freight carriers, but is associated with market segment factors that impede their usage of rail-truck multimodal freight carriers. The CTL has a positive parameter in segment 6 indicating that freight shippers with relatively high cargo containerization level (either or both of the shipper's primary and secondary cargo is containerized) are likely to consider reduction of overall service quality (ROS) and rail service flexibility (RSF) can impede their usage of rail-truck multimodal freight carriers.

3.4.2 Behavioral characteristics of different market segments and policy insights

The MMNL models suggest that a freight shipper's expectation of in-transit visibility (HIT) is an important behavioral characteristic for determining its factors that foster and impede collaboration. Freight shippers who expect relatively high in-transit visibility (equal or higher than departure/arrival update) are likely to consider using rail-truck multimodal freight carriers under traffic congestion (TRC), truck driver shortage (TDS) and rising environmental concerns (REC), indicated by the positive parameter of HIT in segment 3. However, they also concerned of transshipment delay (TSD) reflected by the positive parameter for HIT in segment 4.

Future usage willingness (FUW) is also an important behavioral characteristic for a freight shipper's likelihood of belonging to a market segment. For segment 1, freight shippers with high future usage willingness of rail-truck multimodal freight carriers are likely to consider rising fuel costs (RFC), truck driver shortage (TDS) and improving operational safety (IOS) as the factors that foster their usage of rail-truck multimodal freight carriers. Comparing to the collaboration willingness for truck carriers, majority of freight shippers (more than 60%) show relatively high willingness (likely or very likely) to use rail-truck multimodal freight carriers if such service available. For segment 5, FUW has a normally distributed random parameter with a mean of 0.35 and a standard deviation of 0.28. It implies majority of freight shippers (89.4%) who have relatively high willingness to use rail-truck multimodal freight carriers are likely to consider transshipment delay (TSD) and scope of operation (SOO) would impede their usage of rail-truck multimodal freight carriers. Only small portions (10.6%) of such carriers do not consider these factors would impede their usage of rail-truck multimodal freight carriers. The FUW has a positive parameter for segment 4, indicating that freight carriers with high willingness to use rail-truck multimodal freight carriers consider TSD would impede their usage of rail-truck multimodal freight carriers.

Freight shipper's rating of rail freight carriers (HRP) is an important behavioral characteristic for determining its factors that foster and impede their usage of rail-truck multimodal freight carriers. Freight shippers who rate rail freight carriers' overall performance relatively good (good, very good or extremely good) are likely to consider rising fuel costs (RFC), truck driver shortage (TDS) and improving operational safety (IOS) as the factors that foster their usage of rail-truck multimodal freight carriers, but less likely on traffic congestion (TRC) and rising environmental concern (REC), indicated by the positive parameter of HRP in segment 1 and negative parameter in segment 3. In segment 6, the HRP has a normally distributed parameter with a mean of -0.23 and a standard deviation of 0.25. It illustrates that the majority of freight shippers (82.1%) are less likely to consider reduction of service quality (ROC) and rail service flexibility (RSF) when their assessment of rail freight carriers' overall performance is relatively good. However, a significant number of freight shippers (17.9%) would consider ROC and RSF as the factors that impede their usage of rail-truck multimodal freight carriers, implying that a positive perception of rail freight carriers' performance may not necessarily indicate by itself an inclination for good service quality and higher flexibility of rail-truck multimodal freight carriers.

CHAPTER 4. POLICY INSIGHTS

4.1 Policy insights from truck freight carrier perspective

The analysis of the six MMNL models for truck freight carriers provides a few broader insights for rail-truck multimodal freight collaboration that illuminate policy considerations and suggest further study directions. This study profiles the truck freight carrier market segments based on the factors that foster or impede rail-truck multimodal freight collaboration from the truck freight carrier perspective. The MMNL models link a truck carrier's operational and behavioral characteristics to factors that foster or impede collaboration. Such linkages are summarized in Tables 18 and 19.

Table 18. Truck freight carrier's operational and behavioral characteristics related to factors that foster collaboration

Truck freight carrier's operational and behavioral characteristics (Mnemonics)	Factors that foster collaboration			
	RFC	TDS	TCG	LMT
Primary service range (LGH or SHH)	Long	Long	Medium	Short
Use of technology (UOT)	Limited	Limited	Limited	Extensive
Level of concern with traffic congestion affecting the operations (TCA)	High	High	High	Low
Level of concern with truck driver shortage affecting the operations (TSA)	Low	High	High	Low
Assessment of rail freight carriers' performance level (RCO)	Poor	Poor	Poor	Good
Future collaboration willingness (FCW)	Low	High	High	Low

