A Dissertation

entitled

Technology Systems and Practices in Transportation and Logistics: Exploring the Links Toward Competitive Advantage in Supply Chains

by

Sarah E. Schafer

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the Doctor of Philosophy Degree in Manufacturing and Technology Management

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May 2015

An Abstract of

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Higher demands for a variety of products add not only to the complexity of coordinating a supply chain, but also to the number of freight movements to support those demands. The increased demand for moving materials and goods contributes to higher levels of congestion and pollution during a time when businesses, customers and governments are increasingly concerned with reducing carbon footprints. To this end, new technologies and data capabilities are emerging that can add integrated visibility (monitoring and tracing), efficiency and even sustainability within the supply chain in order to mitigate these issues and cultivate an ever desired competitive advantage.

Companies continuously look for innovative ways to evolve and compete within their dynamic environments. One untapped area that can provide a significant source of competitive advantage is within the complex supplier network and distribution channels; specifically, within the logistics and transportation functions. In an era of increasingly complex supplier network relationships, there is a growing need to connect and automate the extended supply chain between organizations.

Application of information technologies (IT) is seen as key enablers to mitigate these issues, yet widespread use is not evident between trade partners and transportation providers. Applications of IT enabled systems (i.e. intelligent transportation systems for freight and transportation management systems) and practices (i.e. integrated information sharing and third party provided supply chain and logistics managers) can be used to improve efficiencies, reliability, and reduce carbon effects of freight movements. Benefits derived from the movement of freight can, in turn, benefit the wider supply chain through faster response times and lower holding costs realized from reduced inventories.

Drawing on contingency theory and organizational information processing theory, this research conceptualizes a model to study the relationships between the major constructs (1) External Environmental Pressures, (2) Internal Organizational Environment, (3) IT Enabled Systems and Practices, (4) Transportation Outcomes, and (5) Competitive Advantage of the Supply Chain.

Examining transportation as the link between enterprises in the supply chain is not well understood. This work is expected to open a new area for examining the interfaces between organizations in order to improve overall performance for supply and distribution networks. The development of a reliable instrument to test these relationships will contribute to research and practice. Hypothesized relationships were tested through a combined statistical analysis of primary data collected from 260 transportation providers. By providing researchers with a better understanding of contextual factors that drive organizational technology adoption, it will become easier to

identify factors of success for future innovative technology initiatives, particularly pertaining to the transportation and logistics industry.

Moreover, managers are expected to find results from evaluating specific types of IT enabled systems and practices particularly useful as they provide metrics for evaluating investments in those systems and practices based on performance measures for transportation outcomes in efficiency, reliability, responsiveness, quality, carbon emissions reduction, and equipment utilization.

Results indicate that some IT enabled systems and practices, mainly intelligent transportation systems for freight and integrated information sharing, do positively impact transportation outcomes. Other IT enabled systems and practices were found to have weak impacts (i.e. using a transportation management system) or non-significant relationships (i.e. using a third party provided supply chain and logistics manager). Implications for these findings are discussed.

Finally, results indicate a strong relationship between positive transportation outcomes and the competitive advantage of the supply chain network. Thus indicating the importance of utilizing transportation providers to differentiate service offerings and build a competitive advantage for the supply chain. Contributions to research and implications of these results for practice are discussed.

To my daughters Jeana and Kaylee, you have inspired me to reach beyond my limits. I hope you are both inspired on your journey through life! To my parents, Matt and Jeri, your unconditional love and support have made this all possible. I love you all!

Acknowledgements

It is with deep gratitude to many individuals that this work is completed and submitted. Dr. Mark Vonderembse, I cannot thank you enough for agreeing to be committee chair even after your retirement. I have so much appreciation for your guidance, mentoring, encouragement and friendship throughout this process. Dr. Peter Lindquist, your mentoring, encouragement and friendship over the years helped shape this path for me, thank you. I appreciate all of your support throughout this journey. Committee members, Dr. Tom Sharkey and Dr. P. Sundararagavan, thank you for your suggestions and comments they have made a positive impact on this dissertation. Dr. Sachin Modi, thank you for your guidance in methods, your time and effort are truly appreciated. Thank you to all COBI professors who have contributed to the program!

Special thanks to Richard Martinko and Christine Lonsway, at the UT ITI, this work was made possible from your support and funding from the IT Highway project sponsored in partnership with CFIRE at the University of Wisconsin. Thanks to all the respondents, Q Sort participants and interview participants.

Finally, this work would not have been possible without my daughters' patience and understanding, thank you Kaylee and Jeana you're troopers! The love, support and encouragement from my parents, Matt and Jeri, and friend, Tammy, were instrumental in completing this work. Guy Schafer, thank you for helping me put it all into perspective. Thank you to all of my friends, colleagues, and fellow PhD students past and present for your contributions and influence on this work.

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Chapter 1

Introduction

Companies continuously look for innovative ways to evolve and compete within their dynamic environments. By adopting new systems, practices, and policies (Daft, 1982; Damanpour & Evan, 1984; Zaltman et al., 1973, Damanpour, 1991) companies can find innovative solutions to gain a competitive advantage. One untapped area that can provide a significant source of competitive advantage is within the complex supplier network and distribution channels (Dias et al., 2009). Specifically, logistics and transportation functions connecting trade partners have been recognized as an area of potential competitive advantage (Loebbecke and Powell, 1998). Recently, the locus of competition is discussed more often among supply chains than between individual organizations themselves (Christopher, 1992, 1998; Bowersox, 1997; Bradley et al., 1999; Cox, 1999; Lambert and Cooper, 2000; Chen and Paulraj, 2004; Dias et al, 2009; Caridi et al., 2010).

In an era of increasingly complex supplier network relationships, there is a growing need to connect and automate the extended supply chain between organizations (Cecere, 2014). Higher demands for a variety of products add not only to the complexity of coordinating a supply chain, but also to the number of freight movements to support those demands. What's more, the higher demand for moving materials and goods contributes to higher levels of congestion and pollution during a time when businesses, customers (Bjorklund, 2012; Blanchard, 2014; CSCMP, 2012) and government regulations (Benjaafar et al., 2013) are increasingly concerned with reducing carbon footprints. To this end, new technologies and data capabilities are emerging that can add integrated visibility (monitoring and tracing), efficiency and even sustainability within the supply chain in order to mitigate these issues (Golob et al., 2002; Crainic, 2009) and cultivate an ever desired competitive advantage (Bowersox et al, 1989; Bowersox et al., 1992; Jeffers, 2010).

Greater visibility in terms of transparency in the supply chain, allows supply partners to monitor and trace materials and goods through the use of integrated information sharing and connected system technologies. Nonetheless, in spite of available technologies, a recent industry study by Supply Chain Insights, LLC finds that firms desire greater visibility among supply chain partners, yet the implementation of technology systems and practices that could help achieve this desired goal is limited (Cecere, 2014). In other words, the ability to share information for monitoring the flow of goods, materials and funds is sought after among supply chain partners; however few partners have actually implemented information technology (IT) enabled systems and practices in order to attain the desired outcome. In fact, findings from the study suggest that the transportation and logistics network is regarded as the most important area for visibility within the supply chain, yet this area has one of the largest gaps for visibility performance (Cecere, 2014). Meaning that firms want to have real-time access to information regarding the status of their material shipments, though few are confident this is achieved to satisfaction with supply partners.

IT is rapidly evolving and has become a necessity in many areas of business. In transportation and logistics, IT provides a bridge for information sharing between shippers, drivers, and receivers. IT also provides a platform for monitoring conditions affecting flows of goods and materials. Conditions such as congestion, weather, and other driver or road delays play an important role in the timeliness of deliveries. A platform for communication allows supply chain partners the ability to make decisions based on the most current information.

Research in the area of information and computer technology adoption and use in transportation is mainly conceptual in nature and has only recently begun to examine freight movements (Perego et al., 2011; Crainic et al., 2009). Furthermore, the underlying results from current research are in line with the industry study showing that overall, the degree of integrated information and computer technology in logistics and transportation is quite low (Evangelista et al., 2006; Marchet et al. 2009; Zeimpekis et al., 2006). A lack of empirical research is likely inhibiting the widespread adoption of technologies and practices with the potential to improve the efficiency, reliability and responsiveness of links in the supply chain.

In today's environment where a growing number of high-value and high-tech goods require more responsive delivery systems (Crainic et al., 2009; USDOT, 2008), moving goods faster, with higher levels of transparency and traceability through the supply chain via the transportation system is particularly important. In order to achieve this level of efficiency and transparency in freight movements, two main elements must be well understood. First, transportation infrastructure must be available and reliable to move goods and materials. Second, communication and coordinating systems between supply partners and transportation service providers must be seamlessly integrated.

The U.S. economy depends on the efficient, reliable, and responsible delivery of materials and goods from suppliers, to manufacturers, to markets (USDOT, 2008). In the U.S., trucks provide the backbone for these freight movements (IFC Consulting, 2003) observing that eighty-five percent by value and seventy percent by weight of all freight moved is by truck (IFC Consulting, 2003; ATA, n.d.; Kirschner, 2011) and these levels are expected to increase over the next decade (Blanchard, 2014). As the economy grows, the subsequent demand for goods will also increase, resulting in higher requirements for their related transportation services (USDOT FHWA, 2008). In 2010 the effects of congestion on the trucking segment alone cost an estimated $23 billion in the U.S. in wasted fuel and hours of delay (USDOT, 2013). Furthermore, increases in transportation service requirements will add further strain and congestion, thus bringing the efficiency and reliability of the transportation system into question. Therefore, one major challenge becomes implementing the mechanisms (i.e. technology systems and/or practices) that maintain - or even improve - expected delivery service levels in light of increased strain and congestion on the transportation system.

Furthermore, businesses are increasingly concerned with sustainability. Because transportation is a large generator of carbon emissions in the supply chain, if specific technologies and practices can be used to improve fuel efficiency and otherwise reduce carbon emissions, it is logical to assume their widespread usage. Systems and practices (such as intelligent transportation systems (ITS) for freight, transportation management systems (TMS), integrated information sharing (IIS) for visibility and transparency in the supply chain, and the use of third party supply chain and logistics managers (3PL SCLM)) are designed to enhance transportation and supply chain performance (IFC Consulting, 2003) to improve efficiency, reliability, responsiveness, quality, reduce carbon emissions and even improve utilization of equipment. However, barriers for implementing new technologies and operating practices (Wolfe et al., 2005; Perego et al., 2011) and a lack of quantitative research (Perego et al., 2011) are inhibiting their widespread adoption.

This research aims to address these issues. A comprehensive review of the literature has revealed gaps in previous research that contribute to the motivation for this work. The next section discusses the problem statement and research gaps in more detail and is followed by the research questions and objectives section. The chapter closes with a section on the expected contributions to research and practice.

1.1 Problem Statement/Research Gaps

Researchers have long acknowledged the link between implementation of technology systems (Reed et al., 1990) and practices with gaining a competitive advantage (O'Leary, 2008; PWC, 2008; Bayraktar et al., 2010; Barros et al., 2013). However, there is a lack of empirical research linking technology systems and practices to quantified performance outcomes in logistics and transportation (Perego et al., 2011). Barriers to adopting certain technologies and practices are inhibiting their widespread use (Wolfe et al., 2005; Perego et al., 2011). In particular, a lack of knowledge assessing both the availability and benefits of IT enabled systems and practices have led to a lack of adoption in transportation and logistics (Wolfe et al., 2005; Perego et al., 2011).

A review of the literature, along with a handful of interviews with industry leaders in the trucking, third party logistics providers, and manufacturing industries provided insight highlighting three current issues in transportation and supply chain management that could potentially be improved through the application of new technologies and practices. These problems include;

1. *mitigating congestion* (IFC Consulting, 2003) to improve efficiency and reliability of materials and goods movements (Golob et al., 2002),
2. *information sharing* to increase transparency and visibility (Klein, 2009; Cecere, 2014) so the supply chain is more responsive, and
3. *reducing carbon emissions* (Catulli et al., 2012; Kolosz et al., 2013) to address the increasing concerns of sustainability.

One glaring gap in the operations and supply chain literature is a discussion linking the effects of transportation on operations. A couple of researchers have even suggested that transportation is the forgotten factor in supply chain management (Quinn, 2000; Mason et al., 2007). Businesses use public infrastructure as an extension of their own operations (Hsu, 2007) when moving materials and goods between supply chain partners and ultimately to market. Yet virtually no discussion is found in these streams of literature regarding the availability or capacity of infrastructure to handle freight movements originating from organizational processes.

The focus of this dissertation is on linking truck freight movements to manufacturing, although it should be noted that capacity and congestion issues are also prevalent on the rail system and at ports (USDOT, 2008) that link international global suppliers to U.S. manufacturers and markets. Congestion and capacity shortages can be a major problem particularly with the prevalent use of just-in-time (JIT) (USDOT, 2008) manufacturing practices in many industries. JIT requires the production and delivery of the right quantity at the right time with consistent conformance to performance and product specifications (Canel et al., 2000; Kros et al., 2006).

Substantial changes in the trucking industry over the last 35 years have in turn led to changes in practice by the manufacturing sectors they serve. First, deregulation of the trucking industry brought about by the Motor Carriers Act of 1980 resulted in a more efficient and flexible trucking industry. This, in turn, contributed to the development of JIT deliveries and other mechanisms that fed the evolution of advanced logistics systems and supply chain management (Crainic et al., 2009; IFC Consulting, 2003). These practices revolutionized manufacturing by reducing inventory levels from their facilities and warehouses; however they added congestion and other constraints to the transportation system. By consequence, more trucks were required to service increasingly complex supply chains with origins and destinations of suppliers and customers across the global spectrum (USDOT, 2008). By moving inventories out of facilities and warehouses and onto trucks (Crainic et al, 2009), and relying on smaller payloads for deliveries, the total number of required deliveries increased and as a result, congestion increased (IFC Consulting, 2003). Increased congestion not only reduces efficiency and reliability of the system, but also contributes to the level of carbon emissions through increased delays and lower fuel efficiencies (Catulli et al., 2012; Kolosz et al., 2013).

1.1.1 Technology System Applications in Logistics and Transportation

Application of information technologies (IT) are seen as key enablers to mitigate the issues discussed above (Bowersox and Closs, 1996; Closs et al., 1997; Bharadwaj, 2000; Spanos et al., 2002; Golob et al., 2002; Giannopoulos, 2004; Wolfe et al., 2005). Applications such as intelligent transportation systems (ITS) for freight movements and transportation management systems (TMS) can be used to improve efficiencies, reliability, and reduce carbon effects of movements (Crainic et al, 2009; Bharadwaj, 2000; Chapman et al., 2003; Mason et al., 2003; Pokharel, 2005). Benefits derived from the movement of freight can, in turn, benefit the wider supply chain (Jakobs et al., 2001) through faster response times and lower holding costs realized from reduced inventories.

ITS in general is defined as the application of new developments in information processing, communications, sensing, and computer control technologies used to solve surface transportation problems (Barfield and Dingus, 1998; Vandezande et al., 2012). ITS for freight are associated with commercial vehicle operators (CVO) and are defined as the ‘‘advanced systems aimed at simplifying and automating freight and fleet management operations at the institutional level,” (Crainic et al. 2009, p. 544). This is a promising area in freight transportation to help mitigate increased congestion and help improve connections between entities. ITS is based on the use of computer and communication technologies to improve the sustainability of transportation movements, infrastructure and improve the even flows of freight. It is accepted among transportation planners that in a time of limited resources (*i.e.* space and funding) building evermore infrastructure is not sustainable, thus smarter alternative solutions must be sought (Crainic et al., 2009; Zhou and Shen, 2010). The goals and objectives of ITS are to improve the efficiency and flow of traffic, reduce transportation-generated pollution, improve safety, and to produce economic benefits through the application of information and computer technology (Iguchi, 2002; Zhou and Shen, 2010; Vandezande et al., 2012). Early research in ITS focused primarily on passenger automobiles on public infrastructure (Crainic et al., 2009, Perego et al., 2011). Recently, the focus of ITS is shifting to include freight movements (Crainic et al., 2009; Perego et al., 2011). Some research even refers to freight ITS as intelligent freight technologies (IFT) (Wolfe et al., 2005).

TMS on the other hand, is a modular type of decision support system which facilitates transportation planning, optimization and execution, in addition to the typical functionalities of traditional fleet management including carrier load tendering, routing and scheduling, shipment tracking and tracing, and freight payment and auditing (Tyan et al., 2003; Mason et al., 2003; McCrea, 2013). TMS works in conjunction with a firm's enterprise resource planning (ERP) system to bring visibility to the transportation area of the enterprise (Roche, 2013). In general, ERP systems facilitate the planning, ordering and scheduling of facility operations based on customer orders. Integrating these systems helps identify the most cost effective and timely transportation options for shipments; in turn, information generated from the TMS system can be used for post-shipment analysis of the carriers' performance (Mason et al., 2003). Scheduling and routing functions allow for trip optimization (Kia et al., 2000) which has resulted in some recognized environmental benefits, including air pollution reduction and decrease of fuel consumption (Button et al., 2001). In addition, TMS can be used to facilitate dynamic pricing quotes (Moore, 2014). This study proposes the examination of several system types, whereas few studies examine more then one type of technology to gain a more comprehensive insight (Perego et al., 2011).

In addition, most of the literature on applications of information and computer technologies in transportation primarily discusses the public or institutional side of this issue with limited discussion of application effects to private enterprises (Wootton et al., 1995; Iguchi, 2003; Giannopoulos, 2004; Crainic et al., 2009). Perego et al. (2011) state there is no literature on the role of information and computer technologies in logistics and transportation using the company perspective. Given the growing interest in the area, this work seeks to address this gap by examining the company perspective of transportation providers within the supply chain.

1.1.2 Practices in Logistics and Transportation

The development of information and computer technology applications in transportation is directly related to shifts in commercial and industrial practices of the early 2000's (Crainic et al., 2009). A change in business structures and models in both the trucking and manufacturing industries has added to the complexity of coordinating transportation services between entities. In general, manufacturing company structures and models have evolved. The traditional vertical silo-type structure – where the company owns and/or controls every aspect from materials sourcing to customer distribution with its own fleet – is moving toward more open models. Newer models use strategic outsourcing for transportation, logistics and other non-core business functions thus enabling companies to focus on their core competences (Langley et al., 2005). In essence, companies are outsourcing more of their transportation services rather than dealing with the cost, maintenance, and capital investment of owning a trucking fleet and managing additional employee drivers.

Private fleets make up less than forty percent of the market share (Schulz, 2013). Consequently, for-hire trucking companies provide the bulk of the remaining market share services. These companies focus on servicing the supply and distribution of materials and goods for a variety of customers and trade partners. However, business models in the trucking industry are also evolving as more carriers move toward owner/operator models and break away from owning equipment. Many carriers own only a small portion of their fleet equipment and instead rely heavily on contracts with independent owner/operator truck drivers to fulfill customer deliveries (Paetz, 2014; Nagel, 2014). On the one hand, this model reduces capital investment, maintenance and other requirements that go along with owning a fleet; on the other hand it brings out a new set of challenges.

The variety and number of players involved in freight transportation adds significant complexity (Crainic and Laporte, 1997). Accordingly, the added complexity of coordination between multiple entities and owner/operator service providers is driving the need for improved visibility and traceability throughout the transportation segments in the supply chain. IT enabled platforms can facilitate communication efforts between transportation providers and trading partners. The practice of integrated information sharing through channels of communication can improve coordination efforts (Klein, 2009; Reed et al., 1990).

Information sharing helps to achieve better coordination which in turn fosters the reduction of transaction costs between different partners (Clemons and Row, 1993). This is exemplified in companies that apply JIT practices and achieve greater cost savings than competitors. Increasing the flow of information allows firms to solve customer problems in a timely manner (Rogers et al. 1993), and consequently provides better after sales service levels (Bowersox et al. 1999). This of course can be translated to increased performance, attributable to greater efficiency in resource management. Applications that foster inter-organizational sharing are recognized for increases in productivity, higher flexibility, and easier communication exchange (Patterson et al., 2003). In spite of these described benefits, the theme of integrated information sharing is underrepresented in the logistics and freight transportation literature (Perego et al., 2011). Specifically, the types and channels of communication are not well understood for effectiveness in the industry. This dissertation seeks to address this gap by empirically examining types and effects of integrated information sharing across the logistics and freight transportation links in the supply chain.

Finally, the use of third party logistics and supply chain logistics management providers (3PL SCLM) can improve coordination and performance in the supply chain (Ying et al., 2005). 3PLs are professional third party logistics and supply chain management providers that perform some or all of the logistics services (*i.e.* design, execution, operations) and related functions for the focal firm (Sink et al., 1996; Ying et al, 2005; Bayraktar et al., 2010). Several benefits are recognized from the use of 3PLs including operating and capital cost reductions, improvements to service levels, and prioritizing core competences (Coyle et al., 1996; Bayraktar et al., 2010).

Enterprise nodes in the supply chain are joined together by business processes (Lambert and Cooper, 2000) and transportation services. A 3PL provider can better integrate logistics business processes with the business processes of the wider supply chain members (Ying et al., 2005). Moreover, when materials, information, and financing flows are seamlessly connected within the trade flow of the supply chain, a 3PL can provide greater stability of business processes while providing customized services to supply chain members (Ying et al., 2005). The use of 3PLs should be based on a strategic partnership to eliminate waste and add value to operations (Caplice et al., 2013). 3PL firms build economies of scale and offer better services at lower costs for a large range of customers. Many companies overlook the value proposition of using a 3PL (Caplice et al., 2013) because applied research is lacking on the performance effects of using 3PL providers. More research should be done to gain a better understanding of how 3PLs add value through increased coordination and performance of the supply chain.

A current review of the literature suggests that adopting certain technology systems and business practices such as the use of ITS for freight, TMS, IIS, and 3PL SCLM in transportation and logistics can lead to improved transportation performance which can in turn provide an avenue of competitive advantage for the supply chain as a whole. Research examining transportation as key links in a supply chain is lacking. Additionally, more research is necessary to understand the effects of technology systems and business practices together and how they affect transportation outcomes to gain a competitive advantage for the supply chain. These are the primary motives for this work. Transportation providers are uniquely situated actors in the supply network because they handle transfers of materials and goods between upstream and downstream manufacturers, distributors and also to consumer markets.

The next section addresses the research questions raised from the literature and preliminary interviews and describes the research objectives for this work.

1.2 Research Questions and Objectives

In order to address these gaps, a research model is used to examine the technology systems and practices most influential in achieving the best transportation performance outcomes. The primary objective of this research is to examine the interfaces between organizations in a supply chain to gain a better understanding of the systems and practices that enable the efficient, reliable, and responsible delivery of materials and goods. By conducting an investigation of the transportation providers that form the connecting links between suppliers, firms, and their customer markets, a better understanding can be gained regarding the structure of material and information flows between entities. In turn, by understanding the effects of transportation outcomes from certain systems and practices, the propensity for gaining a competitive advantage through implementation of these systems and practices can begin to be understood within the context of the wider supply chain.

The global transportation industry is projected to spend $130 billion on IT in 2014 with expected increases to over $150 billion by 2018 (Liu and Narisawa, 2014). This is a significant amount of investment spending for transportation providers on IT alone, especially while some reports find diminishing returns from increased IT spending on productivity (PWC, 2008). Psychometric factors of technology adoption for individuals have been well examined (Ajzen, 1991; Fishbein and Ajzen, 1975; Rogers, 1995; Davis, 1989; Venkatesh et al., 2003) although, technology adoption decisions in organizations, particularly in transportation and logistics, are not well understood (Wolfe et al., 2005; Perego et al., 2011). Therefore, the first question this research considers is the environmental or contextual conditions that drive IT investments in the transportation industry.

- What environmental forces drive the decision making process for adopting IT enabled systems and practices in transportation and logistics?

IT enabled systems and practices are becoming increasingly important as more players interact on both the physical roadway infrastructure and on information communication and technology networks. Not only is it important to understand and mitigate increased infrastructure congestion effects, but it is also important to gain a greater understanding of the communication and technology links between organizations that can facilitate overall improvements to transportation and logistic segments of the supply chain. Previous research indicates that firms with higher levels of IT integration and sophistication have operational and strategic advantages over logistics firms with less sophisticated IT (Bardi et al., 1994).

Given the growing interest and importance of IT in the transportation and logistics industry, investigating the impacts of specific IT enabled systems and practices on transportation performance outcomes is relevant (Button et al., 2001). Moreover, limited empirical research (Perego et al., 2011) and some with mixed and dated results (Bowersox and Daugherty, 1995) add to the importance of new research examining the question:

- Which IT enabled systems and practices influence improvements to transportation performance outcomes?

Logistics and transportation functions have been recognized as an area of potential competitive advantage (Loebbecke and Powell, 1998). IT systems are considered by some to be the new "competitive weapons" for the logistics industry (Piplani et al., 2004). A key to gaining a competitive advantage is the effective management of time (Bowersox and Daugherty, 1995). IT used to affect time compression has become a significant component toward improved transportation and logistics functions (Bowersox and Daugherty, 1995). Firms may seek to exploit logistics and transportation competencies to maintain or gain a competitive advantage (Bowersox and Daugherty, 1995). Thus, individual firms can expect some level of competitive advantage from unique logistics capabilities, the question is then posed:

- Do performance improvements in transportation outcomes affect the competitive advantage of the supply chain as a whole?

The next section describes the expected contributions to research and practice upon addressing these questions.

1.3 Contributions

Examining transportation as the link between enterprises in the supply chain is not well understood. It is even coined as the forgotten factor in supply chain management by some (Quinn, 2000; Mason et al., 2007). More empirical research is necessary to understand how implementation of information and computer technology in transportation affects private enterprises (Perego et al., 2011). No previous work in operations or supply chain management is known to empirically examine this interface between organizations. Therefore, this work is expected to open a new area for examining the interfaces between organizations in order to improve overall performance for supply and distribution networks. Data collection instruments, methodology, and results will contribute to both research and practice.

Contributions to research begin with the development of a reliable instrument to gain a better understanding of the causal relationships between environmental drivers of IT enabled system and practice adoption, performance outcomes, and competitive advantage for the supply chain. Hypothesized relationships will be tested through a combined statistical analysis of primary data collected from transportation providers. Examining environmental factors of technology adoption in the transportation and logistics area from a company perspective will contribute to the current understanding of technology adoption literature for organizations. By providing researchers with a better understanding of contextual factors that drive organizational technology adoption, it will become easier to identify factors of success for future innovative technology initiatives, particularly pertaining to the transportation and logistics industry. Additionally, by examining multiple IT enabled systems and practices in a single study a better understanding can be gained as to which systems and practices – or combinations of systems and practices – are the most influential in contributing to the best performance outcomes. Results from examining these relationships are expected to contribute to the competitive performance literature for links in the supply chain.

Moreover, managers are expected to find results from evaluating specific types of IT enabled systems and practices particularly useful as they will provide metrics for evaluating investments in those systems and practices based on performance measures of transportation outcomes for efficiency, reliability, responsiveness, quality, carbon emissions reduction and equipment utilization. Providing managers with a better understanding of environmental factors that drive organizational technology adoption will help them identify successful conditions for future innovative technology initiatives in the transportation and logistics industry; which can in turn contribute to the competitive advantage of their respective supply networks.

Chapter 2

Theoretical Framework and Model Development

Transportation and logistics services provide a vital function in the supply chain and a fair amount of research has integrated the two (Lai et al., 2004; Liu and Ma, 2005; Jayaram and Tan, 2010; Kayakutlu et al 2011). While today's evolving technology, such as ITS for freight, TMS, IIS and 3PL SCLM, allows service providers to be fully integrated actors within the supply chain, there is a gap in the application of these technologies to achieve optimal performance, and in the integration and visibility of these functions within the wider supply chain (Cecere, 2014).

Furthermore, when providers do use IT enabled systems and practices; the data are often unintelligible to users and lack necessary decision support system capabilities (Crainic et al., 2009). Decision support systems are specialized software applications that typically provide users with a tool to quickly understand and evaluate solutions based on available data. It is nearly impossible for an individual user to make accurate decisions based on large amounts of data without assistance from custom programs or applications. Further research is needed to help address these gaps and add greater insight into the technology systems and practices that provide optimal performance outcomes for the transportation and logistics segments in the supply chain (Perego et al., 2011).

This research seeks to address these gaps through the creation and investigation of a research model that examines environmental conditions leading to the adoption of IT enabled systems and practices that can in turn create measurable improved performance outcomes. The research context is viewed through the lens of a blended theoretical framework utilizing contingency theory and organizational information processing theory. This chapter lays out this theoretical framework, defines each construct from the literature, and describes the importance within the study context.

The literature review examines the external and internal environmental drivers for a range of adopted IT enabled systems and practices within the fields of logistics and transportation. This is followed by definitions and discussion of IT enabled systems (*i.e.* ITS for freight, and TMS) and practices (*i.e.* IIS and 3PL SCLM) from the literature. Finally, using literature support, a testable model and hypotheses development are presented; for which empirical primary data has been collected from trucking and logistics companies and statistical analyses performed to test the relationships identified in the model.

2.1 Theoretical Framework

Valuable research helps explain relationships between the study phenomena through a theoretical perspective. This theoretical framework is based on contingency theory (CT) (Thompson, 1967; Van de Ven et al., 1985) and organizational information processing theory (OIPT) (Galbraith, 1973; Tushman and Nadler, 1978). Combining these theories provides a powerful lens to understand the complex relationships among environmental drivers, adopted IT enabled systems and practices, performance outcomes and building a competitive advantage through transportation and logistics functions in the supply chain.

A dynamically changing environment affects strategic decision-making within an organization. Managers make decisions based on conditions in the external environment and their best understanding of the firm's internal environment. When these antecedents of successful systems/practices implementation strategies are well understood, managers have a better opportunity to effectively implement new IT in a manner that achieves highly leveraged outcomes. Not only are the success factors of IT adoption important, but also having an understanding of the performance outcomes for the systems/practices under consideration are salient when making large capital investment decisions; especially with continuously evolving technology. Furthermore, once IT enabled systems/practices are in place they must be able to handle an abundance of dynamically changing information in order to facilitate decision-making toward optimal performance outcomes. Together, this framework suggests that environmental conditions affect strategic behavior (e.g. adoption of IT enabled systems and practices) used to advance performance outcomes that build or continue a competitive advantage (see Figure 2.1).

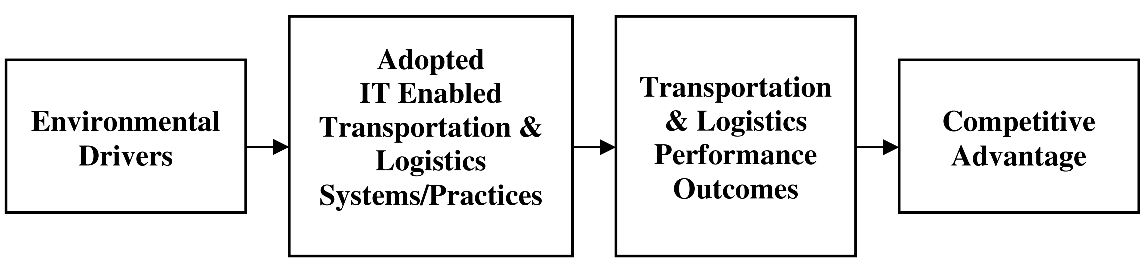


Figure 2.1: Conceptual Model of Relationships between Driving Forces and Performance Outcomes of IT Enabled Systems/Practices Adoption in Transportation and Logistics

2.1.1 Environmental Drivers

Contingency theory states that a firm's performance is conditioned upon the alignment between its internal and external environments and its strategic behaviors (Van de Ven et al., 1985). When managers understand the context of their external environment, strategic decisions can be made to adapt internal structures and processes in order to improve the firm's competitive position. Contingency theory views the firm as an open system, where information is exchanged through an input-process-output procedure (Thompson, 1967). As such, an open system is changeable and adaptable based on dynamic input factors. "Input" refers to the contextual issues (e.g., environmental conditions) that reside within or outside organizational boundaries that create uncertainties or opportunities (Thompson, 1967), thus influencing how the firm should operate in the supply chain (Wong, C.W., 2011). The "openness" of this system allows a firm to adapt and change and to improve decision-making as new information becomes available to ultimately improve performance within its environmental constraints.

Similar to many companies, transportation companies must assimilate changing environmental factors related to regional economics, trade partners, competitors, and industry and market trends for decision-making. Though unique to transportation companies, they must also monitor roadway conditions for congestion and weather effects. In addition, these companies operate between changing regulatory environments set forth by governing authorities along routes which goods and materials traverse. These environmental conditions are subject to change and impact internal structures affecting strategic decision-making in the firm; particularly in regards to systems and practices.

2.1.2 IT Enabled Systems and Practices

On one hand, input factors refer to how managers perceive the organization's external and internal environment for decision-making, particularly for implementing new strategies such as IT enabled systems and practices. On the other hand, once implemented, "input" also refers to the context of data received from IT enabled systems and practices. (e.g., coordination with partners, demand fluctuations, roadway and IT network conditions). IT enabled systems and practices in transportation and logistics act as the catalyst for the input-process-output of contingency theory in the context of the wider supply chain. "Process" refers to the organizational operations, in this case IT enabled systems and practices that manage and cope with those contextual issues, both by sharing information and coordinating business processes (Wong, C.W., 2011) among trade partners.

However, in a modern dynamic environment where businesses search for greater quantities and quality of information (Daft and Lengel, 1986; Galbraith, 1973) recognizing and processing environmental cues alone is not adequate. Businesses must also be able to use and interpret relevant information to react, make, and adapt decisions based on their dynamic environment. To this end, recent attention has turned to organizational information processing theory (OIPT) (Galbraith, 1973; Tushman and Nadler, 1978) in supply chain management (Williams et al., 2013).

Based on OIPT, an organization must find alignment between its information processing needs and capabilities (Williams et al., 2013). Organizations must be able to collect, combine and assimilate information in a coordinated manner across the organization (Burns and Wholey, 1993) and the wider supply chain network. Being able to process information in a planned and logical manner helps reduce uncertainty and provides decision makers the ability to develop a shared understanding (Daft and Lengel, 1986). Because supply chain information is dispersed not only across people and departments within the organization (Williams et al., 2013), but also across various organizations within the supply network, information processing is an important capability.

Massive amounts of informational data are collected from IT enabled transportation and logistics systems that need to be processed, managed and analyzed in an effective manner. Implementing business intelligence tools allow firms access to valuable useable information through these decision support systems. Negash (2004) explains it clearly:

> Business intelligence systems combine operational data with analytical tools to present complex and competitive information to planners and decision makers. The objective is to improve the timeliness and quality of inputs to the decision process. Business Intelligence is used to understand the capabilities available in the firm; the state of the art, trends, and future directions in the markets, the technologies, and the regulatory environment in which the firm competes; and the actions of competitors and the implications of these actions (Negash, 2004, p.177).

In other words, business intelligence systems are a collection of decision support technologies for the enterprise that enable decision-makers such as executives, managers, and analysts to make better and faster decisions (Chaudhuri et al., 2011). For example, business intelligent technology is used in manufacturing for order shipment and customer support and also in transportation for fleet management (Chaudhuri et al., 2011). IT enabled systems and practices are business intelligent tools used in and among supply partners and transport providers. Through OIPT, using the right set of business intelligent tools provides the greatest advantage for improving performance outcomes.

2.1.3 Performance Outcomes

Finally, in contingency theory "output" refers to the outcomes of process procedures, that in turn reflect how well firms "process, adapt, or mitigate issues arising from the environment (i.e., input)," (Wong, C.W., 2011, p. 163). In other words, how well IT enabled systems and practices aid data interpretation to coordinate efforts among trade partners and assist decision-makers in responding optimally will affect performance outcomes. Wong, C. W. et al. (2011) describe their use of a contingency perspective to examine integrated information systems within a supply chain setting. Results from their study show that the performance outcomes of information integration are contingent on both external environmental conditions and internal operational characteristics. Furthermore, they conclude that information integration improves the firms' ability to perform, particularly when they operate under favorable environmental conditions. Their findings advance contingency research on the performance outcomes of information integration for supply chain management.

Organizational processes and assets bundled with IT enabled systems and practices can enhance competitive performance (Nevo and Wade, 2010). It is generally accepted in operations management that core performance measures are based on cost, quality, flexibility, and reliability (Skinner, 1969; Schmenner and Swink, 1998; Flynn and Flynn, 2004; Ferdows & DeMeyer, 1990; Rosenzweig & Easton, 2010). Therefore, general performance outcomes are adapted and extended in this work to assess the transportation and logistics links in the supply chain.

2.1.4 Competitive Advantage

Through contingency theory researchers have gained a better understanding of how organizations gather and process changing environmental cues. In the context of using IT enabled systems and practices it is important to combine CT with OIPT to ensure that information is used, analyzed, and interpreted to facilitate optimal decision making in order to gain or maintain a competitive advantage. A competitive advantage is attained by firms that add value and differentiate products and services (Porter and Millar, 1985; Ulrich, 1991; Barney, 1995) from competitors to gain market share. Careful management and coordination of links in the supply chain can be a valuable source of competitive advantage (Porter et al., 1985). As such, the theoretical framework presented in Figure 2.1 combines CT with OIPT to build performance outcomes that lead to a competitive advantage through the links - also known as the transportation segments - in a supply chain.

Overall, this framework attempts to show that internal and external environmental cues should be interpreted to adopt and assimilate the right type of information processing capabilities in order to make decisions leading to optimal performance outcomes. A key factor of success in the current global environment is the ability to respond to competitive challenges and maintain a competitive advantage (Teece et al., 1997; Porter, 1991; Prahalad and Hamel, 1990).   Theoretically, high performance outcomes that add value and/or differentiate products and services will in turn create an environment for sustainable competitive advantage.

2.2 Literature Review

Innovation in logistics and transportation can be viewed as complementary functions in the supply chain, and Stieglitz and Heine (2007) show how complementary functions play a crucial role in explaining sustainable competitive advantages through innovation. Complementarity is achieved when the marginal return of one activity increases the returns of another, thus increasing synergistic value above that of each part separately. In other words, the combination of complimentary functions together has a greater value than the sum of each part separately. IT enabled systems and practices are tools that can help create synergy within the wider supply network through the innovation of transportation and logistics functions.

In the context of this study, transportation performance outcomes are examined based on the use of adopted IT enabled systems and practices. IT innovation is defined as "innovation in the organizational application of digital computer and communication technologies," (Swanson, 1994 p. 1072). The main proposed reasons transportation companies choose to innovate through IT enabled systems and practices is to improve performance outcomes for efficiency, reliability, responsiveness, quality, carbon emissions reduction, and to improve equipment utilization from transportation functions.

Relevant literature streams are reviewed across transportation and information systems, in addition to operations and supply chain management in order to understand a complete range of constructs and sub-constructs within the study context. Table 2.1 lists the major constructs and definitions along with literature sources for the environmental drivers, adopted IT enabled transportation and logistics systems and practices, transportation and logistics performance outcomes, and competitive advantage.

Environmental drivers include both external environmental pressures and internal organizational environmental factors that impact technology adoption decisions for IT enabled transportation and logistics systems and practices. IT enabled transportation and logistics systems include ITS for freight and TMS components, while IT enabled practices include constructs for integrated information sharing (IIS) and third party provided supply chain and logistics management (3PL SCLM).

There is a fundamental difference between IT enabled systems and practices. IT enabled systems are tangible technology components. For example, ITS for freight and TMS are systems that include various hardware and software components that assist users in collecting, viewing and managing data for transportation and logistics decision-making. Conversely, IT enabled practices use an IT platform to function (e.g. these can be the firm's ITS and TMS or another web based system), but the true construct examines relationship interactions between entities. To state a simplified analogy; the systems are the toys in a sandbox and the practices are the interactions between the individuals (*i.e.* how well they play together) with their toys in the sandbox.

Finally, Table 2.1 includes constructs for transportation performance outcomes and competitive advantage. When systems and practices add value or differentiate transportation services for superior performance, a competitive advantage can be attained.

Table 2.1: Major Constructs and Definitions

Construct	Definition	Source
Environmental Drivers		
External Environmental Pressures	The extent of pressure from the external environment originating from customers, regulations, competition, industry technology changes or other external sources.	Perego et al. (2011) Catulli and Fryer (2012)
Internal Organizational Environment	The extent of pressure from within the organization originating from Management, Drivers/Owner-Operators, or other internal sources.	Bardi et al. (1994) Perego et al. (2011) Catulli and Fryer (2012)
IT Enabled Systems and Practices		
Intelligent Transportation Systems (ITS) for freight	Advanced information based technologies such as GPS, sensors, transponders, RFID, smart cards, weigh-in-motion, onboard displays and other web technolohies aimed at simplifying and automating freight and fleet management operations at the institutional level for asset tracking, gateway facilitation, and monitoring vehicle, freight and network status.	Barfield and Dingus (Eds.) (1998) Wolfe and Troup (2005) Jarasuniene (2007) Fries, Gahrooei, Chowdhury, and Conway (2012)
Transportation Management System (TMS)	A decision support system that facilitates transportation planning, optimization and execution, with typical functionalities of fleet management including carrier load tendering, routing and scheduling, shipment tracking and tracing, and freight payment and auditing.	Gilmore and Tompkins (2000) Tyan et al. (2003) Mason et al. (2003) McCrea (2013)
Integrated Information Sharing (IIS)	Ability of the organization to communicate and interact with trade partners (i.e. transportation provider, origin shipper and destination receiver facilities) accurately and reliably at the right time.	Klein (2009) Reed et al. (1990)
3PL Supply Chain and Logistics Management (3PL SCLM)	Use of professional third party logistics and supply chain management providers that perform some or all of the logistics services (i.e. design, execution, operations) and related functions for the focal firm.	Sink et al. (1996) Ying et al. (2005) Bayraktar et al. (2010)
Performance Outcomes		
Transportation Outcomes	The reliability and timeliness of inbound and outbound flows of goods for optimal service levels. Based on efficiency, reliability, responsiveness, quality, carbon emissions reduction, and equipment utilization.	Jayaram, Vickery, and Droge (2000) Skinner (1969) Schmenner and Swink (1989) Fisher (2007) Lee (2002) Lieb and Lieb (2010)
Competitive Advantage	The level of value or differentiation created for customers through short lead times, low cost, high quality, and/or responsiveness to changing needs.	Porter and Millar (1985) Ulrich (1991) Barney (1995)

Figure 2.2 is a conceptual representation of the relationships between major constructs defined in Table 2.1. Adopted IT enabled systems and practices are the focal point of this model. These particular constructs emerged from both industry stakeholder interviews (McAvoy, 2014; Paetz, 2014; Nagel, 2014) and literature sources (e.g. Perego et al., 2011). IT enabled systems and practices is conceptualized as a second order construct manifested by latent variables ITS for freight, TMS, IIS, and 3PL SCLM.

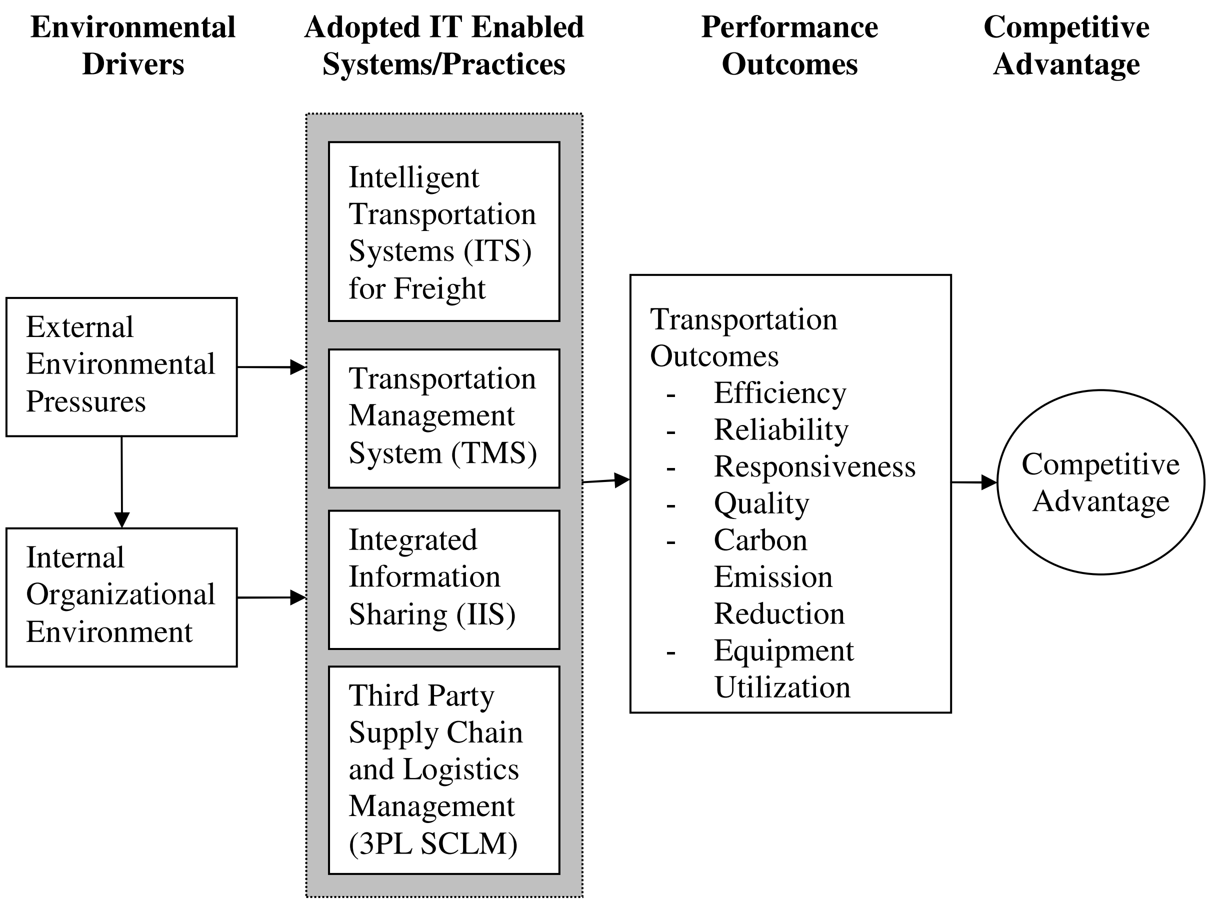


Figure 2.2: Conceptual Model of Construct Relationships

The remainder of this section discusses each major construct and sub-constructs in more detail.

