An Empirical Analysis of Factors Affecting Autonomous Truck Adoption

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An Empirical Analysis of Factors Affecting Autonomous Truck Adoption

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A Dissertation Submitted to the Graduate School at the University of Missouri – St. Louis in partial fulfillment of the requirements for the degree Doctor of Philosophy in Business Administration with an emphasis in Logistics and Supply Chain Management

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Abstract

Autonomous vehicles have the potential to revolutionize the transportation industry. The segment of truck transportation is no exception. Autonomous vehicles have the potential to improve trucking safety, to increase shipping velocity, and to decrease costs. Additionally, autonomous trucks could be an important tool to help alleviate the ongoing driver shortage that the trucking industry is contending with.

Autonomous truck adoption is not guaranteed. Transportation equipment decisions are market-based, and autonomous trucks must present a compelling business case to transportation professionals. As such, it is imperative to understand the decision-making factors that drive transportation solution adoption, and how autonomous trucks could take advantage of those factors to be a competitive force in the transportation marketplace. It is also important to understand the potential effects that autonomous trucks could have on industry as well, so that companies can develop contingency plans to deal with these effects.

This study uses Grounded Theory to analyze semi-structured interviews with twelve professionals from the transportation industry. A conceptual model detailing major factors that affect transportation decisions and propositions about autonomous trucks' effects on industry are presented, along with a discussion. The dissertation concludes with an identification of avenues of future research to further the information uncovered in this study, and to address its limitations.
**Chapter 1 - Introduction**

Autonomous vehicles – those capable of guiding themselves from one location to another without human intervention (Technopedia 2018) – are a potentially disruptive force in the transportation sector. Authors such as Fagnant and Kockelman (2015) believe that private autonomous vehicles could have many benefits for society, such as: increased road safety, lower fuel consumption and emissions, and greater opportunities through mobility-challenged people who must rely on rides or public transportation. Some automakers already offer semi-autonomous features that aid drivers in operating their vehicles, such as Subaru’s (2019) eyesight feature. With the availability of semi-autonomous features on current production vehicles, it is reasonable to assume that in the future a human driver will not be required for vehicle operation (Liedtke and Krishner 2019). Some automotive manufacturers, such as General Motors, are already experimenting with fully autonomous personal vehicles (Wayland 2020).

Autonomous vehicles also have the potential to revolutionize the trucking industry. As with personal vehicles, autonomous trucks could be safer than their human-driven counterparts. The Insurance Institute for Highway Safety (IIHS) estimated that 4000 people were killed in large truck crashes in 2016 (2017), and the National Safety Council (NSC) estimates that driver error is a contributing factor to 94 percent of overall road crashes (NSC 2019). Certainly, not all fatal crashes involving large
trucks are the fault of the truck driver, but autonomous trucks would have the potential to decrease the number of roadway fatalities.

Additionally, autonomous trucks would not be subject to the hours-of-service regulations stipulated by the Federal Motor Carrier Safety Administration (FMCSA), which require that drivers take a mandatory 10-hour rest period after driving for 11 hours (FMCSA 2020). Not having to comply with hours-of-service regulations would allow an autonomous truck to provide a faster service velocity for the shipper.

Autonomous trucks could drive a significant change in the cost of truck transportation. Driver wages and benefits comprise 44 percent of the costs of operating a truck (Robinson 2020). With all else held equal, the elimination of driver wages and benefits from the trucking cost equation could upend the accepted cost structure that underlies the design of ground-based transportation networks.

Finally, autonomous trucks could present a solution to the ongoing driver shortage that affects the trucking industry. Edmonson (2018) estimates that the trucking industry is 50,000 drivers short. Autonomous trucks could help to alleviate, or could eliminate the driver shortage altogether.

Levels of Autonomy

The National Highway Transportation Safety Administration (NHTSA) lists six levels of vehicle autonomy, ranging from Level 0 through Level 6 (NHTSA 2020).
Level 0 is a vehicle with no autonomous features, while levels 1 through 6 have increasing amounts of features (NHTSA 2020). They are:

- **Level 1** – Driver assistance only
- **Level 2** – Partial automation, such as adaptive cruise control
- **Level 3** – Conditional automation, in which the vehicle can operate for short periods of time without driver intervention but requires the driver to be able to take over control at any time
- **Level 4** – High automation, in which the vehicle is capable of performing driving functions without driver intervention under certain conditions, but may allow the driver the option to take control of the vehicle
- **Level 5** – Full automation, in which the vehicle is capable of performing all driving functions without human intervention but may allow the driver to take control of the vehicle.

As described earlier in the introduction, low levels of automation are already available on many automobiles. Non-adaptive cruise control is a driver assist feature. Adaptive cruise control and lane-keeping assist features fall under Level 2 automation. For the purpose of this research, the term, “autonomous,” will refer to Levels 4 and 5 of automation. These levels represent types of vehicle automation in which the driver is not necessary while the vehicle is under self-control.