Table 19 Truck freight carrier's operational and behavioral characteristics related to factors that impede collaboration

Truck freight carrier's operational and behavioral characteristics (Mnemonics)	Factors that impede collaboration			
	LIR	CWA	TDE	ROS
Fleet size (FLS)	Small	Small	Small	Medium to large
Primary service range (LGH or SHH)	Long	Short	Short	Long
Cargo containerization level (CTL)	Low	High	High	Low
Use of technology (UOT)	Limited	Limited	Limited	Extensive
Collaboration frequency with rail freight carriers (WFR)	Low	Low	Low	High
Assessment of rail freight carriers' performance level (RCO)	Poor	Good	Good	Good
Future collaboration willingness (FCW)	Low	Low	Low	High

The significance of the truck freight carrier's primary service range (SHH or LGH) for the factors that foster or impede rail-truck multimodal freight collaboration indicates that decision-makers should use different tactics towards regional and national truck freight carriers to foster such collaboration. In most instances, short-range truck freight carriers are market-driven. Unlike the limited role of drayage companies in the rail-truck intermodal freight transportation, they expect to expand their current market through rail-truck multimodal freight collaboration without losing their current market base. It indicates that the collaboration between rail and truck freight carriers is market-driven (large market potential), and the need to understand the freight shippers' demand and expectations towards the rail-truck multimodal transportation. Unlike short-range carriers, long-range truck carriers are burdened by rising fuel costs and truck driver shortage, and seek to mitigate these issues by collaborating with rail freight carriers.

4.2 Policy insights from freight shipper perspective

This study analyzes the opportunities and barriers for freight shippers in the U.S. to use rail-truck multimodal freight carriers and the perceptional differences between freight shippers and truck carriers on the rail-truck multimodal freight collaboration. A stated preference survey of freight shippers in the U.S. Midwest region was conducted for this purpose. Based on the survey results for this study and the study of Guo and Peeta (2014), freight shippers and truck carriers reveal significant differences on their perception towards rail-truck multimodal freight collaboration, using Spearman's rank correlation coefficients. In addition, cluster analysis is used to identify the freight shipper market segments that exhibit distinct factors that foster or impede their usage of rail-truck multimodal freight collaboration. Mixed logit models are estimated to determine a freight shipper's likelihood of belonging to a market segment based on their operational, freight shipping and behavioral characteristics. Thereby, these characteristics are linked to the factors that foster and impede freight shippers' usage of rail-truck multimodal freight carriers. Such linkages are summarized in Table 8a and Table 8b respectively. A strong correlation is recognized between a freight shipper's primary used mode of carriers and its factors that foster and impede freight shippers' usage of rail-truck multimodal freight carriers. In addition, random parameter variations are found for some parameters associated with the operational and behavioral characteristics of the freight shippers, indicating that heterogeneity exists in some of the freight shipper market segments. These suggest that a range of strategies targeting different freight shippers and truck carriers should be considered by decision-makers to foster rail-truck multimodal freight collaboration. The MMNL models link a freight shipper's operational and behavioral characteristics to factors that foster or impede collaboration. Such linkages are summarized in Tables 20 and 21.

Table 20 Freight shippers operational and behavioral characteristics related to factors that foster collaboration

Freight shipper's operational and behavioral characteristics (Mnemonics)	Factors that foster collaboration				
	RFC	TRC	TDS	REC	IOS
Primary mode of freight shipping (TCP)	Truck	Truck	Truck	Others	Truck
Primary freight shipping range (LHL)	Short	Medium to long	Short	Medium to long	Short
In-transit visibility expectation (HIT)	Medium	High	High	High	Medium
Business size in terms of annual revenue (SBS)	Small	Small	Medium to large	Medium to large	Medium to large
Future willingness to use rail-truck multimodal freight carriers (FCW)	High	Low	High	Low	High
Assessment of rail freight carrier performance (HRP)	Good	Poor	Good	Poor	Good

Table 21 Truck freight carrier's operational and behavioral characteristics related to factors that impede collaboration

Freight shipper's operational and behavioral characteristics (Mnemonics)	Factors that impede collaboration			
	TSD	SOO	ROS	RSF
Primary mode of freight shipping (TCP)	Other	Other	Truck	Truck
Primary freight shipping range (LHL)	Short	Medium to long	Short	Short
Cargo containerization level (CTL)	Low	Low	High	High
In-transit visibility expectation (HIT)	High	Medium	Medium	Medium
Business size in terms of annual revenue (SBS)	Small	Medium to large	Small	Small
Future willingness to use rail-truck multimodal freight carriers (FCW)	High	High	Low to high	Low to high
Assessment of rail freight carrier performance (HRP)	Poor	Poor	Good	Good

REFERENCES

American Trucking Association (ATA). (2013), U.S. Freight Forecast to 2024, ATA.