2.2.1 Environmental Drivers of IT Enabled System/Practice Adoption

Various factors contribute to the organization's environment and ultimately its decision-making process for the adoption of IT enabled systems and practices in transportation and logistics. Much of the extant technology adoption and acceptance research focuses on the antecedents of acceptance and use mainly through an individual's perspective. This research seeks to enrich current models by developing environmental factors from the organization's perspective. A number of models have been developed to understand the individual behaviors of technology acceptance. The basic concept of user acceptance models includes individual reactions to the technology, intentions to use the technology and then actual use. Some prevalent models include the Theory of Planned Behavior (TPB) (Ajzen, 1991), Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), the Diffusion of Innovation (DOI) (Rogers, 1995), and the Technology Acceptance Model (TAM) (Davis, 1989).

Another model, the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al., 2003) combines key concepts from the above and other models to improve explanatory power of user acceptance of technology. In the unified model behavioral intention is predicted by three antecedents: performance expectancy, "the degree to which an individual believes that using the system will help him or her to attain gains in job performance," (Venkatesh et al., 2003, p. 447); effort expectancy, "the degree of ease associated with the use of the system," (Venkatesh et al., 2003, p. 450); and social influence, "the degree to which an individual perceives that important others believe he or she should use the new system," (Venkatesh et al., 2003, p. 451). Use behavior is then determined by behavioral intention to adopt and facilitating conditions, “the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system,” (Venkatesh et al., 2003, p. 453). In general, the UTAUT model portrays the importance of environmental conditions and expected outcomes in facilitating technology adoption, acceptance and use. These general premises were considered when selecting the environmental factors affecting technology adoption decisions in transportation and logistics for this study.

It is important to examine the relationships between environmental conditions and technological change (Tushman and Anderson, 1986) particularly with the emphasis and reliance on technology as a driving force in business. Several factors come into play when organizations choose to adopt new technology. Driving forces from both the organization’s internal and external environment impact the decision process (Wolfe et al., 2005). Literature review findings for this study indicate that widespread adoption and use of technology in logistics and transportation functions – which typically span across organizations – lag behind their intra-organizational system/practice counterparts (Cecere, 2014). For example, an internal system such as enterprise resource planning (ERP) features a centralized database which various departments and divisions can use to access the organization’s internal operating information. Investments in these types of systems are common. However, similar systems that span across organizations to facilitate communication and coordination among supply chain partners have been less successful. Compatibility of systems and trust among trade partners and service providers are two commonly noted barriers (Wolfe et al., 2005) of adopting these types of systems. It is therefore vital to gain a better understanding of not only the environmental driving forces for adoption of IT enabled systems and practices in logistics and transportation, but also some of the associated barriers to adopting these technologies.

In general, previous research findings indicate that adoption of IT based applications in freight transportation is quite low (Marchet et al., 2009; Zeimpekis and Giaglis, 2006). Indeed there are exceptions. Specifically, logistics operators seem to understand the importance of using mobile services and which ones to offer to their customers (Zeimpekis and Giaglis, 2006; Paetz, 2014). Additionally, order tracking and tracing seem to have widespread adoption through the use of vehicle position monitoring (Perego et al., 2011). Conversely, adoption drivers of many IT enabled systems and practices for logistics and transportation functions are not as well understood and require further exploration (Perego et al., 2011, Wolfe et al., 2005).

Examining environmental factors of technology adoption in the transportation and logistics area from a company perspective will contribute to the current understanding of technology adoption literature. Next, the external and internal environmental factors of IT enabled systems and practices for adoption are discussed.

2.2.1.1 External Environmental Pressures

Many aspects affect the context of a firm's external environment; such as, customers, competitors, technology changes, regulations, and globalization and disbursement of SC partners, among other things. In the case of transportation service firms, navigating the physical environment also comes into play. Time delays due to congestion, road closures, tolling booths and even weigh stations affect the company's ability to meet customer demands. In turn, these forces affect the firm's decision-making process for adopting IT enabled systems and practices to help mitigate both contextual and physical environmental effects. External environmental pressures are defined in Table 2.2 as the extent of pressure from the external environment originating from customers, regulations, competition, industry technology changes or other external sources that influence the adoption and use of IT enabled systems or practices (Perego et al., 2011; Catulli and Fryer, 2012).

The context of an organization's external environment plays a key role in the decision-making processes of the firm. Results of a 2008 survey of CEOs by Lieb and Lieb (2010) indicated that pressure from customers and competitive pressures from other firms affect the firm's decision making process to adopt certain practices as indicated in Table 2.2. The transportation sector is a known producer of greenhouse gases and IT enabled systems in particular (Wolfe et al., 2005; Crainic et al., 2009), and practices (Lieb and Lieb, 2010), are implemented to reduce effects of carbon emissions.

Regulation mechanisms, such as the Kyoto Protocol, were set up as part of the United Nations Framework on Climate Change (http://unfccc.int), as part of a global effort to help reduce greenhouse gas emissions to limit the effects of climate change and provide further incentives for carbon reduction (Diabat and Simchi-Levi, 2009). The use of clean energy technologies are generated by market pull (Klassen et al., 1996; Melnyk et al., 2003; Wolfe et al., 2005), regulations (Wolfe et al., 2005), and other external environmental forces as identified in Table 2.2.

Recently, competition among firms to become greener is more prominent as a greater effort is being made by companies to be more appealing to a growing number of environmentally-conscious consumers as well as a next generation workforce that is eager to positively impact the world (Sorrell, 2003). Findings from the United Nations 2014 Climate Summit Report recognize certain technologies as a way to mitigate climate change (United Nations, 2014). Various IT enabled systems and practices in transportation and logistics can be used to facilitate coordination among supply partners through information sharing for load planning and shipment consolidation for deliveries. Some systems are used to mitigate and navigate congestion and traffic effects in the physical environment, and even help reduce carbon emissions to limit the effects of climate change.

In spite of these advances, there are still barriers to the adoption of these enabling technologies. Several barriers discussed in the literature pertain to the external environment for technology adoption in transportation and logistics. First, compatibility of technology systems (Wolfe et al., 2005; Pokharel, 2005; Zeimpekis and Giaglis, 2006) is discussed as a complex issue fueled both by trust (Wolfe et al., 2005) and technological standards (Evangelista and Sweeney, 2006) among trade partners and service providers. Partners must have an adequate level of trust among players in order to willingly build standardized platforms for information sharing. The issue of trust is further accentuated with the integration of transportation providers that play a complementary, yet critical, role in the supply chain.

Next, the influence of other companies (Forster and Regan, 2001) in the supply chain can also inhibit technology adoption. When partners try to integrate systems across organizations there can be limitations within the supply chain environment and possibly even reluctance of other firms to participate in integrating compatible systems (Forster and Reagan, 2001). Based on these premises, Table 2.2 lists and defines individual sub-constructs that make up external environmental pressures affecting the adoption decision-making process of IT enabled systems and practices.

Table 2.2: External Environmental Pressures and Sub-constructs

Construct	Definition	Source
External Environmental Pressures	The extent of pressure from the external environment originating from customers, regulations, competition, industry technology changes or other external sources.	Perego et al. (2011) Catulli and Fryer (2012)
Customers/Market	The extent to which our customers demand shipment tracking capabilities, reliability of deliveries, improved delivery lead times.	Lieb and Lieb (2010) Klassen et al. (1996) Melnyk et al. (2003) Wolfe et al. (2005) Diabat and Simchi-Levi (2009)
Competitors	The extent to which other companies compete through shipment tracking capabilities, reliable deliveries, improved delivery lead times.	Diabat and Simchi-Levi (2009) Forster and Reagan (2001)
Regulations	The extent to which our company faces rules and requirements imposed by agency authorities.	Sorrell (2003) Wolfe et al. (2005)
Technology Change	The extent to which the rate of obsolescence and degree of new ideas and techniques are presented to the industry.	Crainic et al. (2009) Wolfe et al. (2005)
Technology Standards	The extent to which common technology systems and platforms are available, used, and expected in the industry.	Pokharel (2005) Zeimpekis and Giaglis (2006) Evangelista and Sweeney (2006)

2.2.1.2 Internal Organizational Environment

Technology and practice adoption from the internal organizational environment is defined as the extent of pressure from within the organization originating from management, drivers/owner-operators, or other internal sources to adopt and use new IT enabled systems or practices (Bardi et al., 1994; Perego et al., 2011; Catulli and Fryer, 2012). Top management involvement, as defined in Table 2.3, is well supported in the literature to promote change and encourage the need for innovation (Lai et al., 2008; Brown, 1991). In addition, the company's current technological development (i.e. current level of IT in place) and the company culture as exhibited by corporate policy and attitudes toward the implementation of IT (for example, the company's willingness to support IT devices) are among the most influential factors in the company's strategic decision of IT adoption (Pokharel, 2005). Some recognized barriers to new technology adoption can even be overcome through the support of top management (Brown, 1991).

In transportation and logistics companies, drivers, and in some cases their unions, are identified, as indicated in Table 2.3, as sources of significant change for the organization that can impact technology adoption decisions (McAvoy, 2014). Unions can impose restrictions which limit management decision-making capabilities that impact the firm (Kerkvliet and McMullen, 1997).

The adoption and use of IT enabled systems stem from the pursuit of gaining a competitive advantage (Nevo and Wade, 2010; Wolfe et al., 2005) particularly against other logistics companies (Zeimpekis and Giaglis, 2006). Pokharel (2005) results are consistent in general with organizational behavior literature suggesting that larger companies are more motivated to adopt IT compared to smaller ones based on their tendency to focus on longer-term objectives and have higher business volume expectations in regards to economic aspects.

Similarly, Evangelista and Sweeney (2006) find low adoption levels of relatively sophisticated technologies among all 3PL types among small logistics service providers in the Italian 3PL market. Consistent with early interview findings from this study, in their study, the most used applications were telephone, fax, mobile phones, internet and e-mail, followed by other tools such as EDI and local area networks. Their overall findings suggest the degree of technology integration in the supply chain appears quite low, which is surprising given the potential improvements from using IT enabled systems and practices. This clearly suggests there are barriers to technology adoption in the transportation and logistics sectors that must be overcome.

Several IT adoption barriers that stem from an organization's internal environment are indicated in the literature. One main barrier addresses a lack of top management support (Proudlock et al., 1999; Pokharel, 2005). In some cases, company decision-makers are reluctant to invest in technology changes (Button et al., 2001). What's more, integrating new IT means that employees and drivers have new hardware and software to learn. Learning a new system is hindered in companies with a culture reluctant to change. This is evident in both employees and drivers (Button et al., 2001) particularly when personnel training is inadequate (Piplani et al., 2004; Pokharel, 2005; Evangelista and Sweeney, 2006; Zeimpekis and Giaglis, 2006).

In addition, another key barrier is finding appropriate IT within limited economic or financial resources as stated in Table 2.3. Firms hindered by financial or economic reasons are often reluctant to take on a sizeable technology investment risk (e.g. Hollenstein, 2004; Pokharel, 2005; Zeimpekis and Giaglis, 2006; Evangelista and Sweeney, 2006). Long implementation periods (Pokharel, 2005) associated with a perception of technology obsolescence risk (Piplani et al., 2004; Pokharel, 2005) and a lack of knowledge regarding the return on investment (Evangelista and Sweeny, 2006) are frequently cited investment risk barriers. Likewise, it is fairly complicated to quantify both tangible and intangible benefits together in order to evaluate the true value new IT can contribute to the firm (Piplani et al., 2004; Pokharel, 2005; Evangelista and Sweeney, 2006; Zeimpekis and Giaglis, 2006).

Finally, the level of IT awareness and involvement identified in Table 2.3 also plays a key role in adopting innovative IT. Zeimpekis and Giaglis (2006) suggest that, in general, transportation industry providers have a limited awareness of innovative IT enabled systems and practices. Integrating new IT with current technologies is a frequently cited barrier (Button et al., 2001; Pokharel, 2005; Evangelista and Sweeney, 2006) particularly when considering the costs and problems associated with installation, interfacing and integrating new systems with current IT systems (Pokharel, 2005). Limited knowledge of available IT combined with the complexity of evaluating new IT solutions has deterred many firms from adopting potentially useful IT, or conversely, into adopting IT that does not provide the expected benefits (Perego et al., 2011).

This section discussed the key internal and external environmental drivers of technology adoption in transportation and logistics. When managers and researchers have a better understanding of contextual factors that drive technology adoption, it becomes easier to identify factors of success for innovative technology initiatives. The next section continues with discussion of specific IT enabled systems and practices in transportation and logistics. It is suggested here that innovative technology adoption will help firms achieve better and more sustainable transportation and delivery outcomes which, in turn, will lead to a competitive advantage. Table 2.3 lists and defines individual sub-constructs that make up the internal organizational environment affecting the decision-making process of adopting IT enabled systems and practices in transportation and logistics.

Table 2.3: Internal Organizational Environment and Sub-constructs

Construct	Definition	Source
Internal Organizational Environment	The extent of pressure from within the organization originating from Management, Drivers/Owner-Operators, or other internal sources.	Bardi et al. (1994) Perego et al. (2011) Catulli and Fryer (2012)
Top Management	The extent to which top management is supportive of IT improvement efforts, increased resources, and inter-organizational communications.	Proudlock et al. (1999) Pokharel (2005) Button et al. (2001) Chen and Paulraj (2004) Choi and Chang (2009)
Organizational Culture	The extent to which organizational culture fosters a learning environment, teamwork, fexibility, autonomy, and trust.	Harper and Utley (2001) Piplani et al. (2004) Pokharel (2005) Evangelista and Sweeney (2006) Zeimpekis and Giaglis (2006) Choi and Chang (2009) Shad et al. (2011)
Economic/Financial Resources	The extent to which the company invests in innovative projects.	Hollenstein (2004) Pokharel (2005) Zeimpekis and Giaglis (2006) Evangelista and Sweeney (2006) Choi and Chang (2009)
IT Awareness/ Involvement	The extent of IT management knowledge and their company role.	Button et al. (2001) Pokharel (2005) Evangelista and Sweeney (2006) Zeimpekis and Giaglis (2006)
Employee IT Adoption Input	The extent to which middle managers and office staff influence IT implementation decisions.	Button et al. (2001) Tarafdar et al. (2010) McAvoy (2014)
Driver IT Adoption Input	The extent to which company employed or indepentent drivers influence IT implementation decisions.	Button et al. (2001) McAvoy (2014)
Unions IT Adoption Input	The extent to which unions influence the adoption decision of IT.	Kerkvliet and McMullen (1997) McAvoy (2014)

2.2.2 IT Enabled Systems and Practices

Most of the Nation's freight is shipped using a collection of organizations referred to as supply chain partners, which include shippers, cargo handlers and receivers (Butler, 2009). Many of these partners do not communicate electronically, resulting in delays, lost goods, and reduced efficiencies throughout the process (Butler, 2009). Reliable and inexpensive tracking methods essential for business success are limited (Butler, 2009). To add further complication, freight supply chain partners are likely to have a variety of incompatible technology infrastructures and application platforms that are usually unable to share data (Butler, 2009). Improving the fit between information sharing needs and data handling capabilities can add necessary visibility and traceability through information sharing in the system. This improved information flow can add business value.

In previous work relating IT to supply chain performance, Premkumar et al. (2005) developed a classification of "information processing needs" (based on the procurement environment) and "information processing capabilities" (based on the level of IT support) using Galbraith's (1973) information processing theory of fit between the two to examine performance. Results indicated the "fit as matching" (with roots from Venkatraman, 1989) positively affects procurement performance. In addition, Nevo and Wade (2010) examined the relationship between IT assets and business value and proposed that IT assets combined with organizational resources can create synergistic IT-enabled resources leading to capabilities that build competitive advantage. Their paper proposed that IT assets can play a strategic role when combined with other organizational resources. Similarly, Bhatt and Grover (2005) results suggest that by leveraging IT enabled capabilities with cultural attributes (i.e. organizational learning propensity) significantly affects competitive advantage. In regards to the use of IT in buyer-supplier coordination efforts, Sanders (2008) evaluated how two patterns of IT use by suppliers (exploitation and exploration) relate to two specific types of coordination activities with buyers (operational and strategic), which in turn are posited to promote organizational benefits.

Other work by Ward and Zhou (2006) addresses how managers should balance investments between lean/JIT practices and IT in order to minimize lead time. Their study empirically evaluates internal and external IT integration with JIT practices on lead time. Their results confirm that implementing lean/JIT practices significantly reduces lead time. Also, lean/JIT practices mediate the influence of IT integration on lead-time performance. Given earlier discussion regarding the deregulation effects of the transportation industry's contribution to JIT practices in manufacturing, it is surprising that so little has been done in this area examining the transportation effects on operations and supply chain management. Particularly in the area of IT enabled systems and practices which can help integrate the flows of materials, information and funds across organizations in their given supply and distribution networks. More work is necessary to fully understand the contributions to these performance effects.

Many major challenges in the freight transportation industry have directly resulted from changes in logistical processes in commerce. First, Crainic et al. (2009) explains how inventory reduction practices led to JIT procurement practices, thereby moving inventory out of facilities and onto trucks. Next, globalization led to the restructuring of manufacturing distribution channels worldwide and the creation of free trade zones to bring in components for final assemblies from distant locations (often from emerging economy countries e.g. China, India, Brazil). Furthermore, centralized warehousing facilities and value-added distribution centers have changed the flow of goods all over.

Therefore, new technologies and practices are necessary to maintain or improve flows among trade partners in increasingly complex supply networks.

Based on the following review of literature, highlighted in Table 2.4, it is suggested that IT enabled systems (e.g. ITS for freight and TMS) and practices (e.g. IIS and 3PL SCLM) can be used to mitigate the above issues and help improve performance outcomes. Information and communication technologies have increasingly improved over recent decades. Subsequently, several recent phenomena in the transportation and supply chain industry are driving the need for a better understanding of the technology systems and practices that result in higher performance outcomes.

2.2.2.1 Intelligent Transportation Systems (ITS) for Freight

ITS is defined in Table 2.4 as the application of new developments in information processing, communications, sensing, and computer control technologies used to solve surface transportation problems (Barfield and Dingus, 1998; Vandezande et al., 2012). The goals of ITS are generally to improve the safety of transportation, to reduce traffic congestion by maintaining traffic flow, to reduce transportation-generated pollution, to improve transport efficiency, and to produce economic benefits (Zhou and Shen, 2010). ITS does this by combining better infrastructure, advanced communication technologies, and information and control technologies across the entire transportation system rather than building more infrastructure (Zhou and Shen 2010) which is not sustainable. Some of these technologies include the use of photo enforcement, electronic tolling, vehicle-mile taxing, weigh-in-motion, connected vehicle technologies, fleet management, computer-aided dispatch (CAD), automatic vehicle location (AVL), automatic cargo tracking, electronic pre-clearance, vehicle compliance checking, and driver monitoring (Fries et al., 2012; Jarasuniene, 2007).

Specifically, ITS for freight are associated with commercial vehicle operators (CVO) and are defined as the ‘‘advanced systems aimed at simplifying and automating freight and fleet management operations at the institutional level,” (Crainic et al. 2009, p. 544). Wolfe et al. (2005) refer to ITS for freight as intelligent freight technologies (IFT) and succinctly categorize them into five main areas as defined below (p. 4):

- ***Asset tracking*** *uses mobile communications, radio frequency identification (RFID), and other tools to monitor the location and status of tractors, trailers, chassis, containers and, in some cases, cargo.*
- ***On-board status monitoring*** *uses sensors to monitor vehicle operating parameters, cargo condition, and attempts to tamper with the load.*
- ***Gateway facilitation*** *uses RFID, smart cards, weigh-in-motion, and nonintrusive inspection technologies to simplify and speed operations at terminal gates, highway inspection stations, and border crossings.*
- ***Freight status information*** *uses web-based technologies and standards to facilitate the exchange of information related to freight flows.*
- ***Network status information*** *uses services to integrate data from cameras and road sensors and uses display technologies to monitor congestion, weather conditions, and incidents.*

ITS for freight is a promising area for investments, however previous research in this area is mainly conceptual in nature, hence there is a call for more studies with quantifiable metrics (Perego et al., 2011). Thus far in practice, ITS has primarily been hardware driven and lacks the full exploitation of available data. Consequently, the transportation literature calls for operations management research to develop software components, models, and decision-support tools to analyze and make the optimal use of data components from ITS (Crainic et al., 2009). Currently, detailed data gathered from these systems are often acted on by human operators without the use of decision-support tools (Crainic et al., 2009; Paetz, 2014).

2.2.2.2 Transportation Management System (TMS)

Typically, companies have used fleet management software to manage day to day transportation operations. Recently though – and quite possibly due to changing structures of transportation functions – TMS is becoming more prevalent across transportation and manufacturing industries for its integrative and analytical capabilities. TMS is defined in Table 2.4. It is a decision support system that facilitates transportation planning, optimization and execution, in addition to typical functionalities of fleet management including carrier load tendering, routing and scheduling, shipment tracking and tracing, and freight payment and auditing (Gilmore and Tompkins, 2000; Tyan et al., 2003; Mason et al., 2003; McCrea, 2013).

TMS works in conjunction with ERP to bring visibility to the transportation area of the enterprise (Roche, 2013). It helps identify the most cost effective and timely transportation options for shipments; in turn, information generated from the system can be used for post-shipment analysis of the carriers' performance (Mason et al., 2003). Scheduling and routing functions allow for trip optimization (Kia et al., 2000) which has resulted in some recognized environmental benefits, including air pollution reduction and decrease of fuel consumption (Button et al., 2001). In addition, TMS can be used to facilitate dynamic pricing quotes to improve company cost saving measures (Moore, 2014).

Few studies examine more than one type of technology to gain comprehensive insight on effects (Perego et al., 2011). Examining the effects of TMS in conjunction with other IT enabled systems and practices provide a broader context to identify specific technology factors leading to logistics and supply chain performance. Furthermore, TMS provides a platform for information sharing across entities.

2.2.2.3 Integrated Information Sharing (IIS)

Recently, supply chain management literature has given considerable attention to information sharing and even more recently, to supply chain visibility. Some of the visibility and information sharing literature is based on the underlying assumption that greater information access increases an organization's ability to respond quickly to changes in its business environment (Williams et al., 2013). For logistics, higher levels of integration are demonstrated by increased communication and coordination between carriers, suppliers and customers (Stock et al., 2000; Chen and Paulraj, 2004). However, a lack of functional infrastructure is inhibiting advances in leveraging "big data" that comes from information sharing in order to help optimize the supply chain (Langley et al., 2014). Furthermore, mixed results from some studies have found more integration is not always optimal, rather that the right fit between information needs and information sharing capability is necessary (Kim et al., 2006).

Integrated information sharing is the practice of sharing information over compatible systems among supply partners and transportation service providers. In some extant literature the architecture platforms for sharing information among partners is referred to as supply chain engines (SCE) (Verwijmeren, 2004) or supply chain executions (SCE) (Perego et al., 2011). Integrated information sharing (IIS) is defined in Table 2.4 as the ability of the organization to communicate and interact with trade partners (i.e. transportation provider, origin shipper and destination receiver facilities) accurately and reliably at the right time (Chen and Paulraj, 2004; Li et al., 2005; Jin et al., 2014). In other words, IIS is the sharing of the right type of information, in the right amount over compatible systems (Williams et al., 2013; Klein, 2009; Reed et al., 1990).

Information sharing helps to achieve better coordination which in turn fosters the reduction of transaction costs between different partners (Clemons and Row, 1993). This is highly exemplified in companies that apply JIT practices and achieve greater cost savings than competitors. Furthermore, a clear understanding of the factors that support and constrain the development of an effective system that supports information exchange, analysis, improved accuracy, and timeliness of decisions, policy makers and practitioners alike can proceed with greater confidence in their outcomes (Yang and Maxwell, 2011). Although, merely increasing the type and amount of information does not necessarily lead to the best solution in supply chain management (Kim and Umanath, 1999). Too little sharing and optimal decision-making is not achieved for the supply chain, while too much sharing places proprietary systems and practices in jeopardy. In some cases, it makes sense to contract with a third party for access to these capabilities.

2.2.2.4 Third Party Provided Supply Chain and Logistics Management (3PL SCLM)

Achieving a responsive, efficient, and well coordinated supply chain with supply partners and transportation providers sometimes requires the help of contracted third parties that already have the appropriate capabilities in place. 3PL SCLM is defined in Table 2.4 as the use of professional third party logistics and supply chain management providers that perform some or all of the logistics services (i.e. design, execution, operations) and related functions for the focal firm (Sink et al., 1996; Ying et al., 2005; Bayraktar et al., 2010).

A recent survey of shippers showed 82% of respondents' use 3PLs, however a significant IT gap in the difference between the percentage of 3PL users that identify IT capabilities as a required 3PL expertise and the percentage of 3PL users that are satisfied with the 3PL IT capabilities experienced in their relationship (Langley et al., 2014). Therefore, opportunities have been identified to optimize supply chains through greater end-to-end visibility by using a 3PL and leveraging additional "Big Data" from the 3PL (Langley et al., 2014).

Table 2.4: IT Enabled Systems and Practices

Adopted IT Enabled Systems		
Intelligent Transportation Systems (ITS) for freight	Advanced information based technologies such as GPS, sensors, transponders, RFID, smart cards, weigh-in-motion, onboard displays and other web technolohies aimed at simplifying and automating freight and fleet management operations at the institutional level for asset tracking, gateway facilitation, and monitoring vehicle, freight and network status.	Barfield and Dingus (Eds.) (1998) Wolfe et al. (2005) Jarasuniene (2007) Fries, Gahrooei, Chowdhury, and Conway (2012)
Transportation Management System (TMS)	A decision support system that facilitates transportation planning, optimization and execution, with typical functionalities of fleet management including carrier load tendering, routing and scheduling, shipment tracking and tracing, and freight payment and auditing.	Gilmore and Tompkins (2000) Tyan et al. (2003) Mason et al. (2003) McCrea (2013)
Adopted IT Enabled Practices		
Integrated Information Sharing (IIS)	Ability of the organization to communicate and interact with trade partners (i.e. transportation provider, origin shipper and destination receiver facilities) accurately and reliably at the right time.	Williams et al. (2013) Klein (2009) Reed et al. (1990)
Third Party Supply Chain and Logistics Management (3PL SCLM)	Professional external transportation organization that performs some or all of the logistics services (i.e. load tendering, design, execution, operations) and related functions for the focal firm.	Sink et al. (1996) Ying et al. (2005) Bayraktar et al. (2010)

2.2.3 Performance Outcomes and Competitive Advantage

The first four performance outcomes in this study are related to competitive performance in manufacturing systems (e.g. cost, delivery, flexibility, and quality) (Skinner, 1969; Schmenner and Swink, 1998). The fifth performance outcome, carbon emissions reduction, has been added to this study due to its prominence in literature and practice (Lieb and Lieb, 2010; Cooke, 2008; Murphy, 2008; Diabat and Simchi-Levi 2009; Catulli and Fryer, 2012; McAvoy, 2014). The sixth performance outcome, equipment utilization is examined as an additional operational measure (Safizadeh and Ritzman,1997; Dahal, 2003). These are defined in Table 2.5.

Efficiency in transportation and logistics is related to the cost performance, meaning materials are handled and delivered in a cost effective manner. Reliability is related to the delivery performance, because the premise of this research is based on delivery of materials, reliability refers to consistently delivering goods within a specified time window. Responsiveness is related to the flexibility performance and refers to the ability to act or respond quickly in changing environments. Quality refers to the ability to securely deliver damage free materials and products. Carbon emissions reduction refers to the ability to reduce carbon emission levels in the supply chain. Equipment utilization refers to the extent to which firms make use of available equipment.

Efficiency and responsiveness are well accepted strategies in supply chain management (Fisher, 2007; Lee, 2002). However, some researchers have integrated the related concepts of flexibility and responsiveness and referred to this as an agile supply chain strategy (Swafford et al., 2008; Lee, 2002). Early work on competitive capabilities discussed trade offs among capabilities (Skinner, 1969; Schmenner and Swink, 1998);

although mixed results have led more recent work to examine the area of cumulative capabilities (Flynn and Flynn, 2004; Ferdows & DeMeyer, 1990; Rosenzweig & Easton, 2010). In a hypercompetitive environment characterized by continuous change, combinative capabilities are the strategic capability that provides firms with a competitive advantage (Kristal et al., 2010). Swink and Way (1995) stressed that more studies of combinations of capabilities and performance measures are needed, in order to establish links between cumulative capabilities and performance (Flynn and Flynn, 2004). Results of the current study are expected to contribute to the competitive performance literature stream by extending findings to the transportation and logistics links in the supply chain.

Furthermore, the logistics and transportation segments have recently been suggested as an area for improving competitive advantage in supply chains (Dias et al., 2009; Loebbecke and Powell, 1998). By differentiating service offerings (Porter and Millar, 1985; Ulrich, 1991; Barney, 1995), transportation providers can create value for customers through shortened lead times, low cost, high quality, and/or responsiveness to changing needs. In so doing, transportation providers can create new areas for competitive advantage through the links in the supply and distribution channels of the network. See Table 2.5 for the definition used in this study.

Table 2.5: Performance Outcomes and Competitive Advantage

Performance Outcomes and Competitive Advantage		
Transportation Outcomes	The reliability and timeliness of inbound and outbound flows of goods for optimal service levels. Based on efficiency, reliability, responsiveness, quality, carbon emissions reduction, and equipment utilization.	Jayaram, Vickery, and Droge (2000) Schmenner and Swink (1989)
Efficiency	The extent to which materials are handled and delivered in a cost effective manner.	Skinner (1969) Schmenner and Swink (1989) Fisher (1997) Lee (2002)
Reliability	The extent to which goods are delivered consistently within a specified time window	Skinner (1969) Schmenner and Swink (1989) Fisher (1997) Lee (2002)
Responsiveness	The extent to which the firm and its drivers are able to act quickly when faced with changing environments for pick-up/delivery circumstances.	Skinner (1969) Schmenner and Swink (1989) Fisher (1997) Lee (2002)
Quality	The extent to which the firm and its drivers are able to securely deliver damage free materials and products.	Skinner (1969) Schmenner and Swink (1989)
Carbon Emissions Reduction	The extent to which the firm is able to reduce carbon levels in the supply chain.	Lieb and Leib (2010) Cooke (2008) Murphy (2008) Diabat and Simchi-Levi (2009) Catulli and Fryer (2012) McAvoy (2014)
Equipment Utilization	The extent to which the firm is able to make use of available equipment.	Safizadeh and Ritzman (1997) Dahal (2003)
Competitive Advantage	The level of value or differentiation created for customers through short lead times, low cost, high quality, and/or responsiveness to changing needs.	Porter and Millar (1985) Ulrich (1991) Barney (1995)

2.3 Model and Hypotheses Development

2.3.1 External Environmental Pressures

Environmental pressures from both internal and external organizational forces affect a firm's decision-making, particularly for technology adoption. Some research has shown that internal organizational environments are influenced by their external environment (Gordon, 1991). External forces from customers, markets, other firms, regulations, technology changes and standards, and even location can influence decision-making within the firm. When firms experience pressures from external sources, they will quite possibly respond to those pressures by changing their organizational structures and cultural norms in order to gain legitimacy among key stakeholders (Rogers et al., 2007).

Adding new technology based on pressure from an external source is an internal decision made in response to outside forces. Frequently, a firm's survival and profitability depend on how decision-makers reconfigure and adapt structural systems to appropriately respond to those external environmental forces (Gordon, 1991; Ciborra, 1996). Therefore, the following hypothesis is proposed:

H1: External environmental pressures will influence the internal organizational environment.

Additionally, diverse streams of literature suggest that factors in the external environment can influence the adoption of an assortment of IT. Zablah et al. (2005) discuss how the adoption of boundary-spanning IT is influenced by several factors including environmental factors. Several researchers discuss the influence of customers and market pull on adoption decisions for new technological systems (Klassen et al., 1996; Melnyk et al., 2003; Wolfe et al., 2005) and practices (Lieb and Lieb, 2010; Sorrell, 2003). In some cases, competitors or other firms have been shown to influence this decision-making (Sorrell, 2003; Forster and Reagan, 2001). Other firms are expected to significantly influence IT enabled systems and practices decisions for transportation firms that engage with both shipper and receiver firms. Furthermore, regulations can play a major role in influencing IT adoption (Diabat and Simchi-Levi, 2009) particularly in the transportation industry (Wolfe et al., 2005).

A few researchers have shown that changes and innovation in the technology itself can influence a firm's decision to adopt and use new technology in transportation (Crainic et al., 2009; Wolfe et al., 2005). In other cases, many researchers have shown the importance of set technology standards among supply partners (Pokharel, 2005; Zeimpekis and Giaglis, 2006; Evangelista and Sweeney, 2006). Set technology standards help supply partners integrate systems to help coordinate activities of the supply network. Because transportation providers play an integral role in supply networks, it is expected that results from previous studies will also hold for their transportation service providers. Specific empirical research on technology adoption in the transportation and logistics industry is relatively limited (Perego et al., 2011).

Furthermore, in rare cases the literature discusses specific external environmental pressures and specific components under investigation in this study. For instance, Lieb and Lieb (2010) identify customers as being particularly influential when choosing 3PLs. This study aims to identify other specific factors that influence specific IT enabled systems and practices. Based on the literature reviewed and general logic, the following hypothesis is proposed:

> H2: External environmental pressures will influence the adoption of IT enabled systems and practices in transportation and logistics.

2.3.2 Internal Organizational Environment

The external environment may set forth conditions requiring a response from decision-makers within the firm, but ultimately decision-making for IT enabled systems and practices resides within the firm itself. A firm's top management team has been shown by several researchers (Proudlock et al., 1999; Pokharel, 2005; Button et al., 2001) to significantly influence IT adoption decision-making. Not only does top management have the authority to designate funds for new IT projects, but also top management is observed by other staff and can influence the use of new IT throughout the organization. Similarly, organizational culture is shown to influence a variety if IT adoption decisions (Piplani et al., 2004; Pokharel, 2005; Evangelista and Sweeney, 2006; Zeimpekis and Giaglis, 2006). In particular, organizations with a propensity for learning and with openness toward change assimilate well into new IT.

Although, regardless of top management support and culture, if adequate resources are not available often times new IT cannot take place. Previous research has shown in other settings that economic and financial resources are a key factor to adopting new IT (Hollenstein, 2004; Pokharel, 2005; Zeimpekis and Giaglis, 2006; Evangelista and Sweeney, 2006). This appears to be an even bigger challenge for smaller firms.

In many cases, research has shown that the level of IT awareness and involvement (Button et al., 2001; Pokharel, 2005; Evangelista and Sweeney, 2006; Zeimpekis and Giaglis, 2006) play a major role in the adoption of new IT. When a firm is aware of existing technology and possible derived benefits, there is more likely to be a push from within to adopt the new IT. This push can come from the IT department itself, but is also suggested to come from management, employees, drivers and even unions for transportation companies (Bardi et al., 1994; Button et al., 2001; McAvoy, 2014). Bardi et al. (1994) established that firms with high levels of logistics IT awareness from top management provide better customer support and delivery feedback at the operational level and at the strategic level these companies have a higher tendency to use IT to develop new areas of operational efficiencies and competitive practices to gain advantages in the marketplace as compared to companies with low levels of top management IT awareness.

In addition to generating improvements for efficiency and responsiveness within the supply chain, one salient reason today for technology implementation in freight transportation and logistics is to support sustainability efforts toward carbon reduction programs (Lieb and Lieb, 2010; Diabat and Simchi-Levi 2009; Catulli and Fryer, 2012). The 2008 survey of CEOs by Lieb and Lieb (2010) indicated that these implementations are driven from a corporate desire to do the right thing, to enhance the company's image, and to attract green customers. Carbon reduction capabilities are important for implementation of both IT enabled systems (Catulli and Fryer, 2012; Wolfe et al., 2005) and practices such as the selection of 3PL providers (Lieb and Lieb, 2010). The IT enabled systems and practices under evaluation in this study are expected to help with a firm's carbon reduction efforts in addition to other benefits. Transportation and logistics firms are more likely to adopt IT when there is an expected benefit to the individual firm (Sternberg and Andersson, 2014). Therefore, based on the literature reviewed, the following hypothesis is presented:

> H3: Internal environmental pressures will influence the adoption of IT enabled systems and practices in transportation and logistics.

2.3.3 IT Enabled Systems and Practices

2.3.3.1 ITS for Freight

In the freight sector, improvements to truck fuel-efficiencies have helped reduce transportation costs, and in turn a higher importance was placed on transport as an input to production (e.g. substitution of on-site warehousing for JIT deliveries) (Goldman and Gorham, 2006). Authorities and organizations alike have recently turned their attention toward IT applications, such as ITS, in order to improve both efficiency and environmental affects of freight transportation (Sternberg and Andersson, 2014). ITS technology components help improve reliability in travel times, safety, and reduce environmental impacts (Chowdhury & Sadek, 2003).

Button et al. (2001) conducted one of the few empirical freight ITS studies on a limited scale for a diversified transportation company, the Nova Group, Ltd. Their results document an average driver productivity improvement of 24% after implementation of the company's proprietary ITS technology called Dispatch Tools. Increases in driver productivity were likely due to improved dispatch efficiencies. Improved efficiencies in the transportation industry stemming from a wider use of ITS can reduce total vehicle miles traveled resulting in lower fuel consumption and also reduced carbon emissions. Additionally, an unanticipated effect was a decrease in stress on the dispatchers and improved communications between dispatchers and office personnel (Button et al., 2001).

Furthermore, the U.S. Department of Transportation (US DOT) has identified a number of ITS user benefits, specifically for the private sector, based on a series of field operational tests (Wolfe et al., 2005). Various tests have identified ITS user improvements in efficiency, reliability, responsiveness, quality, and carbon reduction. Two examples are based on efficiency improvements for transportation providers. For instance, their Cargo*Mate evaluation (testing chassis tracking and e-seals) estimated an annual carrier benefit of $210.35 per container chassis (Wolfe et al., 2005). Additionally, evaluations of ITS tracking systems for Hazardous Materials Safety and Security identified $7k to $15k of cost savings per tractor per year in addition to environmental benefits (Wolfe et al., 2005). Reliability and service quality improvements have also been identified due to better schedule adherence, speed and other flexibility of operations that have in turn led to both inventory management and customer service benefits (Wolfe et al., 2005).

Results from these government based operational field tests are a promising start toward empirical evidence, however these technologies are not mature "across the board and many benefit scenarios are incomplete," (Wolfe et al., 2005, p. 31). Empirical results for ITS are lacking (Perego et al., 2011).

2.3.3.2 Transportation Management System (TMS)

TMS technology helps companies move freight efficiently and reliably from origin to destination (Robinson, 2014). TMS helps identify and evaluate the best transportation strategies to move materials and products within existing equipment, timing, and capacity constraints (Bowersox et al., 2007). Equipment scheduling and yard management functions assure that pick-ups and deliveries are handled in a timely manner with limited wait and idol time for drivers. Load planning and routing functions directly impact transportation efficiency. For example, an efficient load plan can reduce the number of required trucks saving the company time, money, and lowering carbon emissions by reducing the number of trucks on the road.

Scheduling and routing functions allow for trip optimization (Kia et al., 2000) which has resulted in some recognized environmental benefits, including air pollution reduction and decreased fuel consumption (Button et al., 2001). TMS can act as a component toward information sharing between partners which adds flexibility and responsiveness to the supply chain (Verwijmeren, 2004; Bowersox et al., 2007). TMS use wireless technology and communication networks to facilitate information sharing to improve costs, lead time and visibility of shipments (Pokharel, 2005). Furthermore, data access and information sharing features of TMS act as a control mechanism for tracing and identifying shipment status (Bowersox et al., 2007). Providing this feedback to customers enhances overall customer service quality.

Ironically, industry surveys have shown that only about a third of companies that would benefit from TMS have adopted them (McCrea, 2011), this is quite possibly due to limited empirical results demonstrating system benefits (Perego et al., 2011). More companies should adopt TMS to improve efficiencies in transportation spending reductions, improve route planning and optimization, and achieve better collaboration across the supply chain (McCrea, 2011).

2.3.3.3 Integrated Information Sharing

Technological systems in general enable organizational collaboration (Reed and DeFillipi 1990) which, in turn, enhances the success of the organization. Wu et al. (2006) describes how computer applications enabled a fast response to market changes providing superior performance over competitors who did not adopt similar technologies. Increasing the flow of information allows firms to solve customer problems faster (Rogers et al. 1993), and in turn provides better after sales service levels (Bowersox et al. 1999). This of course can be translated to increased performance, attributable to the greater efficiency in resource management.

IT is shown to increase responsiveness to changing business conditions (Williams et al., 2013). Extant research has shown that information processing capabilities are derived from the organization's internal integration activities (Hultet al., 2004; Rosenzweig et al., 2003; Swink et al., 2007; Wong et al., 2011). Internal integration involves cross-functional collaborations that enable the overall organization to absorb and utilize information in ways that enhance flexibility (Schoenherr and Swink, 2012). Furthermore, intra-organizational information sharing literature reveals organizational problem solving capabilities can be built through facilitating information sharing (*i.e.,* Ardichvill et al., 2003; Cress and Kimmerle, 2006). In this context, three main intangible dimensions of the value of communicating information within organizations are identified as: 1) superior product quality through customized and superior quality products and services, 2) improved customer service through being more responsive to customer needs, and 3) synergy and coordination through improved coordination and sharing of resources across organizational divisions (Bharadwaj et al., 1999). It is suggested here that similar results could be found through inter-organizational information sharing through integrated systems.

Information sharing helps to achieve better coordination which in turn fosters the reduction of transaction costs between different partners (Clemons and Row, 1993). This is highly exemplified in companies that apply Just-In-Time (JIT) practices and achieve greater cost savings than competitors. Furthermore, with a clear understanding of the factors that support and constrain the development of an effective system that supports information exchange, analysis, improved accuracy, and timeliness of decisions, policy makers and practitioners alike can proceed with greater confidence in their outcomes (Yang and Maxwell, 2011). Internal systems are not enough (*i.e.* WMS, TMS, ERP) firms must have a coordinating system across organizations (Verwijmeren, 2004). Moreover, in order to achieve successful supply chain management the integration of information, material flows, and other business processes within the supply network is necessary (Lambert et al., 1998).

Through this logic it is expected that inter-organizational information sharing, or rather the practice of IIS through the adaptation of compatible systems between supply partners and transportation service providers, will influence multiple measures of transportation performance.

2.3.3.4 Third Party Supply Chain and Logistics Management

It is suggested that 3PLs drive innovation, create value for their customers, and provide innovative ways to improve logistics effectiveness. Major benefits are identified as: logistics cost reduction, inventory cost reduction, logistics fixed asset reduction, improved order fill rates, and improved order accuracy. Other benefits of long-term 3PL contracts include increased flexibility, access to specialized knowledge and capabilities, and also the ability to engage in financial incentives and value-added services (Langley et al., 2014).

In the U.S. between 1996-2004 the 3PL/contract logistics market grew from an estimated $31 billion to an $85 billion industry (Langley et al., 2005). Thus it is not surprising that logistics outsourcing has become an expanding source of competitive advantage and cost savings (Tian et al., 2008; Mitra, 2006; Perrons and Platts, 2005; Rabinovich et al., 1999). Some findings indicate that 3PL's involved in customer embedded relationships also develop important capabilities, such as organizational learning and enhanced innovation, thereby promoting supply chain improvements in addition to operational and market performance (Hofer et al., 2009; Panayides and So 2005; Sinkovics and Roath 2004; Stank et al 2003). These capabilities can be translated into performance improvements for efficiency, reliability, responsiveness, and quality. Conversely, other researchers have found mixed results from 3PL providers depending on the level of IT sophistication in the firms (Evangelista and Sweeney, 2006); suggesting that further research should be conducted in the area of 3PLs.

Some researchers have identified "environmental partnerships" with 3PLs as being extremely important to the 3PL industry's successful sustainability efforts (Lieb and Lieb, 2010). These environmental partnerships, many of which stem from government agencies, provide new perspectives, access to data, larger networks, and experience to help 3PLs meet sustainability goals (Lieb and Lieb, 2010) which overall contribute to carbon emission reduction efforts.

Based on the literature reviewed on ITS for freight, TMS, IIS, and 3PL SCLM the following hypothesis is presented:

> H4(abcd): The adoption of IT enabled systems and practices (ITS, TMS, IIS, 3PL SCLM) will positively influence transportation performance outcomes for efficiency, reliability, responsiveness, quality, carbon emissions reduction and equipment utilization.