**Problem Statement**

Promising economic, social and environmental benefits can be realized from commercial shippers adopting autonomous vehicles. However, autonomous truck
adoption will be market driven through transportation professionals choosing to use autonomous trucks instead of traditional trucks. Implementation barriers and risks challenge adoption rates. An understanding of the factors that affect commercial users’ likelihoods to adopt autonomous trucks is necessary in order to obtain the benefits and minimize risks of autonomous truck deployment, since this understanding will allow for autonomous truck developers and marketers to recognize the goals and concerns of shippers and trucking companies. A conceptual model that explains the factors that affect the commercial adoption of autonomous trucks can provide this understanding.

Little research has been conducted regarding commercial adoption of autonomous trucks. Most research on this topic has been focused on technological aspects (Zeziulin, et al. 2018). A structured literature review, presented in Chapter 2, confirms this. Researchers have conducted studies to gauge public perception of autonomous vehicles, and some of this research has successfully influenced the public’s acceptance of commercial AVs (Schoettle and Sivak 2014). High market penetration rates in a given vehicle use segment are necessary for society to fully reap the benefits of this technology in that segment (Hamilton and Seul 2017). The factors “pro-AV attitude,” enjoyment of driving, and environmental concern, were found to influence public acceptance of AVs (Haboucha 2017). No comparable research has been identified that involves commercial users and autonomous trucks.
Research Objectives and Research Questions

The objective of this research is to develop a conceptual model in order to better understand the phenomenon of commercial autonomous truck adoption. Conceptual models are visualizations of the relationships between different variables or sociological constructs (Green 2014). The model developed in this research will identify the factors that affect the adoption of autonomous trucks by transportation professionals. This study defines transportation professionals as:

- Owners and lessees of over the road trucking equipment, such as trucking companies, individual owner-operators, or private fleet operators
- Freight brokers, freight forwarders, or third-party logistics companies
- Customers purchasing truck transportation services

The model will be constructed through a Grounded Theory analysis of interviews with transportation professionals and will be framed within Rogers (2003) “Diffusion of Innovation,” theory. The study will focus on the individual professional as the unit of analysis. Grounded Theory methodology is described in Chapter 3 of this document, and Rogers “Diffusion of Innovation” theory is described in Chapter 2.

This study will answer the following three Research Questions:

- How do transportation professionals choose a method of transportation or carrier for their business?
- Why would transportation professionals choose to adopt autonomous vehicles versus other transportation methods?
How do transportation professionals expect their businesses to be affected by autonomous vehicles?

**Significance of the Study**

The benefits of vehicle automation could be more pronounced in commercial truck operations than they are in private automobile operations due to the larger number of miles traveled per year by large trucks versus private automobiles and the deadly potential of large truck crashes. However, availability of autonomous trucks will not necessarily translate into high penetration rates as a matter of course. Vehicle and vehicle operator selection are market-based decisions. Supply Chain Management textbooks describe transportation decisions in terms of maximizing profit or minimizing costs, subject to meeting internal requirements or customer requirements (Bowersox et al. 2020). An understanding of the factors influencing transportation decisions, and how autonomous trucks must fit in to those factors, is essential to provide autonomous trucks with a strong chance of market adoption.

This study is expected to contribute to practice and theory because it will allow for an understanding of transportation professionals’ needs, and the factors that affect the scope of transportation professionals’ adoption of autonomous trucks. The research products of this study are expected to shed light on the factors that will affect autonomous truck adoption and, therefore, market penetration. An understanding of these factors will help to guide manufacturers’ development of autonomous truck
technology by illuminating the market’s usage goals for the vehicles. Public policymakers will be able to make more informed decisions regarding regulation that will foster, rather than hinder, the market adoption of autonomous trucks. Direct industry users will have access to information about industry intentions, risk concerns, and legal issues. Indirect industry stakeholders such as the aforementioned insurance companies and legal firms may gain an understanding of how their clients perceive this technology. The study’s output may be useful in ameliorating public opinion about sharing the road with autonomous trucks. Finally, this study may also have a theoretical benefit since there is little rigorous academic research that addresses the phenomenon of the factors affecting autonomous truck adoption.

**Scope and Risks**

This study is based upon autonomous truck use in the United States. While research from other countries is cited for informative purposes, the scope of this study only includes the United States. This is due primarily to resource availability, but also to the differing transportation laws and economic environments present in other countries. Including other countries in the research would cloud the focus of this study, although this could be an avenue for further research on the topic.

A risk of this research is the possible low availability of transportation companies and individuals with experience with autonomous vehicles. Since this topic is relatively unexplored, an interview-based case study approach is adequate because it will enable
to gain an in-depth understanding of the phenomenon from the participants’ points of view. This type of research is intended to explore new phenomena and it does not require as large of samples as survey-based research. Purposeful sampling of typical cases will be used in this study. Purposeful sampling is a nonprobability sampling technique that enables the researcher to choose distinctive cases in order to confirm the findings or explore how the phenomena manifests in other contexts (Gall, Borg, and Gall 1996; cited in Siegle n.d. and Patton 2002).
Chapter 2: Literature Review

Introduction

A literature review was conducted in order to gain an understanding of the current state of scholarly research in the field of Autonomous Vehicle (AV) use and to better inform the scope and positioning of this study. A preliminary review of the literature was conducted prior to the definition of the research goal in order to gain background understanding about the topic. The Summon tool available at the University of Missouri - St. Louis (UMSL) Library and Google Scholar were both used in the preliminary review. While these initial searches provided general information and were useful for formulation of the problem, they did not provide an in-depth understanding of the state of academic literature addressing commercial AV use. Thus, a structured literature review (SLR) methodology was used to complete the understanding of the topic.