Anderberg, M. R. Cluster analysis for applications. Academic Press, New York, 1973.

Arunotayanun, K. and Polak, J. W. (2011), "Taste heterogeneity and market segmentation in freight shippers' mode choice behaviour", Transportation Research Part E: Logistics and Transportation Review, Vol. 47 No. 2, pp. 138-148.

Bergantino, A. S., Bierlaire, M., Catalano, M., Migliore, M., and Amoroso, S. (2013), "Taste heterogeneity and latent preferences in the choice behaviour of freight transport operators", Transport Policy, Vol. 30, pp. 77-91.

Bontekoning, Y. M., C. Macharis, and J. J. Trip. Is a new applied transportation research field emerging? — A review of intermodal rail-truck freight transport literature. Transportation Research Part A: Policy and Practice, Vol. 38, No. 1, 2004, pp. 1-34.

Brown, T. A. Freight brokers and general commodity trucking. Transportation Journal, Vol. 24, No. 2, 1984, pp. 4-14.

Bureau of Transportation Statistics (BTS). Commodity Flow Survey. http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/commodity_flow_survey/index.html, 2008. Accessed May 7, 2013.

Burnson, P. 23rd Annual State of the Logistics Report: Slow and Steady. Logistics Management, July, 2012, pp. 26-39.

Chui, T., D. Fang, J. Chen, Y. Wang, and C. Jeris. A robust and scalable clustering algorithm for mixed type of attributes in large database environment. Proceedings of the 7th ACM SIGKDD International Conference in Knowledge Discovery and Data Mining, Association for Computing Machinery, San Francisco, CA, 2001, pp. 263-268.

Costello, B. Truck driver shortage update, 2012. American Truck Associations (ATA). http://www.trucking.org/StateIndustry/Documents/Driver%20Shortage%20Update%20 November%202012.pdf. Accessed Dec. 2012.

Danielis, R., Marcucci, E., and Rotaris, L. (2005), “Logistics Managers’ stated preferences for freight service attributes”, Transportation Research Part E: Logistics and Transportation Review, Vol. 41 No. 3, pp. 201-215.

Dewan, M., Z. Islam, J. Dinwoodie and M. Roe. Promoting development through multimodal freight transport in Bangladesh. Transportation Reviews, Vol. 26, No. 5, 2006, pp. 571-591.

Evers, P., D. Harper and P. Needham. The determinants of shipper perceptions of modes. Transportation Journal, Vol. 36, No. 2, 1996, pp. 13-25.

Fowkes, A., Nash, and G. Tweddle. Investigating the market for inter-modal freight technologies. Transportation Research A: General, Vol. 25, No. 4, 1991, pp. 161-172.

Francis, V. (2008), “Supply chain visibility: lost in translation?”, Supply Chain Management: An International Journal, Vol. 13 No. 3, pp. 180-184.

Fries, N., G. Jong, Z. Patterson, and U. Weidmann. Shipper willingness to pay to increase environmental performance in freight transportation. Transportation Research Record: Journal of Transportation Research Board, No. 2168, 2010, pp. 33-42.

Golob, T., and A. Regan. Impacts of highway congestion on freight operations: perceptions of truck industry managers. Transportation Research Part A: Policy and Practice, Vol. 35, No. 7, 2001, pp. 577-599.

Gorman, M. Evaluating the public investment mix in US freight transportation infrastructure. Transportation Research Part A: Policy and Practice, Vol. 43, No. 1, 2008, pp. 1-14.

Goel, A. (2010), “The value of in-transit visibility for supply chains with multiple modes of transport”, International Journal of logistics: Research and Application, Vol. 13 No. 6, pp. 475-492.

Gray, R. (1982), “Behavioural approaches to freight transport modal choice”, Transport Reviews, Vol. 2 No. 2, pp. 161-184.

Greene, W. LIMDEP version 7.0. 1998.

Guo, Y., and Peeta, S. (2014), “Exploring the opportunities and barriers to rail-truck multimodal freight collaboration: truck freight carrier perspective”, in proceedings of 93rd Transportation Research Board Annual Meeting, January 2014, Washington, D.C., USA.

Harper, D., and P. Evers. Competitive issues in intermodal railroad-truck service. Transportation Journal, Vol. 32, No. 3, 1993, pp. 31-45.

Hensher, D., and W. Greene. The mixed logit model: the state of practice. Transportation, Vol. 30, 2003, pp. 133-176.