2.3.4 Performance Outcomes and Competitive Advantage

Business strengths, stemming from logistics resources, can be developed as a key strategy for gaining a sustainable competitive advantage (Daugherty, 2009). Key logistics resources can in turn, add value to improve service levels and contribute to long-term competitive advantage. Results from several studies world wide suggest that logistics competences lead to a competitive advantage (Matwiejczuk, 2013). "Competitive advantage is more likely to be sustainable if it arises from activities that have more than one optimal configuration," (Porter et al, 2008 p. 37) such as a combination of performance outcomes.

Matwiejczuk (2013) suggests several key logistics competences that contribute to competitive advantage. Among those are components also addressed in this study including, information systems and technology, TMS, some ITS components, integration with customers and suppliers (comparable to integrated information sharing), and performance measures similar to efficiency, reliability, responsiveness and quality. As such, the following hypothesis is presented:

H5: High transportation performance outcomes will positively influence the competitive advantage of the supply chain.

Figure 2.3 displays a detailed model of the hypothesized relationships as presented in this chapter.

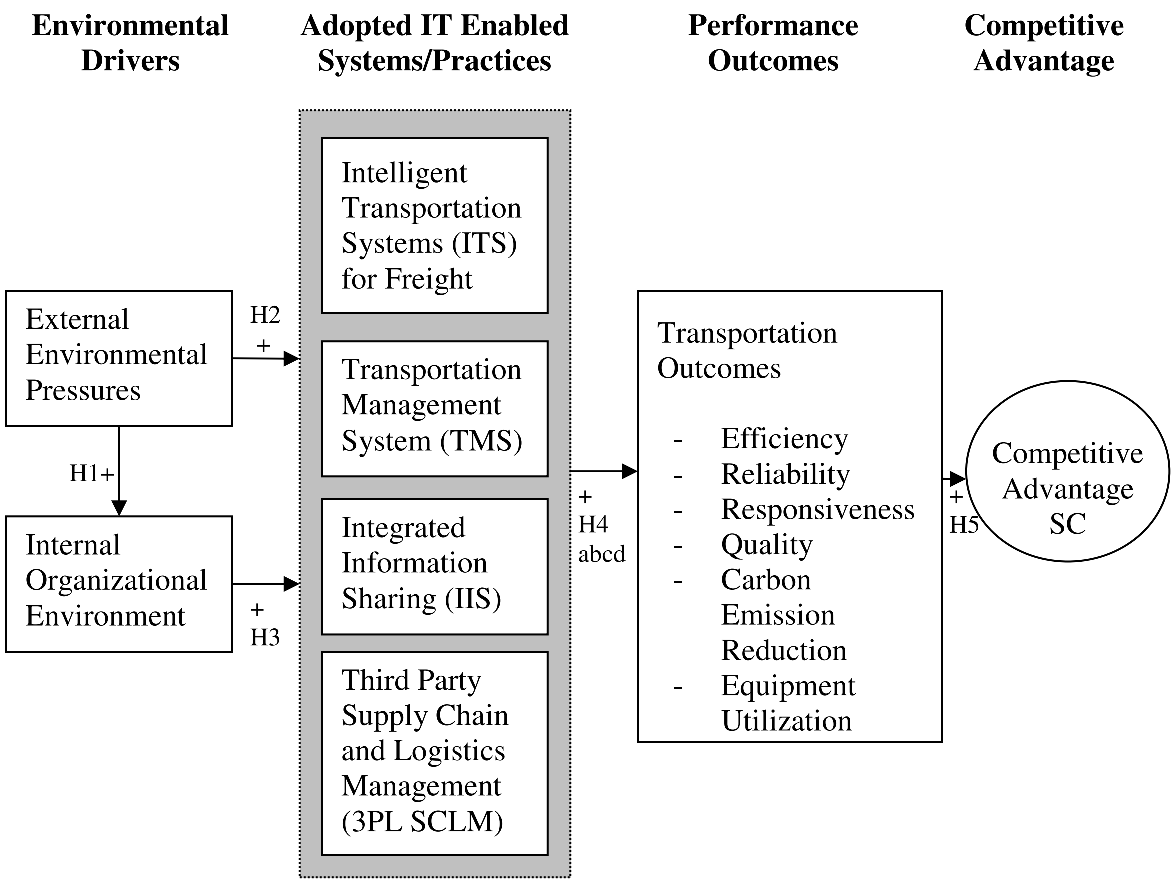


Figure 2.3: Detailed Model of Hypothesized Relationships

The next chapter discusses research methods for measuring and testing the relationships presented in Figure 2.3.

Chapter 3

Instrument Development: Item Generation and Pilot Test

In order to establish suitability of the research subject, a preliminary literature review was conducted early on and followed up with semi-structured interviews of individuals from transportation, manufacturing, and 3PL companies along with two academicians. Considering the main goal of this research is to test hypothesized relationships between the 'environmental drivers' for 'adopted IT enabled systems and practices' and their 'performance outcomes' to better understand how these affect 'competitive advantage' of the supply chain, valid measures must be developed for each construct. This chapter discusses instrument development through 1) item generation, 2) structured interviews and pretesting, and 3) a Q Sort pilot study for validating measurement items for the constructs presented in the research model (see Figure 2.3). A similar three phase process for instrument development is suggested by Churchill (1979). Next, item generation is discussed for the constructs (1) External Environmental Pressures, (2) Internal Organizational Environment, (3) IT Enabled Systems and Practices, (4) Transportation Performance Outcomes, and (5) Competitive Advantage for the Supply Chain.

3.1 Item Generation

Initial items were generated based on a thorough literature review and interviews with experts to establish content validity. This is the first step in achieving reliable empirical research. In general, content validity indicates that measurement items in the instrument explicate the main construct domain content (Churchill, 1979). The remainder of this section identifies the relevant literature for items in each construct and its dimensions along with measurement scales. Refer to Tables 2.1 – 2.5 in the previous chapter for construct and sub-construct definitions and literature support used as a basis for the following discussion on item generation (Churchill, 1979).

Literature reviewed for External Environmental Pressures identified five dimensions of the construct and items were generated for each of the following (1) customers/market (Pokharel, 2005; Lieb and Leib, 2010; Klassen et al., 1996; Melnyk et al., 2003; Wolfe et al., 2005); (2) competitors (Forster and Regan, 2001; Diabat and Simchi-Levi, 2009; Wolfe et al., 2005); (3) regulations (Sorrell, 2003; Wolfe et al., 2005); (4) technology change (Pokharel, 2005; Crainic et al., 2009; Wolfe et al., 2005); and (5) technology standards (Pokharel, 2005; Zeimpekis and Giaglis, 2006; Evangelista and Sweeney, 2006). A five point Likert type scale was used for these measurement items (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

Literature reviewed for Internal Organizational Environment identified seven dimensions of the construct and items were generated for each of the following (1) top management (Pokharel, 2005; Proudlock et al., 1999; Button et al., 2001; Chen and Paulraj, 2004); (2) organizational culture (Piplani et al., 2004; Pokharel, 2005; Evangelista and Sweeney, 2006; Zeimpekis and Giaglis, 2006; Harper and Utley, 2001;

Choi and Chang, 2009); (3) economic/ financial resources (Hollenstein, 2004; Pokharel, 2005; Zeimpekis and Giaglis, 2006; Choi and Chang, 2009; Evangelista and Sweeney, 2006); (4) IT awareness/involvement (Pokharel, 2005; Button et al., 2001; Evangelista and Sweeney, 2006; Zeimpekis and Giaglis, 2006); (5) employees (Button et al., 2001; Tarafdar et al., 2010); (6) drivers (Button et al., 2001; McAvoy, 2014), and (7) unions (McAvoy, 2014). A five point Likert type scale was used for these measurement items (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

Literature reviewed for IT enabled systems and practices identified four main components. Two of these components were identified as IT enabled systems including (1) ITS for freight (Barfield and Dingus (Eds.), 1998; Jarasuniene, 2007; Fries, Gahrooei, Chowdhury, and Conway, 2012; Wolfe et al., 2005) and (2) TMS (Gilmore and Tompkins, 2000; Tyan et al., 2003; Mason et al., 2003; McCrea, 2013). While the other two components were identified as IT Enabled Practices and items were generated for each of the following (1) IIS (Williams et al., 2013; Klein, 2009; Reed et al., 1990; Chen and Paulraj, 2004; Li et al., 2005; Jin et al., 2014) and (2) 3PL SCLM (Sink et al., 1996; Ying et al., 2005; Bayraktar et al., 2010). A five point Likert type scale was also used for these measurement items (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

After the literature review, a number of structured interviews were conducted with industry experts to validate and refine construct dimensions and to further refine scales as discussed next.

3.2 Structured Interview Pretests

In order to refine construct dimensions and scales, structured interview pretests were conducted as part of experience surveys (Churchill, 1979) with industry professionals possessing considerable domain knowledge. The first two individuals were CEO and COO at two local small and mid-size trucking companies respectively. Both have been in the trucking industry for over twenty years, providing considerable experience. The next three individuals were interviewed as part of a break-out roundtable session at the Logistics, Trade, and Transportation Symposium in Gulfport, Mississippi. These individuals represented a mega-carrier with over 30,000 trucks, a top tier parcel package delivery carrier, and a 3PL firm. These participants had between ten and twenty years of industry experience each.

Initially, all participants were given a brief description of the study and presented with the theoretical research model, major construct dimensions and definitions. Feedback was solicited regarding construct dimensions and definitions based on the participants' experience. As a result, an additional dimension was added to the internal organizational environment construct and some definitions were refined during this exercise. In addition, discussion on industry technology components and practices provided valuable information for clarity of item wording on the survey instrument. Consequently, the procedure helped strengthen the content validity of the study and also helped shape and refine items entering the Q Sort process discussed next.

3.3 Q Sort Pilot Test

Q Sort techniques have been used in supply chain integration studies and results have been useful in eliminating validity and reliability issues in early scale development (Boon-itt and Paul, 2005). In this method, first, a set of statements are generated (completed in the previous chapter through the literature review), then participant judges match the statements with definitions on a "free sort" basis (Ekinci and Riley, 1999). Two general rules apply according to Hinkin et al. (1997); first, a definition only exists if at least two statements describe it. Second, statements are qualified when 70% of the sample allocates them to the same definition. At least four to six statements per scale are suggested to maintain internal consistency. Thirty to fifty samples are suggested (Brown, 1986), however results are possible with only one subject (Kerlinger, 1983) though some bias can be exhibited with small sample sizes (McKeown and Thomas, 1988). Q Sorts are correlated conventionally using Pearson's r, where a higher positive correlation between two statements suggests they are similarly placed (Brown, 1986).

Six individual industry professionals and academics participated as judges for the Q Sort procedure. The main idea of this procedure is to clarify and refine items used to measure constructs and sub-constructs. At the beginning of each interview, judges were briefed with a description of the study and presented with the research model and definitions of constructs. The Q Sort procedure was fully explained and participating judges were encouraged to ask questions throughout the process. Three rounds with two judges each were conducted. Judges were asked to sort statements into the most appropriate construct category based on their knowledge, expertise and experience. All of the statements were printed on cards and shuffled randomly for placement into construct categories, a not applicable (NA) category was also presented to ensure statements were not forced into a category (Boon-itt and Paul, 2005).

During each round two judges were asked to sort the items into appropriate categories and assessed based on two criteria. First, Moore and Benbasat's hit ratio is evaluated, which is a measure of the proportion of judges' placement based on the researchers theoretical expectations (Moore and Benbasat, 1991). A higher percentage indicates better agreement between theoretical and actual categories. However, some authors have argued that the overall observer agreement is artificially high due to chance agreements and should be corrected accordingly (Cohen, 1960; Warrens, 2014). Therefore, the second measure, Cohen's Kappa coefficient, is assessed as a measure of inter-rater agreement (Cohen, 1960) that measures the level of agreements between judges while also considering agreements made merely by chance. Cohen's Kappa can be further described as a chance corrected version of the observed agreements (Warrens, 2014). The calculation is explained as such:

> The numerator of kappa is the difference between the actual probability of agreement and the probability of agreement in the case of statistical independence of the ratings. The denominator of kappa is the maximum possible value of the numerator. Kappa has value 1 when there is perfect agreement between the observers, 0 when agreement is equal to that expected by chance, and a negative value when agreement is less than that expected by chance (Warrens, 2014).

Some extant research has suggested that scores above .65 are acceptable for the measure (Moore and Benbasat, 1991; Jarvenpaa 1989).

3.3.1 First Round Q Sort Results

In the first round, two transportation academics participated as judges in the Q Sort. In all, five major constructs were presented with a total of twenty-two sub-constructs to be measured by 96 items. Table 3.1 below lists items entering the Q Sort process.

Table 3.1: Items entering Q Sort

Construct	Subconstruct	# of Items
External Environmental Pressures (EEP)	Customers	4
	Competitors	3
	Regulations	4
	Technology Change	3
	Technology Standards	4
Internal Organizational Environment (IOE)	Top Management	4
	Organizational Culture	6
	Economic/Financial Resources	4
	IT Awareness/Involvement	4
	Employee IT Adoption Input	4
	Driver IT Adoption Input	4
	Unions IT Adoption Input	4
Adopted IT Enabled Systems and Practices (ITESP)	Intelligent Transportation Systems for freight	5
	Transportation Management System	6
	Integrated Information Sharing	6
	Third Party Supply Chain and Logistics Management	3
Performance Outcomes (PO)	Efficiency	3
	Reliability	4
	Responsiveness	4
	Quality	5
	Carbon Emissions Reduction	4
	Equipment Utilization	4
Competitive Advantage		4
Total		96

To calculate the hit ratio, all items correctly sorted into the expected theoretical category by each of the participants is divided by twice the total number of items to account for placements by two judges. In this round, the total number of items correctly placed was 179 and the total placements were 192. Because higher percentages indicate better agreement between theoretical and actual categories, the overall hit ratio score of 93.2% (see Table 3.2) is acceptable.

Table 3.2: Items Placement Ratio – First Sorting Round

Construct		Actual																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	NA	Total	% Hits
Theoretical	1	8																								8	100%
	2		6																							6	100%
	3			8																						8	100%
	4				6																					6	100%
	5					8																				8	100%
	6						8																			8	100%
	7							12																		12	100%
	8							1	7																	8	88%
	9							1		7																8	88%
	10										8															8	100%
	11											8														8	100%
	12												8													8	100%
	13													8	1	1										10	80%
	14													1	10	1										12	83%
	15													1	1	10										12	83%
	16																6									6	100%
	17																	4	1					1		6	67%
	18																		8							8	100%
	19																			8						8	100%
	20																				10					10	100%
	21																	1				7				8	88%
	22																	1					7			8	88%
	23																	1						7		8	88%
Total Item Placements: 192										Hits: 179										Overall Hit Ratio: 93.2%							

Construct category labels along the axis are available in Table 3.3.

Table 3.3: Constructs Legend

Legend for Variables 1 - 23	
1 Customers	13 ITS for freight
2 Competitors	14 TMS
3 Regulations	15 IIS
4 Technology Change	16 3PL SCLM
5 Technology Standards	17 Efficiency
6 Top Management	18 Reliability
7 Organizational Culture	19 Responsiveness
8 Economic/Financial Resources	20 Quality
9 IT Awareness/Involvement	21 Carbon Emissions Reduction
10 Employee IT Adoption Input	22 Equipment Utilization
11 Driver IT Adoption Input	23 Competitive Advantage
12 Union IT Adoption Input	

Table 3.4: Inter-judge Raw Agreement Scores – First Sorting Round

	Judge 1																						
Judge 2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	4																						
2		3																					
3			4																				
4				3																			
5					4																		
6						4																	
7							6																
8								3															
9									3														
10										4													
11											4												
12												4											
13													4										
14														4									
15															5								
16																3							
17																	1						
18																		4					
19																			4				
20																				5			
21																					3		
22																						3	
23																							3
Total Items: 96							Number of Agreements: 85									Agreement Ratio: 88.5%							

The inter-judge agreement ratio is also acceptable at 88.5% (see table 3.4 above). Next, Cohen's Kappa coefficient (K) is calculated to account for any chance agreements. Table 3.5 below is used to determine the calculation.

Table 3.5: Cohen's Kappa Calculation – Q Sort Round 1

		Judge 1		
		Accept	Reject	Total
Judge 2	Accept	85	8	93
	Reject	1	2	3
	Total	86	10	96

K = (96*85) – (86+93) / (96^2) – (86+93)

K = 0.8831

According to Landis and Koch (1977), values above .80 are almost perfect agreement.

Overall, assessment measure results for round one suggest strong agreements between the judges. Nonetheless, there are a few constructs that exhibit clustering in the items placement ratio test, particularly among the IT enabled systems and practices sub-constructs. Round two is carried out to confirm and refine initial findings.

3.3.2 Second Round Q Sort Results

Two academics participated as judges in the Q Sort round. One academic is considered an expert in supply chain management while the other is an expert in industrial geography, both have some transportation background. These judges were selected specifically to test agreements across subject backgrounds. Again, the same five major constructs were presented with a total of twenty-two sub-constructs to be measured by 96 items.

In this round, the total number of items correctly placed was 177 and the total placements were 192. The overall hit ratio score of 92.2% (see table 3.6 below) decreased slightly from the first round, but is still considered acceptable. Again, some clustering is noted among the IT enabled systems and practices sub-constructs, thus indicating that revisions should be made for the next round. The judges offered some suggestions for refining these items.

Table 3.6: Items Placement Ratio – Second Sorting Round

Construct		Actual																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	NA	Total	% Hits
Theoretical	1	8																								8	100%
	2		6																							6	100%
	3			7	1																					8	88%
	4				6																					6	100%
	5					8																				8	100%
	6						7			1																8	88%
	7							12																		12	100%
	8							1	6	1																8	75%
	9									6	2															8	75%
	10										8															8	100%
	11											8														8	100%
	12												8													8	100%
	13													8	1	1										10	80%
	14													1	10	1										12	83%
	15													1		10	1									12	83%
	16																6									6	100%
	17																	6								6	100%
	18																		8							8	100%
	19																			8						8	100%
	20																				9			1		10	100%
	21																					8				8	100%
	22																	1					6	1		8	75%
	23																							8		8	100%
Total Item Placements: 192									Hits: 177										Overall Hit Ratio: 92.2%								

Construct category labels along the axis are available in Table 3.3.

The inter-judge agreement ratio also decreased slightly to 86.5% (see Table 3.7), but is still considered acceptable.

Table 3.7: Inter-judge Raw Agreement Scores – Second Sorting Round

		Judge 3																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Judge 4	1	4																						
	2		3																					
	3			3																				
	4				3																			
	5					4																		
	6						3																	
	7							6																
	8								3															
	9									2														
	10										4													
	11											4												
	12												4											
	13													3										
	14														4									
	15															5								
	16																3							
	17																	3						
	18																		4					
	19																			4				
	20																				4			
	21																					3		
	22																						3	
	23																							4
Total Items: 96								Number of Agreements: 83									Agreement Ratio: 86.5%							

Next, Cohen's Kappa coefficient (K) is calculated to account for any chance agreements. Table 3.8 is used to determine the calculation.

Table 3.8: Cohen's Kappa Calculation – Q Sort Round 2

		Judge 3		
		Accept	Reject	Total
Judge 4	Accept	83	5	88
	Reject	6	2	8
	Total	89	7	96

K = (96*83) – (89+88) / (96^2) – (89+88)

K = 0.8619

According to Landis and Koch (1977) values above .80 are almost perfect agreement. As a result, even though the agreement values decreased slightly during this round, construct reliability and validity can be considered strong. Due to the lack of agreement for two items among all four judges, these items were considered ambiguous and removed before entering the next round.

3.3.3 Third Round Q Sort Results

Two C-level transportation professionals participated as judges in this Q Sort round. Both judges had over thirty years of experience in the trucking industry and can be considered experts in their field. The same five major constructs were presented with a total of twenty-two sub-constructs to be measured by 94 items this round. Two were removed based on results from the previous rounds.

Table 3.9: Items Placement Ratio – Third Sorting Round

Construct		Actual																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	NA	Total	% Hits
Theoretical	1	8																								8	100%
	2		6																							6	100%
	3			8																						8	100%
	4				5	1																				6	83%
	5				2	6																				8	75%
	6						8																			8	100%
	7							12																		12	100%
	8						1		6		1															8	75%
	9									6																6	100%
	10										8															8	100%
	11											8														8	100%
	12												8													8	100%
	13													8	1	1										10	80%
	14													1	10	1										12	83%
	15															9	1									10	90%
	16																6									6	100%
	17																	4						2		6	67%
	18																		8							8	100%
	19																			8						8	100%
	20																				10					10	100%
	21																	1				6	1			8	75%
	22																	1					7			8	88%
	23																			2	1			5		8	100%
Total Item Placements: 188										Hits: 170										Overall Hit Ratio: 90.4%							

Construct category labels along the axis are available in Table 3.3.

In this round, the total number of items correctly placed was 170 and the total placements were 188. The overall hit ratio score of 90.4% (see table 3.9 above) decreased slightly from the previous round, but is considered acceptable. Again, some clustering is noted among the IT enabled systems and practices sub-constructs. The judges offered valuable suggestions for refining a few items in the ITS, TMS, and IIS sub-construct categories for clarity among industry responders.

The inter-judge agreement ratio also decreased slightly during this round to 83% (see table 3.10 below), but is considered acceptable.

Table 3.10: Inter-judge Raw Agreement Scores – Third Sorting Round

		Judge 5																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Judge 6	1	4																						
	2		3																					
	3			4																				
	4				2																			
	5					2																		
	6						4																	
	7							6																
	8								3															
	9									3														
	10										4													
	11											4												
	12												4											
	13													3										
	14														4									
	15															4								
	16																3							
	17																	1						
	18																		4					
	19																			4				
	20																				5			
	21																					2		
	22																						3	
	23																							2
Total Items: 94								Number of Agreements: 78									Agreement Ratio: 83%							

Next, Cohen's Kappa coefficient (K) is calculated to account for any chance agreements. Table 3.11 is used to determine the calculation.

Table 3.11: Cohen's Kappa Calculation – Q Sort Round 3

		Judge 5		
		Accept	Reject	Total
Judge 6	Accept	78	1	79
	Reject	13	2	15
	Total	91	3	94

K = (94*78) – (91+79) / (94^2) – (91+79)

K = 0.8264

As stated earlier, according to Landis and Koch (1977) values above .80 are almost perfect agreement. Therefore, even though the agreement values decreased slightly during this round, construct reliability and validity overall are considered strong.

Table 3.12: Items Post Q Sort Process

Construct	Subconstruct	# of Items
External Environmental Pressures (EEP)	Customers	4
	Competitors	3
	Regulations	4
	Technology Change	3
	Technology Standards	4
Internal Organizational Environment (IOE)	Top Management	4
	Organizational Culture	6
	Economic/Financial Resources	3
	IT Awareness/Involvement	3
	Employee IT Adoption Input	4
	Driver IT Adoption Input	4
	Unions IT Adoption Input	4
Adopted IT Enabled Systems and Practices (ITESP)	Intelligent Transportation Systems for freight	4
	Transportation Management System	6
	Integrated Information Sharing	5
	Third Party Supply Chain and Logistics Management	4
Performance Outcomes (PO)	Efficiency	3
	Reliability	4
	Responsiveness	4
	Quality	5
	Carbon Emissions Reduction	4
	Equipment Utilization	4
Competitive Advantage SC (CASC)		4
Total		93

Finally, the judges were instrumental in making suggestions toward refining items for clarity and also suggested another item dimension for the 3PL SCLM sub-construct. Two other items were removed because it was agreed they were too ambiguous to clearly categorize and were problematic for all rounds. Consequently, the total items refined for the large scale survey deployment were 93 (see Table 3.12 above). Results were used to refine the instrument prior to the large scale survey deployment described in the next chapter.

Chapter 4

Large Scale Survey Deployment and Instrument Validation

After instrument development, a large scale survey was deployed in order to collect data valuable for validating the instrument and testing the hypothesized relationships depicted in Figure 3. In this chapter, methodology used for survey deployment, data collection and sample characteristics are discussed. In turn, the confirmatory factor analysis (CFA) methodology used in measurement model testing for validity and reliability of the instrument is presented. Structural equation modeling (SEM) procedures are used. One advantage to SEM is that it draws a distinction between the measurement model, which relates the constructs to their measures, and the structural model, which relates the constructs to each other (Jarvis et al, 2003). Methodology for structural model testing, used to test hypothesized relationships between constructs, is discussed in Chapter 5.

4.1 Survey Design and Deployment

The survey instrument for data collection was designed and executed in an online platform called *Survey Monkey* available at www.surveymonkey.com. The site is user-centered and provides tools for building questions in a variety of ways including multiple choice, dropdown menus, and matrix formats among others. Tools are also available for building page logic into the survey design that allow certain questions to be skipped based on how a previous question is answered, or to randomize questions for general response rigor. Figures 4.1 and 4.2 depict a visual image of the design mode for the initial welcome page (Figure 4.1) and the first couple qualifying questions (Figure 4.2). The full final survey is available in Appendix A Figures A3-A33.

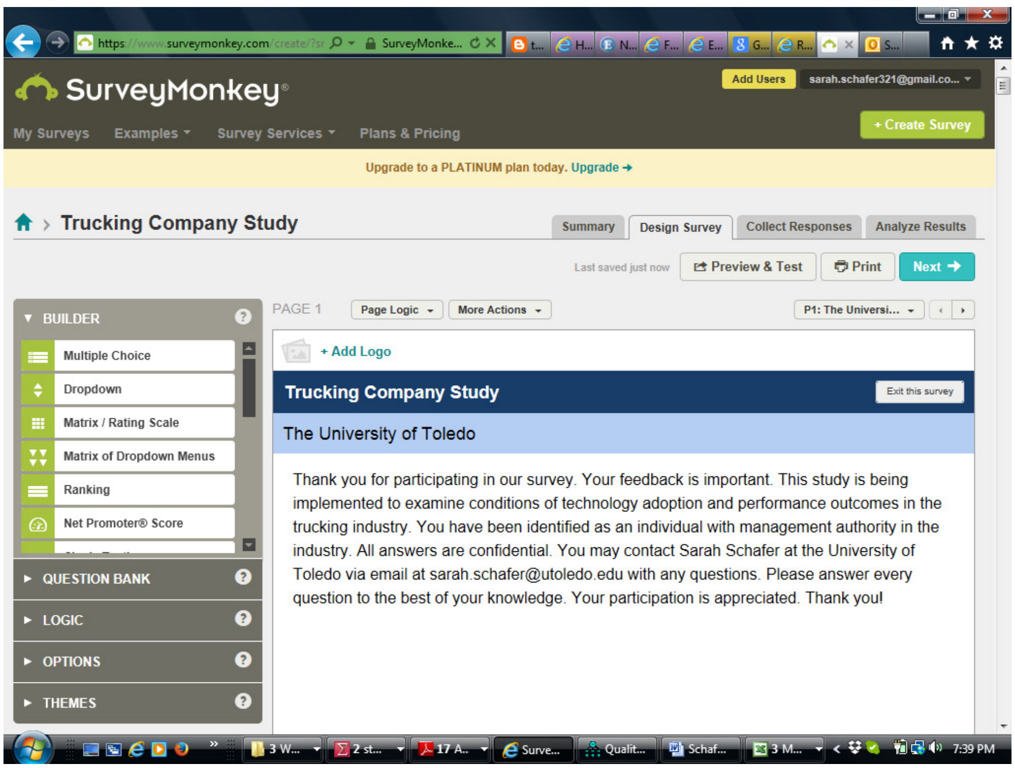


Figure 4.1: Welcome Page in Design Mode

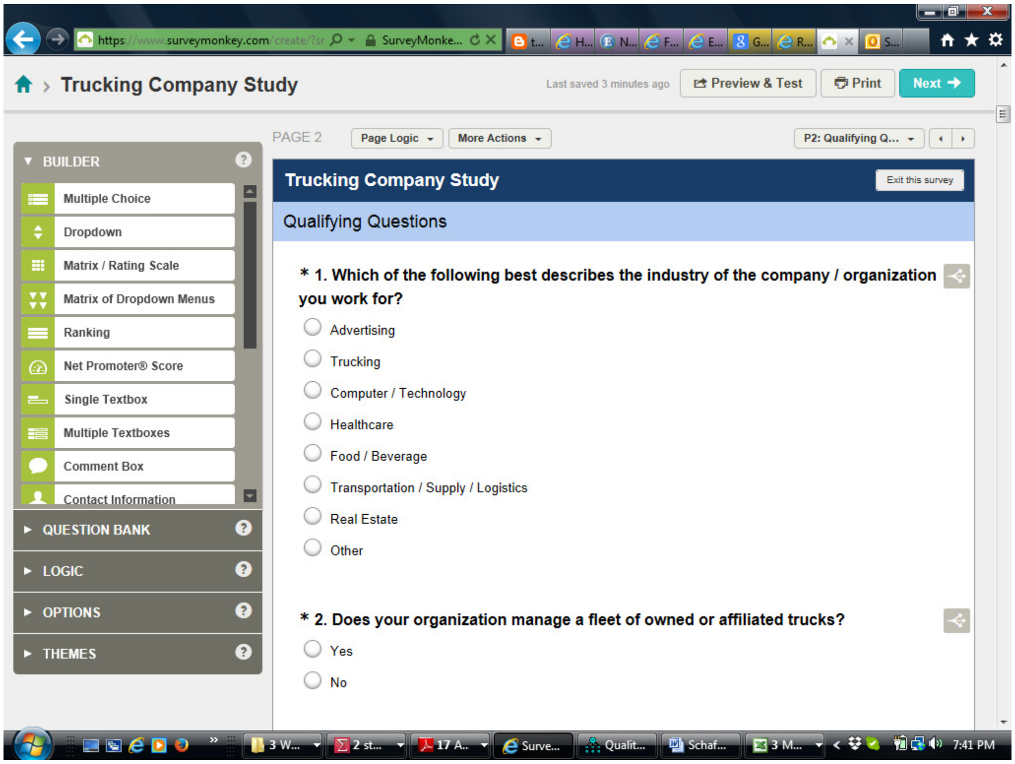


Figure 4.2: Initial Qualifying Questions in Design Mode

Upon survey design completion via Survey Monkey, ResearchNow was engaged to administer the large scale survey deployment for this study. The firm provides access to over 6.5 million individual panelists for survey responses (http://www.researchnow.com/en-US.aspx) across most industries in the U.S. and 38 countries globally. Among other areas, ResearchNow serves a key niche area for academic research. They specialize in providing high quality, hard to access, professional respondents. In a time when it is becoming more difficult to access busy executives for rigorous research, their database not only allows researchers to target suitable respondents by industry, but also by executive authority level.

Because this research required targeted respondents specifically in the trucking and supply chain management areas, the level of granularity provided by ResearchNow offered greater access to a larger number of key industry executives who were qualified to answer this survey. Additionally, qualified respondents were disbursed across the U.S. (see Figure 4.3) thus, incorporating greater generalizability of respondents among regions.

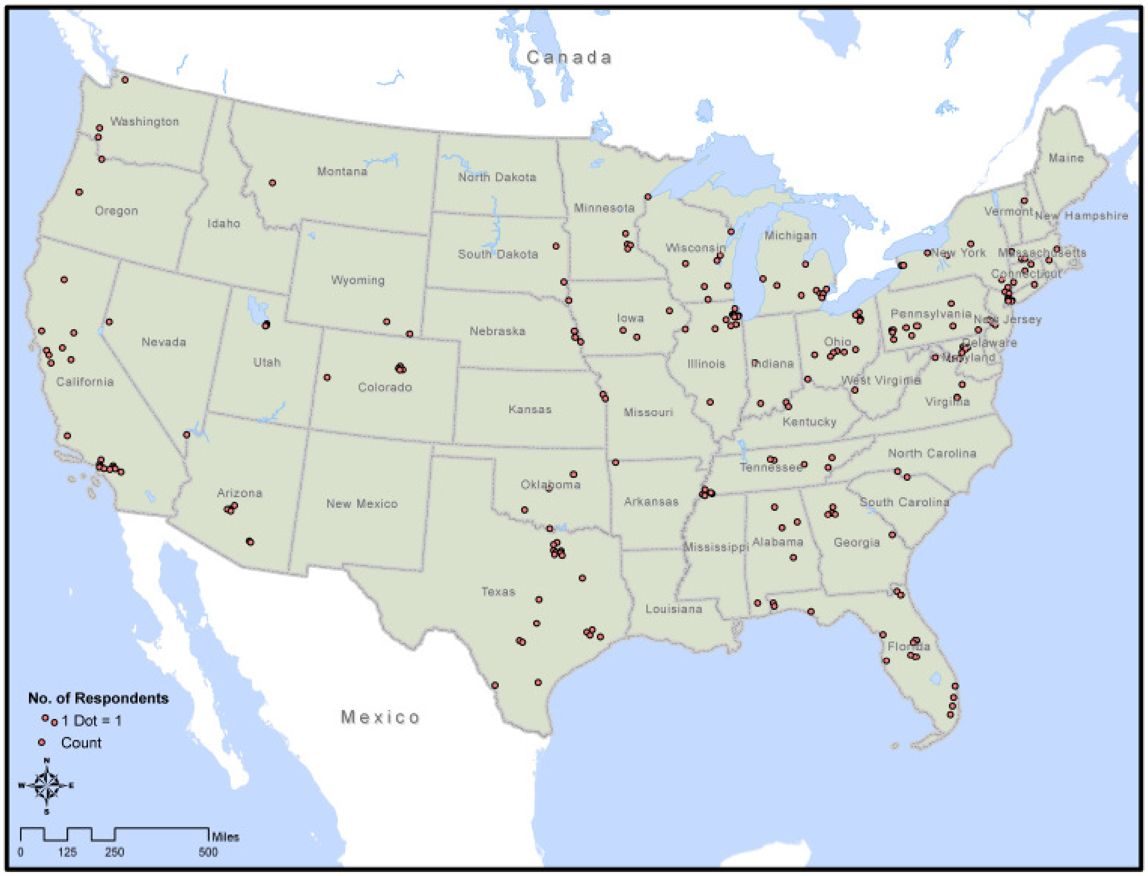


Figure 4.3: U.S. Point Map of Respondents

Another advantage of using panelist respondents is obtaining complete data with no missing values; all required questions must be answered in order for the response to be considered complete or the respondent does not receive their incentive for participating. ResearchNow invited 5,389 panelists to participate in the survey. From those invitations, 640 individuals responded favorably to participate. At that point, in order to qualify, respondents had to work in the trucking, transportation, supply, or logistics industry and their company had to directly manage a fleet of either owned or affiliated trucks (see figures 4.4 and 4.5 below). Of those who responded to take the survey, 260 qualified responses were completed. Therefore, a high response rate of 40.62% (260/640) was realized. Accordingly, the response rate based on all invitations sent out at 4.82% (260/5,389), is still considered acceptable (Jin et al., 2014) and inline with researchers suggesting that response rates in general, and for online surveys in particular, have decreased over time (Sheehan, 2001; Kaplowitz, Hadlock, & Levine, 2004). Particularly with lower response rates, the research must be careful to examine non-response errors that can be present.

4.2 Non-Response Bias Testing

Bias due to non-response errors can be an issue in survey based research. It is important for respondents to be representative of the population and that there are no contributing biases from non-respondents. To make certain there were no differences between respondents and non-respondents, a non-response bias test was performed. It is generally accepted in survey research that late respondents can act as a proxy for non-respondents. As such, a chi-square difference test was performed between early (first round responders) and late responders (last round responders) to test for significant differences in firm size based on the total number of employees and fleet size between these two groups. Chi-square tests show there are no significant differences between the two groups, based on total employees or fleet size (see Tables 4.1 – 4.1). As a result, non-response bias is not detected in this study.

Table 4.1: Test for Non-response Bias – Firm Size Based on Total Employees

How many total employees does your company have? * Respondent Crosstabulation

			Respondent		Total
			Early	Late	
How many total employees does your company have?	1-25	Count	31	22	53
		% within Respondent	20.7%	20.0%	20.4%
		% of Total	11.9%	8.5%	20.4%
	26-50	Count	13	8	21
		% within Respondent	8.7%	7.3%	8.1%
		% of Total	5.0%	3.1%	8.1%
	51-100	Count	13	12	25
		% within Respondent	8.7%	10.9%	9.6%
		% of Total	5.0%	4.6%	9.6%
	101-500	Count	21	18	39
		% within Respondent	14.0%	16.4%	15.0%
		% of Total	8.1%	6.9%	15.0%
	501-1000	Count	5	6	11
		% within Respondent	3.3%	5.5%	4.2%
		% of Total	1.9%	2.3%	4.2%
	Over 1000	Count	67	44	111
		% within Respondent	44.7%	40.0%	42.7%
		% of Total	25.8%	16.9%	42.7%
Total		Count	150	110	260
		% within Respondent	100.0%	100.0%	100.0%
		% of Total	57.7%	42.3%	100.0%

Table 4.2: Test for Non-Response Bias – Chi-Square Results Between Early and Late Respondents

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.733[a]	5	.885
Likelihood Ratio	1.722	5	.886
Linear-by-Linear Association	.034	1	.853
N of Valid Cases	260		

a. 1 cells (8.3%) have expected count less than 5. The minimum expected count is 4.65.

Table 4.3: Test for Non-response Bias – Firm Size Based on Fleet Size

What is your company's total fleet size? * Respondent Crosstabulation

			Respondent		Total
			Early	Late	
What is your company's total fleet size?	1-25	Count	40	30	70
		% within Respondent	26.7%	27.3%	26.9%
		% of Total	15.4%	11.5%	26.9%
	26-50	Count	16	16	32
		% within Respondent	10.7%	14.5%	12.3%
		% of Total	6.2%	6.2%	12.3%
	51-100	Count	18	9	27
		% within Respondent	12.0%	8.2%	10.4%
		% of Total	6.9%	3.5%	10.4%
	101-250	Count	9	10	19
		% within Respondent	6.0%	9.1%	7.3%
		% of Total	3.5%	3.8%	7.3%

	251-500	Count	12	7	19
		% within Respondent	8.0%	6.4%	7.3%
		% of Total	4.6%	2.7%	7.3%
	500-1000	Count	6	5	11
		% within Respondent	4.0%	4.5%	4.2%
		% of Total	2.3%	1.9%	4.2%
	Over 1000	Count	49	33	82
		% within Respondent	32.7%	30.0%	31.5%
		% of Total	18.8%	12.7%	31.5%
Total		Count	150	110	260
		% within Respondent	100.0%	100.0%	100.0%
		% of Total	57.7%	42.3%	100.0%

Table 4.4: Test for Non-Response Bias – Chi-Square Results Between Early and Late Respondents

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.925[a]	6	.818
Likelihood Ratio	2.930	6	.818
Linear-by-Linear Association	.212	1	.645
N of Valid Cases	260		

a. 1 cells (7.1%) have expected count less than 5. The minimum expected count is 4.65.

4.3 Respondent Screening/Qualifying Questions and Sample Demographics

4.3.1 Qualifying Questions

Even though invitations were sent only to individuals whose profiles indicated they were in middle management or above in the trucking, transportation, supply, or logistics industry, screening questions were essential to ensure that respondents have not changed industry or position from their profile on record with ResearchNow. The first screening question qualified participants based on the industry they work in (see Figures 4.4a & b). If participants selected an industry other than trucking or transportation/ supply/logistics, they were disqualified on the first question. See Figure 4.4b for the final respondents' industry breakdown. 22.69% were in the trucking industry while 77.31% indicated they were in the transportation/supply/logistics industry.

First qualifying question:
Which of the following best describes the industry of the company/organization you work for?

Answer Choices	Responses	
Advertising	0.47%	3
Trucking	13.59%	87
Computer / Technology	1.88%	12
Healthcare	0.47%	3
Food / Beverage	0.47%	3
Transportation / Supply / Logistics	68.75%	440
Real Estate	0.63%	4
Other	13.75%	88
Total		640

Figure 4.4a: Responses from Initial 640 Participants

Answer Choices	Responses	
Advertising	0.00%	0
Trucking	22.69%	59
Computer / Technology	0.00%	0
Healthcare	0.00%	0
Food / Beverage	0.00%	0
Transportation / Supply / Logistics	77.31%	201
Real Estate	0.00%	0
Other	0.00%	0
Total		260

Figure 4.4b: Responses from Final 260 Qualified Participants

For this research, it was essential for respondents to be knowledgeable about the handling of IT related components, systems, and practices for truck fleets. Therefore, the second screening question was also a qualifying question and respondents were disqualified if they answered 'no' for their organization managing a fleet of vehicles (see Figures 4.5a & b).

Second qualifying question:
Does your organization manage a fleet of owned or affiliated vehicles?

Answer Choices	Responses	
Yes	54.84%	351
No	45.16%	289
Total		640

Figure 4.5a: Responses from Initial 640 Participants

Answer Choices	Responses	
Yes	100.00%	260
No	0.00%	0
Total		260

Figure 4.5b: Responses from Final 260 Qualified Participants

4.3.2 Additional Screening Questions

4.3.2.1 Respondent Business Title or Role

A variety of additional screening questions were also presented, however responses to these questions did not disqualify respondents from participating. Because middle managers and above were targeted for this survey, it was decided that disqualifying a participant on the basis of their title or role was not necessary. Approximately 78% of participants were in middle or upper management (see Figure 4.6).

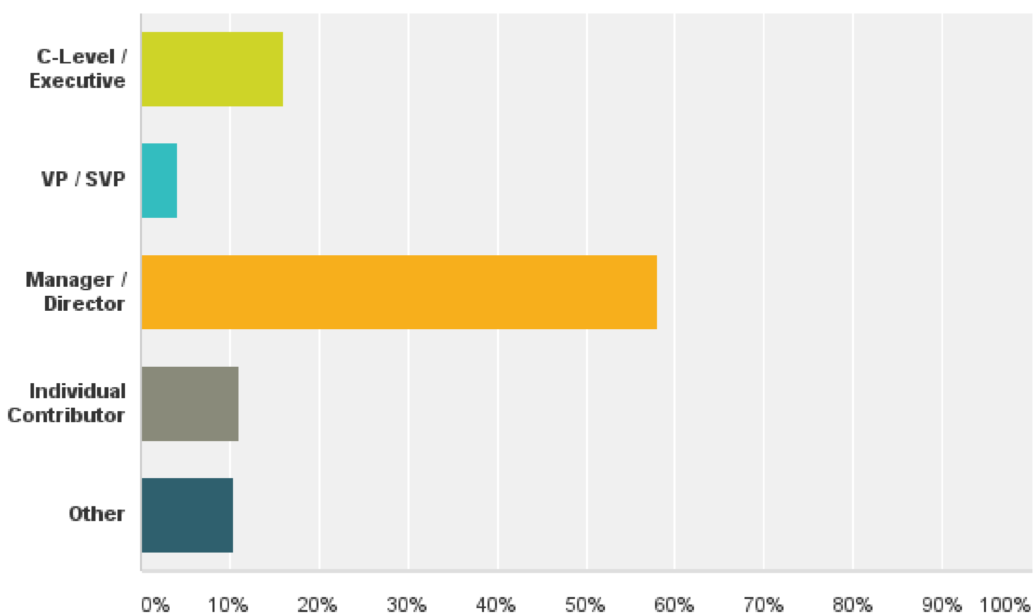


Figure 4.6: Respondent Business Title or Role

4.3.2.2 Respondent IT Decision-Making Authority

Additionally, approximately 80% of respondents reported having some level of decision-making involvement for new technology implementation within their firm (see figure 4.7).

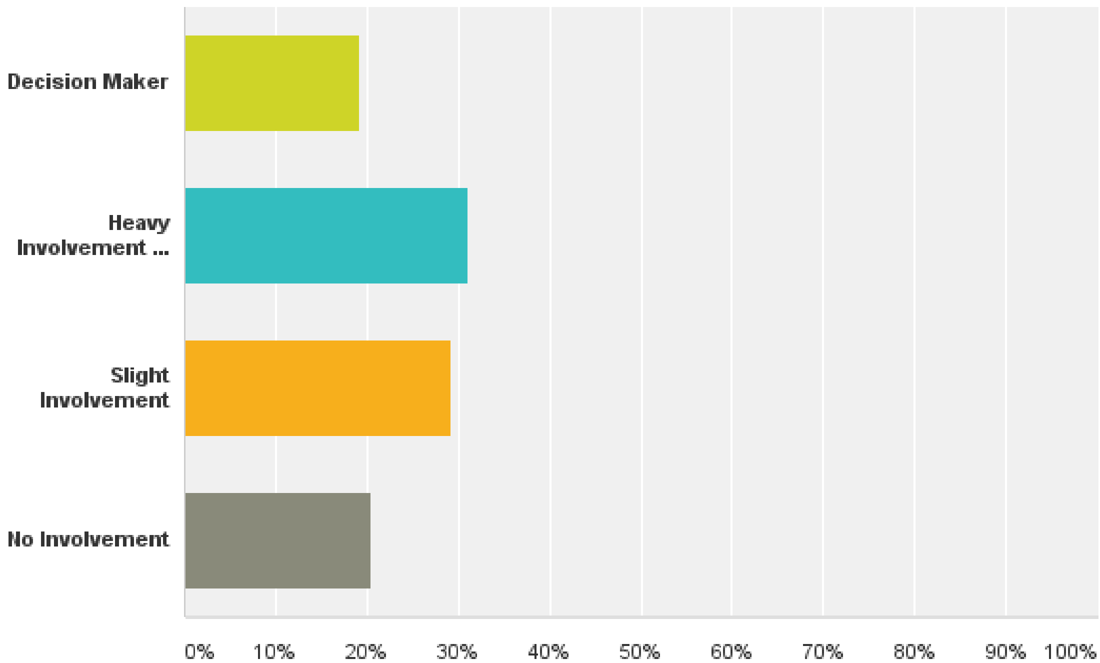


Figure 4.7: Decision-Making Involvement in New Technology Implementation

4.3.2.3 Respondent Department or Functional Role

Another important consideration for respondents is the operational role they play in their organization. Approximately 80% of respondents identified as being either in a management or operations related (e.g. operations, logistics and shipping) position in the firm. The remaining respondents were scattered between the customer service, IT, human resources, accounting, maintenance, legal, and marketing departments. Figure 4.8 (below) shows the breakdown of respondents' operational or functional roles in the firm.