The literature review is organized as follows: In Section 1, the theoretical background is explained. In Section 2, the SLR process is introduced and the approach used to conduct it is described. In Section 3, the descriptive analysis of the literature review results is presented and in Section 4, the conclusions from those results are described.
Section 1: Theoretical Background

Rogers (2003) general theory of, “Diffusion of Innovation,” is used in this study to describe commercial AV adoption. The four main elements of Diffusion of Innovation are: the innovation itself, which is the concept or invention; the communication channels, which are the means through which participants share information; time, which represents how diffusion of the innovation happens across the time horizon; and the societal system, which represents the patterns and norms of the participants’ sociological group (Sahin 2006). These four elements combine to influence if, and when, individuals will adopt new technology and if adopters will keep using it (Sahin 2006 and Herrenkin 2019). Sahin (2006) states that, “much diffusion research involves technological innovations so Rogers (2003) usually used the word “technology” and “innovation” as synonyms.” AVs are, in many ways, a new technology in transportation rather than an evolution of an existing technology. Bansal and Kockelman et al. (2015) claim that autonomous vehicles are, “the biggest technological advancement… in personal transportation in over a century” (pp 1.). Coughlin et al. (2019) also asserted that self-driving cars are a new technology rather than an evolution of existing technology. With this in mind, Diffusion of Innovation is an appropriate overarching theory to use when approaching the Research Questions. Also, there is little research on two aspects of diffusion of innovation (Sahin 2006): how the perception of innovations’ attributes influences adoption rates, and how to manage adoption of innovation in organizations rather than by individual consumers. This study addresses these research gaps.
Section 2: Structured Literature Review

A structured literature review (SLR) is a systematic method of cataloguing academic literature in order to produce a rigorous and objective understanding of the body of research related to a topic (Tranfield, et al. 2003). The SLR methodology uses a positivist approach to review the literature by using search terms and filters through appropriate databases to ensure quality in the results (Tranfield, et al. 2003). Thus, it allows for a descriptive statistical analysis of academic literature which may lead to findings that are not apparent while simply reading the papers uncovered. The methodology allows for reproducibility and greater academic rigor (Tranfield, et al. 2003). Since the goal of this dissertation is to evaluate a relatively new phenomenon that is expected to have major impacts on industry and society, it is important to approach the evaluation of previous research with an academically rigorous methodology.

The approach used to conduct the SLR is gleaned from Tranfield’s (2003) example. The recommended steps are shown in Figure 1. Redding (2018) and Tewari (2018) offer similar methodologies but Tranfield’s (2003) approach was chosen for being the most succinct and for specifically referencing business literature. Tewari (2018) is an example of the SLR used in an academic dissertation. The SLR in this study was conducted according to Tranfield’s (2003) three phases: I) planning the review, II) conducting the review, and III) reporting and dissemination. Each of these three stages was comprised of a number of phases as shown in Figure 1. A description of the SLR methodology is provided in this section.
Stage 1 – Planning the Review

Phase 0: Identify need for a review
Phase 1: Prepare proposal for review
Phase 2: Develop review protocol

Stage 2 – Conducting the Review

Phase 3: Identification of research
Phase 4: Selection of studies

Stage 3 – Reporting and dissemination

Phase 8: Report and recommendations
Phase 9: Getting evidence into practice

Figure 1 Structured literature review approach employed by Tranfield (2003)

Stage I: Planning the Review

Stage I is comprised of three phases that must be conducted before searching for the literature, in order to ensure that the results are comprehensive and reliable.

Phase 0: Identification for the need for a review

As stated above, the decision to conduct a SLR was made after the preliminary literature review, in order to apply a scientific and structured approach to evaluating the state of academic literature surrounding the topic of the research.

Phase 1: Preparation of a Proposal for a Review

The objectives of the SLR were defined, a preliminary set of questions to be answered were documented, and a plan of action was developed. A preliminary outline of the literature review chapter was created based on knowledge gathered from the preliminary literature review. That knowledge was helpful to focus the
literature search on the topics of interest. The outline was continually adapted as more papers were reviewed, and as new information led to new ideas to improve the chapter.

The outline of the Structured Literature Review is displayed in the Table of Contents. The plan of action includes the steps described in this section.

**Phase 2: Development of a Review Protocol**

A review protocol was created to specify the search terms, the literature databases and the filters that would be used in the review. These elements were defined so as to connect the literature returned to the set of questions defined in Phase 1 (Redding and Tjahjono 2018).