IBM. IBM SPSS Statistics 21 Brief Guide. ftp://public.dhe.ibm.com/software/analytics/spss/documentation/statistics/21.0/en/client/Manuals/IBM_SPSS_Statistics_Brief_Guide.pdf. Accessed Oct. 23th, 2013.

Krapfel, R. E., and Mentzer, J. T. (1982), “Shippers’ transportation choice processes under deregulation”, Industrial Marketing Management, Vol. 11 No. 2, pp. 117-124.

Ketchen Jr, D. and C. Shook. The application of cluster analysis in strategic management research: an analysis and critique. Strategic Management Journal, Vol. 17, 1996, pp. 441-458.

Larson, P. Deregulation of and mergers among American and Canadian railroads: A study of four decades. Research in Transportation Business & Management, Vol. 6, 2013, pp. 11-18.

Ludvigsen, J. Freight transport supply and demand conditions in the Nordic Countries: Recent evidence. Transportation Journal, Vol. 39, No. 2, 1999, pp. 31-54.

McFadden, D. L. and K. E. Train. Mixed MNL models for discrete response. Journal of Applied Econometrics, Vol. 15, 2000, pp. 447-470.

McKelvey, B. Guidelines for the empirical classification of organizations. Administrative Science Quarterly, Vol. 20, 1975, pp. 509-525.

Moberg, C. R., Cutler, B. D., Gross, A., and Speh, T.W. (2002), "Identifying antecedents of information exchange within supply chains", International Journal of Physical Distribution & Logistics Management, Vol. 32 No. 9, pp. 755-770.

Motraghi, A. Rail research projects: Case studies. Research in Transportation Economics, Vol. 41, Issue. 1, May 2013, pp.76-83.

Murphy, P., and P. Hall. The relative importance of cost and service in freight transportation choice before and after deregulation: an update. Transportation Journal, Vol. 35, No. 1, 1995, pp. 30-38.

Murphy, P., J. Daley, and P. Hall. Carrier selection: do shippers and carriers agree, or not?. Transportation Research Part E: Logistics and Transportation Review, Vol. 33, No. 1, 1997, pp. 67-72.

Okazaki, S. What do we know about mobile Internet adopters? A cluster analysis. Information & Management, Vol. 43, 2006, pp.127-141.

Peeta, S., J. L. Ramos, and R. Pasupathy. Content of variable message signs and on-line driver behavior. Transportation Research Record: Journal of the Transportation Research Board, No. 1725, 2000, pp. 102-108.

Patterson, Z., G. Ewing, and M. Haider. Shipper preferences suggest strong mistrust of rail: results from stated preference carrier choice survey for Quebec City-Windsor Corridor in Canada. Transportation Research Record: Journal of Transportation Research Board, No. 2008, 2007, pp. 67-74.

Premeaux, S. R. (2002), “Motor carrier selection criteria: perceptual differences between shippers and motor carriers”, Transportation Journal, Vol. 42 No. 2, pp. 28-38.

Samimi, A., Kawamura, K., and Mohammadian, A. (2011), “A behavioral analysis of freight mode choice decisions”, Transportation Planning and Technology, Vol. 34 No. 8, pp. 857-869.

Slack, B. Along different paths: intermodal rail terminals in North America and Europe. Proceedings 7th World Congress on Transportation Research, Vol. 4, Sydney, Australia, 1996, pp. 123-131.

Spychalski, J., and P. Swan. US rail freight performance under downsized regulation. Utilities Policy, Vol. 12, 2004, pp. 165-179.

Tan, P. N., M. Steinbach, and V. Kumar. Introduction to data mining. Pearson Addison-Wesley, Inc., Boston, 2006.

Taylor, J. and G. Jackson. Conflict, power, and evolution in the intermodal transportation industry’s channel of distribution. Transportation Journal, Vol. 39, No. 3, 2000, pp. 5-17.

Tsamboulas, D., and S. Kapros. Decision-making process in intermodal transportation. Transportation Research Record: Journal of the Transportation Research Board, Vol. 1707, No. 1, 2000, pp. 86-93.

Train, K. Discrete choice methods with simulation. Cambridge University Press, Inc., Cambridge, 2009.

U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations. Freight Facts and Figures, 2012. http://www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/12factsfigures/table2_1.htm. Accessed May 8, 2013.

Van Schijndel, W. J., and J. Dinwoodie. Congestion and multimodal transport: a survey of cargo transport operators in the Netherlands. Transport Policy, Vol. 7, No. 4, 2000, pp. 231-241.

Wilson R. (2013), "24th Annual State of the Logistics Report: Is this the new normal?", available at http://www.fmsib.wa.gov/reports/powerPoints/RosalynWilsonStateofLogisticsReport2013.pdf (accessed 6 March 2014).