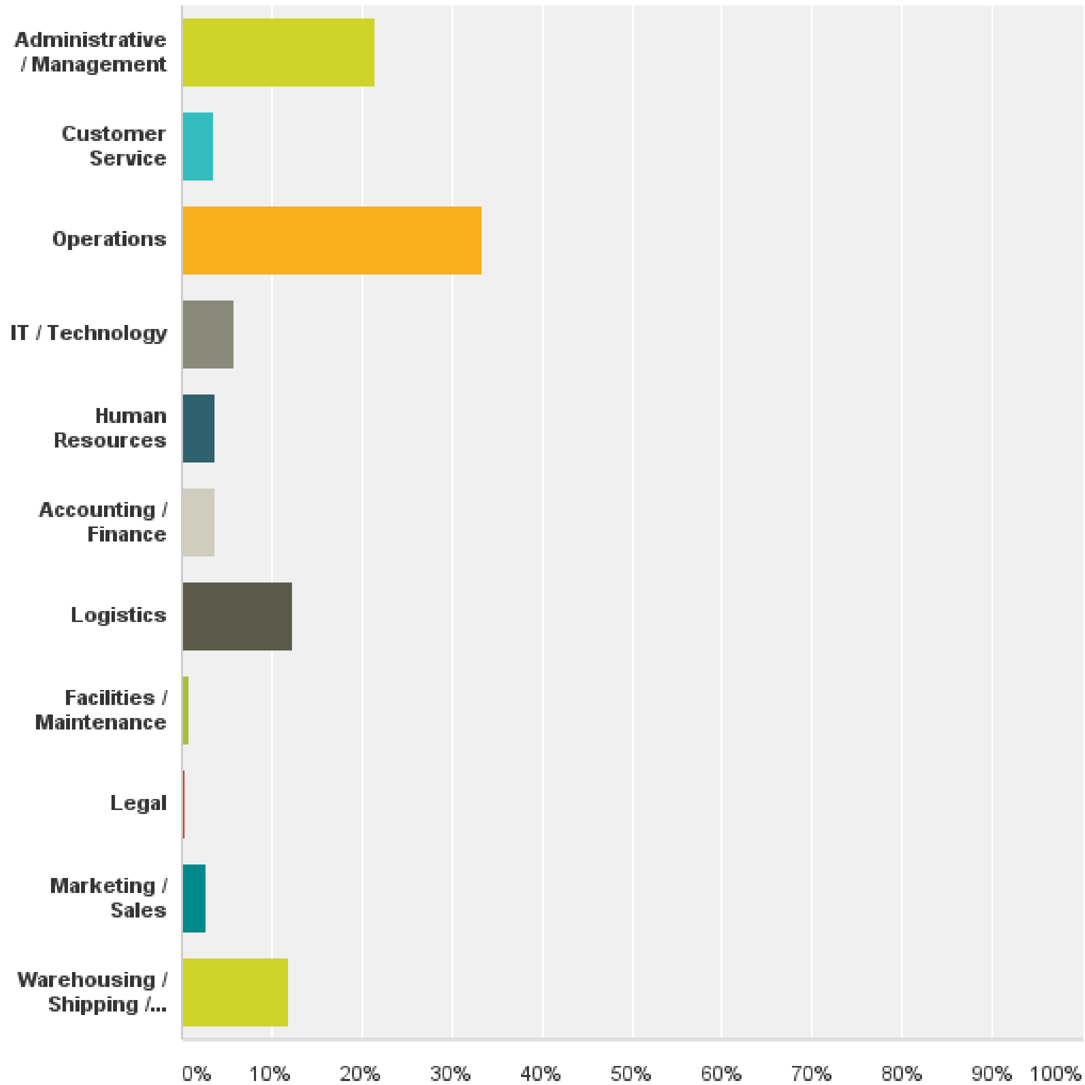


Figure 4.8: Respondent's Department/Functional Role in the Company

4.3.2.4 Market Competitiveness

Because the ultimate goal of this research examines the competitive advantage of the supply chain through the use of IT enabled systems and practices, it is important to have some understanding of the environmental competitiveness of respondents' markets. Over half of respondents identified their markets as being very competitive, while over 30% of respondents indicated their markets as competitive (see figure 4.9 below).

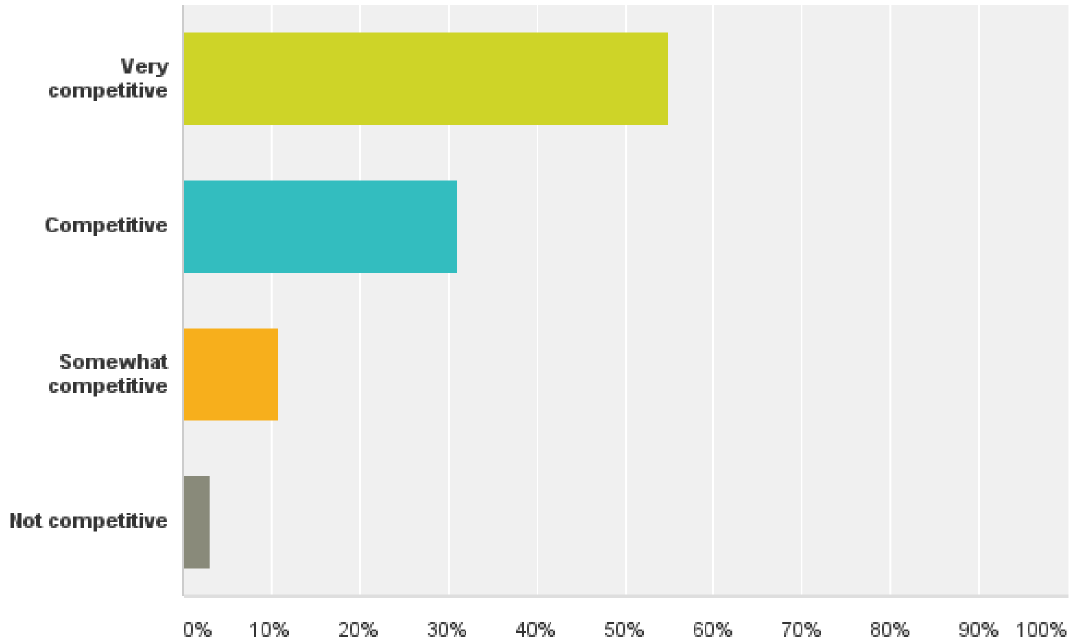


Figure 4.9: Market Competitiveness

4.3.3 Sample Firm Demographics

4.3.3.1 Primary Service

In the trucking/logistics/supply industry several main services are offered including truckload, less-than-truckload, expedite, flatbed, bulk, tanker, refrigerated, and package/parcel. Many carriers offer more than one of these services; however it is important to capture company demographics based on the primary service provided to customers. Figure 4.10 depicts the primary service the respondents' organization is engaged in. A majority of respondents provide either truckload service or package/parcel service.

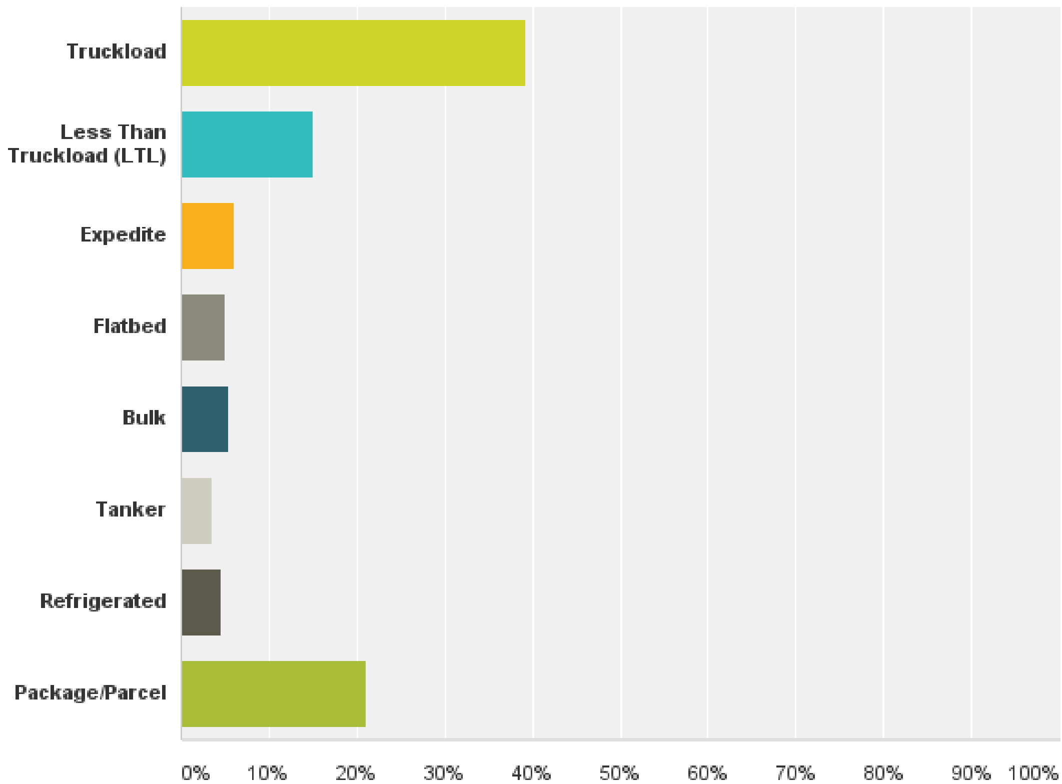


Figure 4.10: Primary Company Service

4.3.3.2 Company Size

It is typical in the trucking industry for companies to be either very large or fairly small organizations. Fewer medium sized companies exist in practice. The current sample is consistent with that industry pattern on several measures for evaluating company size. Annual revenue, number of employees, and fleet size are all examined as measures of company size. Approximately 40% of respondents indicated their company annual revenues are under $10 million, while almost 37% of respondents indicated their company revenues were above $200 million (see Figure 4.11).

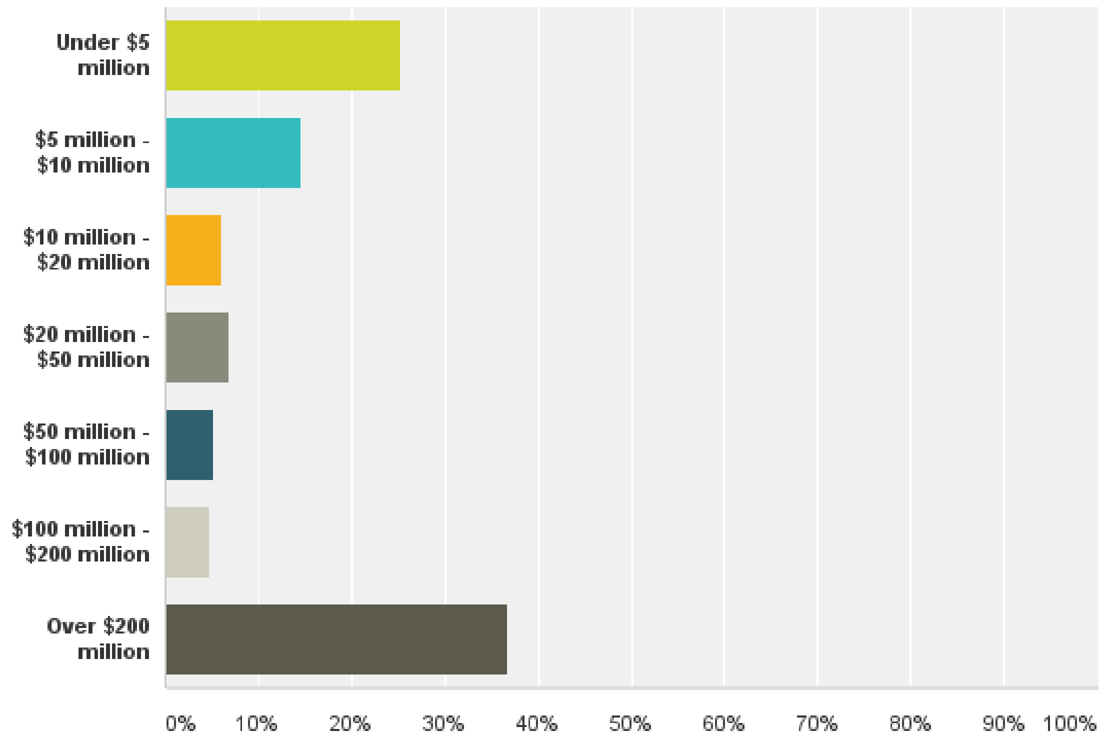


Figure 4.11: Annual Revenue

The sample pattern for fleet size is consistent with that of annual revenue as shown in figure 4.12. As such, the sample indicates that almost 40% of respondents are from companies with a small fleet size of 50 trucks or less, and approximately 32% of respondents are from companies with a very large fleet size of over 1000 trucks. These fleets include both company owned trucks in addition to any affiliated owner operated vehicles managed by the company. Furthermore, respondents indicated the mean percentage of company owned vehicles is 77% of the fleet, while the mean percentage of affiliated owner operated vehicles is 23% of the fleet for all responses.

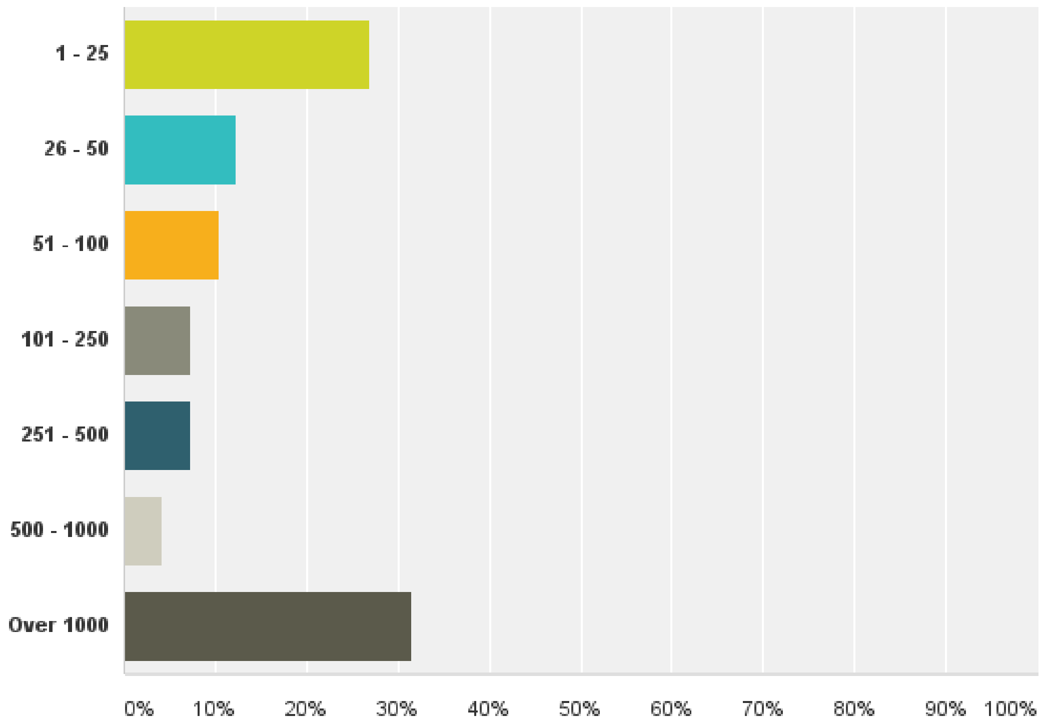


Figure 4.12: Company Fleet Size (including owned and managed affiliated trucks)

Total number of employees was also used as a measure of company size. Similar to annual revenue and fleet size, more respondents indicated having either a very small number of employees or a very large number. 28% of respondents indicated fifty or less total employees worked for the company, while 42% of respondents indicated over 1,000 people were employed by the company (see figure 4.13 below). Additionally, Figure 4.14 depicts the number of employed drivers respondents indicated for their firm.

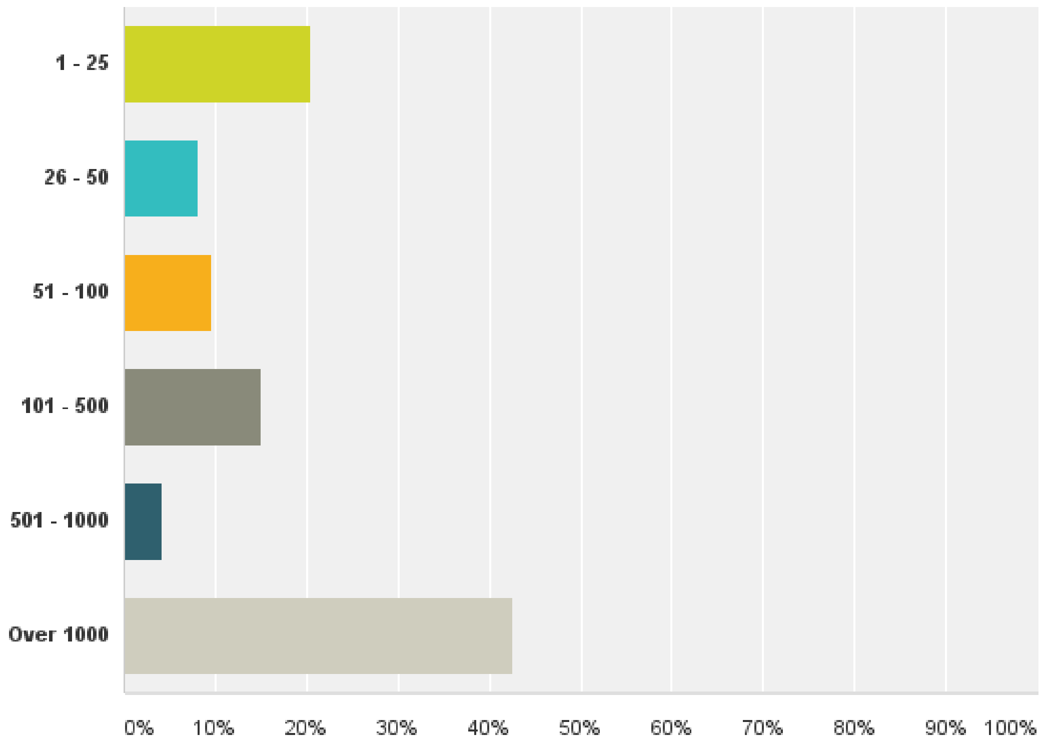


Figure 4.13: Total Employees

Answer Choices	Responses	
1 - 25	**30.00%**	78
26 - 50	**13.85%**	36
51 - 100	**12.31%**	32
101 - 500	**10.77%**	28
501 - 1000	**6.15%**	16
Over 1000	**26.92%**	70
Total		**260**

Figure 4.14: Number of Employed Drivers

Other sample demographics examined the union status of company drivers (see figure 4.15) and the number of owner operator drivers affiliated with the company (see figure 4.16).

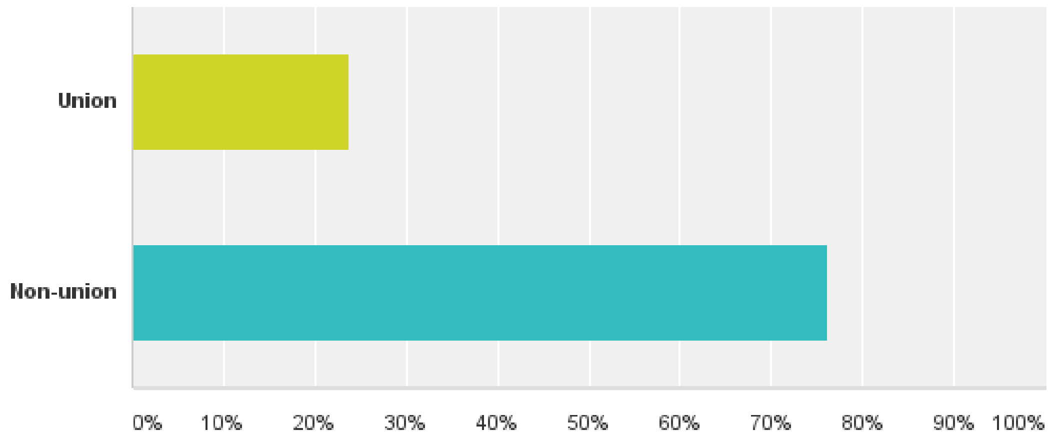


Figure 4.15: Driver Union Status

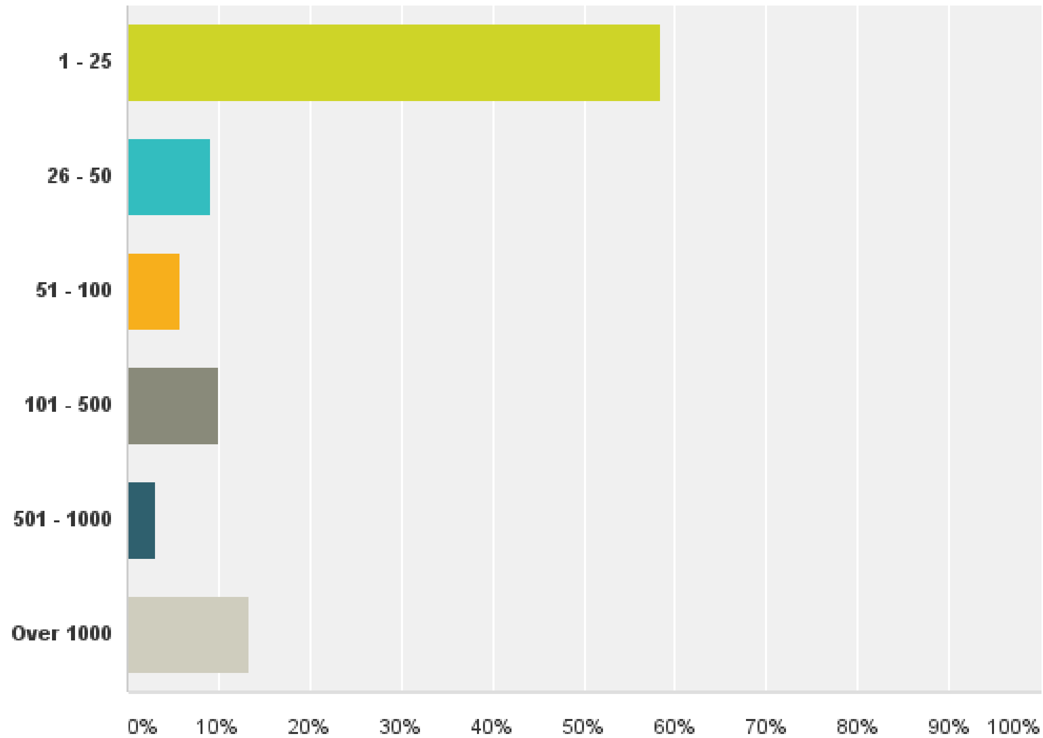


Figure 4.16: Number of Affiliated Owner Operators

4.4 Large Scale Instrument Validation

Meaningful empirical research results are obtained by connecting theoretical construction and testing through valid and reliable measurement instruments; while also rigorously controlling for measurement error (Bagozzi and Phillips, 1982; Bagozzi et al., 1991). Initially, content validity was assessed through a comprehensive literature review to ensure coherence of the theoretical constructs (Nunnally, 1978), as discussed in Chapter 2. The main objective of this section is to discuss evaluation tests for the validity and reliability of the measurement instrument.

In order to ensure measurement instruments are valid and reliable tools for testing proposed theories, a series of rigorous tests are conducted to assess both construct validity and reliability (Bagozzi et al., 1991). Two aspects of construct validity were proposed by Campbell and Fisk (1959); convergent and discriminant validity. Convergent validity is the degree to which measurement items measure one and only one concept (Bagozzi et al., 1991; Hair et al., 2010). In turn, discriminant validity is the degree to which a construct is distinct from other constructs (Bagozzi et al., 1991; Hair et al., 2010). In this study, confirmatory factor analysis (CFA) and statistical testing are conducted using structural equation modeling (SEM) with SPSS AMOS 20.0 software to evaluate convergent and discriminant validity.

Additionally, reliability measures the extent to which item indicators of a latent construct are all internally consistent and measuring the same construct repeatedly (Cronbach, 1951; Nunnally, 1978; Hair et al., 2010). Validity and reliability assessments are used to evaluate the measurement model and are discussed in greater detail next.

4.4.1 Measurement Model Validity and Reliability

4.4.1.1 Goodness of Fit Indexes

Validating the measurement model involves evaluating construct validity and reliability of the research model. In order to make this assessment in SEM, measurement model goodness-of-fit (GOF) indices are evaluated. GOF compares theory to reality by assessing the estimated and observed covariance matrices respectively. In essence, model fit statistics give an indication of how well the model fits the sample data. A perfect fit would indicate no differences between the two matrices.

In general, three main types of fit indices are used. Absolute fit indices provide a basic assessment of how well theory fits the sample data (e.g. X^2, CMIN/df, GFI, RMSEA, RMR). Incremental fit indices compare how well the estimated model fits compared to another baseline model, typically one with no correlations among observed variables (e.g. NFI, CFI). Finally, parsimony fit indices relate the model fit to the level of its complexity (e.g. AGFI). For example, a more complex model will have a better fit with the data while a simpler model will rely on fewer estimated parameter paths.

A considerable amount of debate exists among researchers in evaluating fit indices in SEM. Therefore, it is suggested that indices from each type should be used to ensure the overall model fit is acceptable (Hair et al., 2010). As such, a variety of GOF indices are presented for each construct's measurement model under consideration. Table 4.5 provides a summary of acceptable GOF index values and acceptable values for other validity and reliability statistical tests for measurement models.

Table 4.5: Acceptable Cut-off Values for Measurement Model Indices
(Hair et al., 2010; Chou and Bentler, 1995; Hooper et al., 2008; Barrett, 2007)

CMIN/df	< 3
GFI	> .90
RMR	< .10
CFI	> .90
NFI	> .90
AGFI	> .80
RMSEA	< .10
AVE	> .50
α	> .70

Furthermore, there are different methods for assessing GOF. Maximum likeliness (ML) is the most common, however the general least squares (GLS) method can also be used. One advantage in using ML is that it has been found to provide robust estimates even when normality is violated (Chou and Bentler, 1995). This can be an important consideration when using Likert type scales for interval data, which can often have some normality issues. In this study, GOF indices were evaluated for each sub-construct and then for the construct as a whole to evaluate convergent and discriminant validity. Some researchers suggest evaluating all constructs together for an overall measurement model fit (Hair, 2010). GOF indices for each construct were then parceled to evaluate the full measurement model, provided at the end of this chapter.

4.4.1.2 Convergent and Discriminant Validity and Reliability Testing

Several tests are available for evaluating convergent and discriminant validity and reliability. Those used in this study for assessing the measurement model are discussed here. Convergent validity was assessed by examining factor loadings and average variance extracted. Statistically significant standardized loading estimates of .7 or above are ideal, while estimates of .5 or above can be acceptable when theoretically sound. Average variance extracted (AVE) is calculated as a summary indicator of convergence for items loading on a construct. AVE values of .5 or higher suggests adequate convergence and indicates that more variance is explained by the latent factor structure than error remaining in the items (Hair et al., 2010).

Initial discriminant validity assessment began with the Q Sort pilot test discussed in Chapter 3. The Q Sort procedure contributes to discriminant validity by eliminating items that do not discriminate well between categories of items (Zait and Bertea, 2005). Discriminant validity was further evaluated for more similar constructs based on a pair-wise comparison of those constructs using Chi-square differences tests. For this analysis, Chi-square statistics are compared between an uncorrelated single factor model and the correlated two factor model. When the two models are significantly different, discriminant validity is supported showing that the items represent two different constructs (Zait and Bertea, 2005; Hair et al., 2010). Discriminant validity is supported when the difference in the two Chi-square values (df = 1) is significant at the $p < 0.05$ level (Joreskog, 1971).

Finally, in this study, reliability was assessed using Cronbach's alpha. Cronbach's alpha values range between 0 and 1 with values above .7 considered acceptable (Nunnally, 1978). The remainder of this chapter discusses measurement model analysis in detail for each construct in the results section next.

4.5 Large Scale Measurement Model Analysis and Results

This section discusses the analysis and results of first order measurement model testing for the five major constructs including sub-constructs for (1) external environmental pressures, (2) internal organizational environment, (3) IT enabled systems and practices, (4) performance outcomes, and (5) competitive advantage of the SC.

4.5.1 External Environmental Pressures Measurement Model

The external environmental pressures construct is composed of five dimensions (customers, competitors, regulations, technology change, technology standards) with a total of 18 survey items. Purification and validation for each sub-construct dimension is discussed in turn and all analysis values are summarized together in Table 4.6.

4.5.1.1 Customers

The customers sub-construct was measured with four items. The initial model fit was fair, but not strong. Consequently, the model was purified by freeing a within factor correlated residual between Ce1 and Ce4. Correlating error terms should be done with caution and based on theory (Hooper et al., 2008; Hair et al., 2010; Blunch, 2013). Both of these items affect customer lead time and receiving plans and therefore can theoretically be expected to correlate. The final fit was strong in all areas (see Table 4.6).

Convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .70, indicating strong factor loadings for each manifest variable. AVE is also acceptable at .635. Cronbach's alpha was calculated; its value of .862 is a strong indication of reliability.

4.5.1.2 Competitors

The competitors sub-construct was measured with three items. Model fit indices were tested using a correlated model including the technology standards construct. Final model fit indices were strong across all measures (see Table 4.6).

Moreover, convergent validity was assessed through factor loadings and AVE. Lambdas were all above .72 indicating strong factor loadings for items on the latent construct. AVE was also strong at .663. To test reliability, Cronbach's alpha was calculated at .846, well above the .70 threshold for reliability.

4.5.1.3 Regulations

The regulations sub-construct was initially measured with four items. However, item ER4 was removed during purification. First, the factor loading was quite low with a lambda value of .57. Upon reevaluating the items, removing this item follows the theoretical standpoint considering it identified levels of regulatory paperwork whereas the other items in the sub-construct identified actual transportation system friction points such as weigh stations, toll booths, and highway checkpoints. After this review it was decided the item was not a good fit and removed from the model. Final model fit indices were tested using a correlated model including the customers construct; all fit measures indicated a good model fit (see Table 4.6).

Furthermore, convergent validity was evaluated again for the remaining items through factor loadings and AVE. Remaining lambdas represented adequate factor loadings and AVE at .649 is representative of convergent validity. Cronbach's alpha is calculated at .838 indicating reliability of the measures.

4.5.1.4 Technology Change

Three items were used to measure the technology change sub-construct. Overall model fit indices were tested using a correlated model including this construct and the technology standards construct. The measurement model exhibited strong fit indices across all measures (see Table 4.6).

Additionally, convergent validity was assessed through item factor loadings and AVE calculations. Lambdas for all three items were above .73 indicating strong factor loadings. Likewise, AVE is also acceptable for convergent validity with a calculated value at .712. Reliability was evaluated based on Cronbach's alpha; the test statistic of .870 is well above the .70 value deemed acceptable for reliability.

4.5.1.5 Technology Standards

Four items were used to measure the technology standards sub-construct. The initial model fit was not considered acceptable. After careful review, the model was purified by freeing a within factor correlated residual between TSe1 and TSe2. These two items are expected to be highly correlated. Final model fit values are strong across all indicators (see Table 4.6).

Convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .74, indicating strong factor loadings for each manifest variable. AVE is also strong at .724. Cronbach's alpha test statistic was also evaluated; its value of .922 is another high indication of reliability.

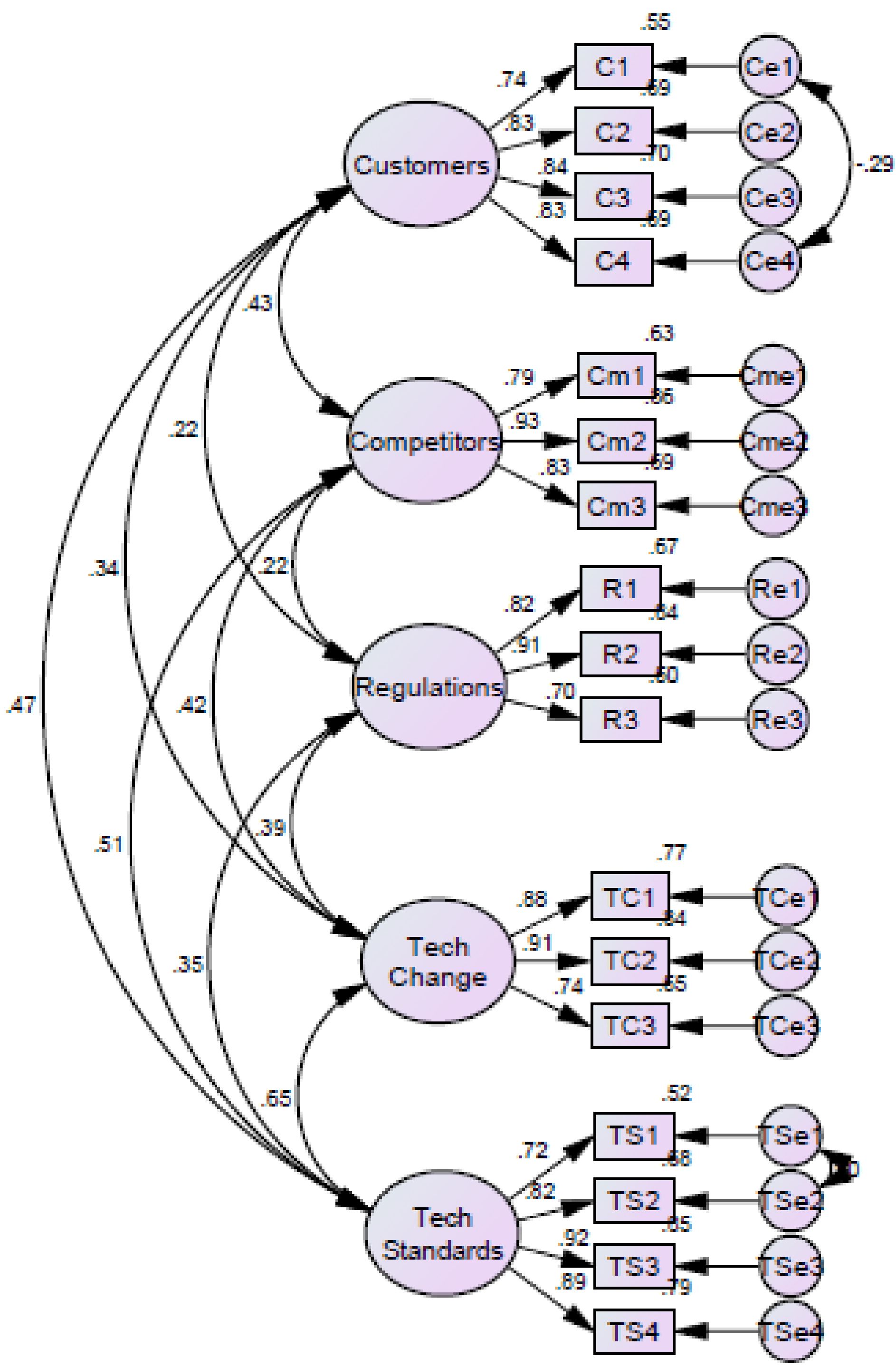
Table 4.6: External Environmental Pressures Measurement Model

External Environmental Pressures: Customers (final AVE = .635, α = .862)			
EC1	Our customers want to know where their materials and goods are during transport. (λ = .70)	CMIN/df = 4.724 GFI = .983 RMR = .022 CFI = .985 NFI = .981 AGFI = .915 RMSEA = .120	CMIN/df = .810 GFI = .998 RMR = .007 CFI = 1.0 NFI = .998 AGFI = .984 RMSEA = .000
EC2	Our customers put pressure on us to increase delivery speed. (λ = .81)		
EC3	Our customers demand accurately specified delivery times. (λ = .82)		
EC4	Our customers want shorter lead times. (λ = .85)		
External Environmental Pressures: Competitors*** (final AVE = .663, α = .846)			
ECm1	Our competitors provide reliable shipment tracking services to their customers. (λ = .72)	CMIN/df = 4.925 GFI = .932 RMR = .034 CFI = .959 NFI = .949 AGFI = .853 RMSEA = .123	CMIN/df = 1.199 GFI = .985 RMR = .029 CFI = .998 NFI = .989 AGFI = .964 RMSEA = .028
ECm2	Our competitors provide acurately specified delivery times to their customers. (λ = .91)		
ECm3	Our competitors provide increased delivery speed to their customers. (λ = .80)		
External Environmental Pressures: Regulations** (final AVE = .649, α = .838)			

Table 4.6: External Environmental Pressures Measurement Model (cont'd)

<table>
<tr><th>Coding</th><th>Item</th><th>Initial Model Fit</th><th>Final Model Fit</th></tr>
<tr><td colspan="4">External Environmental Pressures: Regulations** (final AVE = .649, α = .838)</td></tr>
<tr><td>ER1</td><td>Our fleet faces high levels of highway compliance checkpoints. (λ = .81)</td><td rowspan="4">CMIN/df = 3.419
GFI = .988
RMR = .026
CFI = .988
NFI = .984
AGFI = .939
RMSEA = .097</td><td rowspan="4">CMIN/df = 1.696
GFI = .977
RMR = .034
CFI = .989
NFI = .974
AGFI = .950
RMSEA = .052</td></tr>
<tr><td>ER2</td><td>Our fleet encounters many weigh stations. (λ = .91)</td></tr>
<tr><td>ER3</td><td>Our fleet encounters many toll stations. (λ = .68)</td></tr>
<tr><td>ER4*</td><td>Our company faces high levels of regulatory paperwork. (deleted)</td></tr>
<tr><td colspan="4">External Environmental Pressures: Technology Changes*** (final AVE = .712, α = .870)</td></tr>
<tr><td>ETC1</td><td>Technology often changes in our industry. (λ = .88)</td><td rowspan="3">CMIN/df = 2.181
GFI = .973
RMR = .029
CFI = .990
NFI = .981
AGFI = .938
RMSEA = .068</td><td rowspan="3">No Change</td></tr>
<tr><td>ETC2</td><td>Technology in our industry changes significantly. (λ = .91)</td></tr>
<tr><td>ETC3</td><td>Technology changes provide significant opportunities in our industry. (λ = .73)</td></tr>
<tr><td colspan="4">External Environmental Pressures: Technology Standards (final AVE = .724, α = .922)</td></tr>
<tr><td>ETS1</td><td>Certain IT or other technologies are used because they are industry standard. (λ = .74)</td><td rowspan="4">CMIN/df = 24.22
GFI = .909
RMR = .027
CFI = .944
NFI = .942
AGFI = .544
RMSEA = .299</td><td rowspan="4">CMIN/df = .338
GFI = .999
RMR = .002
CFI = 1.0
NFI = 1.0
AGFI = .993
RMSEA = .000</td></tr>
<tr><td>ETS2</td><td>Certain technology or IT standards are expected in our industry. (λ = .82)</td></tr>
<tr><td>ETS3</td><td>IT standards are expected among customers and other trading partners. (λ = .93)</td></tr>
<tr><td>ETS4</td><td>IT standards for communication are in place among customers and other trading partners. (λ = .90)</td></tr>
<tr><td colspan="4">*Item deleted during purification. **
Overall model fit indices were tested using a correlated model including this construct and the customers construct. ***
Overall model fit indices were tested using a correlated model including this construct and the technology standards construct.</td></tr>
</table>

Figure 4.17: External Environmental Pressures Measurement Model



Measurement Model Fit Indices: CMIN/df = 1.610 GFI = .922 RMR = .082 CFI = .872 NFI = .733 AGFI = .888 RMSEA = .049

4.5.1.6 Discriminant Validity

Because the technology change and technology standards sub-constructs are more similar in nature and are also shown to be more highly correlated than the other constructs, they are tested further for discriminant validity. A pair-wise comparison of the Chi-square test statistic was evaluated between a single factor uncorrelated model and a two factor correlated model. The two models are significantly different at the $p < .001$ level, providing further evidence of discriminant validity. Results are displayed in Table 4.7 (below).

Table 4.7: Chi-square Difference Test – Technology Change/Technology Standards

	Chi-Square (df)		
Construct Pair	**Single**	**Correlated**	**Difference**
Ext-TC & Ext-TS	80.250 (8)	11.485 (7)	68.765

The next section details measurement model analysis for the internal organizational environment construct.

4.5.2 Internal Organizational Environment Measurement Model

The internal organizational environment construct is composed of seven dimensions with a total of 27 survey items. Purification and validation for each sub-construct dimension is discussed in turn and all analysis values are summarized in Table 4.8.

4.5.2.1 Top Management

The top management sub-construct was measured with four items. Some indicator values for the initial model fit were reasonable, but not all values were strong.

Item ITM3 had a lower lambda value of .63. Additionally, the item total statistics indicated an increase in Cronbach's alpha, thus better convergent validity, if the item were removed. Upon further evaluation of the scale items, it was decided that ITM3 should be removed to purify the model. Consequently, the final model fit indices were tested using a correlated model with the organizational culture construct. The final fit is strong across all measures (see Table 4.8).

Convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .85, indicating strong factor loadings for each manifest variable. AVE is also very good at .806, both indicating strong convergent validity. Cronbach's alpha was calculated; its value of .925 is a strong indication of reliability.

4.5.2.2 Organizational Culture

Six items were used to measure the organizational culture sub-construct. The initial model fit was not considered acceptable. The factor loading for IC1 was somewhat low at .66, upon further examination it was noted that the standardized residual covariances were also higher than acceptable. Thus, after careful review of the item, the model was purified by removing IC1. After removal of IC1 the indices were reevaluated, standardized residual covariances were also too high for item IC6. This item was also evaluated and it was decided that it also should be removed to purify the model. Final model fit values are strong across all indicators (see Table 4.8).

Convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .74, indicating strong factor loadings for each manifest variable. AVE is also acceptable at .627. Cronbach's alpha test statistic was also evaluated; its value of .867 is a strong indication of reliability.

4.5.2.3 Economic Resources

The economics resources construct was measured with three items. Overall model fit indices were tested using a correlated model including this construct and the IT awareness construct. The final measurement model exhibited strong fit indices across all measures (see Table 4.8).

Additionally, convergent validity was assessed through item factor loadings and AVE calculations. Lambdas for all three items were above .65 indicating acceptable factor loadings. Likewise, AVE is also acceptable for convergent validity with a calculated value at .687. Reliability was evaluated based on Cronbach's alpha; the test statistic of .852 is well above the .70 value considered acceptable for reliability.

4.5.2.4 IT Awareness

The IT awareness sub-construct was measured with three items. Model fit indices were tested using a correlated model including the economic resources construct. During purification, total item statistics and lower factor loadings indicated item IIT3 should be removed. Upon careful evaluation of the scale items it was removed. Final model fit indices were strong across all measures (see Table 4.8).

Moreover, convergent validity was assessed through factor loadings and AVE. Lambdas were all above .76 indicating strong factor loadings for items on the latent construct. AVE was also strong at .667. To test reliability, Cronbach's alpha was calculated at .794, above the .70 threshold indicating scale reliability.

4.5.2.5 Employees

The employees sub-construct was measured with four items. Some initial model fit indicators were fair, but not all indicated a good fit. Consequently, the model was purified by freeing a within factor correlated residual between IEe1 and IEe2. Both of these items relate to encouraging employees toward aspects of new IT adoption and therefore can theoretically be expected to correlate. The final fit was strong in all areas (see Table 4.8).

Convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .69, indicating acceptable factor loadings for each manifest variable. AVE is also acceptable at .678. Cronbach's alpha was calculated; its value of .894 is a strong indication of reliability.

4.5.2.6 Drivers

The drivers sub-construct was measured with four items. The initial model fit indicated some purification was necessary. Therefore, the model was purified by freeing a within factor correlated residual between IDe1 and IDe4. These items both relate to gaining driver feedback toward aspects of new IT adoption and therefore can theoretically be expected to correlate. The final model indices indicated a good fit in all areas (see Table 4.8).

Convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .73, indicating acceptable factor loadings for each item.

AVE is also acceptable at .728. Cronbach's alpha was calculated; its value of .906 is a strong indication of reliability.

4.5.2.7 Unions

The unions sub-construct was measured with four items. The initial model fit displayed strong indicators across all measures, therefore no purification was necessary (see Table 4.8).

Convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .95, indicating strong factor loadings for each item. AVE is also excellent at .931, both indicating strong convergent validity. To test reliability, Cronbach's alpha was calculated at .983, well above the .70 threshold indicating reliability.