As per Tranfield (2003), the SLR began with clear search terms. The terms were defined prior to beginning the search and were informed by the preliminary literature review, the Research Questions and through discussions with managers and other academics. The search terms used in this study were chosen based on the Research Questions, by knowledge gained about the topic, by reading the preliminary literature and by informal conversations with practitioners at supply chain networking events.

Six search terms were chosen: “commercial use autonomous vehicles,” “autonomous commercial vehicles,” “autonomous trucks,” “self driving trucks,” “driverless trucks,” and “commercial autonomous vehicle.” During searches, the Boolean operator “and” was employed for all words within a search string so that only papers displaying all terms of interest were included in the search results.

Database selection is key for increasing the comprehensiveness of the SLR process (Tranfield et al. 2003; Redding and Tjahjono 2018; Tewari 2017). The database
selection determines the journals that will be included in the study. Redding and Tjahjono (2018) employed nine databases in their study.

Tewari (2017), whose academic thesis was a structured literature review, used three databases but one of them (Scopus) was considered too broad and was restricted to only papers relating to the business fields.

EBSCO Business Source Premier (BSP) was chosen in this research because it is considered a reputable database that would return thorough results. BSP allowed access to over 3,000 publications with particular emphasis in the disciplines of Management, Information Systems, Economics, and Systems Research (Klein 2014). UMSL maintains a subscription to BSP, making papers returned through the searches readily available.

Filters were used to limit the number of results found when the search terms were run in the literature databases. This allowed the focus of the search to be on papers that satisfied predefined criteria (Tranfield et al. 2003). Two filters were applied simultaneously. The first one limited the returns to peer-reviewed articles only. This ensured that only scholarly works were included in the SLR, although many non-peer-reviewed articles were read during the preliminary literature review in order to get an initial grasp about the current relevance of the topic for practitioners and to be informed about the latest news and developments. The second filter limited the returns to articles published between 2014 and 2019. This filter was applied to ensure recency in the search results and also to ensure higher quality returns. Self-driving cars are not a new concept. The first autonomous car was demonstrated in 1939, when GM exhibited an automobile that could guide itself along a path by using remote
control inputs from a magnetic track (Gringer 2018). Pre-2014 scholarly articles returned from each of the search terms largely dealt with quantitative operations management or engineering models. One notable exception was “self-driving trucks,” which returned 23 pre-2014 articles, of which a majority dealt with driver behavior such as risk-taking behavior and seat belt use. A table showing a brief summary of the pre-2014 search results is shown in Appendix 3: Pre-2014 Results.

Stage II: Conducting the Review

In Stage II, the review was executed following five phases: 3) identification of research, 4) selection of studies, 5) study quality assessment, 6) data extraction and monitoring process and, 7) data synthesis (See Figure 1).
nine (7,029) papers were returned from all of the search terms. Some of these 7,029 were duplicates; that is, they were returned for more than one search. Duplicate papers were removed at a later stage in the SLR methodology.

**Phase 4: Selection of Studies**

Tranfield et al. (2003) suggests that only papers which “meet all the inclusion criteria,” should be included in the literature review. Papers that did not meet the inclusion criteria, or that did meet “exclusion criteria,” were not included (Tranfield et al. 2003). In this research, two filters (i.e. peer-reviewed and year of publication) were applied in order to remove papers that did not provide relevant, scholarly material (see Phase 2 of the SLR methodology for definitions of the two filters). Table 1 and Figure 2 display the number of papers that were obtained before and after the filters were applied. From the total 7,029 papers retrieved in Phase 3, a total of 512 papers remained after the application of the “peer-reviewed” filter. This means that only 7.3% of studies identified were scholarly works, which indicates that there is comparatively little academic research in the area of commercial autonomous vehicle use. Limiting the year of publication to 2014 or later, reduced the total number of papers to 363. It is important to note that some of these results were duplicated between searches. For example, some papers that was returned in the search for “self-driving trucks,” also were returned in the search for “driverless trucks.”
The final activity of Phase 4 was to identify and eliminate duplicate papers. Duplicate removal was performed manually by referencing titles and authors returned in searches against the spreadsheet used to track the papers returned from the earlier searches. After duplicate removal, 192 remained in the database (see Table 1).