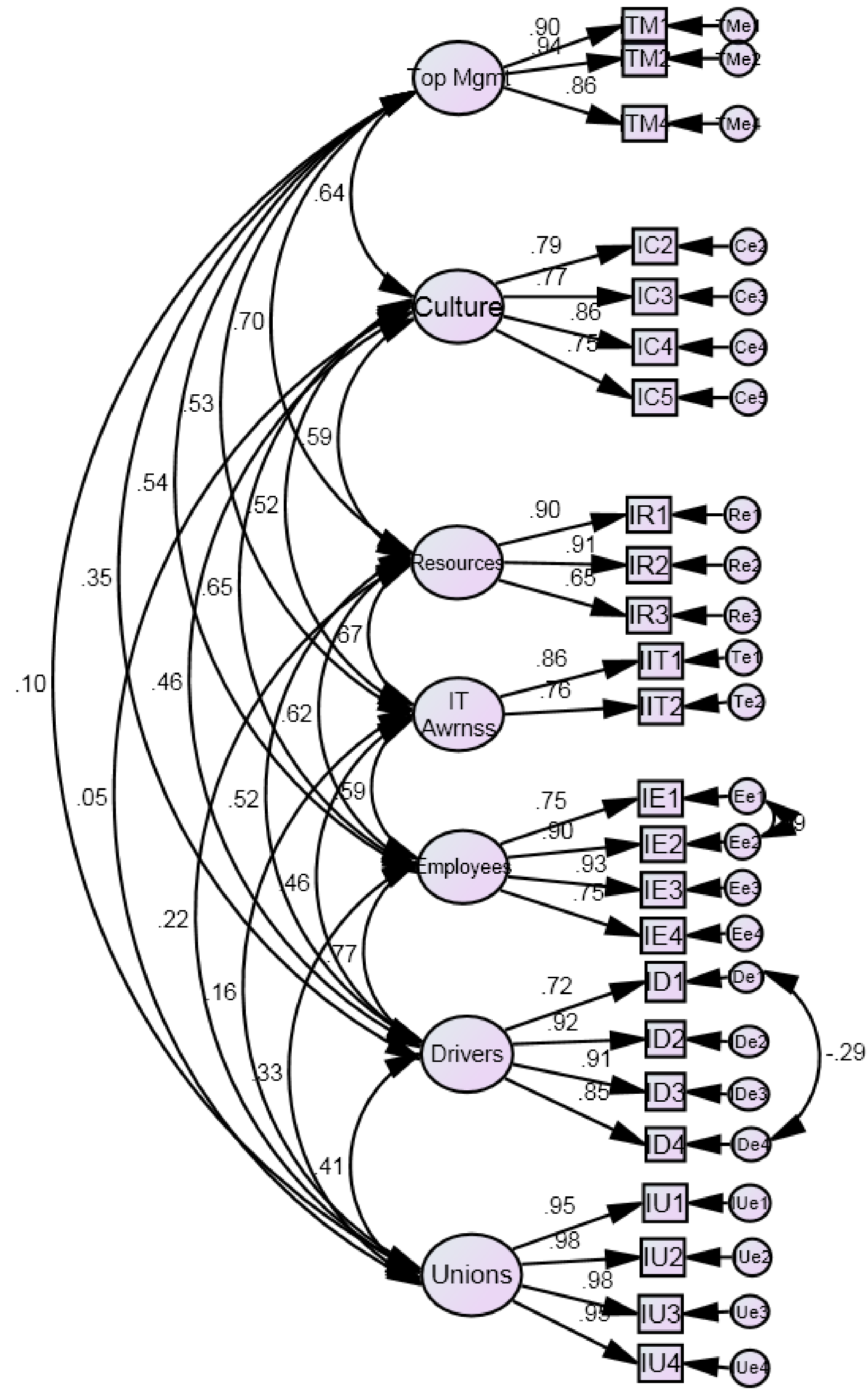
Table 4.8: Internal Organizational Environment Measurement Model

Internal Organizational Environment: Top Management** (final AVE = .806, α = .925)			
ITM1	Top management is supportive of our efforts to improve through IT. (λ = .89)	CMIN/df = 6.032 GFI = .977 RMR = .020 CFI = .986 NFI = .984 AGFI = .884 RMSEA = .139	CMIN/df = 1.467 GFI = .980 RMR = .023 CFI = .995 NFI = .985 AGFI = .956 RMSEA = .042
ITM2	Top management considers IT enabled systems and practices to be a vital part of our corporate strategy. (λ = .95)		
ITM3*	Requests for increased resources are approved by top management. (deleted)		
ITM4	Top management supports the need for inter-organizational information systems. (λ = .85)		
Internal Organizational Environment: Organizational Culture (final AVE = .627, α = .867)			
IC1*	Our company culture values some level of individual autonomy. (deleted)	CMIN/df = 7.538 GFI = .917 RMR = .042 CFI = .932 NFI = .923 AGFI = .807 RMSEA = .159	CMIN/df = 2.634 GFI = .990 RMR = .015 CFI = .994 NFI = .990 AGFI = .952 RMSEA = .079
IC2	Our company culture values trust and/or fairness. (λ = .79)		
IC3	Our company culture values flexibility for planning or retooling systems. (λ = .75)		
IC4	Our company culture values teamwork. (λ = .88)		
IC5	Our company culture values sharing information freely. (λ = .74)		
IC6*	Our company has a strong community for learning. (deleted)		
Internal Organizational Environment: Economic Resources*** (final AVE = .687, α = .852)			
IR1	Our company allocates sufficient budget for innovative IT related projects. (λ = .89)	CMIN/df = 4.335 GFI = .960 RMR = .043 CFI = .996 NFI = .956 AGFI = .894 RMSEA = .113	CMIN/df = 1.718 GFI = .990 RMR = .018 CFI = .996 NFI = .990 AGFI = .961 RMSEA = .053
IR2	Our company provides additional resources for the management team in charge of innovative IT.(λ = .92)		
IR3	Our company has adequate working capital for new projects. (λ = .65)		
Internal Organizational Environment: IT Awareness**** (final AVE = .667, α = .794)			
IIT1	IT managers in our company are knowledgeable about available systems and/or practices. (λ = .87)	CMIN/df = 4.335 GFI = .960 RMR = .043 CFI = .996 NFI = .956 AGFI = .894 RMSEA = .113	CMIN/df = 1.718 GFI = .990 RMR = .018 CFI = .996 NFI = .990 AGFI = .961 RMSEA = .053
IIT2	IT managers play an important role in decision-making. (λ = .76)		
IIT3*	IT managers have executive authority. (deleted)		

Table 4.8: Internal Organizational Environment Measurement Model (cont'd)

Coding	Item	Initial Model Fit	Final Model Fit
Internal Organizational Environment: Employees (final AVE = .678, α = .894)			
IE1	Employees are encouraged to participate when adopting new IT. (λ = .69)	CMIN/df = 10.533 GFI = .959 RMR = .024 CFI = .973 NFI = .971 AGFI = .794 RMSEA = .192	CMIN/df = .122 GFI = 1.0 RMR = .003 CFI = 1.0 NFI = 1.0 AGFI = .998 RMSEA = .001
IE2	Employees are encouraged to suggest innovative IT. (λ = .85)		
IE3	Employee suggestions are considered when making decisions on adopting new IT. (λ = .99)		
IE4	Employees are consulted before the introduction of new IT. (λ = .73)		
Internal Organizational Environment: Drivers (final AVE = .728, α = .906)			
ID1	Company or independent drivers are encouraged to participate when adopting new IT. (λ = .73)	CMIN/df = 7.717 GFI = .972 RMR = .024 CFI = .982 NFI = .980 AGFI = .862 RMSEA = .161	CMIN/df = 1.138 GFI = .998 RMR = .006 CFI = 1.0 NFI = .999 AGFI = .978 RMSEA = .023
ID2	Company or independent drivers are encouraged to suggest innovative IT. (λ = .93)		
ID3	Company or independent driver suggestions are considered when making decisions on adopting new IT. (λ = .90)		
ID4	Company or independent drivers are consulted before the introduction of new IT. (λ = .84)		
Internal Organizational Environment: Unions (final AVE = .931, α = .983)			
IU1	Unions are encouraged to participate when adopting new IT enabled systems and practices. (λ = .95)	CMIN/df = 1.682 GFI = .994 RMR = .003 CFI = .999 NFI = .998 AGFI = .969 RMSEA = .051	No Change
IU2	Unions are encouraged to suggest innovative IT enabled systems and practices. (λ = .98)		
IU3	Union suggestions are considered when making decisions on adopting new IT enabled systems and practices. (λ = .98)		
IU4	Unions are consulted before the introduction of new IT enabled systems or practices. (λ = .95)		

* Item deleted during purification.
**Final model fit indices were tested using a correlated model including this construct and the culture construct.
***Final model fit indices were tested using a correlated model including this construct and the IT awareness construct.
****Final model fit indices were tested using a correlated model including this construct and the economic resources construct.



Measurement Model Fit Indices: CMIN/df = 1.922 GFI = .876 RMR = .043 CFI = .964 NFI = .929 AGFI = .838 RMSEA = .060

Figure 4.18: Internal Organizational Environment Measurement Model

4.5.2.8 Discriminant Validity

The employees and drivers sub-constructs are similar in nature and are also shown to be more highly correlated than the other constructs; therefore, they are tested further for discriminant validity. A pair-wise comparison of the Chi-square test statistic was evaluated between a single factor uncorrelated model and a two factor correlated model. The two models are significantly different at the $p < .001$ level, providing further evidence of discriminant validity. Results are displayed in Table 4.9.

Table 4.9: Chi-square difference test – Employees/Drivers

	Chi-Square (df)		
Construct Pair	**Single**	**Correlated**	**Difference**
Int-Emp & Int-Drv	140.795 (17)	78.123 (16)	62.672

The next section details measurement model analysis for the IT enabled systems and practices construct.

4.5.3 IT Enabled Systems and Practices Measurement Model

The IT enabled systems and practices construct is composed of two dimensions (e.g. systems and practices) each having two components with a total of 19 survey items. Purification and validation for each sub-construct dimension is discussed in turn and all analysis values are summarized in Table 4.10.

4.5.3.1 Intelligent Transportation Systems (ITS)

Four items were used to measure the intelligent transportation systems sub-construct. The initial measurement model exhibited strong fit indices across all measures (see Table 4.10). Therefore, no purification was necessary.

Additionally, convergent validity was assessed through item factor loadings and AVE calculations. Lambdas for all four items were above .68 indicating acceptable factor loadings. Likewise, AVE is also acceptable for convergent validity with a calculated value at .608. Reliability was evaluated based on Cronbach's alpha; the test statistic of .856 is well above the .70 value considered acceptable for reliability.

4.5.3.2 Transportation Management System (TMS)

The TMS sub-construct was measured with six items. Some initial measurement model fit indices were outside acceptable levels. As such, during the purification process item EST5 was noted for having the lowest factor loading. Additionally, total item statistics indicated an improvement to Cronbach's alpha if the item were removed. Upon careful evaluation of the scale items, it was removed. The item referred to the use of shipment tracking capabilities, it is quite possible that these capabilities are expected in modern logistics and therefore variability in the data would be difficult for statistical analysis. Responses from this particular item exhibited a negative skew, even though SEM maximum likeliness methods have been shown to be robust even with some non-normal data (Chou and Bentler, 1995) it is possible the skew was too great due to the number of 4 and 5 responses in the sample. Therefore, the item was removed.

The model was reexamined; similarly item EST6 exhibited low factor loadings and was further examined. Item total statistics indicated additional improvement to Cronbach's alpha if the item is removed. Upon comparing the item with other scale items, it is the only remaining item that is not referenced as a decision support system measure for TMS. Consequently, item EST6 is also removed. Final model fit indices were strong across most measures (see Table 4.10).

Moreover, convergent validity was assessed through factor loadings and AVE. Final lambdas were all above .86 indicating strong factor loadings for items on the latent construct. AVE was also strong at .834. To test reliability, Cronbach's alpha was calculated at .953, well above the .70 threshold indicating scale reliability.

4.5.3.3 Integrated Information Sharing (IIS)

Five items were used to measure the integrated information sharing sub-construct. The initial model fit was not considered acceptable. The factor loading for EPI1 was considerably lower than the other items' lambdas. Additionally, the item-total statistics indicated an improvement to Cronbach's alpha with the removal of the item. Upon comparison to the other scale items, this is the only item that does not refer to types of information exchange. Consequently, after careful review of the item, the model was purified by removing EPI1. After removal of EPI1 the indices were reevaluated and it was necessary to further purified by freeing a within factor correlated residual between EPIe2 and EPIe3. These items can be expected to correlate, both relate to how the process of exchanging information is carried out among trading partners. Final model fit values are strong across all indicators (see Table 4.10).

Furthermore, convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .81, indicating strong factor loadings for each manifest variable. AVE is also acceptable at .827. Cronbach's alpha test statistic was also evaluated; its value of .950 is a strong indication of reliability.

4.5.3.4 Third Party Supply Chain and Logistics Management (3PL SCLM)

The third party supply chain and logistics management sub-construct was measured with four items. The initial model fit displayed strong indicators across all measures, therefore no purification was necessary (see Table 4.10).

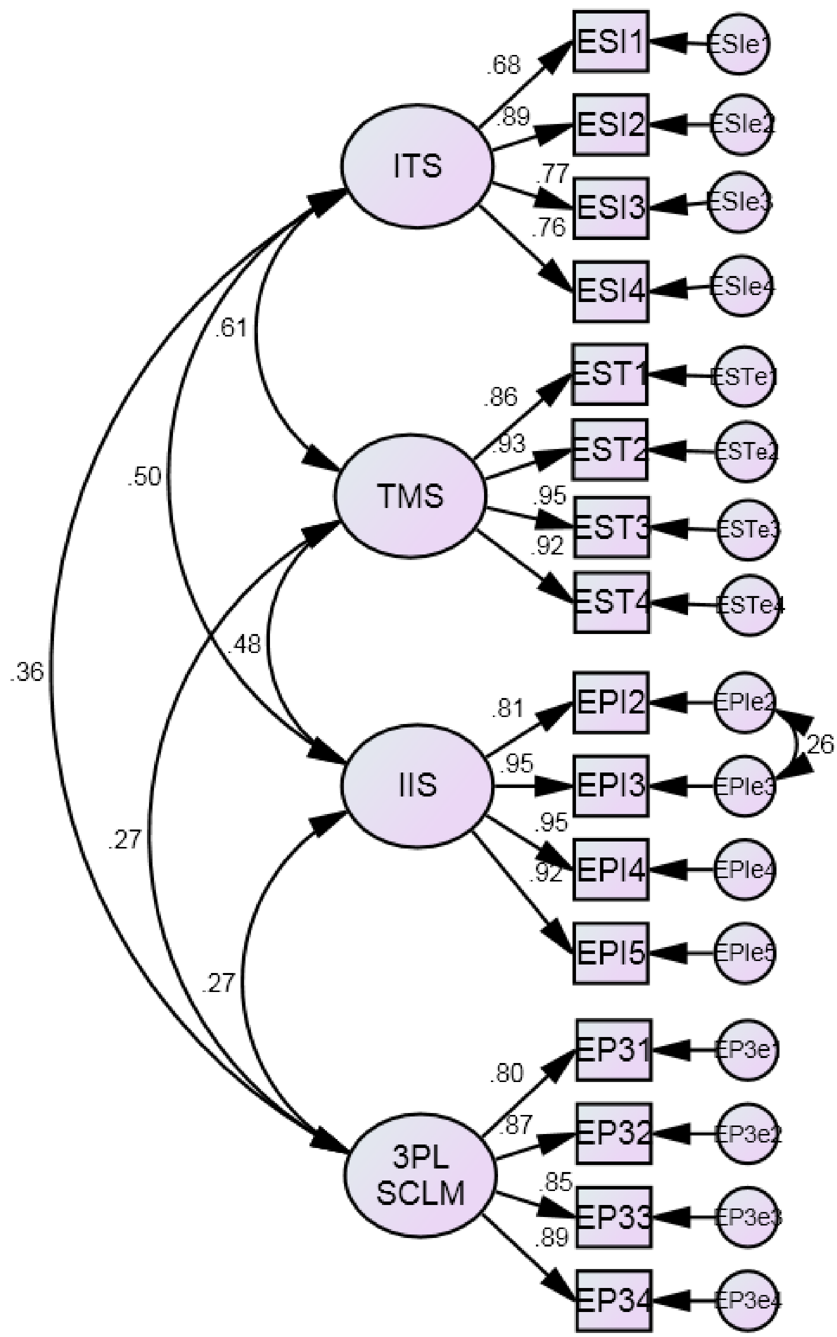
Convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .81, indicating strong factor loadings for each item. AVE is also very good at .732, both indicating strong convergent validity. To test reliability, Cronbach's alpha was calculated at .915, well above the .70 threshold indicating good reliability.

Table 4.10: IT Enabled Systems and Practices Measurement Model

Coding	Item	Initial Model Fit	Final Model Fit
IT Enabled Systems: ITS (final AVE = .608, α = .856)			
ESI1	Our company uses GPS, satellite, mobile technology, radio frequency identification (RFID), or other technologies to monitor location or status of some or all tractors, trailers, containers and/or cargo. (λ = .68)	CMIN/df = .657 GFI = .997 RMR = .164 CFI = 1.0 NFI = .997 AGFI = .987 RMSEA = .001	No Change
ESI2	Our company uses sensors or other technology to monitor vehicle operating conditions, cargo conditions and load tampering. (λ = .91)		
ESI3	Our company uses transponders, RFID, smart cards, weigh-in-motion, or other technologies to improve operations for tolls and terminal gates, highway inspections, or border crossings. (λ = .77)		
ESI4	Our company uses onboard display technologies to monitor congestion and weather conditions from road sensors, cameras and web or GPS technology. (λ = .74)		
IT Enabled Systems: TMS (final AVE = .834, α = .953)			
EST1	Our company uses a decision support system for routing. (λ = .86)	CMIN/df = 15.983 GFI = .856 RMR = .077 CFI = .912 NFI = .908 AGFI = .664 RMSEA = .241	CMIN/df = 4.585 GFI = .982 RMR = .011 CFI = .994 NFI = .992 AGFI = .911 RMSEA = .118
EST2	Our company uses a decision support system for scheduling. (λ = .92)		
EST3	Our company uses a decision support system for transportation planning. (λ = .95)		
EST4	Our company uses a decision support system for trip or load optimization. (λ = .92)		
EST5*	Our company uses shipment tracking capabilities. (deleted)		
EST6*	Our IT system provides accurate and timely information for logistics operations. (deleted)		

Table 4.10: IT Enabled Systems and Practices Measurement Model (cont'd)

Coding	Item	Initial Model Fit	Final Model Fit
IT Enabled Practices: Integrated Information Sharing (final AVE = .827, α = .950)			
EPI1*	Our IT system provides interorganizational coordination with our trading partners. (deleted)	CMIN/df = 19.547 GFI = .879 RMR = .047 CFI = .934 NFI = .931 AGFI = .638 RMSEA = .268	CMIN/df = .173 GFI = 1.00 RMR = .001 CFI = 1.00 NFI = 1.00 AGFI = .997 RMSEA = .001
EPI2	Information exchange between our trading partners and us is timely. (λ = .81)		
EPI3	Information exchange between our trading partners and us is accurate. (λ = .95)		
EPI4	Information exchange between our trading partners and us is complete. (λ = .95)		
EPI5	Information exchange between our trading partners and us is reliable. (λ = .92)		
IT Enabled Practices: 3PL SCLM (final AVE = .732, α = .915)			
EP31	Our company partners with an external firm for logistics services. (λ = .81)	CMIN/df = 3.367 GFI = .987 RMR = .017 CFI = .994 NFI = .991 AGFI = .937 RMSEA = .096	No Change
EP32	Our company partners with an external firm for load tendering. (λ = .87)		
EP33	Our company partners with an external firm for electronic linkages to customers. (λ = .85)		
EP34	Our company partners with an external firm to improve lane densities. (λ = .89)		
* Item deleted during purification.			



Measurement Model Fit Indices: CMIN/df = 1.633 GFI = .931 RMR = .047 CFI = .964
NFI = .959 AGFI = .903 RMSEA = .049

Figure 4.19: IT Enabled Systems and Practices Measurement Model

4.5.3.5 Discriminant Validity

Discriminant validity is further tested for the IT Enabled Systems and Practices construct. Scale items were validated through the Q sort pilot test, although some results indicated a clustering effect among sub-constructs. Therefore, to ensure rigor in discriminant validity all sub-constructs were tested through pair-wise comparisons of the Chi-square test statistic. The test evaluated a single factor uncorrelated model with a two factor correlated model for each sub-construct pair. In all cases, the two models are significantly different at the $p < .001$ level, providing additional evidence of discriminant validity. Results are displayed in Table 4.11.

Table 4.11: Chi-square Difference Test – IT Enabled Systems and Practices

	Chi-Square (df)		
Construct Pair	**Single**	**Correlated**	**Difference**
ITS & TMS	76.479 (22)	34.267 (21)	42.212
ITS & IIS	120.189 (22)	50.994 (21)	69.195
ITS & 3PL SCLM	89.235 (20)	30.680 (19)	58.555
TMS & IIS	221.738 (31)	157.356 (30)	64.382
TMS & 3PL SCLM	92.529 (24)	24.312 (23)	68.217
IIS & 3PL SCLM	130.908 (24)	46.061 (23)	84.847

4.5.4 Transportation Performance Outcomes Measurement Model

The transportation performance outcomes construct is composed of six dimensions with a total of 24 survey items. Purification and validation for each sub-construct dimension is discussed in turn and all analysis values are summarized in Table 4.12.

4.5.4.1 Efficiency

Three items were used to measure the efficiency sub-construct. Model fit indices were tested using a correlated model including the reliability construct. The initial measurement model exhibited acceptable to strong fit indices across all measures (see Table 4.12). As such, no purification was necessary.

Additionally, convergent validity was assessed through item factor loadings and AVE calculations. Lambdas for all three items were above .69 indicating acceptable factor loadings. Moreover, AVE is acceptable for convergent validity with a calculated value at .723. Reliability was evaluated based on Cronbach's alpha; the test statistic at .874 is well above the .70 threshold considered acceptable for reliability.

4.5.4.2 Reliability

The reliability sub-construct was measured with four items. The initial model fit displayed strong indicators across all measures, therefore no purification was necessary (see Table 4.12).

Convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .82, indicating strong factor loadings for each item. AVE is also very good at .781, both indicating strong convergent validity. To test reliability, Cronbach's alpha was calculated at .934, also indicating high reliability.

4.5.4.3 Responsiveness

The responsiveness sub-construct was measured with four items. The initial model fit displayed strong indicators across all measures, therefore no purification was necessary (see Table 4.12).

Convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .81, indicating strong factor loadings for each item. AVE is also excellent at .719, both indicating strong convergent validity. To test reliability, Cronbach's alpha was calculated at .909, well above the .70 threshold indicating reliability.

4.5.4.4 Quality

Five items were used to measure the quality sub-construct. Some indices in the initial model fit were not considered acceptable. The standardized residual covariances were higher than acceptable for item POQ5. Upon comparison to other scale items, this is the only item that refers to customer satisfaction with quality rather than the company's focus on aspects of quality. Consequently, after careful review of the item, the model was purified by removing POQ5. Final model fit values are strong across all indicators (see Table 4.12).

Furthermore, convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .74, indicating acceptable factor loadings for each item. AVE is also acceptable at .702. Cronbach's alpha test statistic was also evaluated; its value of .899 is a strong indication of reliability.

4.5.4.5 Carbon Emissions Reduction

Four items were used to measure the carbon emissions sub-construct. Some indices in the initial model fit were not considered acceptable. Therefore, after careful review of both scale items and indices, the model was purified by freeing a within factor correlated residual between Ce3 and Ce4. These two items are expected to highly correlate; both consider aspects of carbon emissions reduction in comparison to competitors. Final model fit values are strong across all indicators (see Table 4.12).

Additionally, convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .71, indicating acceptable factor loadings for each item. AVE is also acceptable at .712. Cronbach's alpha test statistic was evaluated; its value of .916 is well above the .70 threshold as high indication of reliability.

4.5.4.6 Equipment Utilization

The equipment utilization sub-construct was measured with four items. Some initial model fit indices were not within acceptable levels. After evaluating the initial model, the factor loading was shown to be considerably lower for POEq1 than the other items. Additionally, the item-total statistics also indicated an improvement to Cronbach's alpha if the item is removed. Compared to the other items, it was the only item that did not compare performance aspects of equipment utilization to competitors. Consequently, the item POEq1 was removed during purification. Final model fit indices were tested using a correlated model including the reliability construct and indices were strong across all measures (see Table 4.12).

Moreover, convergent validity was assessed through factor loadings and AVE. Lambdas were all above .78 indicating strong factor loadings. AVE was also strong at .731. Cronbach's alpha was calculated at .888, indicating high reliability.

Table 4.12: Transportation Performance Outcomes Measurement Model

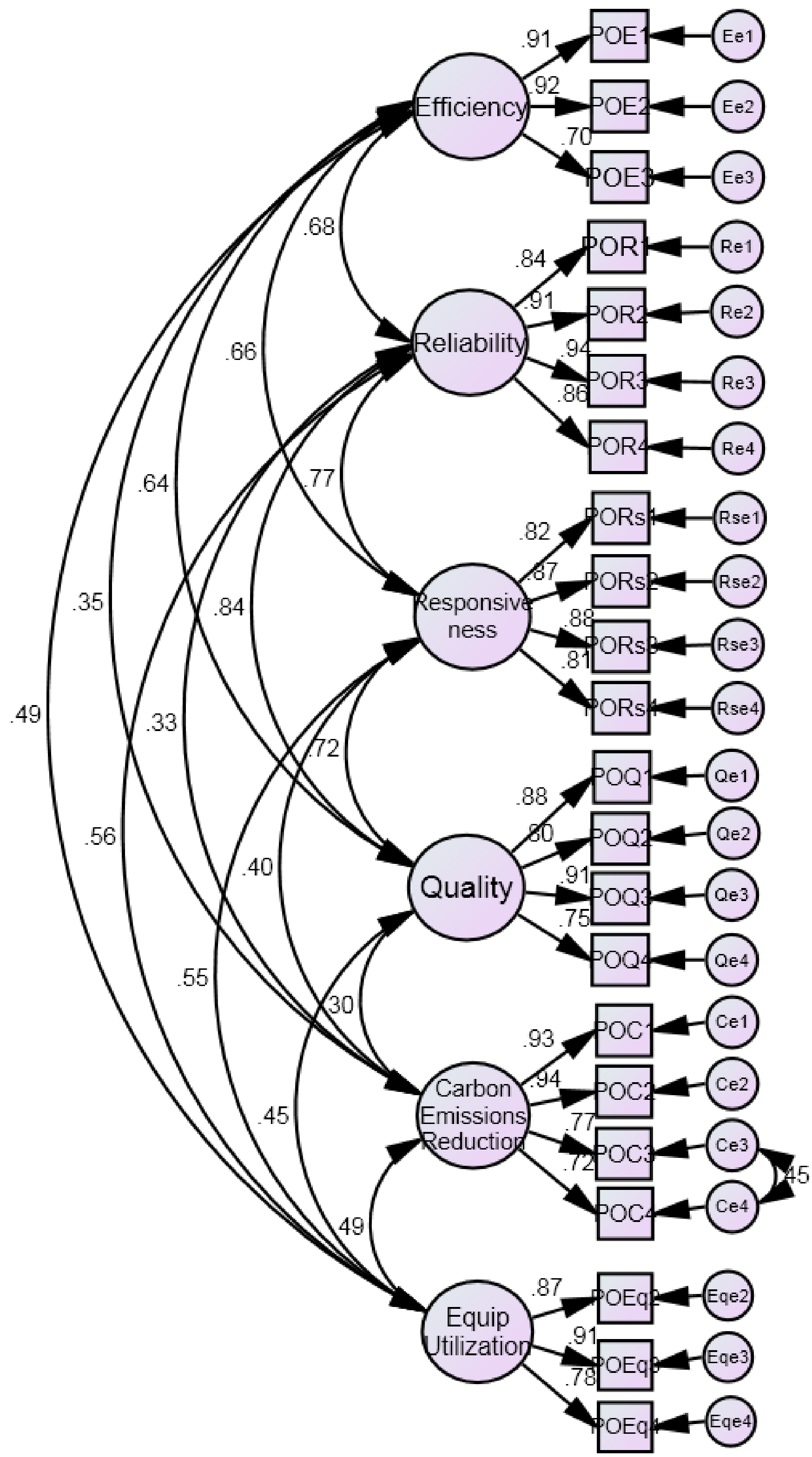
Coding	Item	Initial Model Fit	Final Model Fit
Transportation Performance Outcomes: Efficiency** (final AVE = .723, α = .874)			
POE1	Our company provides cost effective service to our customers. (λ = .91)	CMIN/df = 3.436 GFI = .953 RMR = .023 CFI = .979 NFI = .971 AGFI = .899 RMSEA = .097	No Change
POE2	Our customers are satisfied with the timeliness and cost effective manner our service is provided. (λ = .93)		
POE3	Our company's delivery costs are comparable to or better than our competitors. (λ = .69)		
Transportation Performance Outcomes: Reliability (final AVE = .781, α = .934)			
POR1	Our company offers highly reliable service to customers. (λ = .82)	CMIN/df = .733 GFI = .997 RMR = .004 CFI = 1.0 NFI = .998 AGFI = .986 RMSEA = .001	No Change
POR2	Our company consistently provides customers with deliveries at a specified time. (λ = .92)		
POR3	Our customers are satisfied with the consistency of deliveries at the specified time. (λ = .94)		
POR4	Our company consistently provides deliveries at the specified time comparable to or better than our competitors. (λ = .85)		

Table 4.12: Transportation Performance Outcomes Measurement Model (cont'd)

Coding	Item	Initial Model Fit	Final Model Fit
Transportation Performance Outcomes: Responsiveness (final AVE = .719, α = .909)			
PORs1	Our company responds well to changing customer preferences. (λ = .82)	CMIN/df = 2.516 GFI = .991 RMR = .010 CFI = .996 NFI = .993 AGFI = .945 RMSEA = .077	No Change
PORs2	Our company is able to respond quickly during times of change or unexpected circumstances. (λ = .88)		
PORs3	Our company is comparable to or more responsive than our competitors to change. (λ = .88)		
PORs4	Our drivers can be counted on to respond quickly to changing customer needs. (λ = .81)		
Transportation Performance Outcomes: Quality (final AVE = .702, α = .899)			
POQ1	Our company provides high quality service to our customers. (λ = .85)	CMIN/df = 7.618 GFI = .948 RMR = .019 CFI = .966 NFI = .961 AGFI = .844 RMSEA = .160	CMIN/df = .786 GFI = .997 RMR = .005 CFI = 1.0 NFI = .998 AGFI = .984 RMSEA = .001
POQ2	Our company focuses on delivering damage free materials and products at specified times. (λ = .81)		
POQ3	Our company is able to compete based on quality. (λ = .94)		
POQ4	Deliveries to customers are made in a timely manner with zero defects. (λ = .74)		
POQ5*	Our customers are satisfied with our service quality. (deleted)		
Transportation Performance Outcomes: Carbon Emissions Reduction (final AVE = .712, α = .916)			
POC1	Our company and/or trade partnerships focus efforts on reducing carbon emissions. (λ = .92)	CMIN/df = 29.004 GFI = .901 RMR = .053 CFI = .932 NFI = .930 AGFI = .507 RMSEA = .329	CMIN/df = .642 GFI = .999 RMR = .003 CFI = 1.0 NFI = .999 AGFI = .988 RMSEA = .001
POC2	Our use of technology has helped our efforts to reduce carbon output. (λ = .96)		
POC3	Compared to competitors our company has achieved higher fuel efficiency for our fleet. (λ = .76)		
POC4	Compared to competitors our company has lower idle times for our trucks. (λ = .71)		

Table 4.12: Transportation Performance Outcomes Measurement Model (cont'd)

Coding	Item	Initial Model Fit	Final Model Fit
Transportation Performance Outcomes: Equipment Utilization** (final AVE = .731, α = .888)			
POEq1*	Our company has high levels of equipment utilization. (deleted)	CMIN/df = 7.259 GFI = .975 RMR = .020 CFI = .979 NFI = .975 AGFI = .873 RMSEA = .155	CMIN/df = .887 GFI = .987 RMR = .013 CFI = 1.0 NFI = .992 AGFI = .973 RMSEA = .001
POEq2	Compared to competitiors our company brings in more revenue per ton mile. (λ = .86)		
POEq3	Compared to competitiors our company brings in more revenue per truck. (λ = .92)		
POEq4	Compared to competitors a higher percentage of our fleet is consistently in service. (λ = .78)		
* Item deleted during purification. **Final model fit indices were tested using a correlated model including this construct and the reliability construct.			



Measurement Model Fit Indices: CMIN/df = 2.287 GFI = .870 RMR = .043 CFI = .950
NFI = .916 AGFI = .829 RMSEA = .070

Figure 4.20: Transportation Performance Outcomes Measurement Model

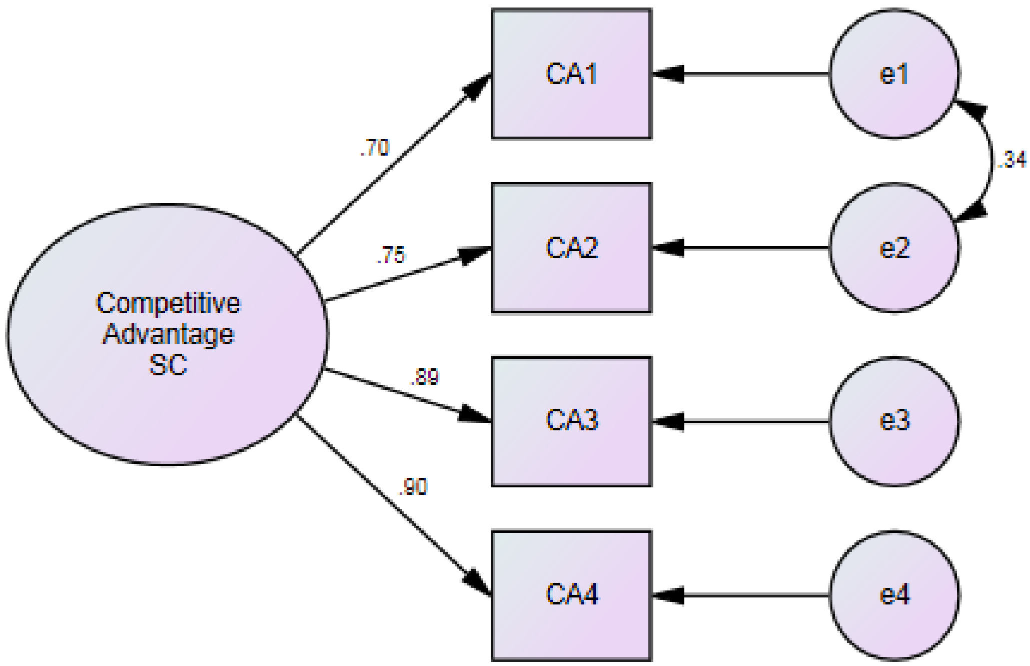
4.5.5 Competitive Advantage of the Supply Chain Measurement Model

Four items were used to measure the competitive advantage of the supply chain construct. Some indices in the initial model fit were not considered acceptable. Therefore, after careful review of both scale items and indices, the model was purified by freeing a within factor correlated residual between e1 and e2. Final model fit values are high for all indicators (see Table 4.14).

Additionally, convergent validity was assessed through factor loadings and AVE. All lambdas represented values at or above .70, indicating good factor loadings for each item. AVE is also acceptable at .664. Cronbach's alpha test statistic was evaluated; its value of .894 is well above the .70 threshold as a strong indication of reliability.

Table 4.13: Competitive Advantage of the Supply Chain Measurement Model

<table>
<tr><th>Coding</th><th>Item</th><th>Initial Model Fit</th><th>Final Model Fit</th></tr>
<tr><td colspan="4">Competitive Advantage (final AVE = .664, α = .894)</td></tr>
<tr><td>CA1</td><td>Our customers are able to have short delivery lead times. (λ = .70)</td><td rowspan="4">CMIN/df = 12.511
GFI = .952
RMR = .024
CFI = .963
NFI = .961
AGFI = .761
RMSEA = .211</td><td rowspan="4">CMIN/df = .703
GFI = .999
RMR = .003
CFI = 1.0
NFI = .999
AGFI = .986
RMSEA = .001</td></tr>
<tr><td>CA2</td><td>Our customers are able to offer lower cost products. (λ = .75)</td></tr>
<tr><td>CA3</td><td>Our customers are able to offer high quality products. (λ = .89)</td></tr>
<tr><td>CA4</td><td>Our customers are able to respond quickly to changing customer/market needs. (λ = .90)</td></tr>
</table>



Measurement Model Fit Indices: CMIN/df = .703 GFI = .999 RMR = .003 CFI = 1.0
NFI = .999 AGFI = .986 RMSEA = .001

Figure 4.21: Competitive Advantage of the Supply Chain Measurement Model

By parceling all construct measurement models, the full measurement model is determined (see Table 4.14).

Table 4.14: Full Measurement Model Parceled Fit Indices

Construct	GFI	RMR	CFI	NFI	AGFI	RMSEA
External Environmental Pressures	0.922	0.082	0.872	0.733	0.888	0.049
Internal Organizational Environment	0.876	0.043	0.964	0.929	0.838	0.060
IT Enabled Systems and Practices	0.931	0.047	0.964	0.959	0.903	0.049
Transportation Performance Outcomes	0.870	0.043	0.950	0.916	0.829	0.070
Competitive Advantage of the SC	0.999	0.003	1.000	0.999	0.986	0.001
Full Measurement Model Fit (Parceled)	**0.920**	**0.044**	**0.950**	**0.907**	**0.889**	**0.046**

In summary, all measurement scales in this study were rigorously validated. Model fit indices were examined for each sub-construct and major construct. In some cases, scale items were purified. All measurement scales were examined for model fit and tested for reliability, convergent and discriminant validity. As such, all scales met the criteria for acceptable to strong measurement models. The next chapter discusses results from hypotheses testing by analyzing the structural model.

Chapter 5

Structural Model Hypotheses Testing and Results

This chapter highlights methodology and analysis results from testing the hypothesized relationships presented in the proposed research model in Chapter 2. Partial least squares structural equation modeling (PLS SEM) is used to test the structural model for this study. Peng et al. (2012) suggest using PLS methodology when the research model is extremely complex because estimation problems can ensue for highly complex models using covariance based SEM (CBSEM) methodology. Considering the current study examines five major constructs with twenty-two sub-constructs, it is highly complex and PLS is an appropriate testing methodology for the structural model.

First, an overview of PLS methodology is discussed; including recommended values for acceptable test statistics. These are followed by results from structural model testing. Next, implications from results and a discussion of hypotheses are presented. A post hoc analysis is also discussed that provides some additional insight regarding more specific performance outcomes from selected IT enabled systems and practices. Finally, controls are discussed for common method and social desirability biases.

5.1 Partial Least Squares (PLS) Methodology

PLS is a component based structural equation modeling technique. It has recently gained research interest to model latent constructs not only under conditions of non-normality with small to medium sample sizes, but also for highly complex models (Chin et al., 2003) that are not handled well using covariance based SEM (CBSEM). CBSEM, such as AMOS 20.0 used in Chapter 4 for measurement model testing, is an appropriate tool for evaluating how well the business environment, based on collected data, fits the proposed research model. However, because certain assumptions for normality, sample size, and model complexity must be met in order to use CBSEM, it can be useful to pursue alternative tools, such as PLS, for testing research models (Peng et al., 2012).

PLS is prediction-oriented and therefore aims to assess the extent to which one part of the research model predicts values in other parts of the research model (Peng et al., 2012). PLS is similar to regression, except it uses an iterative algorithm to simultaneously solve blocks of measurement paths (i.e., relationships between a latent variable and its indicators) and estimates structural path coefficients (i.e., theoretical relationships among latent variables) (Chin et al., 2003; Peng et al., 2012). Thus, the estimation procedure used by PLS allows researchers to estimate highly complex models as long as the sample size is adequate to estimate the most complex relationship in the model (Peng et al., 2012).

Furthermore, the PLS algorithm allows each indicator to vary by how much it contributes to the composite score of the latent variable instead of assuming equal weights for all indicators of a scale (Chin et al., 2003). Consequently, indicators with weaker relationships are given lower weightings that are carried through to an assessment of the theoretical estimates. According to Chin et al. (2003), for this reason, PLS is preferable to techniques such as single-item regression that assumes error free measurement, summated regression that assumes equal-weighted measurement, and factor score-based regression that assumes constrained measurement error within the estimates of the theoretical variables.

The next section examines test statistic parameters for PLS.

5.1.1 PLS Test Statistics

PLS employs several techniques for assessing the structural model. Initially, the sign, magnitude and significance of path coefficients should be evaluated for consistency with theory (Peng et al., 2012). In turn, several test statistics can be evaluated for the model's relevance and predictive ability as further discussed in this section.

The size of the structural path coefficients, or standardized beta coefficients, is used to evaluate the structural model in order to assess interactions between constructs (Chin, 1998). Some researchers suggest the cut-off value for the standardized beta coefficient is 0.20 (although sometimes, coefficients less than 0.20 will be significant at $P < 0.05$) (Chin, 1998). A higher coefficient value indicates a more meaningful relationship between the constructs (Chin, 1998).

T-statistics are used to evaluate the level of significance in the proposed hypotheses (Cohen, 1988; Chin et al., 2003). Because PLS does not assume multivariate normality, traditional parametric-based techniques for significance tests are not appropriate (Chin, 1998; Peng and Lai, 2012). Therefore, a bootstrapping procedure is used in PLS that allows researchers to estimate standard errors and the significance of parameter estimates (Chin, 1998). For two-tailed tests, a *t* value less than 1.96 indicates the hypothesized relationship is not significant ($P < 0.10$) and the statistical power of significance is less than 5%. Thus, concluding the hypothesis is not supported. Conversely, for a *t* value between 1.96 and 2.58, the hypothesized relationship is considered significant at the 0.05 level. Furthermore, for a *t* value greater than 2.58, the hypothesized relationship is considered significant at the 0.01 level (Chin et al., 2003). Once support for the hypothesized relationships is established, predictive power and relevance of the model can be further tested for rigor.

Explained variance (R^2) should be examined for endogenous constructs to evaluate the predictive power of the research model. One objective of PLS is to explain the maximum amount of variance in endogenous variables. It is suggested in the literature that R^2 values of 0.67 are substantial, 0.33 are moderate, and 0.19 are weak (Chin, 1998; Peng et al., 2012).

Next, effect size of predictor constructs can be evaluated using Cohen's f^2 (Cohen, 1988). Effect size is calculated as the increase in R^2 relative to the proportion of variance that remains unexplained in the endogenous latent variable. The literature suggests f^2 values of 0.35 to be large, 0.15 to be medium, and 0.02 as small (Cohen, 1988; Chin et al., 2003; Peng et al., 2012).

Stone-Geisser's Q^2 (Geisser, 1975; Stone, 1974) is used to evaluate predictive relevance. Q^2 is computed using a blindfolding procedure available in most PLS software packages. According to the literature, if Q^2 is greater than 0, then the model is shown to exhibit predictive relevance (Peng et al., 2012).

Finally, a post hoc power analysis should be computed to ensure the statistical power of the research study is acceptable. Effect size, reliability, the number of indicators, and other factors can all affect the statistical power for testing hypotheses. Power analyses cut of values above 0.80 are suggested as acceptable (Peng et al., 2012).

5.2 Proposed Research Model

A somewhat simplified version of the theoretical model proposed in Chapter 2 is presented again in Figure 5.1. The model itself is composed of one exogenous variable, external environmental pressures (EEP), followed by four endogenous variables. Endogenous variables in the model are conceptualized as the internal organizational environment (IOE), IT enabled systems and practices (ITSP) which is composed of four sub-components (ITS, TMS, IIS, and 3PL SCLM), transportation outcomes (TO), and competitive advantage (CA) of the supply chain.

Additionally, as theorized in Chapter 2, the model contains eight hypotheses. Hypothesis 1 is the relationship between EEP → IOE. Hypothesis 2 is the relationship between EEP → ITSP. Hypothesis 3 is the relationship between IOE → ITSP. Hypothesis 4a is the relationship between ITS → TO. Hypothesis 4b is the relationship between TMS → TO. Hypothesis 4c is the relationship between IIS → TO. Hypothesis 4d is the relationship between 3PL SCLM → TO. Hypothesis 5 is the relationship between TO → CA.

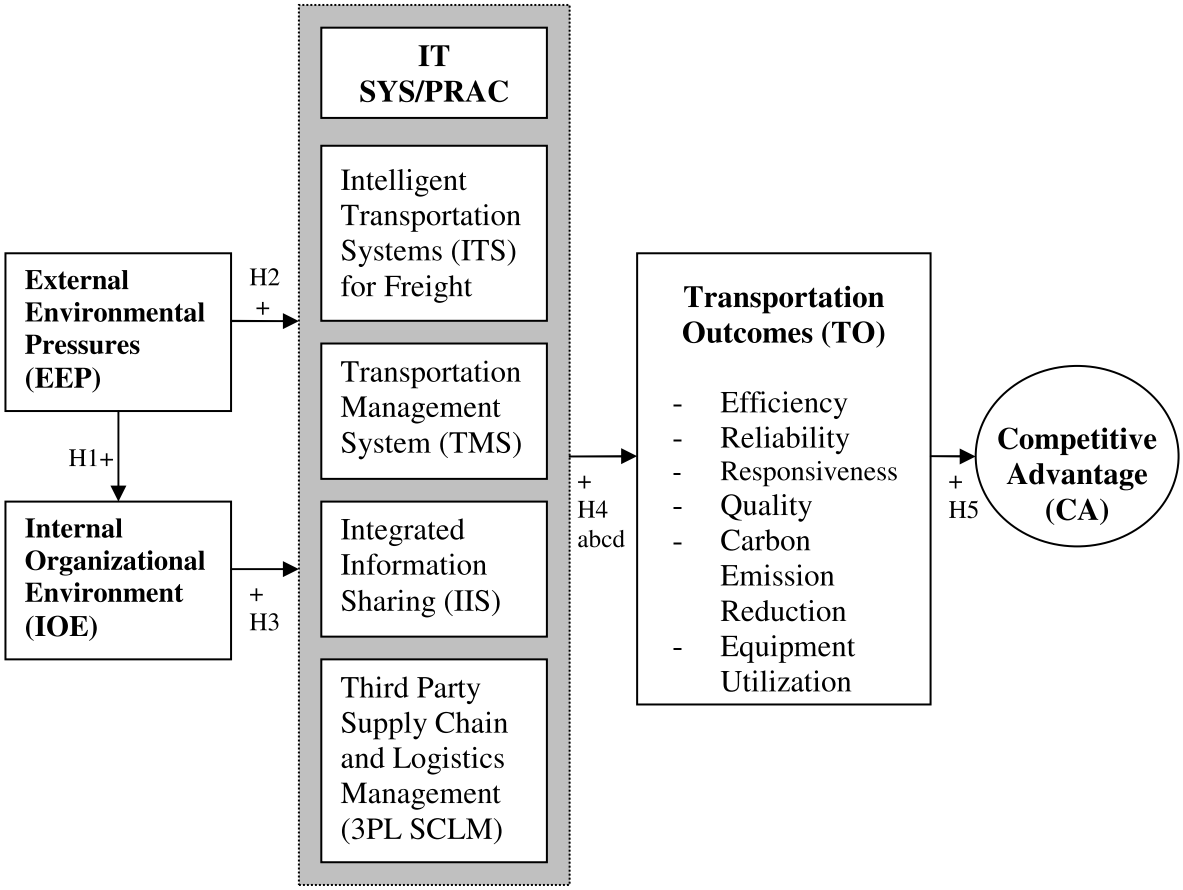


Figure 5.1: Proposed Research Model

The next section discusses testing the structural model using PLS.

5.3 Structural Model Testing Using PLS

Discussed in this section are results obtained from hypotheses testing using SmartPLS 3.2.0 (Ringle et al., 2015). PLS SEM was chosen because the full structural model was too complex to test effectively with the CBSEM used for measurement model testing. "CBSEM and PLS are considered as complementary rather than competitive methods, and both have a rigorous rationale of their own" (Barroso et al., 2010, p. 432).

No empirical methodology is perfect, therefore if the PLS assumptions are met and it is used appropriately, it can be a very useful data analysis technique (Peng et al., 2012).

For the remainder of this section, structural model testing results are displayed, followed by a discussion of hypotheses. Post-hoc analysis results are presented in section 5.4.

5.3.1 Results of the Structural Model

The structural model presented in Figure 5.1 was tested using SmartPLS v.3.2.0 (Ringle et al., 2015). Based on the research model, eight hypotheses were proposed and tested. Support for each hypothesis was determined based on the standardized beta coefficient (also know as the path value), *t*-statistic, and *p* value significance. Six of the proposed hypotheses were fully supported, one hypothesis only generated weak support, and one hypothesis was not supported. Fleet size, number of employees, and service type were used as control variables for testing the model. The full structural model from SmartPLS is available in Appendix B, see Figure B1. The structural model with Bootstraping method output showing t-statistics is also available in Appendix B, see Figure B2.

Hypothesized relationships and test statistic values from structural model testing are presented in Table 5.1.

Table 5.1: Structural Model Testing Results

Hypotheses: Path	Standardized Beta Coefficient [a]	T Statistic	P Values	Variance Explained (R^2) [b]	Predictive Relevance (Q^2) [c]	Effect Size Cohen's (f^2)	Supported
H1: Ext Env -> Int Env	0.474***	7.374	0.000	0.225	0.089	0.290	Yes
H2: Ext Env -> IT Enabled Sys Prac	0.245***	3.944	0.000	0.457	0.201	0.086	Yes
H3: Int Env -> IT Enabled Sys Prac	0.524***	9.184	0.000	0.457	0.201	0.393	Yes
H4a: ITS -> Transportation Outcomes	0.277**	3.178	0.002	0.342	0.159	0.064	Yes
H4b: TMS -> Transportation Outcomes	0.145*	1.952	0.052	0.342	0.159	0.019	Yes
H4c: IIS -> Transportation Outcomes	0.325***	4.551	0.000	0.342	0.159	0.110	Yes
H4d: 3PL SCLM -> Transportation Outcomes	-0.076 [ns]	1.409	0.160	0.342	0.159	0.008	No
H5: Transportation Outcomes -> Competitive Advantage SC	0.646***	14.716	0.000	0.443	0.330	0.727	Yes

[a] *** significant at $p < .001$, ** significant at $p < .05$, * significant at $p < .10$, [ns] not significant.

[b] R^2 values represent variance explained for the endogenous variables.

c Q^2 values represent predictive relevance for the endogenous variables.

The next section discusses the implications of structural model test results in terms of empirical support for the proposed hypotheses. In the case of weak and unsupported hypotheses, alternate theoretical reasoning is also explored.

5.3.2 Discussion of Hypotheses

The main premise of the current study is to gain a better understanding of how applications of IT enabled systems and practices in the trucking services industry influence performance outcomes. In turn, how these improved performance outcomes ultimately lead to a competitive advantage for the supply chain. Three main research questions were examined as part of this study.

5.3.2.1 Research Question 1

The first research question examined the environmental forces that drive the decision-making process for adopting IT enabled systems and practices in the transportation industry. Thus, the first question explored:

- What environmental forces drive the decision making process for adopting IT enabled systems and practices in transportation and logistics?

The first three hypotheses presented examined this question; each through a slightly different lens:

H1: External environmental pressures will influence the internal organizational environment. (Supported)

H2: External environmental pressures will influence the adoption of IT enabled systems and practices in transportation and logistics. (Supported)

H3: Internal environmental pressures will influence the adoption of IT enabled systems and practices in transportation and logistics. (Supported)

In evaluating H1, previous research examined in the literature review, suggests that events in the external organizational environment will affect events and precipitate changes within the organization itself (Gordon, 1991; Rogers et al., 2007). Sample data from this study support this relationship. The standardized beta coefficient and t-statistic are strong at 0.474 and 7.374 respectively. A p-value of .000 is significant at the 99% confidence level. This result extends previous findings into the transportation sector for additional generalizability of the relationship. External forces attributable to customers, competitors, regulations, technology changes, and technology standards can influence decision-making within organizations in the freight transport sector toward IT adoption decisions.

Additionally, in evaluating H2, previous research suggests that factors in the external environment will affect decision-making for the adoption of IT enabled systems and practices (Klassen et al., 1996; Melnyk et al., 2003; Wolfe et al., 2005). Sample data collected for this study also support this relationship. The standardized beta coefficient and t-statistic are 0.245 and 3.944 respectively. A p-value of .000 is significant at the 99% confidence level. Factors examined that contributed to this relationship were customers, competitors, regulations, technology changes, and technology standards. Individually, each factor significantly affected the construct.

Furthermore, in examining H3, previous research suggests that several internal organizational factors will influence decision-making in the adoption of IT enabled systems and practices (Pokharel, 2005; Zeimpekis and Giaglis, 2006; Evangelista and Sweeney, 2006). The sample data analyzed in this study also strongly support this relationship. The standardized beta coefficient and t-statistic are 0.524 and 9.184

respectively. A p-value of .000 shows significance at the 99% confidence level. Internal organizational factors that contributed to this relationship included top management, company culture, economic resources, IT awareness, employees, drivers, and unions. Individually, each factor significantly affected the construct although unions exhibited a weaker impact than the other factors.

5.3.2.2 Research Question 2

The second research question is really the backbone for this study. It explores the types of IT enabled systems and practices that influence improvements to transportation performance outcomes. The second research question explored:

- Which IT enabled systems and practices influence improvements to transportation performance outcomes?

The fourth hypothesis is presented to examine this question. It is tested for two components of IT enabled systems (e.g. ITS and TMS) and two components of IT enabled practices (e.g. IIS and 3PL SCLM) for the overall relationship with transportation outcomes.

H4(abcd): The adoption of IT enabled systems and practices (ITS, TMS, IIS, 3PL SCLM) will positively influence transportation performance outcomes for efficiency, reliability, responsiveness, quality, carbon emissions reduction and equipment utilization. (H4a: supported; H4b: weakly supported; H4c: supported; H4d: not supported)

Technology is constantly changing, thus it is important to have an understanding of how the underlying purpose of various IT enabled systems and practices affect performance. Based on the extensive literature review it was expected that each of the IT enabled systems and practices would have a significant effect on transportation performance outcomes. However, that is not the case for this study. Results suggest that both IT enabled systems and practices do positively impact transportation performance outcomes, although not all types of systems and practices are shown to influence performance outcomes.

On one hand, results indicate that IT enabled systems positively influence overall transportation performance outcomes. For instance, in testing H4a, the sample data analyzed supports the relationship that ITS positively influences overall transportation performance outcomes. The standardized beta coefficient and t-statistic are 0.277 and 3.178 respectively. A p-value of .002 signals the relationship is significant at the 95% confidence level. Equally, when H4b was tested, TMS was expected to have a major impact on transportation performance outcomes, yet the suggested relationship is very weak. The sample data analyzed does suggest a positive influence, however the standardized beta coefficient and t-statistic are only 0.145 and 1.952 respectively. The p-value of .052 suggests the relationship is only significant with 90% confidence. It is often accepted in industry that TMS is a sub-system of ITS, certainly it is possible this relationship has affected results of the current study and should be further investigated.

On the other hand, IT enabled practices exhibited mixed results. When testing H4c, the sample data analyzed indicates a strong positive relationship between IIS and overall transportation performance outcomes. The standardized beta coefficient and t-statistic are 0.325 and 4.551 respectively. The p-vale of .000 indicates the relationship is significant at the 99% confidence level.

Conversely, the sample data tested for H4d indicates a non-significant negative relationship between 3PL SCLM and overall transportation performance outcomes. The standardized beta coefficient and t-statistic for that relationship are -0.076 and 1.409

respectively. The p-value of .16 indicates the relationship is not significant. Indeed this finding is among the most surprising and interesting in the study. Results from prior literature indicated a positive relationship between the use of a 3PL SCLM and performance outcomes (Hofer et al., 2009; Panayides and So 2005; Sinkovics and Roath 2004; Stank et al 2003). The positive relationship was expected to hold, even though some previous research indicated mixed results depending on the level of IT sophistication of the third party logistics provider (Evangelista and Sweeney, 2006).

In retrospect, it is possible that cost is a significant factor when using a third party provided service. Consequently, because overall performance outcomes were examined, cost effectiveness in the efficiency factor may have weighed negatively on the relationship. Certainly, this is an area that should be examined further.

5.3.2.3 Research Question 3

The final research question is presented to explore whether performance improvements on the transportation links in the supply chain affect the competitive advantage of the supply chain. In other words, will differentiating factors such as shortened lead times or more reliable deliveries from transportation service providers impact the performance of their customers or their customers' customers. Thus, the question posed was:

- Do performance improvements in transportation outcomes affect the competitive advantage of the supply chain as a whole?

The fifth hypothesis is presented to examine this question.

H5: High transportation performance outcomes will positively influence the competitive advantage of the supply chain. (Supported)

Sample data analyzed in this study strongly support the relationship between transportation performance outcomes and competitive advantage of the supply chain. The standardized beta coefficient and t-statistic are 0.646 and 14.716 respectively. A p-value of .000 indicates the relationship is significant at the 99% confidence level. In fact, this is the strongest interaction examined in the study and lends support to the premise that IT enabled systems and practices in the transportation industry do contribute to creating a competitive advantage for the entire supply chain.

As such, by examining the level of short and reliable lead times, low cost and high quality products, and responsiveness of transportation providers' customers (and their customers), the study has established a key dyadic relationship toward the interaction effects of transportation providers within the supply chain network. Examining a dyadic relationship as a proxy for the supply chain is common practice in previous supply chain research. In particular, a connection has been established as to how the use of select IT enabled systems and practices contribute to value and service differentiation in gaining a competitive advantage in the supply chain network. By consequence, these findings open the door for further research examining systems and practices for the links and interfaces between organizations in supply chain networks.

5.4 Post-Hoc Analyses

Post-hoc analyses allow the researcher to gain additional insight into the phenomenon at hand. Because one of the theorized paths was found to be insignificant, the first post-hoc analysis involved testing the statistical power of the study. Next, a post-hoc analysis is conducted to examine effects on specific transportation performance outcomes and further between large and small firms. Finally, the section closes with a post-hoc analysis testing for common method bias.

5.4.1 Statistical Power Analysis

It is important to conduct a statistical power analysis when findings indicate non-significant results. In the case of this study, 3PL SCLM was found to have a non-significant interaction with transportation performance outcomes collectively examining efficiency, reliability, responsiveness, quality, carbon emissions reduction, and equipment utilization. A statistical power analysis demonstrates that there is in fact enough statistical power to draw a non-significant conclusion with confidence.

A statistical power analysis was conducted for the endogenous variable, transportation outcomes. It is only necessary to conduct a power analysis on the endogenous variable with an insignificant path. A statistical calculator available at www.danielsoper.com was used for the analysis (see Figure B3 in Appendix B). In order to test statistical power, the number of predictors, observed R^2 value, probability level, and sample size must be entered. For this analysis, the number of predictors is 4 (i.e. one for each variable with a path to transportation outcomes, ITS, TMS, IIS, 3PLSCLM), the R^2 value from Table 5.1 is .342, a probability level of .05 is selected, and sample size is 260. Results indicate observed statistical power is 1.0. Thus, signaling there is adequate statistical power in the model. Observed statistical power above .80 is considered acceptable (Gaskin, 2013).

5.4.2 Additional Post-Hoc Analysis

Because of the non-significant findings for 3PL SCLM and the weak findings for TMS, a further post-hoc analysis was conducted to examine effects on specific transportation outcome factors (e.g. efficiency, reliability, responsiveness, quality, carbon emissions reduction, and equipment utilization). A new model was run in SmartPLS with paths from TMS and 3PL SCLM to each of the transportation outcome factors. Results are displayed in Table 5.2 with significant relationships highlighted.

Table 5.2: Post-hoc Analysis Results for TMS & 3PL SCLM

Post-hoc analysis: Path	Standardized Beta Coefficient [a]	T Statistic	Variance Explained (R^2) [b]
TMS -> Efficiency	0.033 [ns]	0.495	0.596
TMS -> Reliability	-0.062 [ns]	1.601	0.827
TMS -> Responsiveness	-0.035 [ns]	0.74	0.738
TMS -> Quality	-0.090 [ns]	1.622	0.740
TMS -> Carbon Emissions Reduction	0.246***	4.137	0.569
TMS -> Equipment Utilization	-0.034 [ns]	0.524	0.550
3PL SCLM -> Efficiency	-0.032 [ns]	0.735	0.596
3PL SCLM -> Reliability	-0.078**	2.674	0.827
3PL SCLM -> Responsiveness	0.026 [ns]	0.714	0.738
3PL SCLM -> Quality	-0.033 [ns]	0.932	0.740
3PL SCLM -> Carbon Emissions Reduction	0.078*	1.735	0.569
3PL SCLM -> Equipment Utilization	0.081*	1.768	0.550

[a] *** significant at $p < .001$, ** significant at $p < .05$, * significant at $p < .10$, [ns] not significant.
[b] R^2 values represent variance explained for the endogenous variables.

Post-hoc analysis results indicate there is a significant positive interaction between TMS and carbon emissions reduction. The standardized beta coefficient and t-statistic are both strong at .246 and 4.137 respectively and significant at $p < .001$. None of the other tested paths for TMS were found to be significant. Considering previous research results based on the literature reviewed, these findings are certainly unexpected.

Prior to conducting the post-hoc analysis it was logical to expect some paths to be positive and some negative, thus rendering the weak results for total transportation outcome effects. Indeed, this is not the case, though it is a relevant finding and important for both research and practice.

Moreover, results from the post-hoc analysis for 3PL SCLM are interesting. Findings suggest the strongest interaction is with reliability, although there is a negative affect on reliability. The standardized beta coefficient and t-statistic are -0.078 and 2.674 respectively and significant at $p < .05$. This suggests that there could be a lag in information exchange for firms using a third party logistics provider. This finding is somewhat consistent with results from Evangelista and Sweeney (2006) that suggested performance based on the use of a 3PL was mixed depending on the level of IT sophistication of the firm.

Additionally, results indicate weak positive effects on both carbon emissions reduction and equipment utilization from the use of 3PL SCLM. Considering the growing pace of the third party provided logistics industry, further investigation is warranted.

Finally, to further examine weak and non-significant findings, an additional post hoc analysis was conducted by splitting the sample between large and small firms based on the number of drivers as an indication of firm size. Some interesting findings were uncovered from this analysis. On one hand, all relationships examined were significant for large firms (see Table 5.3). Additionally, all relationships except for 3PL SCLM => Transportation Outcomes were positive for large firms thus, suggesting that more research should be conducted on the value of 3PL SCLM to large transportation firms.

Table 5.3: Post-hoc Analysis Results for Large Firms

Hypotheses: Path Results for Large Firms	Standardized Beta Coefficient [a]	T Statistic	P Values	Supported
H1: Ext Env -> Int Env	0.464***	6.512	0.000	Yes
H2: Ext Env -> IT Enabled Sys Prac	0.184*	1.763	0.078	Yes
H3: Int Env -> IT Enabled Sys Prac	0.527***	6.74	0.000	Yes
H4a: ITS -> Transportation Outcomes	0.192*	1.884	0.060	Yes
H4b: TMS -> Transportation Outcomes	0.199*	1.793	0.074	Yes
H4c: IIS -> Transportation Outcomes	0.446***	4.783	0.000	Yes
H4d: 3PL SCLM -> Transportation Outcomes	-0.114*	1.796	0.073	Yes
H5: Transportation Outcomes -> Competitive Advantage SC	0.676***	9.05	0.000	Yes

[a] *** significant at $p < .001$, ** significant at $p < .05$, * significant at $p < .10$, [ns] not significant.

On the other hand, results differed for small firms. The relationships between both TMS and 3PL SCLM on Transportation Outcomes were found to be not significant (see Table 5.4). It is likely that small firms contributed to the weak and non significant original analysis results. These results suggest more research should be conducted to examine the differences in technology applications between large and small firms and their expected value propositions.

Table 5.4: Post-hoc Analysis Results for Small Firms

Hypotheses: Path Results for Small Firms	Standardized Beta Coefficient [a]	T Statistic	P Values	Supported
H1: Ext Env -> Int Env	0.50***	5.374	0.000	Yes
H2: Ext Env -> IT Enabled Sys Prac	0.227**	3.045	0.002	Yes
H3: Int Env -> IT Enabled Sys Prac	0.56***	7.358	0.000	Yes
H4a: ITS -> Transportation Outcomes	0.333**	2.393	0.017	Yes
H4b: TMS -> Transportation Outcomes	0.088 [ns]	0.791	0.429	No
H4c: IIS -> Transportation Outcomes	0.246**	2.42	0.016	Yes
H4d: 3PL SCLM -> Transportation Outcomes	-0.067[ns]	0.860	0.390	No
H5: Transportation Outcomes -> Competitive Advantage SC	0.636***	11.299	0.000	Yes

[a] *** significant at $p < .001$, ** significant at $p < .05$, * significant at $p < .10$, [ns] not significant.

5.4.3 Testing for Common Method Bias

One concern in survey research is common method bias, also known as common method variance. In this regard, various types of common method variance stem from the measurement method rather than the variables of interest (Bagozzi and Yi, 1991). This can occur when the endogenous and exogenous variables are collected at the same time, using the same instrument (Lowry and Gaskin, 2014). One type of common method bias can become evident when both predictor and criterion variables are measured by the same respondent, often referred to as common rater effect (Podsakoff et al., 2003).

Ideally, having different respondents for predictor and criterion variables would combat this effect, however, given low response rates that is not practical. Therefore, two survey design remedies have been suggested to mitigate this issue. First, ensuring the respondents' answer anonymously reduces the likeliness of swaying toward more socially desirable answers. Second, separating criterion from predictor variables by situating them in different sections of the survey can provide some temporal relief for the respondent (Podsakoff et al., 2003). Both suggestions were incorporated into the survey instrument design employed for this research.

Harman's single-factor test is a commonly used statistical technique to determine common method bias (Andersson and Bateman, 1997, Lowry and Gaskin, 2014). The test was conducted for this study to ensure no distortions were evident in the data collected due to common method bias. SPSS was used to conduct an exploratory, unrotated factor analysis to determine the results of Harman's single-factor test for all first order constructs in the study. If a single factor emerges that explains the majority of the variance in the model, then it is likely that a significant level of common method bias is evident (Podsakoff et al., 2003; Lowry and Gaskin, 2014). Results of the exploratory factor analysis for this study produced 18 distinct factors and the largest accounted for only 29.55% of the model's variance thus, suggesting the data is not affected by common method bias.

5.5 Chapter Summary

The beginning of this chapter discussed PLS methodology and acceptable test statistic values. Results from testing the structural model were presented. In turn, hypotheses were discussed based on those findings. Accordingly, results from testing hypotheses 1, 2, and 3 lend support to a priori reasoning and research that have established a connection between internal and external organizational environmental factors and technology adoption. Results from this study extend those findings to the transportation and logistics industry, thus adding generalizability to the body of technology adoption research.

Findings from H4(abcd), testing the relationship between components of IT enabled systems and practices and transportation performance outcomes, were mixed. The work does establish a connection between the use of IT enabled systems and practices and transportation performance outcomes. However, not all components tested exhibited a strong interaction as expected. To the contrary, the use of 3PL SCLM actually exhibited a negative, though non-significant affect on transportation outcomes. This finding is both interesting and surprising. ITS and IIS results indicate a strong interaction between those systems and practices and overall performance outcomes. The use of TMS also indicates a positive influence on overall transportation performance outcomes, although the relationship is weak. Certainly, it is possible this is due to TMS being a generally accepted sub-component of ITS and the interaction effects were picked up in the ITS construct.

Furthermore, findings from testing the relationship in H5 between overall transportation performance outcomes and competitive advantage for the supply chain are encouraging. The interaction results are strong and lend support for opening a new area of research to fully examine the connection between transportation segments and operations in supply chain research. Results also suggest there is value in gaining a better understanding of the interactions and interfaces between organizations in the supply chain. Both transportation service providers and IT enabled capabilities act as connecting links between trading partners in their respective networks.

Additionally, post hoc analyses were conducted to gain a better understanding of results. A statistical power analysis was conducted to confirm non-significant findings for the interaction between 3PL SCLM and transportation outcomes. Then further testing was conducted to analyze specific transportation performance outcomes for TMS and 3PL SCLM because the original findings for total transportation outcome effects were weak or non-significant. Findings from the post-hoc analysis on these constructs indicate that the use of TMS strongly affects carbon emission reduction efforts for the fleet, but has non-significant effects for the other performance outcomes. Results for 3PL SCLM and the interaction with specific performance outcomes are mixed, a negative effect is indicated for reliability, while weak positive effects are exhibited for both carbon emissions reduction and equipment utilization.

Finally, because the same instrument was used in collecting responses for both exogenous and endogenous variables, common method bias testing was conducted. Harmon's single factor test was used to determine that the data is not compromised from common method bias.

Based on these empirical results, the next chapter discusses contributions and implications for both research and practice, limitations of the study, and areas to expand for future research.

Chapter 6

Contributions, Implications, Limitations, and Future Research

Businesses within supply and distribution networks act as nodes connected by both transportation services and information technology links in the system. Examining the transportation segments and information technology interfaces between organizations in the supply chain network are not well understood. Some researchers have even stated that transportation is the forgotten factor in supply chain management research (Quinn, 2000; Mason et al., 2007).

One growing area of interest is that of information technology adoption and implications for performance metrics in the transportation industry (Perego et al., 2011). This study is one of the first of its kind to examine this phenomenon and then draw the link between transportation performance and competitive advantage in the wider supply chain. As such, the study makes several key contributions to both research and practice; nonetheless, it is not without limitations.

In this chapter, important contributions to research are discussed in section 6.1. These are followed by implications for practice in section 6.2. Study limitations are presented in section 6.3. Finally, future areas for expanding this line of research are highlighted in section 6.4, which concludes the study.

6.1 Contributions to Research

A key contribution of this study is in the theoretical framework development for understanding antecedents and outcomes for the use of IT enabled systems and practices in the transportation sector. This began with an extensive literature review and interviews with practitioners in the transportation industry. Through this process the conceptual framework was theorized and grounded in contingency theory and organizational information processing theory. Combining these theories provided a rich foundation to build the framework for this study. Empirically testing the model found full support for 6 of 8 hypotheses, 1 provided weak support, and 1 was not supported.

Second, each construct examined contributed to the line of research. Internal and external environmental factors of technology adoption contribute to research by extending findings to the transportation sector and also to supply chain management research. By providing researchers with a better understanding of contextual factors that drive organizational technology adoption, it will become easier to identify factors of success for future innovative technology initiatives, particularly pertaining to the transportation and logistics industry.

Conceptualization of IT enabled systems and practices is also a contribution to research. This is a new construct not previously found in the literature. It is conceptualized as a modular construct with the understanding that technology systems and the practice of engaging with other entities to share information over those systems must work in conjunction with one another in order to attain measurable performance benefits. ITS, TMS, IIS, and 3PL SCLM were conceptualized as components of IT enabled systems and practices for this study, however as technology changes these modular components can be substituted for systems and practices that are more relevant to another industry or technological timeframe to suite future research needs.

Transportation performance outcomes are conceptualized as a combination of adapted components of competitive performance from operations management literature with newer measures for carbon emissions reduction and equipment utilization. These measures extend the components of competitive performance (e.g. cost, quality, flexibility, delivery) to additional measures for social responsibility and operational usage that are relevant to the transportation sector for performance. In turn, it was conceptualized that these performance outcomes could differentiate transportation service providers in order to add value attributable to competitive advantage for the supply chain.

A third contribution to research was the scale development and validation of measurement instruments for five major constructs with twenty-two sub-constructs. These were all tested and validated through a Q Sort pilot study and empirical data validation through measurement model testing for each construct. All measurement scales and instruments were found to be valid and reliable. These can be used and adapted by other researchers to extend the stream of research linking transportation functions to operations and supply chain management literature.

Fourth, another contribution of the study was to methodology. The use of panel data in academic research is fairly new and facilitated not only the completeness of data, but also expedited data collection time and provided sufficient response rates from qualified respondents for the study. Furthermore, the data collected was used to empirically validate and test measurement models for each construct in addition to testing the structural model to test hypotheses. Additionally, the post-hoc statistical power analysis added credibility to the findings for the insignificant and only weakly supported relationships. When interactions between constructs are found to be insignificant it can sometimes be an indication that there was not enough statistical power in the data sample size or model to draw a significant conclusion (Gaskin, 2013). The power analysis adds credibility and reliability to the significance of the finding. A further post-hoc analysis was conducted to gain additional insight on those weakly supported and insignificant relationships. Post-hoc analysis also included testing for common method bias; results suggest this type of bias is unlikely.

Fifth, findings from this study contribute further to the body of knowledge. Previous work indicated the relationship existed between external environmental forces on the internal environment. Results from this study extend previous findings into the transportation sector for additional generalizability of the relationship. External forces attributable to customers, competitors, regulations, technology standards, and technology changes can influence decision-making within organizations in the freight transport sector toward IT adoption decisions.

Furthermore, external forces were shown to influence adoption of IT enabled systems and practices. This relationship is not as strong as the one between internal organizational environmental factors and adoption of IT enabled systems and practices, but is still an important implication for both researchers and managers. This finding extends generalizability of the relationship to the transport sector as a contribution to research. Part of the developed theoretical framework using contingency theory is supported by these results.

Similarly, the internal organizational environment construct (which includes factors for top management, company culture, economic resources, IT awareness, and IT adoption input from employees, drivers, and unions), also influences IT adoption decisions. Hence, this finding also extends generalizability of the relationship to the transport sector as a contribution to research. Furthermore, examining both internal and external environmental factors of technology adoption in the transportation and logistics area from a company perspective contributes to the current understanding of technology adoption literature for organizations.

Additionally, by examining multiple IT enabled systems and practices in a single study a better understanding is gained as to which systems and practices are the most influential in contributing to the best performance outcomes. Results from examining these relationships indicate that both IT enabled systems and practices contribute to transportation performance outcomes, but some components are more influential than others. ITS and IIS exhibited strong interactions on performance outcomes, TMS exhibited some interaction while 3PL SCLM was found to be insignificant. Although, post-hoc analyses conducted on a more granular level, indicated strong support for the relationship between TMS and carbon emissions reduction.

That finding makes logical sense considering TMS is a decision support system including functions for routing and scheduling which minimize mileage and idle times for loading and unloading. Scheduling and routing functions allow for trip optimization (Kia et al., 2000) which has resulted in some recognized environmental benefits, including air pollution reduction and decrease of fuel consumption (Button et al., 2001). Additionally, post-hoc analysis provides some support for the relationship between 3PL SCLM and transportation performance outcomes for carbon emissions reduction and equipment utilization on a more granular level.

Finally, findings indicate a strong relationship between transportation performance outcomes and contributing to the competitive advantage of the supply chain. This is an important implication that can be built on to further the line of research connecting transportation functions to operations and supply chain management research.

Not only does this study make important contributions for research, but also has some key implications for managers. The next section discusses implications of the study and its findings relevant for practice.

6.2 Implications for Practice

Findings and interpretations of results from this study provide many useful implications for managers. Results indicate that some IT enabled systems and practices do positively impact performance measures for transportation outcomes. Results from this study indicate that ITS and IIS in particular, have a strong impact on performance measures. Transportation outcomes are improved with the use of IT enabled systems and practices because they act as decision support systems primarily to mitigate congestion, improve visibility and transparency between supply partners, and improve sustainability efforts. In turn, findings suggest that high transportation outcomes positively influence the competitive advantage of the supply chain network as a whole.

Managers can use these results for making investment decisions in systems and process improvements to practices. Strong support for the use of ITS influencing transportation performance outcomes was generated in the study.

ITS for freight are advanced information based technologies associated with commercial vehicle operators (CVO) aimed at simplifying and automating freight and fleet management operations at the institutional level for asset tracking, gateway facilitation, and monitoring vehicle, freight and network status. Some notable systems include GPS, satellite, mobile technology, radio frequency identification (RFID), or other technologies used to monitor location or status of tractors, trailers, containers and/or cargo. Other systems include the sensors or other technology used to monitor vehicle operating conditions, cargo conditions and load tampering. Additionally, systems for seamless gateway facilitation include transponders, RFID, smart cards, weigh-in-motion, or other technologies to improve operations for tolls and terminal gates, highway inspections, or border crossings. Finally, onboard display technologies to monitor congestion and weather conditions from road sensors, cameras and web or GPS technology can help drivers navigate more effectively.

According to interviewees at the beginning of this study, some of the above mentioned systems, such as weigh-in-motion systems, can be prohibitively expensive for small size carriers. Certainly results from this study, which indicate clear performance benefits, are useful to management when deciding to invest in those systems.

The use of some IT enabled systems and practices can improve or at least maintain delivery service levels even with increased strain and congestion on infrastructure in the transportation system. ITS systems can be used to help mitigate congestion on roadways (IFC Consulting, 2003) to improve efficiency and reliability of materials and goods movements (Golob et al., 2002). Congestion and infrastructure capacity can be a major problem in some areas, especially for industries heavily reliant on just-in-time (JIT) practices (US DOT, 2008). Considering the performance improvements found in this study from using ITS, supply partners particularly reliant on JIT should consider investments in these systems to improve routing decision-making through web and GPS enabled decision support systems. ITS can also facilitate border and toll crossings in a more efficient manner to improve reliability of movements through the transportation network.

This study provides relevance for investing in IT enabled systems and practices to improve visibility within the logistics links of the supply chain and distribution network. Performance measures indicate improvements to transportation outcomes are realized when using ITS and IIS as visibility enhancing systems and practices. Some ITS provide a framework for sharing information between supply and distribution partners while IIS practices ensure the right fit, amount and type of information are provided to improve transparency and visibility of materials and goods movements.

Enhanced visibility within supply and distribution channels allows firms to make more timely and accurate decisions regarding production and inventory management planning. This in turn, improves decision-making capabilities among trade partners. This is an essential capability in the current climate where more materials and goods are in transit to their next destination rather than waiting in stockpiles of inventory.

Furthermore, information gained through enhanced visibility is relevant for planning lead times and deciphering transit vs. holding costs in decision-making.

Knowing which tools to invest in can help managers invest in systems and practices to improve capabilities for their operations to provide optimal service levels for customers.

Additionally, the use of ITS improves sustainability performance on the transportation segments of supply and distribution channels. As environmental regulations become more stringent, mechanisms to mitigate carbon output will become increasingly valuable to invest in. It is salient that managers have a clear understanding for investing in components that make the best impact for their operations.

That being said, two areas of IT enabled systems and practices investigated did not have strong results, TMS and 3PL SCLM. The impact of using TMS on transportation outcomes was positive, but weak. It is quite possible that these systems are prevalent in the industry and becoming commoditized, and therefore do not differentiate significantly among firms (Bhatt and Grover, 2005). Thus, this result does not limit nor contradict the importance of TMS systems in transportation and logistics operations. To the contrary, these are likely key systems to maintain a level playing field among competitors in the transportation and logistics industry. Firms without TMS may fall behind (Bhatt and Grover, 2005).

Managers should not only understand the importance and value of the TMS system used in their operations, but also the limitations in using these systems. It is possible that firms can bundle their TMS with other proprietary organizational processes (Nevo and Wade, 2010) such as IIS in order to differentiate themselves and improve related transportation performance outcomes.

Among the most surprising and interesting results of this study were the non-significant impacts of using a 3PL SCLM on transportation outcomes. It is again possible that the use of 3PL SCLM is so prevalent in the industry that no differentiation can be identified in transportation outcomes. This finding should be further evaluated and tested in future research.

Finally, results provide managers with a better understanding of environmental factors that drive organizational technology adoption to assist in identifying successful conditions for future innovative technology initiatives in the transportation and logistics industry. Internal organizational and external environmental factors were shown to influence adoption of IT enabled systems and practices. This is an important implication for management particularly because it strengthens the notion that executive managers should be aware of and attuned to external environmental factors in addition to the current organizational climate when making decisions related to the adoption of IT enabled systems and practices. These are important findings that add generalizability to the current understanding of contextual factors for technology adoption in the transportation and logistics industry.

Even though every effort was made to ensure a high level of rigor was met for this study, as with any research, it is not without its limitations. The next section recognizes limitations to the study.

6.3 Limitations

The current study has made several key contributions to research and practice, yet with all research there are certain limitations and this study is no exception. Although discussion in this section is not comprehensive, some limitations are particularly notable. (1) Data collection for the study employed only a single respondent. (2) The study only used cross-sectional data, which limits the depth of understanding surrounding the research. (3) A lack of secondary data to corroborate performance measures. (4) Sample size limitations when taking the size and complexity of the model into consideration. Finally, (5) some results were contrary to expectations. For the remainder of this section, each of these limitations is discussed in turn.

First, using a single respondent is prevalent in survey research methodology, but does contribute to the limitations of this study. Using panelist respondents for data collection limited the options for a multi-informant approach in collecting data that would mitigate any single respondent bias. Rigorous techniques were used in this study to test for common method bias that can be attributable to single respondent methodology. Results of Harmon's single factor test determined that the presence of common method bias is unlikely.

Second, the use of cross-sectional data provides a snapshot of understanding, but does not allow for any temporal depth in the study. Indeed, many researchers call for longitudinal examinations of phenomenon to gain a greater understanding of the phenomenon under investigation. Longitudinal analyses allow the researcher to draw on richer conclusions for causation between research constructs.

Third, no secondary data was used to corroborate performance measures. The addition of secondary data would have enhanced the study and enriched results. Researchers prefer to use multiple methods with a mix of primary and secondary data to enrich findings and add depth to a study. The use of only primary data is a limitation of this study.

Fourth, another limitation lies with the sample size for data collection. Even though a statistical power analysis was conducted and identified there was ample power for the investigation, the 260 sample size could still be considered low given the number of constructs and sub-constructs contributing to the size of the model. Therefore, a larger sample would have been preferred for testing such a complex model.

Fifth, this study used a broad approach to gain an overview level of insight on how IT enabled systems and practices affect performance outcomes in the transportation segments of the supply chain. Some findings in the study were contrary to expectations based on the literature review and interviews with practitioners. The weak support for TMS and non-significant findings for 3PL SCLM affecting transportation outcomes could be due in part to the broad approach used for the analysis. The overall analysis approach possibly proliferate these findings and could certainly be a limitation of the study. A more granular analysis could bring clarity to these surprising results. Furthermore, it is often accepted in industry that TMS is a sub-system of ITS, it is possible this relationship has affected results of the current study and should be further investigated.

This section addressed the limitations of the study. The next section addresses some of these issues as areas for future research and discusses some additional ideas for expanding the line of research.

6.4 Future Research

Several areas can be addressed and extended for future research. First, additional data could be collected and further analyzed to gain another point in time reference in order to bring a longitudinal effect into the study. Additional data collection could also focus on expanding the sample size for further statistical power given the size and complexity of the model.

Second, the study could be expanded to include actual secondary data from transportation service providers' TMS to corroborate survey findings for performance measures. Actual delivery times can be compared to expected delivery times to determine windows of reliability for the service provider as a way of examining at least one type of performance measure. Using multiple methods for research, such as the use of both primary and secondary data is preferred and enriches results of the study.

Furthermore, the study could be expanded to examine performance outcomes and IT enabled systems and practices at a more granular level. Zooming in on the analysis level may provide additional insights that were beyond the scope of the current study. A more granular approach is necessary for future work to contribute to the competitive performance literature stream by extending findings to the transportation and logistics links in the supply chain.

What's more, preliminary post hoc analysis showed significant differences between large and small firms. Additional research should be conducted to better examine the differences in information technology system and practice applications between large and small firms. Greater benefits in value proposition and competitive advantage could be uncovered.

Finally, future research could expand to collect data from upstream and/or downstream players to gain a better understanding of the effects on competitive advantage for the supply chain. A triadic approach would be ideal for examining how the transportation and information technology links and interfaces affect the supply chain. Expanding the level of analysis and collecting data from the shipper, connecting transport service provider, and receiving organizations would add another dimension of rigor and enrich the study results for a better picture of effects across the wider supply and distribution network.