Table 1 Number of papers returned by search term

<table>
<thead>
<tr>
<th>Term</th>
<th>Pre-Filter</th>
<th>Peer Filter</th>
<th>Year Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Use Autonomous Vehicles</td>
<td>37</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Autonomous Commercial Vehicles</td>
<td>738</td>
<td>104</td>
<td>67</td>
</tr>
<tr>
<td>Autonomous Trucks</td>
<td>2416</td>
<td>155</td>
<td>106</td>
</tr>
<tr>
<td>Self Driving Trucks</td>
<td>1323</td>
<td>86</td>
<td>63</td>
</tr>
<tr>
<td>Driverless Trucks</td>
<td>1777</td>
<td>59</td>
<td>57</td>
</tr>
<tr>
<td>Commercial Autonomous Vehicle</td>
<td>738</td>
<td>104</td>
<td>67</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>7029</strong></td>
<td><strong>512</strong></td>
<td><strong>363</strong></td>
</tr>
</tbody>
</table>

1 (note: “Pre-Filter” refers to the total number of papers returned from the search term. “Peer Filter” refers to the removal of papers that were not peer reviewed. “Year Filter,” refers to the restriction of results to only those papers published between 2014 and 2019, when the SLR was conducted. Results in each column include duplicated papers. Duplicate papers were removed at a later stage in the SLR methodology.)
Phase 5: Study Quality Assessment

This phase consisted of an assessment of the papers that remained after the search filters were applied in Phase 4. This quality assessment is “relatively subjective” (Tranfield 2003, pp. 215). Tewari (2018) suggests to first assess the titles and abstracts of the papers. In this research, Tewari’s (2018) approach was extended by also analyzing the methodology and results sections in four consecutive steps. The abstracts were assessed using three criteria: 1) topic of study, which verified if the paper actually referred to autonomous vehicle use; 2) methodology, which categorized papers by methodology; and 3) other keywords which served to categorize papers such as vehicle purchase decisions, public opinion and autonomous vehicle benefits. The introduction sections were examined to further refine the papers that were useful for this study. The methodology sections were inspected, and papers were classified by their research methodologies in order to develop descriptive statistics and to gather information relevant to the research.
Any papers that proved relevant in terms of their abstract, introduction, and methodology were analyzed entirely. The findings of this analysis are included in Section 3: Descriptive Findings. The papers that were found to not make a relevant contribution to the topic were cataloged for descriptive statistical purposes but were discarded after cataloging without being analyzed. All papers discarded after in this phase were of high quality and were appreciated as being valuable and informative in their respective fields.

**Phase 6: Data Extraction and Monitoring Progress**

In this phase of the SLR, ongoing progress was tracked as papers that passed the filters were reviewed in detail. This allowed the papers selected in the previous phases to be analyzed and evaluated (Tranfield et al. 2003).

This phase was implemented by creating three running documents: 1) a spreadsheet that detailed relevant facts about the papers reviewed, 2) a journal that included short summaries of papers and the author’s thoughts that were deemed useful for the study, and 3) a bibliography in the Chicago style of all of the post-filtered papers reviewed. The spreadsheet was used for the descriptive statistics that are provided in Section 3 and included information about the author(s), title, methodology (definitions can be seen in Appendix 1: Definitions), the topic, the publication year, and the publication journal.

**Phase 7: Data Synthesis**

This phase allowed for an analysis of the characteristics and evolution of the academic research in the topic of interest. Descriptive statistics were used to infer
conclusions about the literature gathered in the previous phases (Tranfield, et al. 2003).

Descriptive statistics about the papers evaluated during the SLR were generated using the data collected in the Microsoft Excel spreadsheet, described in Phase 6. As the papers that passed the filters were reviewed, descriptive statistics were compiled in the spreadsheet. Descriptive statistics that were chosen to be reported were: 1) year of publication, 2) Major topics by year, and 3) methodologies by year. The classification of topics used is shown in Appendix 1: Definitions. A list of the methodologies used to classify papers is also shown in Appendix 1: Definitions.

Results of the data synthesis are shown in Section 3: Descriptive Findings in this chapter. The findings of the literature review process are shown in Stage III, Phase 8: The Report and Recommendation.

Stage III: Reporting and Dissemination

The final stage of the SLR consists of the presentation of the conclusions of the analysis of the literature. The resulting report comprises the findings from the descriptive statistics and the conclusions about the scholarly research regarding the subject area. Stage III includes two phases: Phase 8: The Report and Recommendation and Phase 9: Getting Evidence into Practice.

Phase 8: The Report and Recommendation
Descriptive statistics based on the data collected in
Appendix 2: were generated using pivot tables and graphing tools in Microsoft Excel. Charts were prepared to show research trends between 2014 and 2019. An explanation of the terms used for methodologies and topics are provided in Appendix 1: Definitions. The findings are reported in Section 3: Descriptive Findings.

Phase 9: Getting Evidence into Practice

Tranfield et al. (2003) argues that moving research findings from knowledge into practice is often a weak point in knowledge dissemination. That is, practitioners may know something from their research, but may have difficulty effectively acting upon that research, or using the research in real world problem solving. In Phase 9, the body of research identified is discussed in the aggregate, using examples from individual papers as evidence of the conclusions rendered. The outcomes of this stage are provided in Section 4: Theoretical Analysis.

Section 3: Descriptive Findings

Section 3 discusses the descriptive statistics of the papers uncovered in the literature review. Raw data from the SLR is presented and discussed, and then trends in the data are identified. Prior research trends are discussed according to topic and methodology.

Findings related to topics

Engineering dominated the paper topics, representing 28.1% of the total. Operations Research papers were also featured prominently and made up 15.1% of the total. AV
Adoption papers represented 13.0% and papers about the legal implications of autonomous vehicles made up 7.3% of the total. Other less represented topics counted for 11.4 % combined. These results are illustrated in Table 2.