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Appendix A

Data Collection Survey Instrument

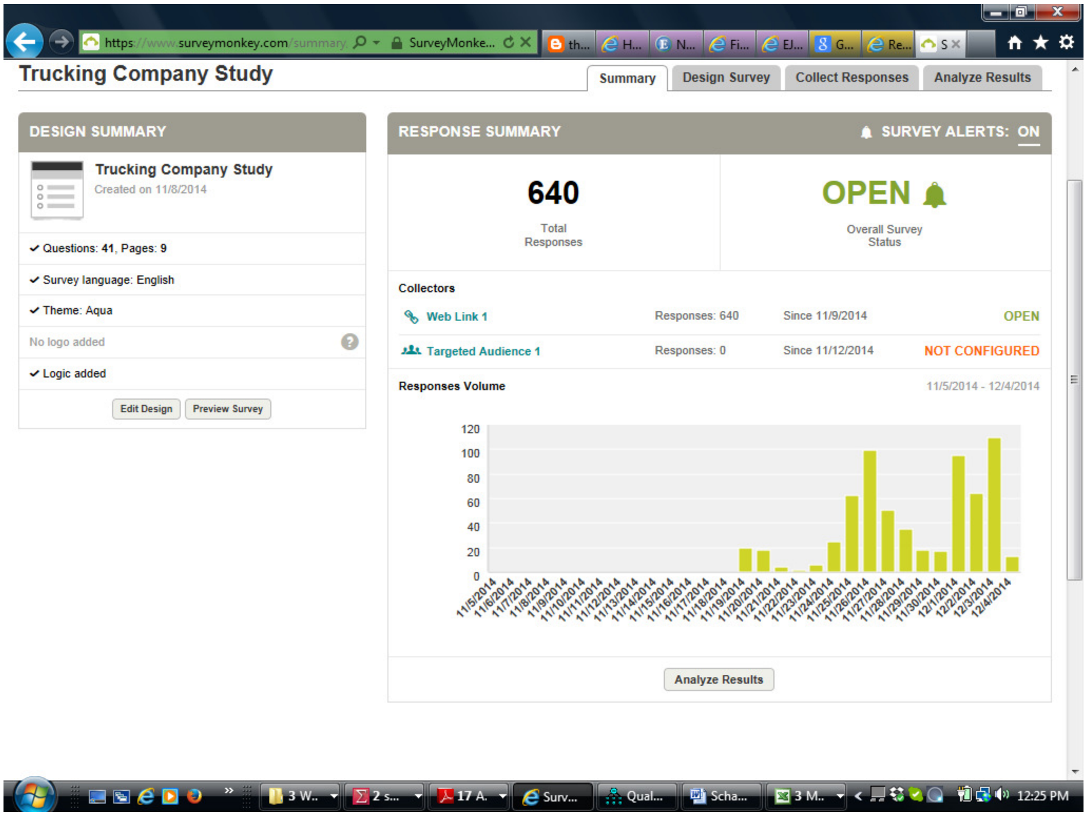


Figure A1: Survey Data Collection Home/Summary Screen

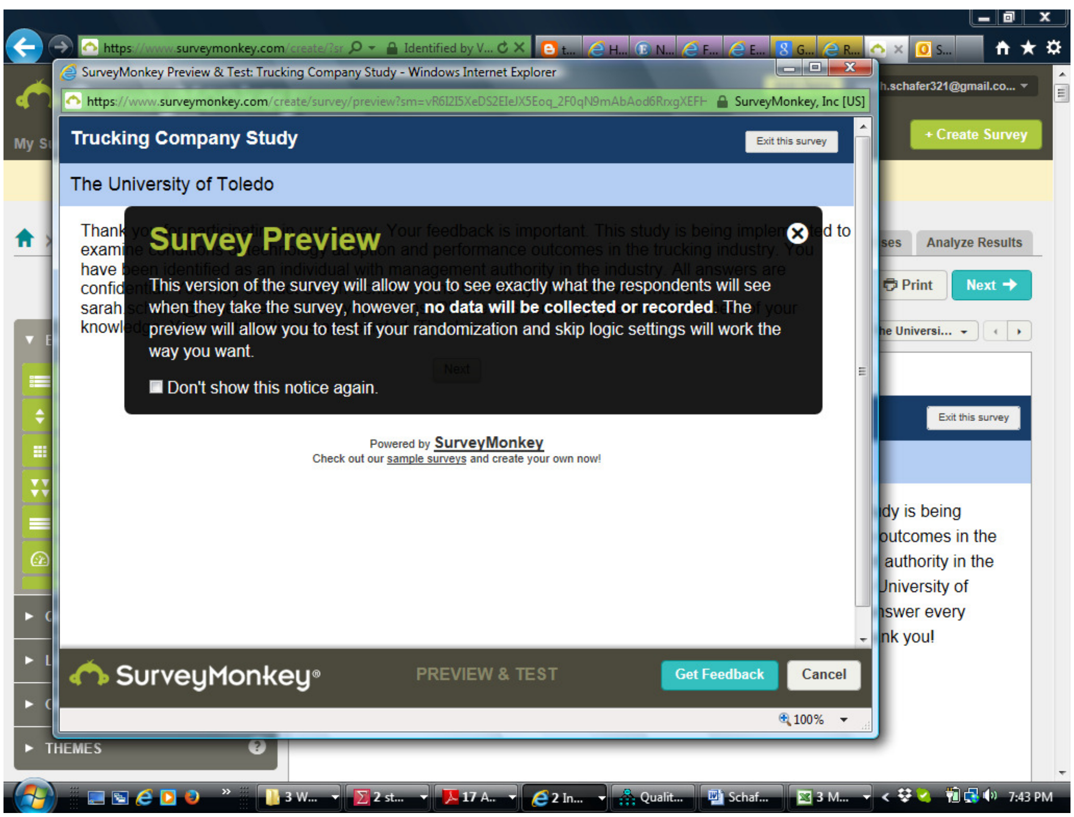


Figure A2: Survey Preview Page

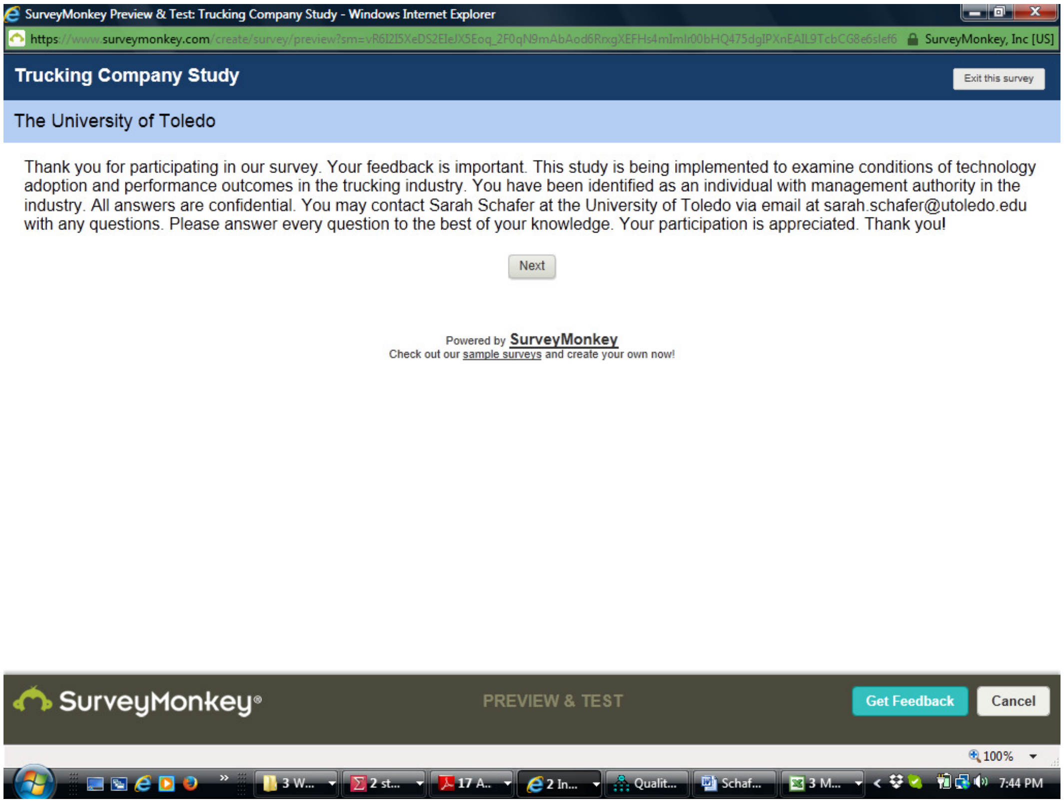


Figure A3: Survey Thank You and Introduction Page

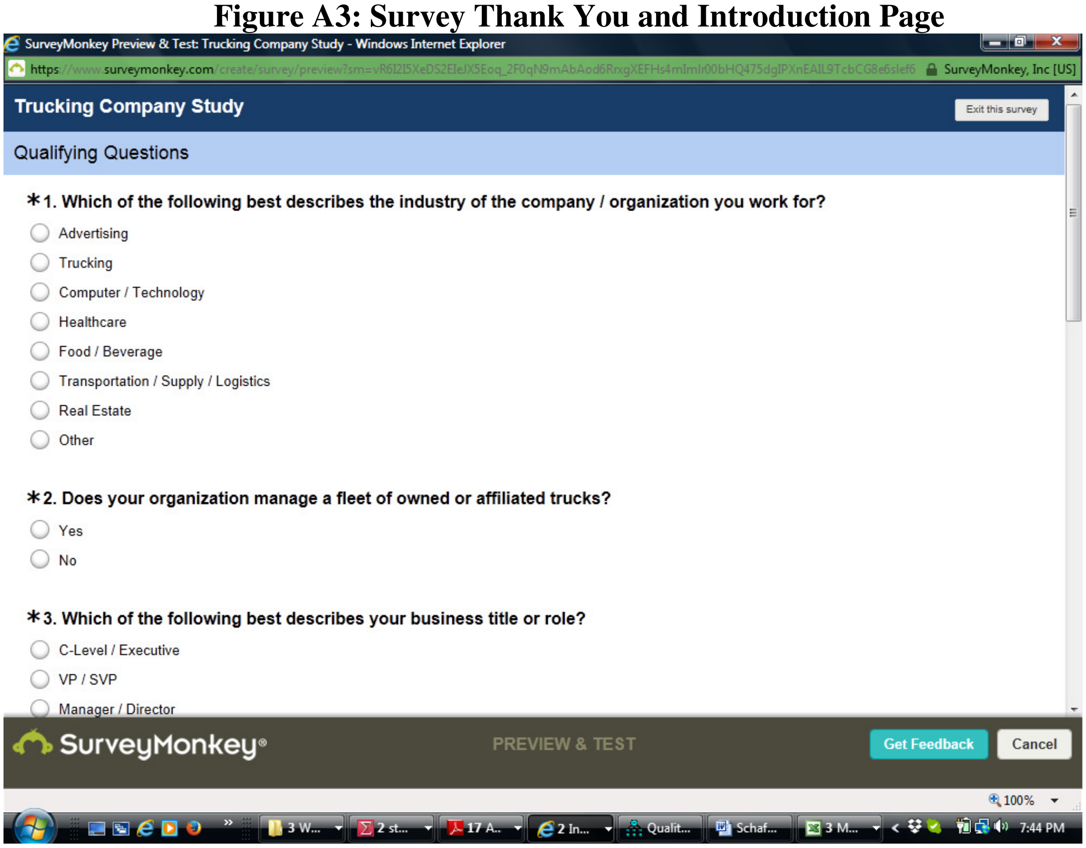


Figure A4: Qualifying Questions 1 and 2

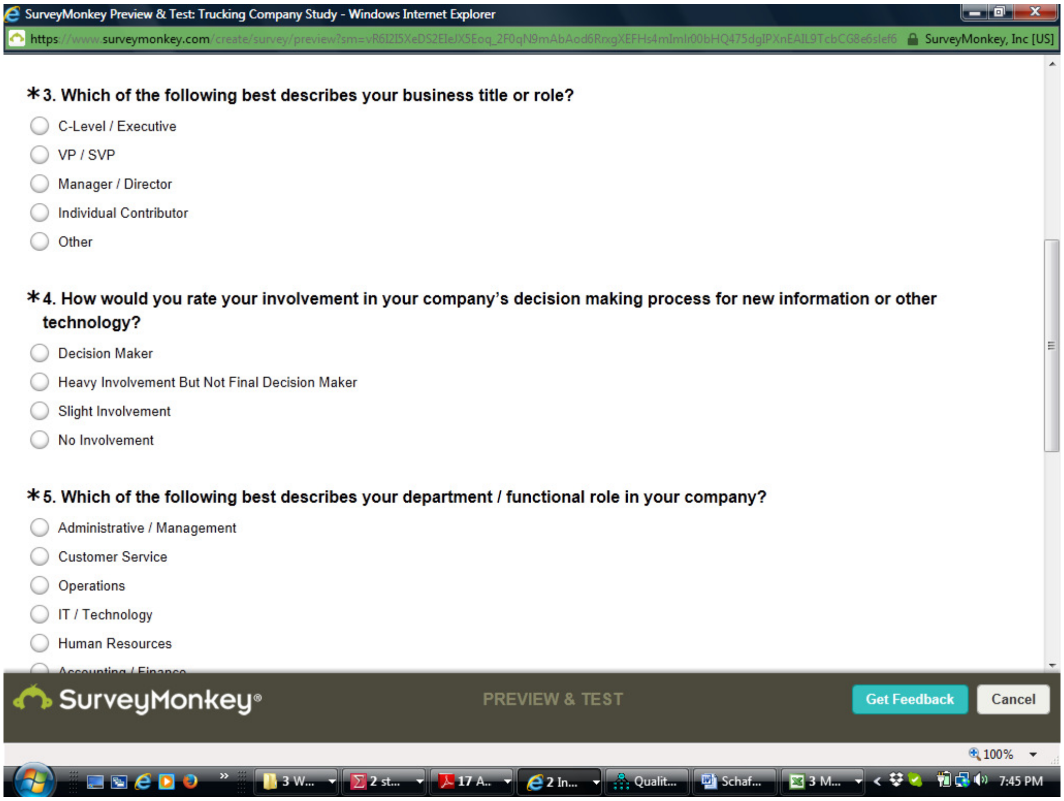


Figure A5: Questions 3 & 4

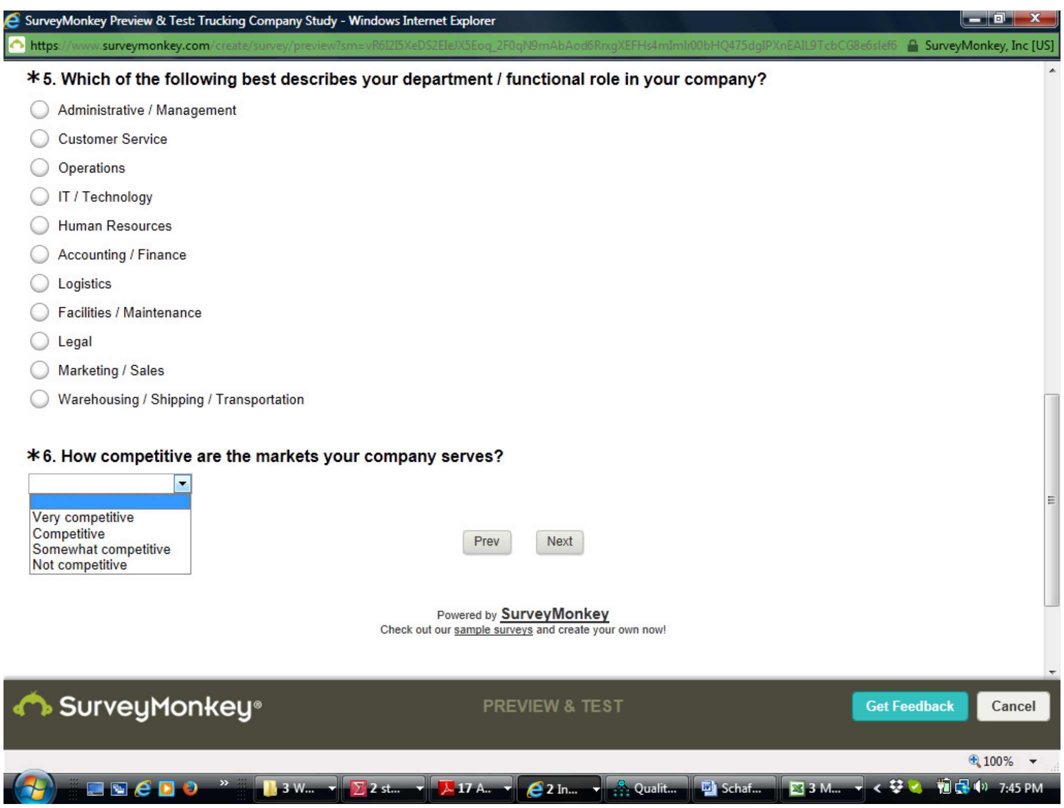


Figure A6: Questions 5 & 6

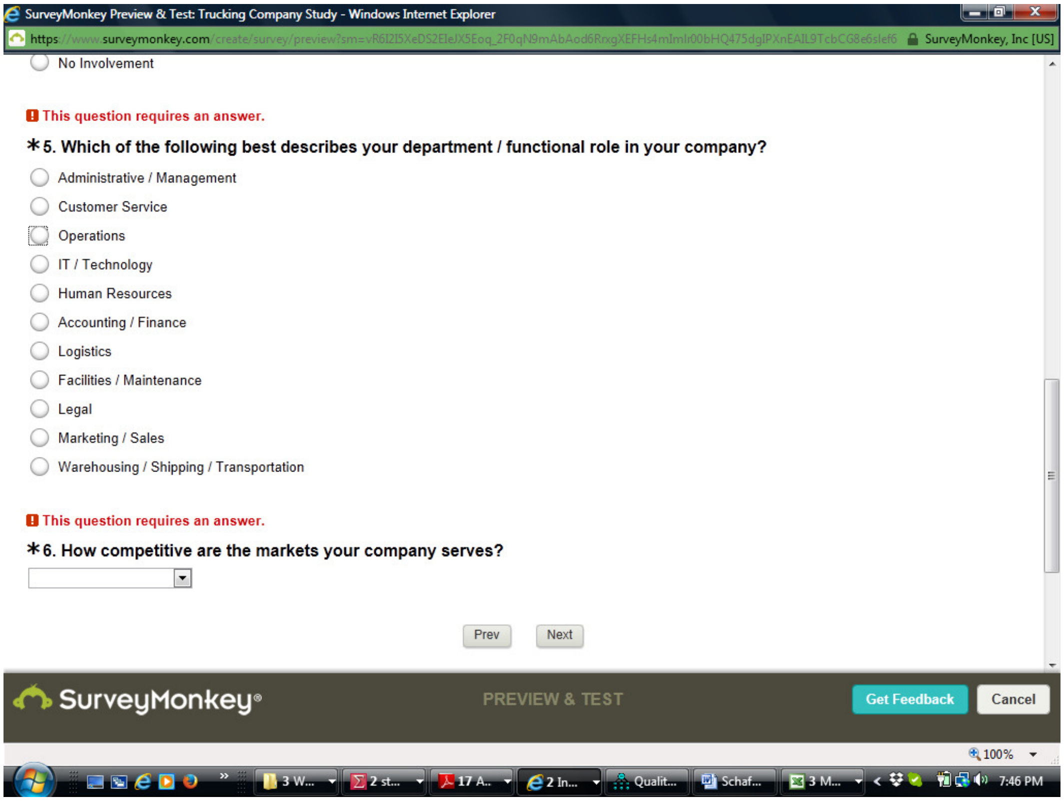


Figure A7: Questions 5 & 6 (with answer requirement message)

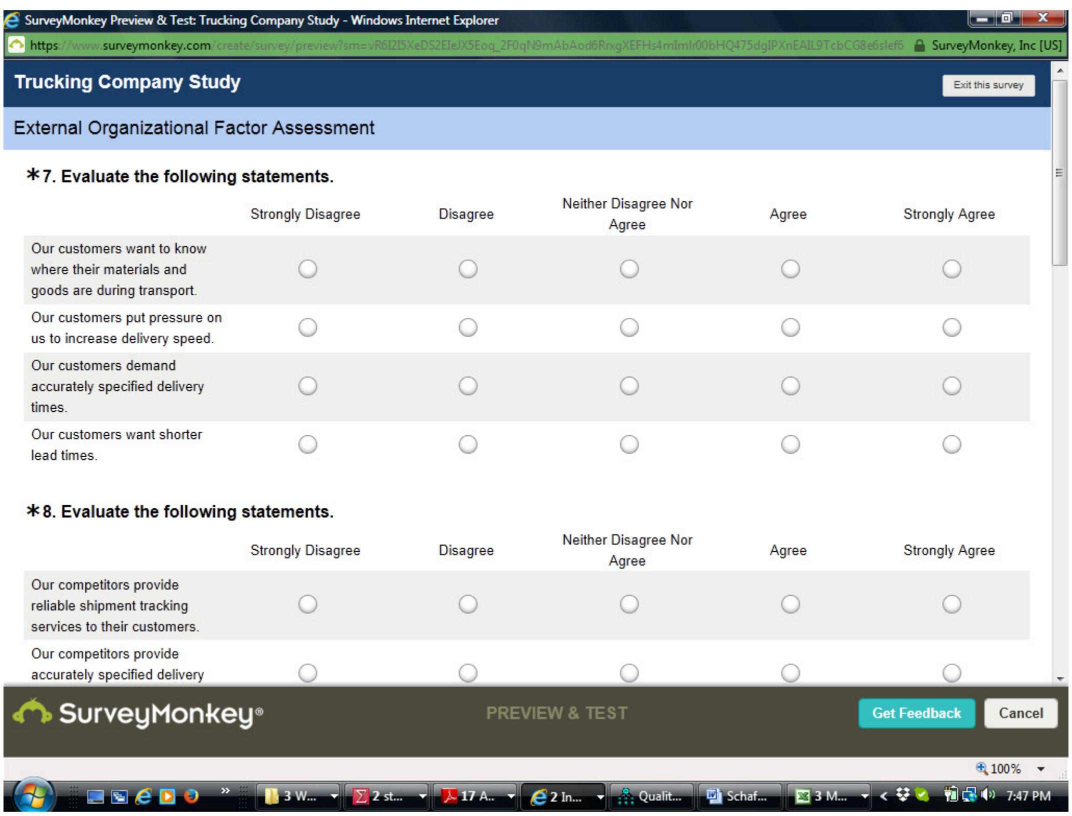
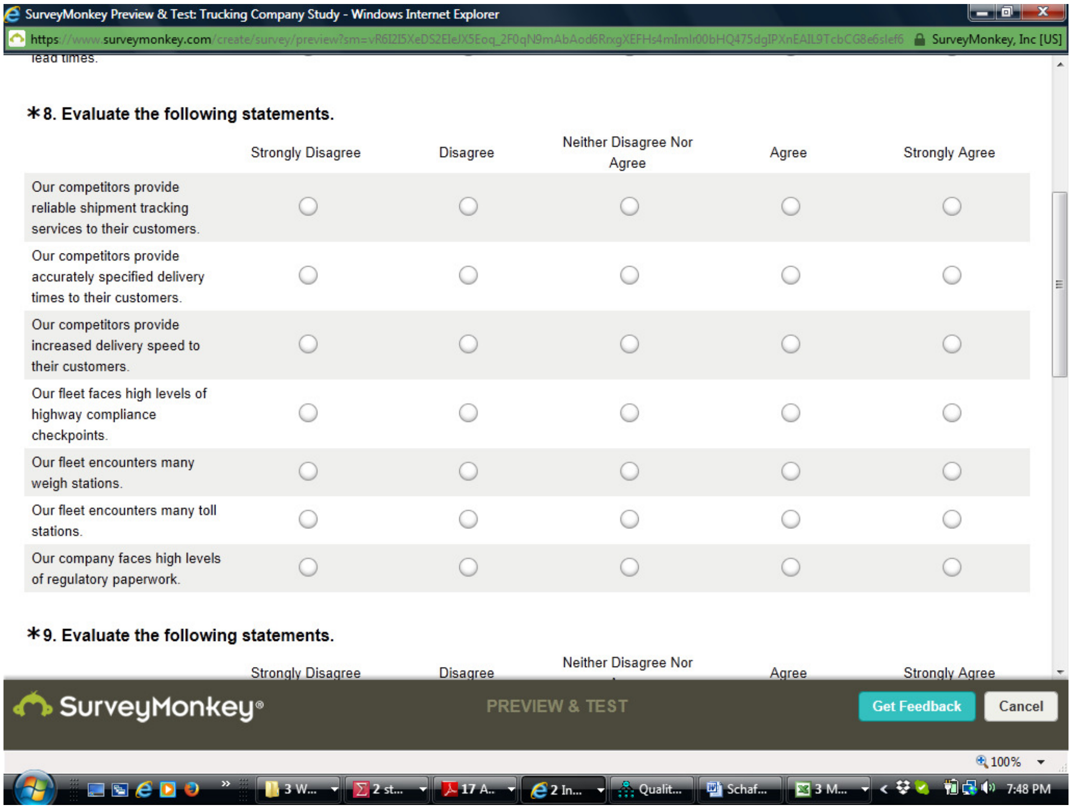


Figure A8: Questions 7 & 8



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lead times.

***8. Evaluate the following statements.**

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Our competitors provide reliable shipment tracking services to their customers.	○	○	○	○	○
Our competitors provide accurately specified delivery times to their customers.	○	○	○	○	○
Our competitors provide increased delivery speed to their customers.	○	○	○	○	○
Our fleet faces high levels of highway compliance checkpoints.	○	○	○	○	○
Our fleet encounters many weigh stations.	○	○	○	○	○
Our fleet encounters many toll stations.	○	○	○	○	○
Our company faces high levels of regulatory paperwork.	○	○	○	○	○

***9. Evaluate the following statements.**

Strongly Disagree | Disagree | Neither Disagree Nor | Agree | Strongly Agree

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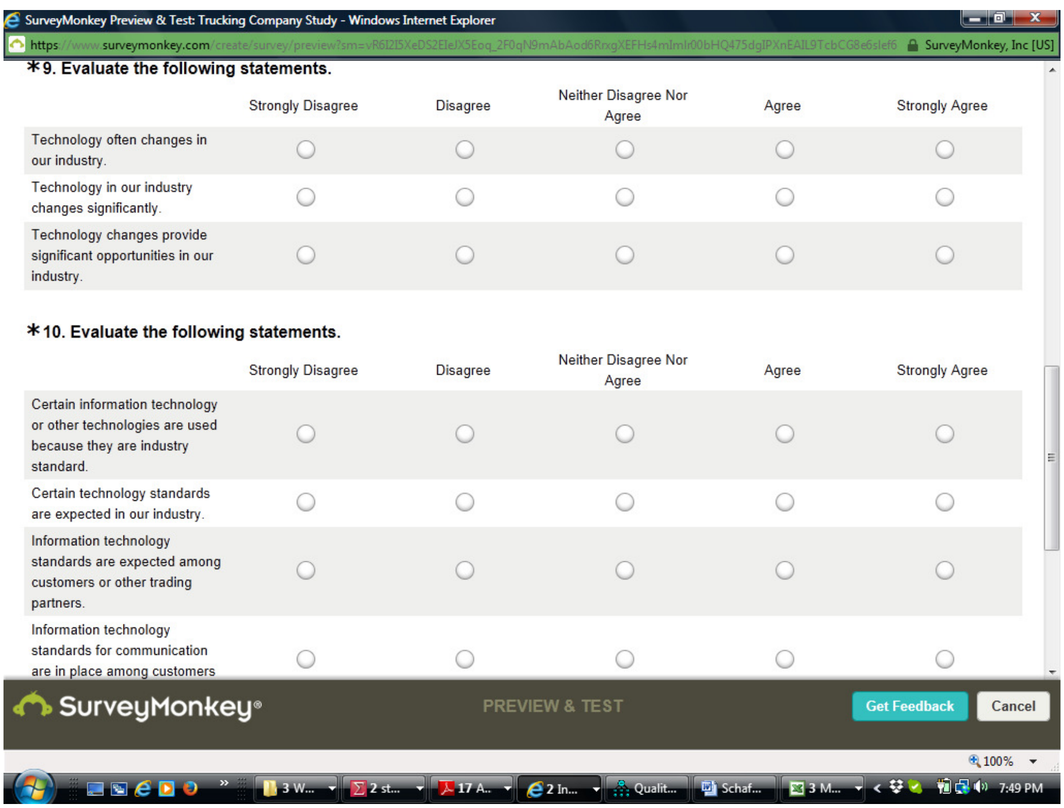
Figure A9: Question 8



SurveyMonkey Preview & Test: Trucking Company Study - Windows Internet Explorer

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***9. Evaluate the following statements.**

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Technology often changes in our industry.	○	○	○	○	○
Technology in our industry changes significantly.	○	○	○	○	○
Technology changes provide significant opportunities in our industry.	○	○	○	○	○

***10. Evaluate the following statements.**

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Certain information technology or other technologies are used because they are industry standard.	○	○	○	○	○
Certain technology standards are expected in our industry.	○	○	○	○	○
Information technology standards are expected among customers or other trading partners.	○	○	○	○	○
Information technology standards for communication are in place among customers	○	○	○	○	○

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Figure A10: Questions 9 & 10

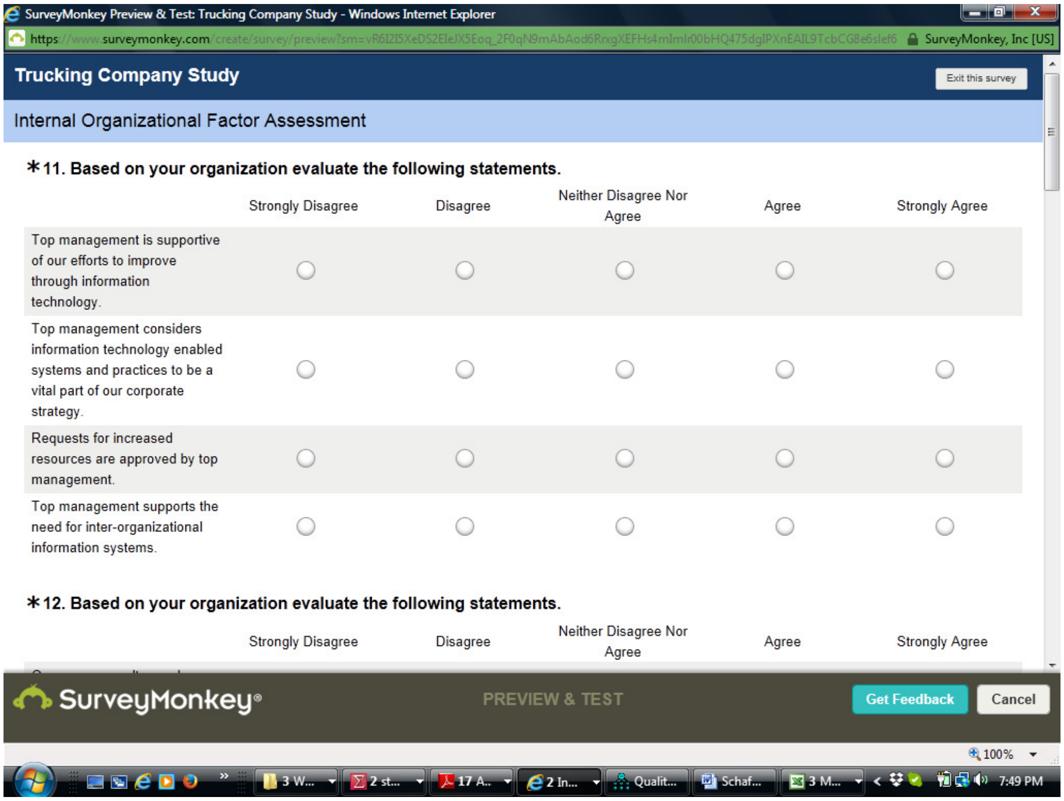


Figure A11: Question 11

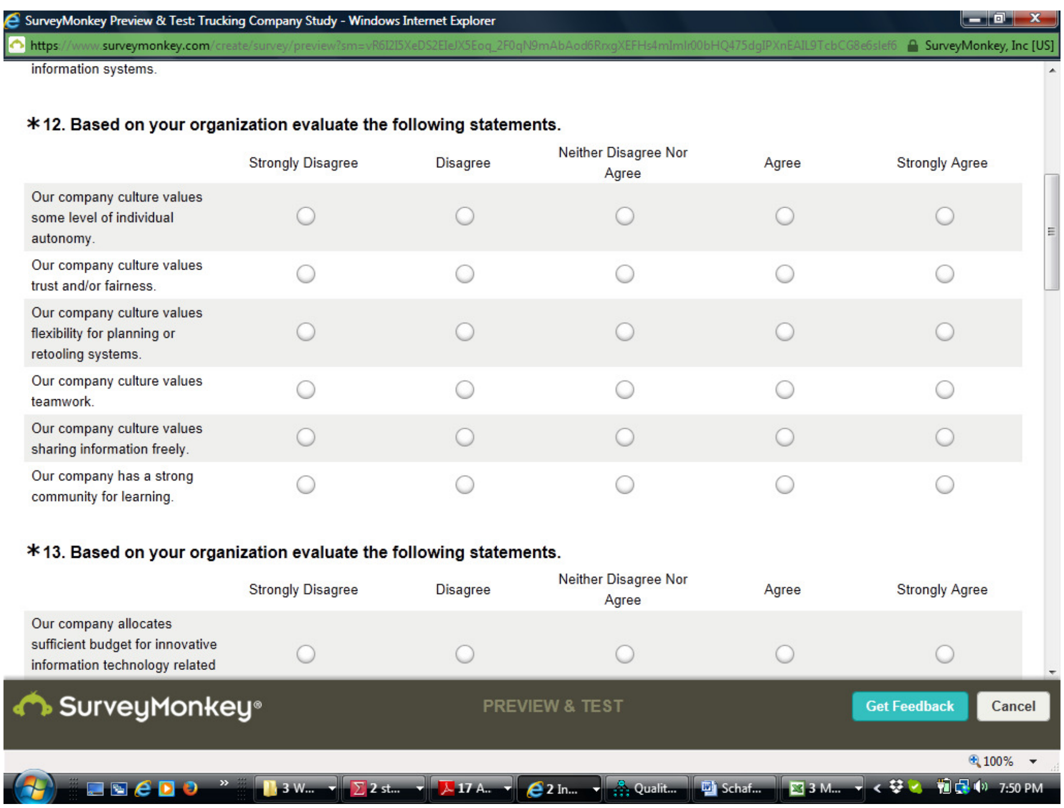


Figure A12: Question 12

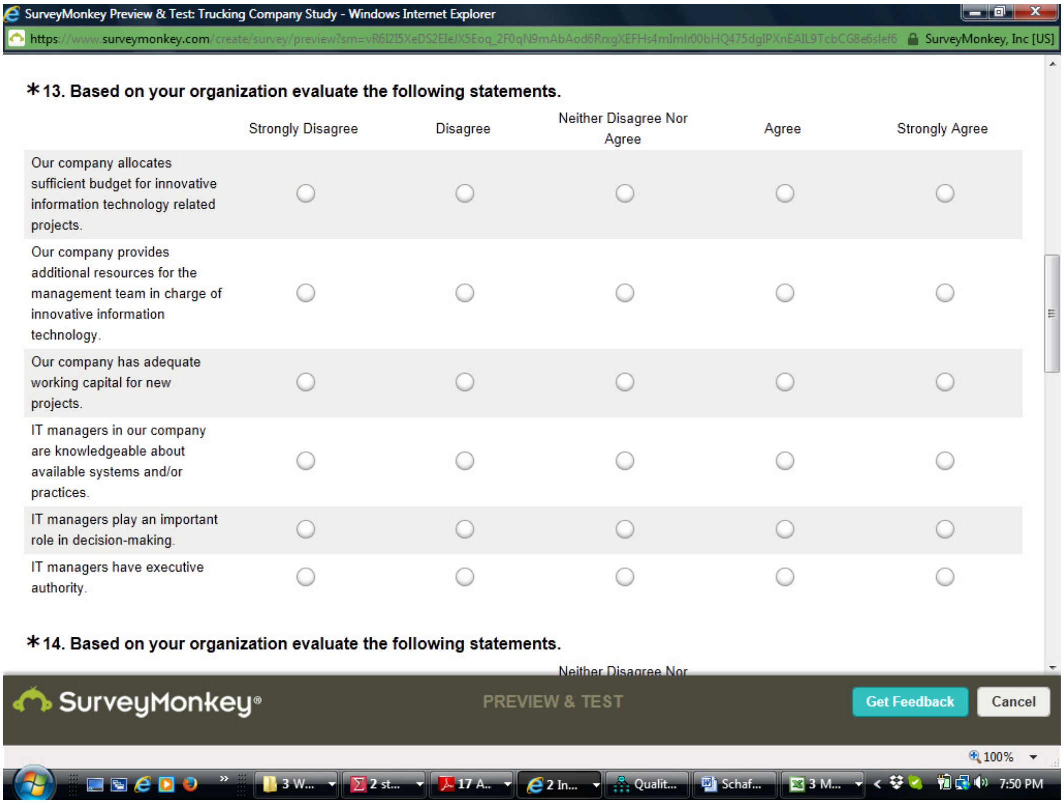


Figure A13: Question 13

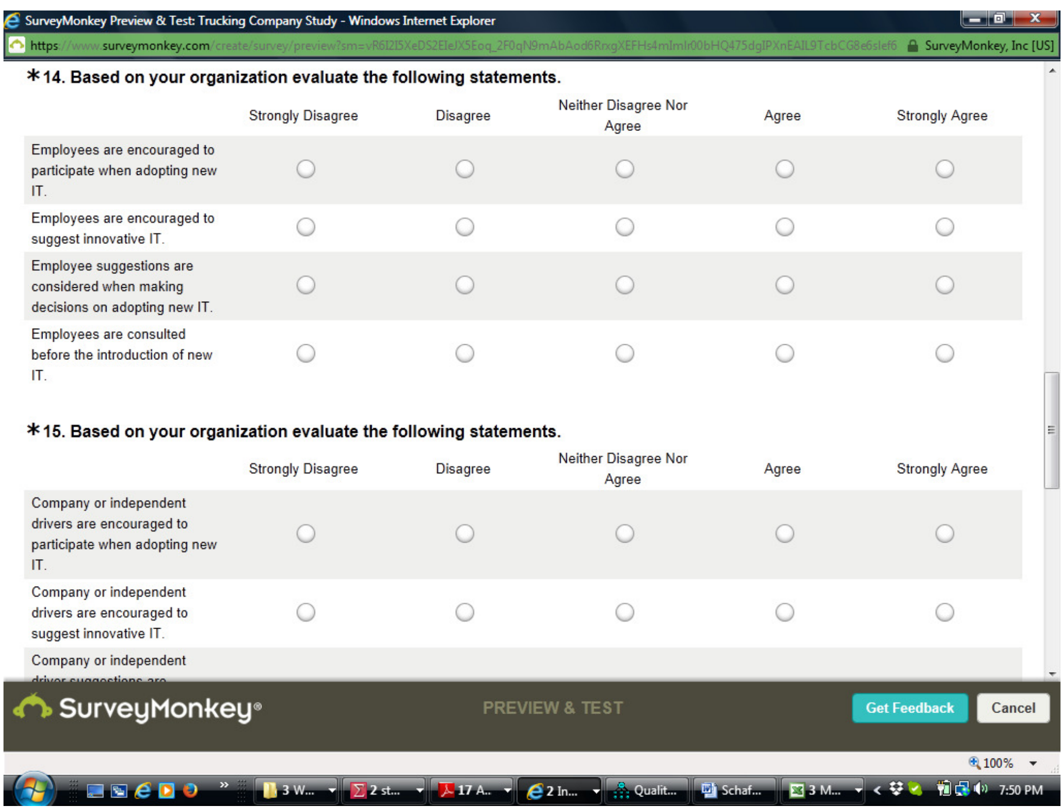


Figure A14: Question 14

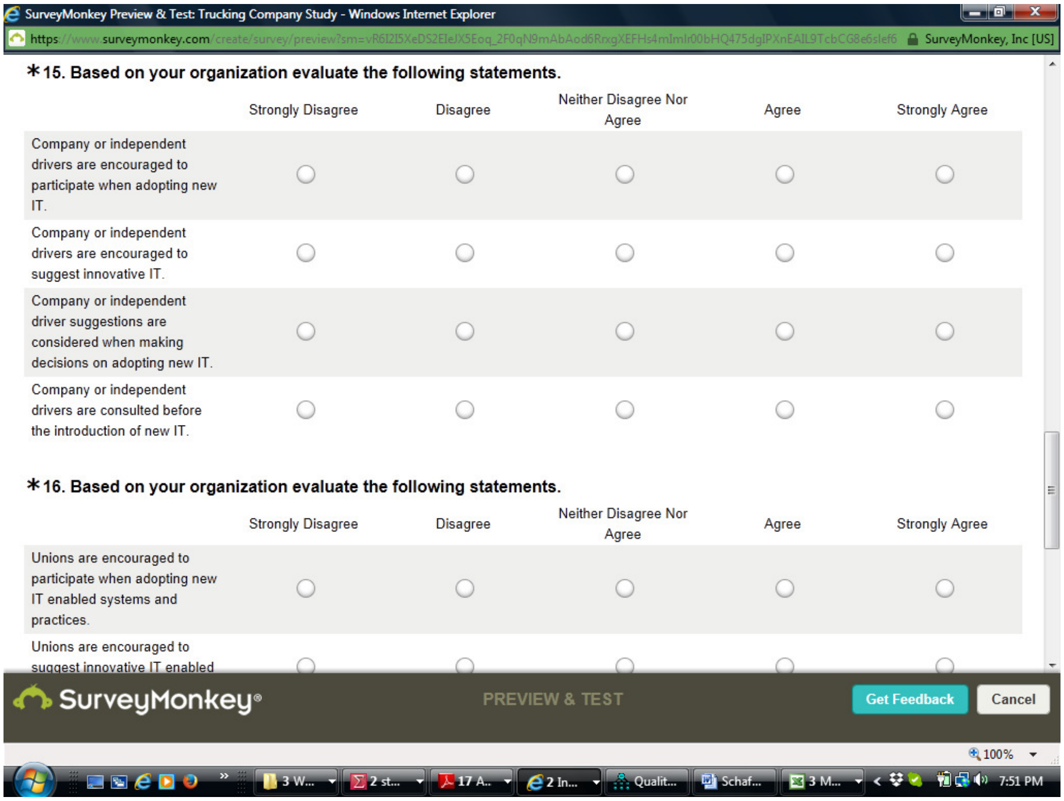


Figure A15: Question 15

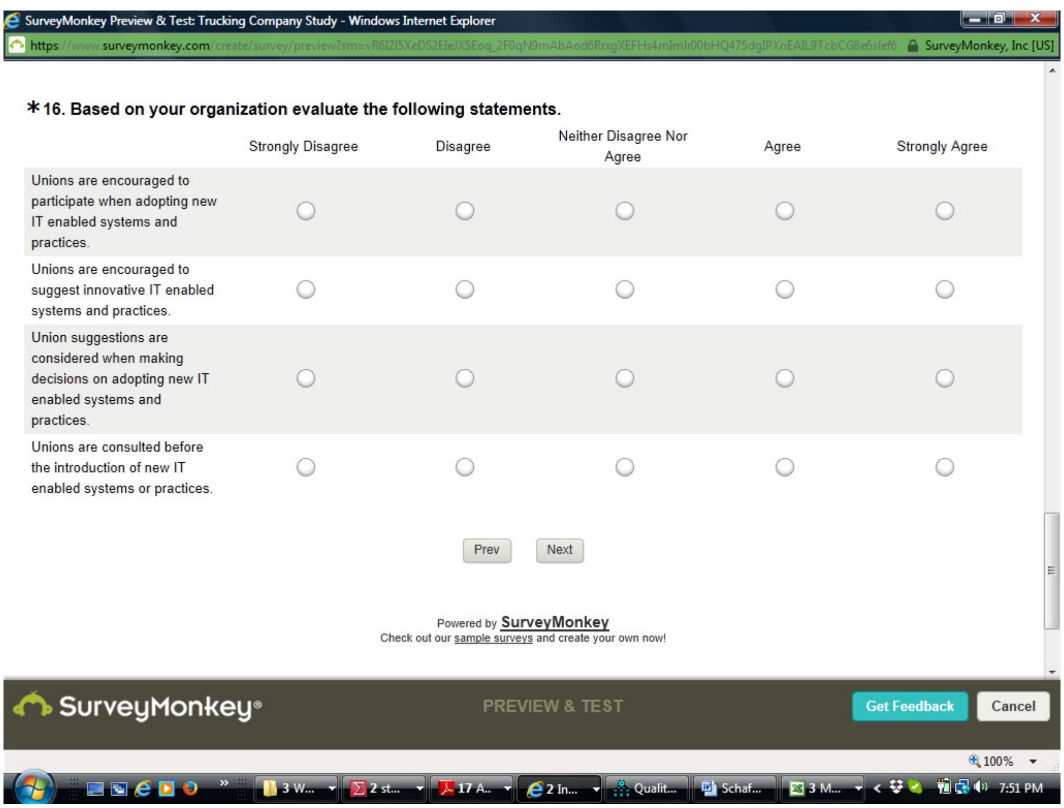


Figure A16: Question 16

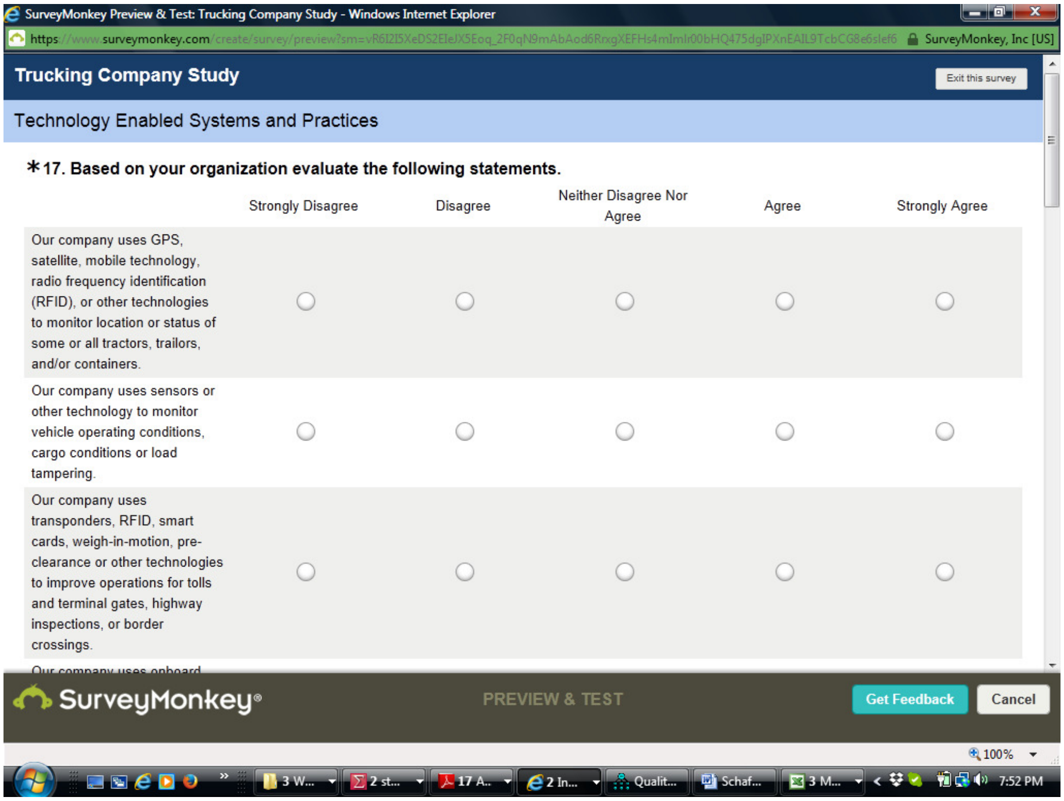


Figure A17: Question 17

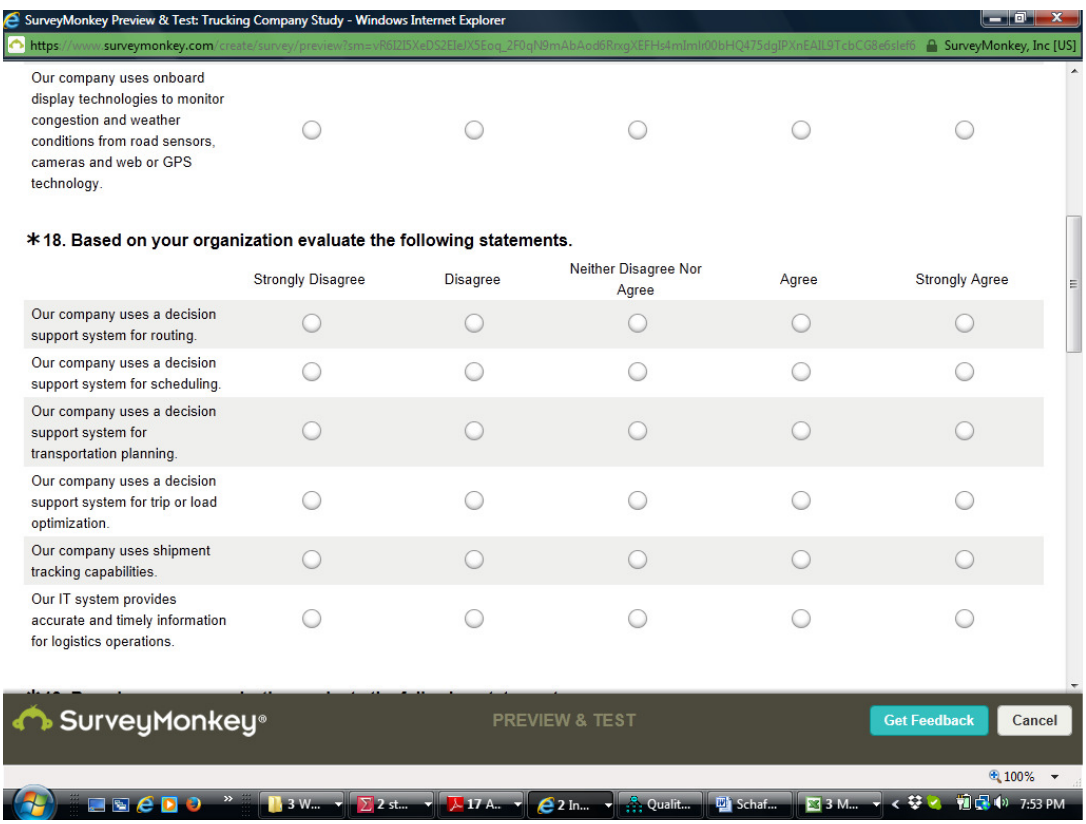
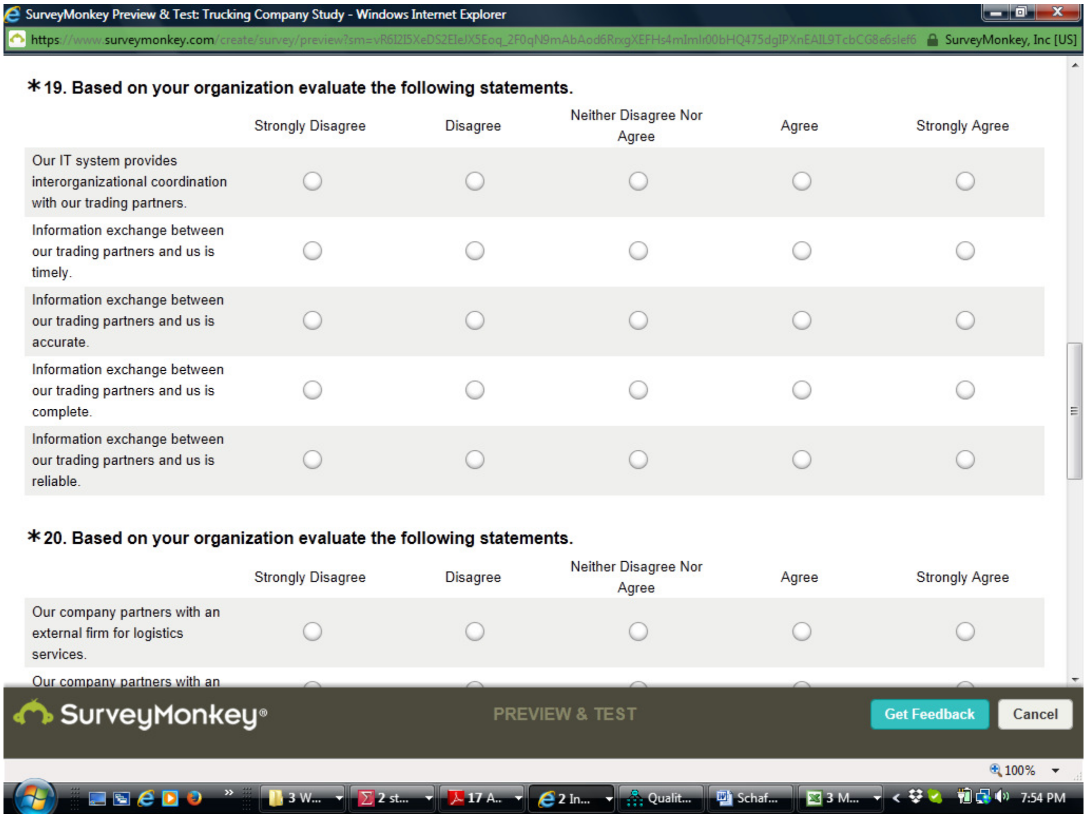


Figure A18: Question 18



SurveyMonkey Preview & Test: Trucking Company Study - Windows Internet Explorer

***19. Based on your organization evaluate the following statements.**

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Our IT system provides interorganizational coordination with our trading partners.					
Information exchange between our trading partners and us is timely.					
Information exchange between our trading partners and us is accurate.					
Information exchange between our trading partners and us is complete.					
Information exchange between our trading partners and us is reliable.					

***20. Based on your organization evaluate the following statements.**

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Our company partners with an external firm for logistics services.					
Our company partners with an					

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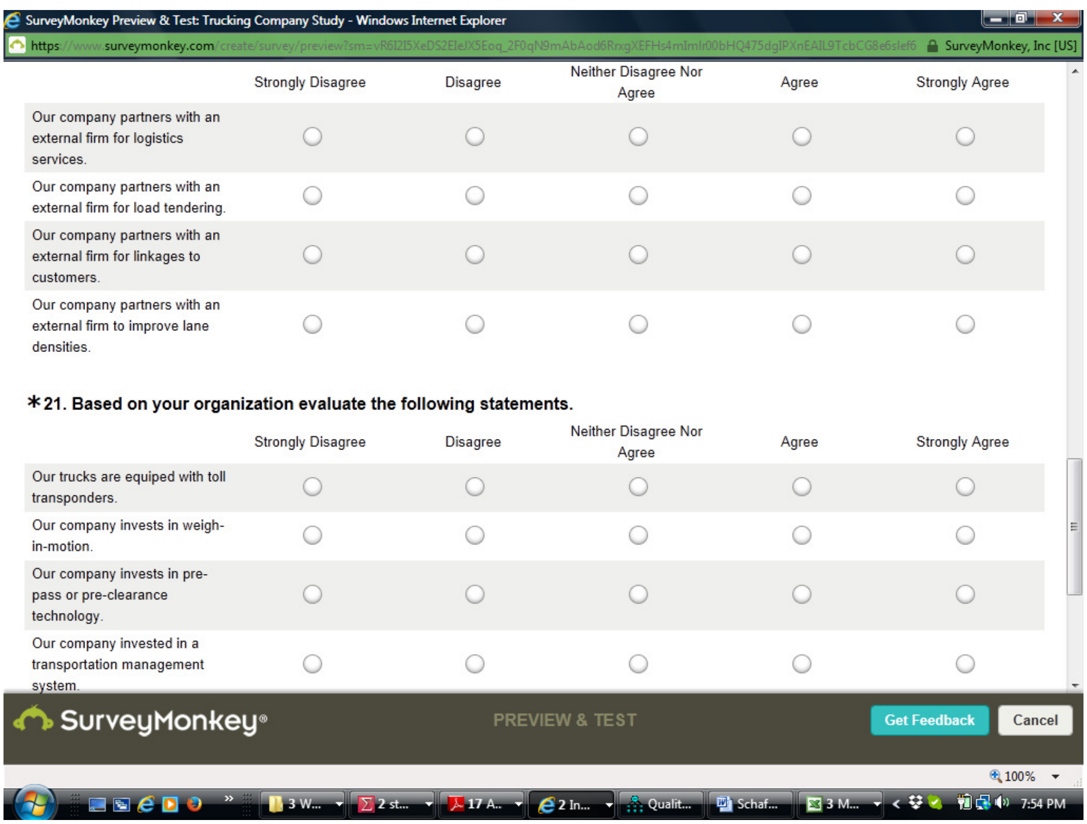
Figure A19: Question 19



SurveyMonkey Preview & Test: Trucking Company Study - Windows Internet Explorer

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Our company partners with an external firm for logistics services.					
Our company partners with an external firm for load tendering.					
Our company partners with an external firm for linkages to customers.					
Our company partners with an external firm to improve lane densities.					

***21. Based on your organization evaluate the following statements.**

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Our trucks are equiped with toll transponders.					
Our company invests in weigh-in-motion.					
Our company invests in pre-pass or pre-clearance technology.					
Our company invested in a transportation management system.					

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Figure A20: Questions 20 & 21

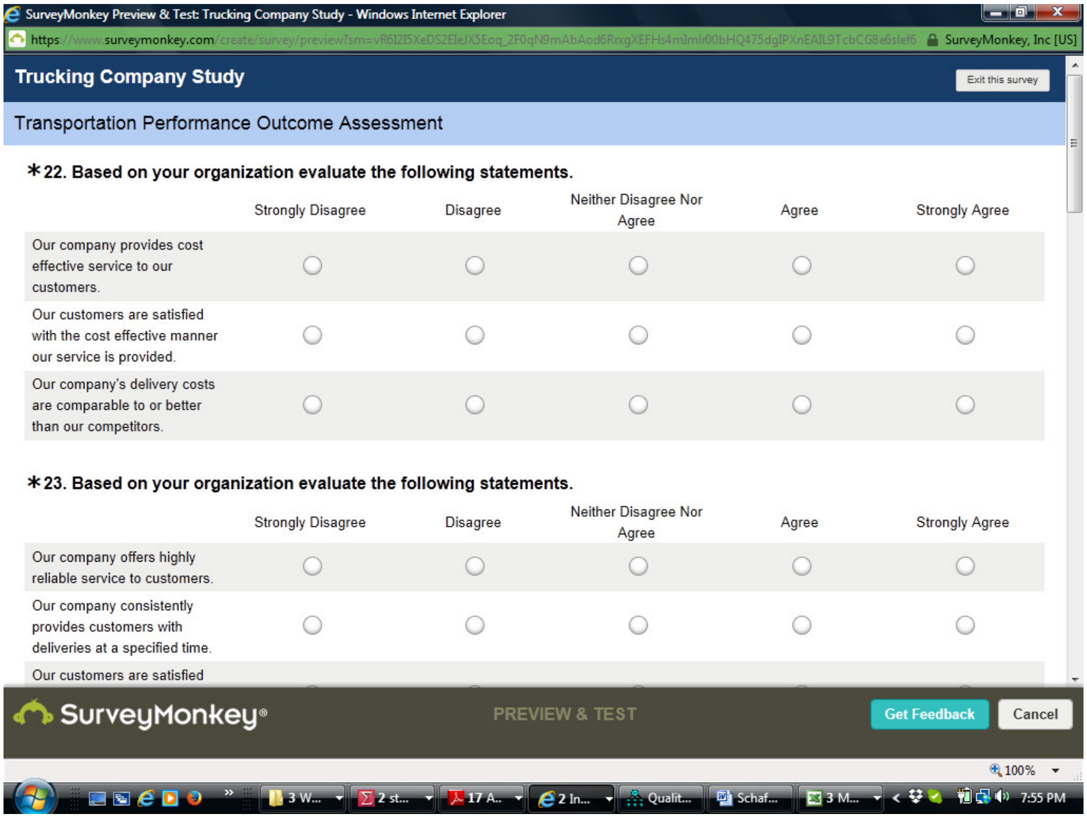

Figure A21: Question 22

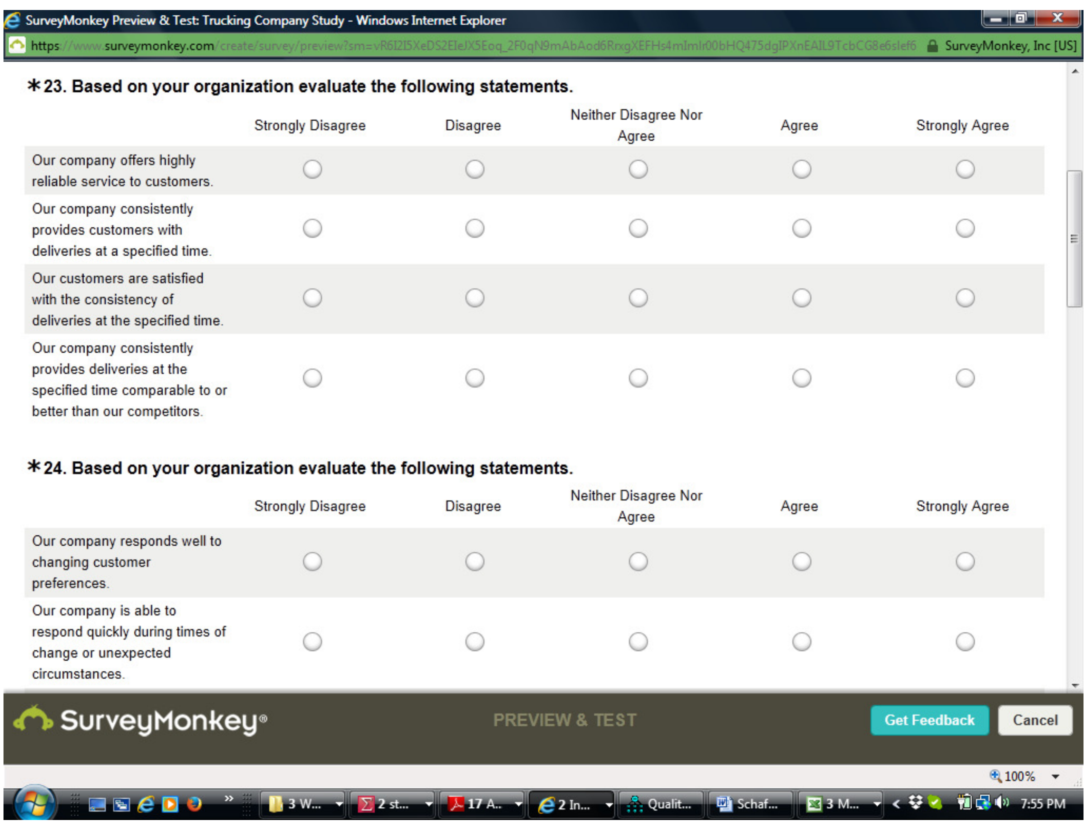

Figure A22: Question 23

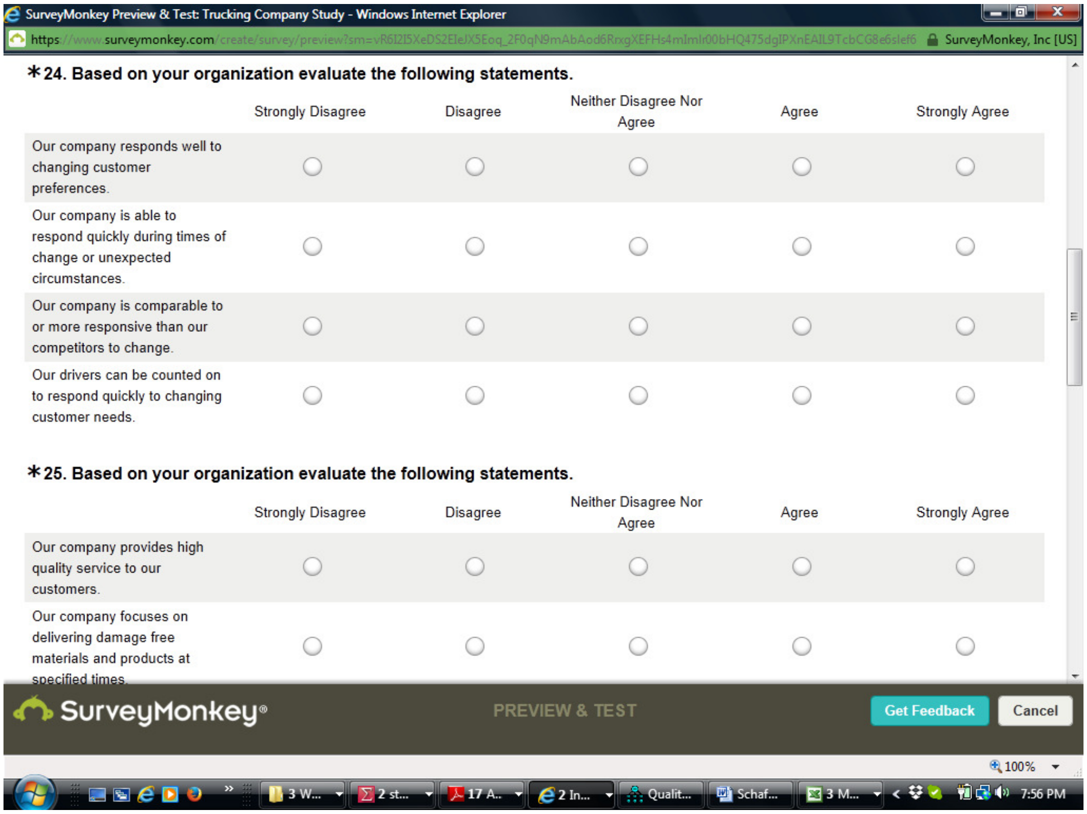

Figure A23: Question 24

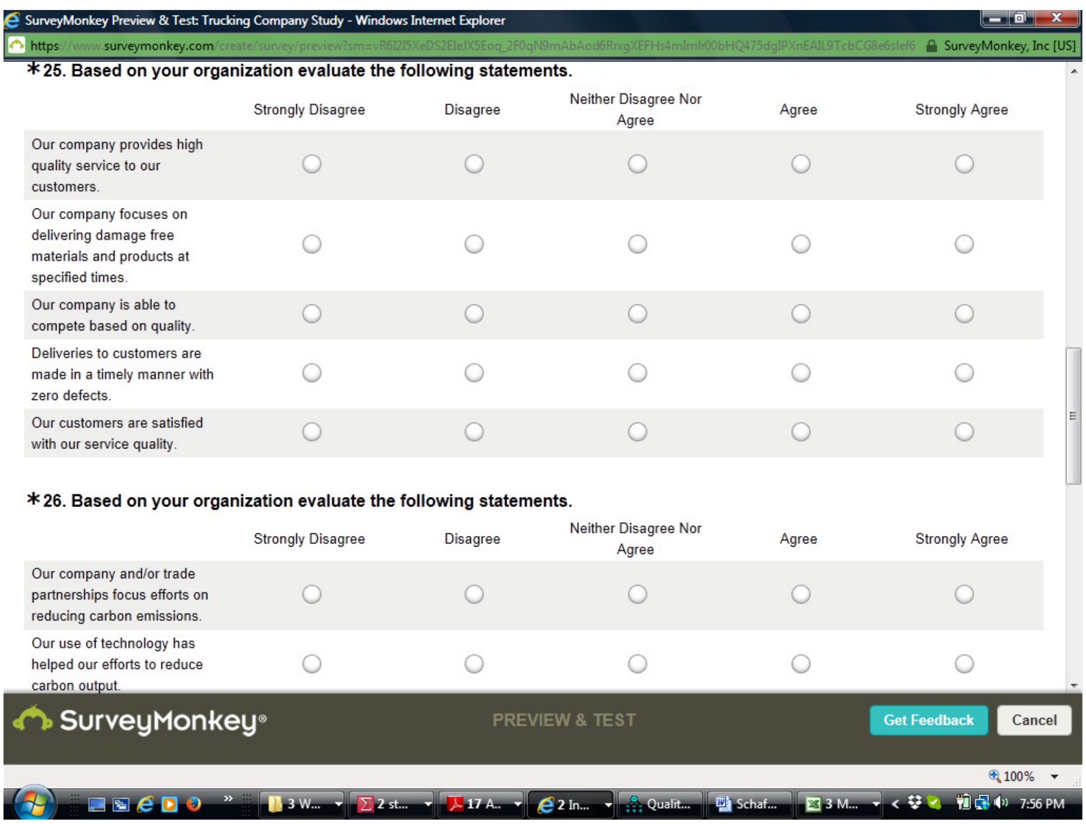

Figure A24: Question 25

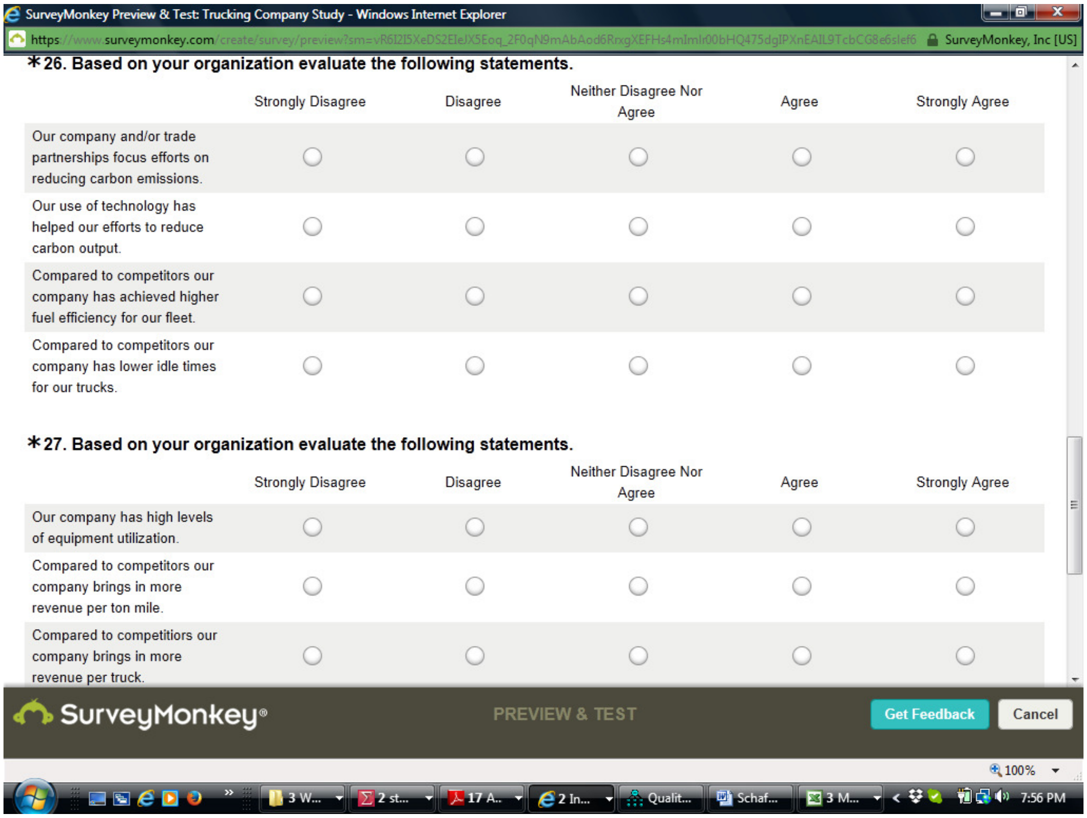

Figure A25: Question 26

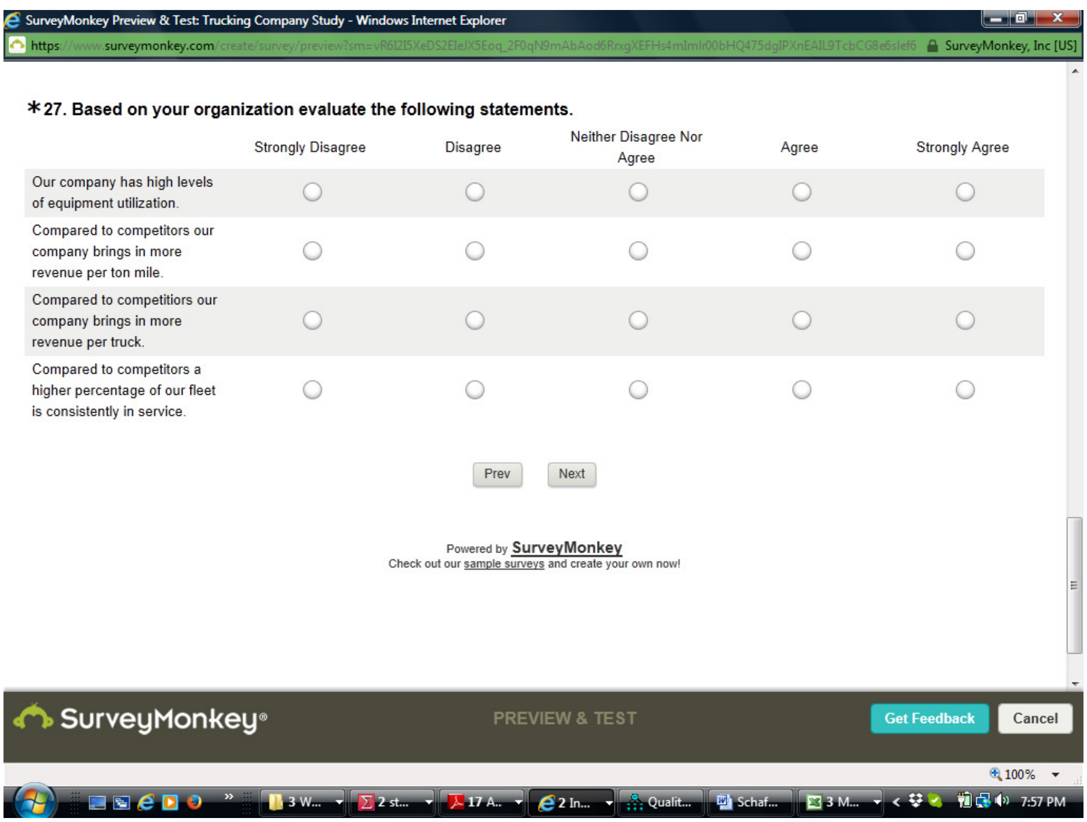

Figure A26: Question 27

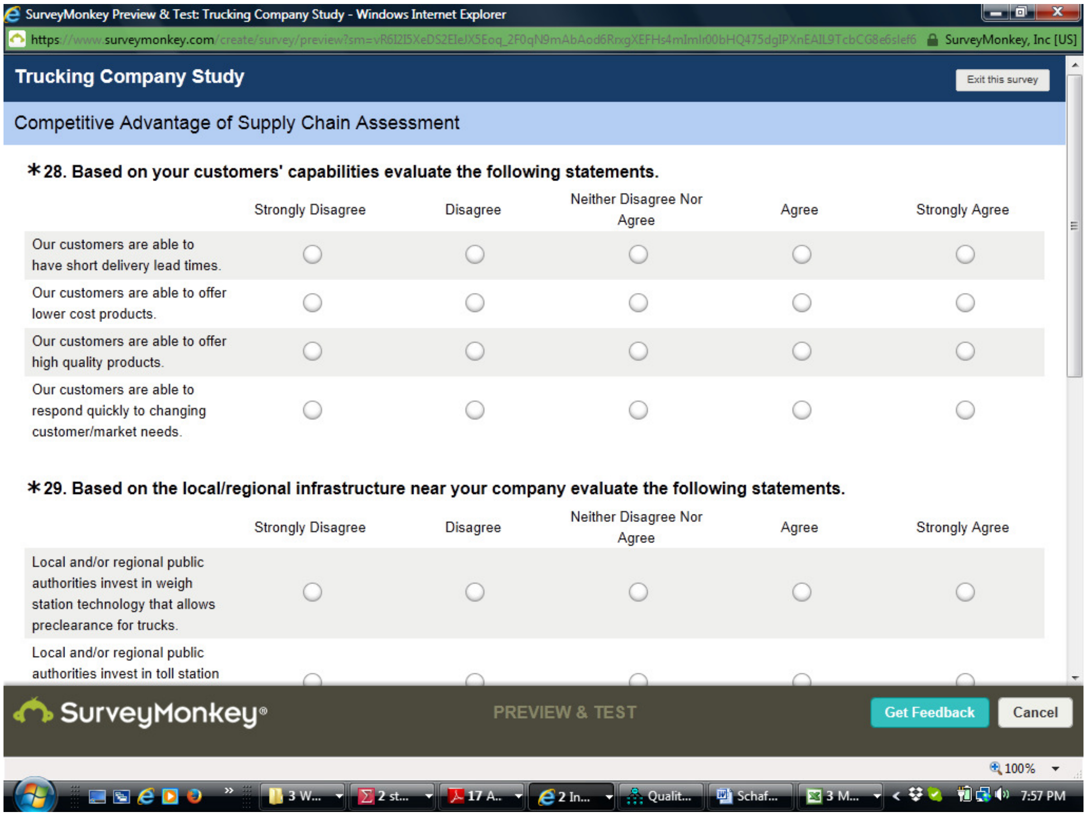

Figure A27: Questions 28 and 29

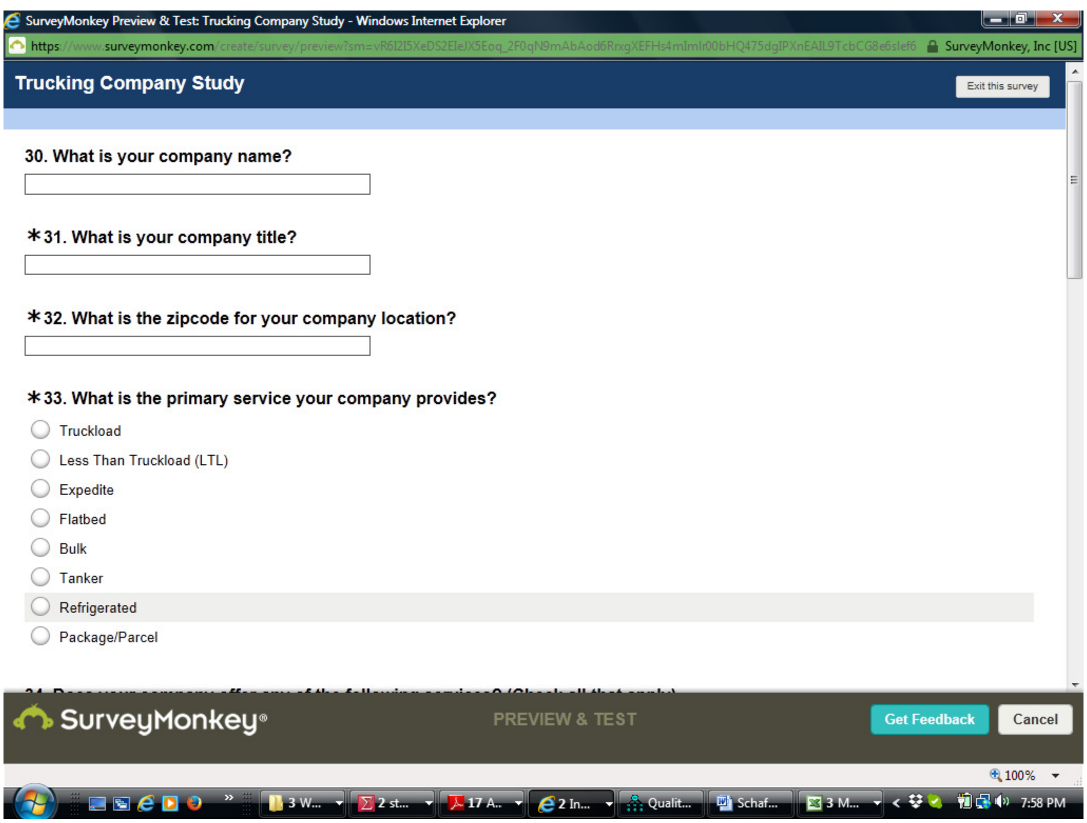

Figure A28: Demographic Questions 30-33

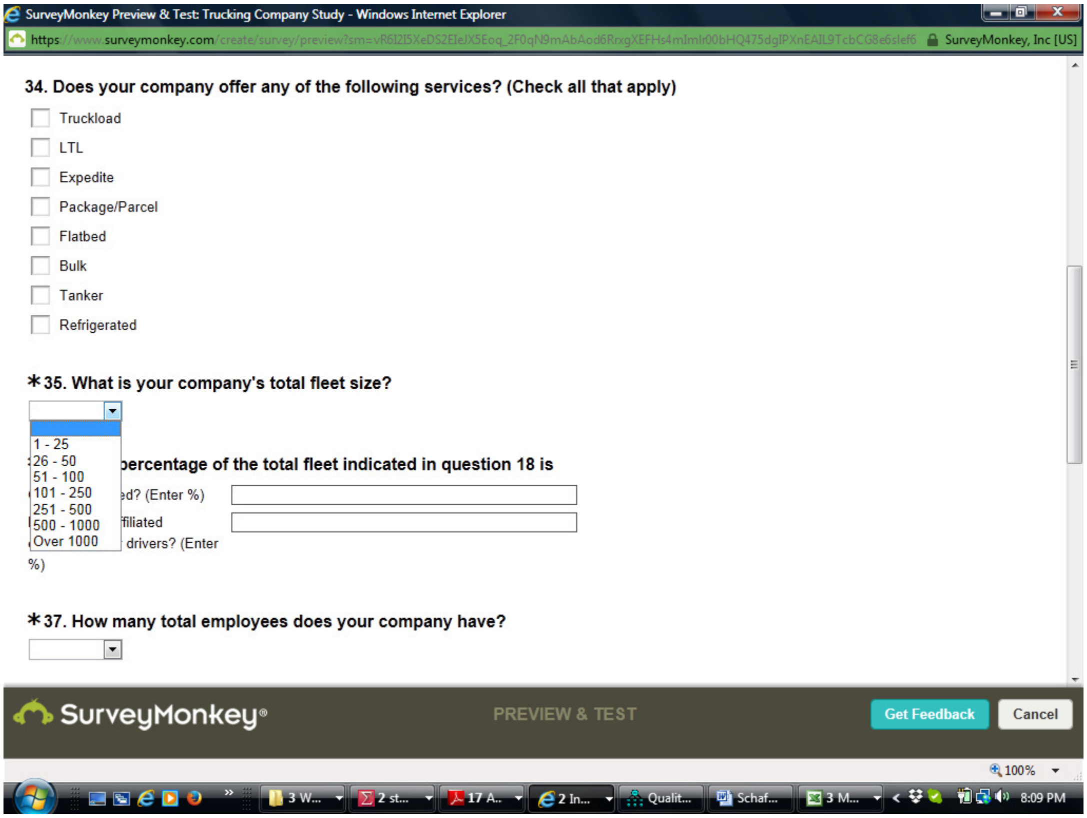

Figure A29: Demographic Questions 34-37

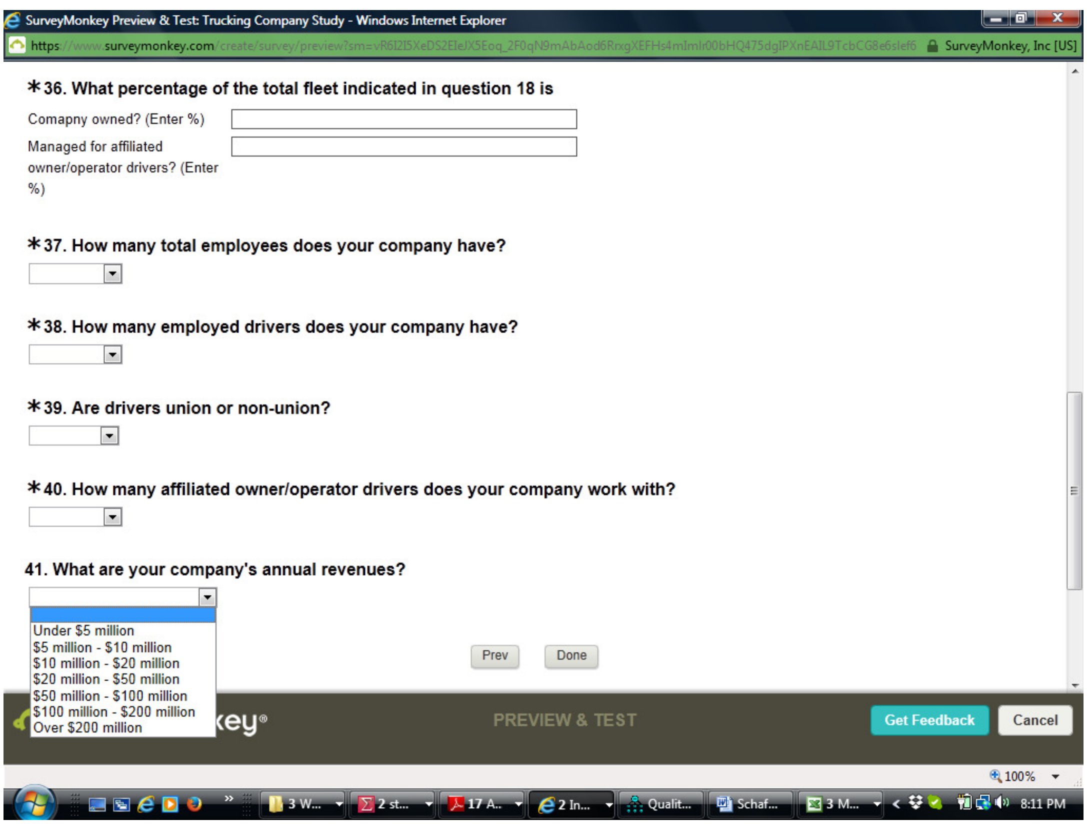

Figure A30: Demographic Questions 36 - 41

The University of Toledo

Thank you for participating in our survey. Your feedback is important. This study is being implemented to examine conditions of technology adoption and performance outcomes in the trucking industry. You have been identified as an individual with management authority in the industry. All answers are confidential. You may contact Sarah Schafer at the University of Toledo via email at sarah.schafer@utoledo.edu with any questions. Please answer every question to the best of your knowledge. Your participation is appreciated. Thank you!

Qualifying Questions

***1. Which of the following best describes the industry of the company / organization you work for?**

- ○ Advertising
- ○ Trucking
- ○ Computer / Technology
- ○ Healthcare
- ○ Food / Beverage
- ○ Transportation / Supply / Logistics
- ○ Real Estate
- ○ Other

***2. Does your organization manage a fleet of owned or affiliated trucks?**

- ○ Yes
- ○ No

***3. Which of the following best describes your business title or role?**

- ○ C-Level / Executive
- ○ VP / SVP
- ○ Manager / Director
- ○ Individual Contributor
- ○ Other

***4. How would you rate your involvement in your company's decision making process for new information or other technology?**

- ○ Decision Maker
- ○ Heavy Involvement But Not Final Decision Maker
- ○ Slight Involvement
- ○ No Involvement

Figure A31: Sample Survey Page in PDF Format

*** 8. Evaluate the following statements.**

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Our competitors provide reliable shipment tracking services to their customers.					
Our competitors provide accurately specified delivery times to their customers.					
Our competitors provide increased delivery speed to their customers.					
Our fleet faces high levels of highway compliance checkpoints.					
Our fleet encounters many weigh stations.					
Our fleet encounters many toll stations.					
Our company faces high levels of regulatory paperwork.					

*** 9. Evaluate the following statements.**

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Technology often changes in our industry.					
Technology in our industry changes significantly.					
Technology changes provide significant opportunities in our industry.					

Figure A32: Sample Survey Page in PDF Format

***10. Evaluate the following statements.**

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Certain information technology or other technologies are used because they are industry standard.	○	○	○	○	○
Certain technology standards are expected in our industry.	○	○	○	○	○
Information technology standards are expected among customers or other trading partners.	○	○	○	○	○
Information technology standards for communication are in place among customers or other trading partners.	○	○	○	○	○

Internal Organizational Factor Assessment

***11. Based on your organization evaluate the following statements.**

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Top management is supportive of our efforts to improve through information technology.	○	○	○	○	○
Top management considers information technology enabled systems and practices to be a vital part of our corporate strategy.	○	○	○	○	○
Requests for increased resources are approved by top management.	○	○	○	○	○
Top management supports the need for inter-organizational information systems.	○	○	○	○	○

Figure A33: Sample Survey Page in PDF Format – Showing Separated Question Sections

Appendix B

SMART PLS Structural Equation Model and Statistical Power Calculator

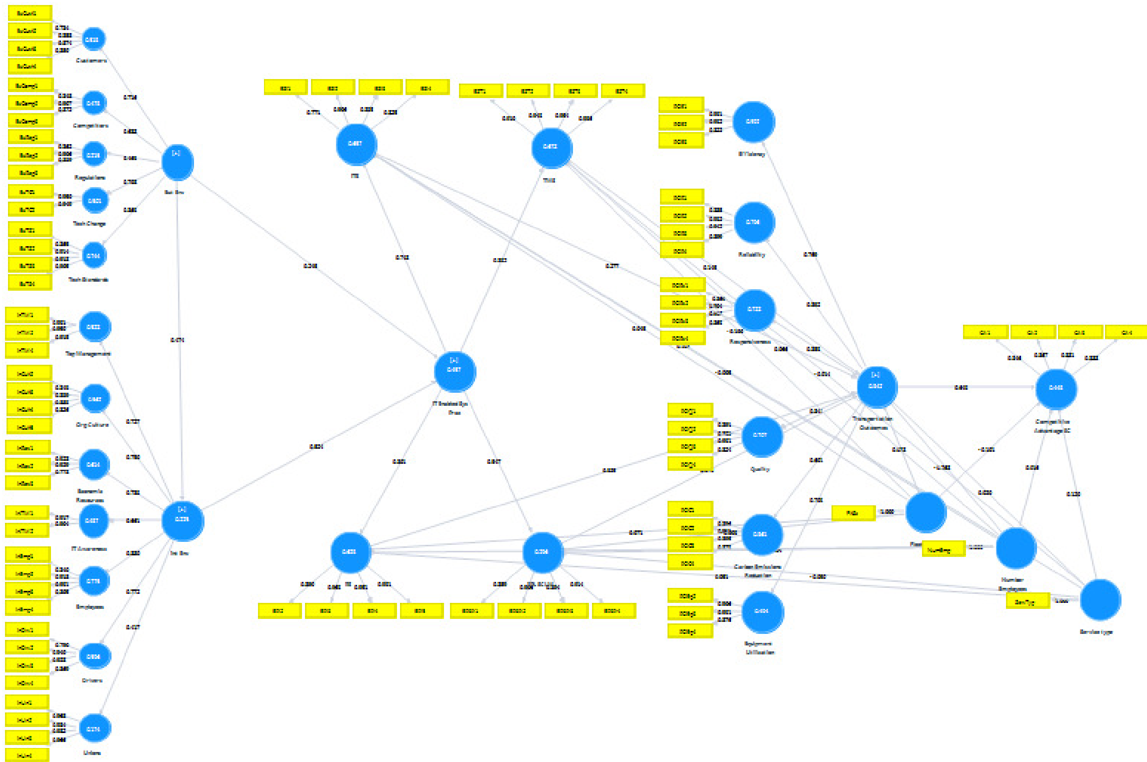

Figure B1: Structural Model – Path Coefficients
(controls included for service type, fleet size, and number of employees)

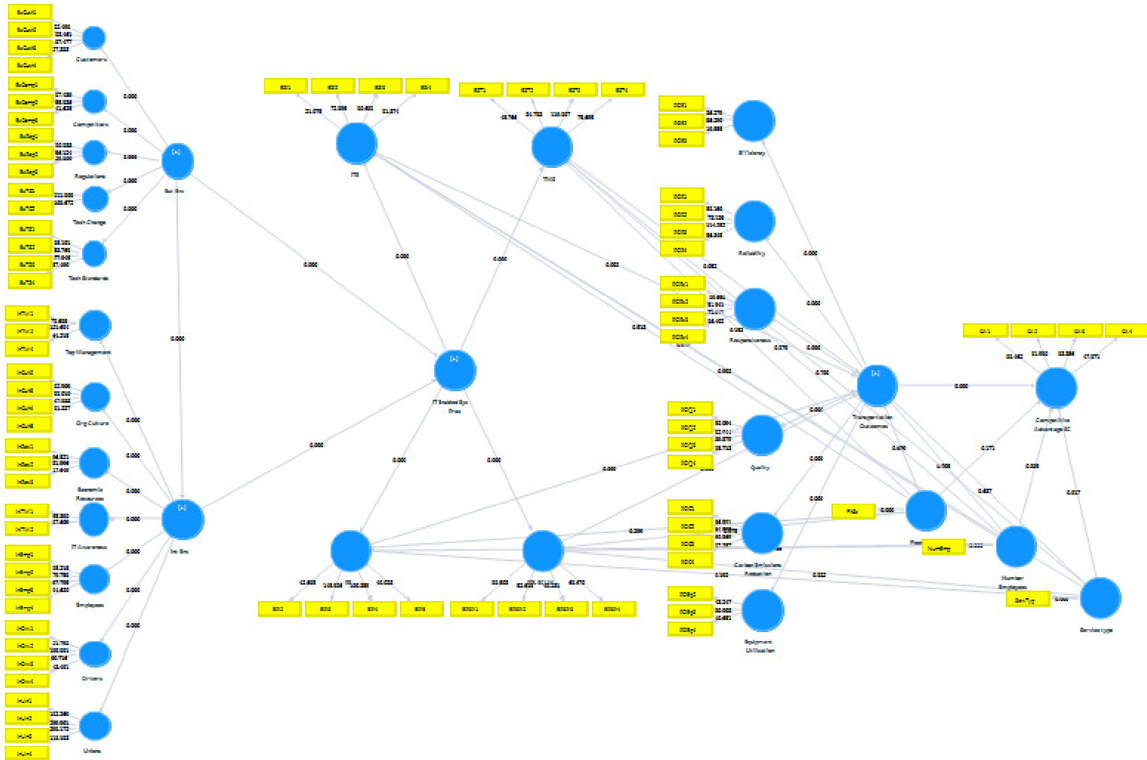

Figure B2: Structural Model - Bootstrap Output with T-statistics (controls included for service type, fleet size, and number of employees)

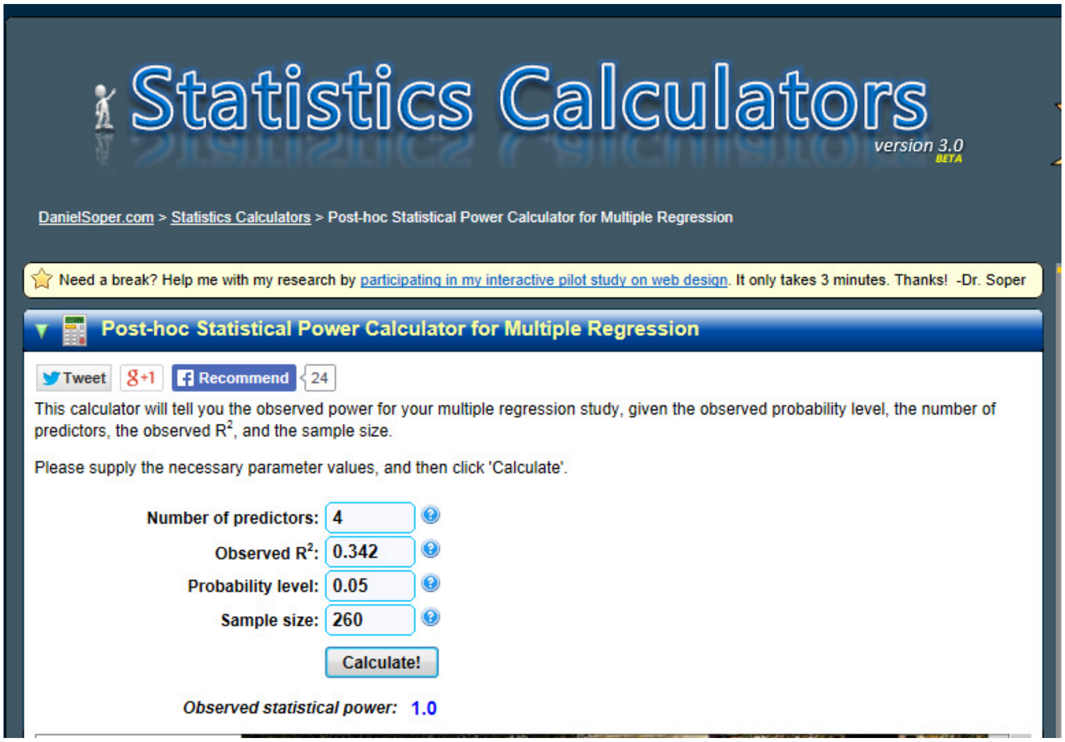

Figure B3: Statistical Power Calculator

(Source: http://www.danielsoper.com/statcalc3/calc.aspx?id=9)