Findings related to methodology

As shown in Table 3, a large percentage (40.63%) of the papers surveyed were conceptual. The next most common methodology was quantitative modeling, which comprised 28.13% of the total papers. Experimental, survey and case study-based papers accounted for 17.7% in combination. Qualitative research represented only three papers (1.56%). Despite the low number of articles, the qualitative category was included in the descriptive findings because it is the methodology used in this research study.

Findings related to publication year

Publication numbers increased along with year. This trend is illustrated in Figure 3. Ninety-five of the 192 total papers (49.7%) were published in 2018 and 2019. Only 14 (7.2%) were published in 2014. Analyzing the evolution of the numbers of papers over time by topic (Figure 5), Engineering papers peaked in 2015, while the number of AV Adoption papers increased somewhat steadily by year until they peaked in 2019. As shown in Figure 4, the methodologies, “Quantitative Model and Conceptual,” increased by year, while the number of qualitative papers remained relatively constant during that timeframe.
Table 2 Topics addressed in the literature by year.

<table>
<thead>
<tr>
<th>Year</th>
<th>Engineering</th>
<th>Operations Research</th>
<th>AV Adoption</th>
<th>Legal</th>
<th>Human Factors</th>
<th>Network Routing</th>
<th>Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2008</td>
<td>1.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
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<td>1.0</td>
<td>0.0</td>
<td>0</td>
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<tr>
<td>2015</td>
<td>6.8</td>
<td>1.6</td>
<td>1.6</td>
<td>1.0</td>
<td>0.5</td>
<td>0</td>
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</tr>
<tr>
<td>2016</td>
<td>3.1</td>
<td>2.1</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
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<tr>
<td>2017</td>
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<tr>
<td>2018</td>
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<td>5.2</td>
<td>2.6</td>
<td>2.1</td>
<td>1.6</td>
<td>2.1</td>
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</tr>
<tr>
<td>2019</td>
<td>6.3</td>
<td>3.1</td>
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<td>1.6</td>
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<tr>
<td>Pct of Total</td>
<td>28.1</td>
<td>15.1</td>
<td>13.0</td>
<td>7.3</td>
<td>5.2</td>
<td>3.6</td>
<td>2.6</td>
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</table>

Table 3 Methodologies by year by percent.²

<table>
<thead>
<tr>
<th>Year</th>
<th>Conceptual</th>
<th>Quant Model</th>
<th>Experimental</th>
<th>Survey</th>
<th>Case Study</th>
<th>Qualitative</th>
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</thead>
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<tr>
<td>2007</td>
<td>0.00</td>
<td>0.00</td>
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<td>0.52</td>
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<td>0.00</td>
</tr>
<tr>
<td>2014</td>
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<td>2.60</td>
<td>1.04</td>
<td>0.52</td>
<td>0.52</td>
<td>0.00</td>
</tr>
<tr>
<td>2015</td>
<td>7.29</td>
<td>4.17</td>
<td>1.56</td>
<td>0.00</td>
<td>0.00</td>
<td>0.52</td>
</tr>
<tr>
<td>2016</td>
<td>7.29</td>
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<td>0.52</td>
<td>0.52</td>
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<td>0.00</td>
</tr>
<tr>
<td>2017</td>
<td>5.73</td>
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<td>1.04</td>
<td>2.08</td>
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</tr>
<tr>
<td>2018</td>
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<td>7.81</td>
<td>1.56</td>
<td>0.52</td>
<td>1.56</td>
<td>0.00</td>
</tr>
<tr>
<td>2019</td>
<td>8.33</td>
<td>7.81</td>
<td>2.60</td>
<td>3.13</td>
<td>0.00</td>
<td>0.52</td>
</tr>
<tr>
<td>Total</td>
<td>40.63</td>
<td>28.13</td>
<td>8.85</td>
<td>6.77</td>
<td>2.08</td>
<td>1.56</td>
</tr>
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</table>

² Low frequency methodologies are omitted from chart.
Figure 3 Number of Papers by Year

Table 4 Methodologies and Topics by percent.³

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Conceptual</th>
<th>Quant Model</th>
<th>Experiment</th>
<th>Unclear</th>
<th>Survey</th>
<th>Case Study</th>
<th>Mixed</th>
<th>Qualitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>9.38</td>
<td>11.46</td>
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<td>0.52</td>
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<tr>
<td>AV Adoption</td>
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<td>3.65</td>
<td>0.00</td>
<td>0.52</td>
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</tr>
<tr>
<td>Legal</td>
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<td>0.00</td>
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<td>0.00</td>
</tr>
<tr>
<td>Human Factors</td>
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<td>2.60</td>
<td>0.00</td>
<td>1.56</td>
<td>0.00</td>
<td>0.00</td>
<td>0.52</td>
</tr>
<tr>
<td>Unclear</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<td>0.00</td>
<td>0.52</td>
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<tr>
<td>Network Routing</td>
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<tr>
<td>Environmental</td>
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<td>0.00</td>
<td>0.52</td>
<td>0.00</td>
</tr>
<tr>
<td>Economics</td>
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<td>0.00</td>
<td>0.00</td>
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<td>0.00</td>
<td>0.00</td>
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<tr>
<td>Public Policy</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Cyber Security</td>
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</tr>
<tr>
<td>Totals</td>
<td>34.90</td>
<td>26.56</td>
<td>8.33</td>
<td>5.21</td>
<td>5.73</td>
<td>1.04</td>
<td>1.56</td>
<td>0.52</td>
</tr>
</tbody>
</table>

³ Low frequency items are omitted except the qualitative methodology.
Figure 4 Methodologies by Year. Low frequency methodologies omitted except qualitative.

Figure 5 Topics by year. Low frequency topics omitted.
Conclusions from the Descriptive Findings

The number of papers published in recent years shows an upward trend, although the percentage of publications about commercial autonomous vehicles in academic journals is low when compared to those in the popular press. This indicates a need for scholarly research work in this field. While the popular press is an excellent way to quickly survey new developments in a field, there is a benefit to applying scientific principles to research. Popular articles are often written in such a way as to gain readership and to stand out from competing publications, and authors may omit some aspects of their findings or exaggerate certain points in their writing in order to make the articles more appealing to readers. Haboucha, et al.. (2017) call for more academic research into the topic of personal adoption of autonomous vehicles, since their survey method has inherent limitations owing to respondents’ level of understanding of the phenomena at hand. Herrenkin, et al.. (2019) also asserted that further academic research about the social acceptance of autonomous vehicles is necessary to truly understand consumer adoption habits. Rigorous academic research must be employed to gain a more complete and objective understanding of autonomous vehicle adoption, if autonomous vehicles are to effectively compete in the transportation market.

Two papers referenced in the literature review that were either selected through snowballing or from the exploratory literature review were included in the descriptive analysis in order to expand the findings.

The number of AV Adoption papers and Engineering papers showed an upward trend, as did the number of Conceptual papers and Quantitative Model papers.
However, the annual number of Qualitative studies returned remained constant (Figure 4) and with a low frequency (Table 3) compared to other types of methodological approaches. Qualitative research is important for understanding the how’s and why’s of phenomena, as these are interpretive questions; further, to fully understand scientific phenomena, understanding from both qualitative and quantitative avenues are necessary (Jones 1995).

This review of the literature indicated that there is no shortage of conceptual studies that discuss autonomous vehicle use, but that there is a lack of qualitative studies to understand the how’s and why’s of autonomous vehicle adoption. This study will illuminate factors motivating AV adoption decisions for commercial freight carriers through gaining an understanding of transportation professionals’ thoughts and perspectives regarding autonomous vehicles. It will represent a dialogue with decisionmakers and influencers in the trucking industry to understand their motivations and how those factors affect their perception and potential use of AVs; this understanding will help to inform the “adoption” decision in Rogers’ Diffusion of Innovation Model, as described in Section 1: Theoretical Background. This understanding can help technology developers and public policy leaders effectively foster an environment to encourage innovation in a way that the industry wants, thereby effectively directing resources to AV research and policy making.

**Section 4: Theoretical Analysis**

This section addresses the outcomes of the SLR. It identifies the major areas of research involving AVs, provides an analysis of the topical and methodological gaps
that motivated this research and describes the overarching theory that underpins this study. The 192 papers that remained after application of the SLR filters (see Figure 2) were reviewed and categorized because they were found to tell part of the story of autonomous vehicle research in the areas of either: Autonomous Vehicle Basics, Engineering Challenges, Public Opinion, Legal and Regulatory Considerations, Autonomous Truck Adoption, or Adoption of Related Technology. However, not all 192 papers were cited in this section since not all of them have a direct bearing on this study. For instance, only a subset of Engineering papers is cited because the engineering aspects of autonomous vehicles are not the focus of the research. The papers reviewed in the section on Engineering Challenges and Navigation, for instance, are those papers that the author considers intriguing or representative of their field. Legal and Regulatory papers are subject to the same considerations. Thirty-nine papers were cited in this section. The section concludes with an overview of the state of autonomous vehicle research.

*Autonomous Vehicle Basics*

Autonomous vehicles are a potentially transformative force in the transportation sector. Bansal and Kockelman (2017) describe AVs as part of a “vehicle-market revolution,” and Mosquet et al. (2015) state that autonomous vehicles are “the auto industry’s most significant inflection in 100 years” (pp. 3). References to self-driving cars or automated aerial delivery are readily found on Internet search engines. Autonomous vehicle technology is better described as a new type of transportation technology rather than as an evolution of an existing technology (Coughlin, et al. 2019). Autonomous vehicles could have major benefits to urban areas in terms of
increased personal mobility, lower congestion, and lower pollution (Allesandrini et al. 2015 and Gruzauskas et al. 2018).

Autonomous vehicle research is an increasingly popular topic, as evidenced by

![Number of Papers by Year](chart.png)

Figure 3. There are many opportunities for research that would make relevant practical and theoretical contributions. Bansal and Kockelman (2017) admit that their analysis of Americans’ adoption of connected and autonomous vehicles is based on public knowledge and opinion of AVs at the time of the study; as that knowledge and opinion evolves, the authors concede that consumer adoption patterns will also change. Zhang et al. (2018) assert that a better understanding of how autonomous vehicle availability will affect consumer travel patterns is required to accurately predict the effect that AVs will have on the number of vehicle miles traveled per consumer. These calls for research both focus on user experiences and preferences. However, these studies focus on personal owners rather than on transportation
professionals. Transportation professionals will have a different set of adoption criteria, but the adoption decision will still be made by individuals or groups of people, and it is therefore necessary to understand the perceptions and decision-making processes of those decision-makers. Areas identified as topics for further research are: 1) Adoption of Related Technology. Engineering Challenges, 2) Navigation, 3) Public Opinion, and 4) Adoption of Related Technology.

Engineering Challenges

Figure 5 shows the prevalence of research on engineering topics related to AVs. Perhaps the most commonly mentioned research opportunities are related to the engineering challenges inherent in autonomous vehicle operation.

In 2003, the Defense Advanced Research Projects Agency (DARPA), announced a manufacturing challenge for manufacturers to build an autonomous vehicle that could navigate a predetermined course. However, none of the vehicles were able to successfully complete their navigation of the challenge course at that time (Urmson and Whittaker 2008).

Navigation

A human being performs many complex risk assessments and calculations without even being conscious of doing so while operating a motor vehicle. A critical feature of motor vehicle operation is navigation - choosing an acceptable route from the origin point to the destination while avoiding obstacles. This offers both a hardware and software challenge to engineers, and many researchers have risen to meet that challenge. Promising research has shown that autonomous vehicles can successfully
avoid obstacles such as objects in the road and other vehicles using technology such as Light Detection and Ranging (LIDAR) and three-dimensional camera systems (Burke 2018 and Zeziulen et al. 2018).

Vehicle control is another major function that human drivers perform with little difficulty after a modest amount of training. After an obstruction free route is planned, though, an autonomous vehicle must have sufficient capability to execute its navigational plan. Researchers have made advancements in physical vehicle control such as parking and reversing (Feng et. al 2019; Liu 2019), and in control responses to roadway features such as hills (Cao 2019).

Public Opinion

Public opinion is a factor affecting the adoption of autonomous vehicles, because travelers will either use AV technology or share roads with AVs. Geller (2015) discussed a public opinion response to a National Highway Transportation Safety Administration (NHTSA) proposal to require connected vehicle technology on new cars. Sentiment was largely negative, with many of the detractors citing privacy concerns. While Geller’s paper discussed connected vehicles rather than autonomous vehicles, connected vehicle technology is tangential to autonomous vehicle technology. Roche-Cerasi (2019) surveyed drivers in Norway about whether or not they saw a driverless shuttle bus as a useful vehicle. Only 16 percent of study respondents thought that the shuttles should operate without a driver (Roche-Cerasi 2019).
Users of an experimental autonomous bus route reported in a survey that they saw the benefits of fully autonomous vehicles, but that they were more comfortable riding on the bus if there was a driver onboard (Herrenkin et al. 2019). Another study by Hudson et al. (2019) surveyed drivers in the European Union and found that many respondents were uncomfortable with the ideas of autonomous truck use and of autonomous car use. Respondents were generally less comfortable with autonomous cars than with autonomous trucks (Hudson et al. 2019). A similar result was observed in a survey of public opinion on autonomous ambulance use, where many respondents indicated that they would prefer to ride in an ambulance operated by a human driver if they required ambulance transportation (Winter et al. 2018). König and Neumayr (2017) performed a similar study and justified the research stream of consumer adoption with the observation that public use and purchasing habits will drive AV market penetration. These studies were representative of the AV adoption literature uncovered in the literature review. Other studies were identified, but most evaluated user attitudes towards personal cars. Others, such as Haboucha’s et al. (2017) study, attempted to use a quantitative logit model to estimate consumers’ willingness to purchase AVs.

Ultimately, academic research about autonomous trucks was scarce when compared to passenger transportation. Much of the research identified regarding AV adoption discussed personal cars (Haboucha et al. 2017 and Neumayr, 2017) or public transportation (Herrenkin et al. 2019). The research involving autonomous trucks that was uncovered often focused on quantitative modeling, such as Tsolakis’ et al. simulation model of autonomous vehicles in a supply chain (2019). Collingwood
(2018) approached autonomous truck adoption from a qualitative perspective, but that paper was geared towards the sociological and legal implications of autonomous truck use.

**Legal and Regulatory Considerations**

Legal considerations such as liability and regulatory framework may play a large part in autonomous vehicle adoption (Liechtung 2018). Some research has been done on this topic, but most is conceptual and dealing with personal vehicles - see Table 4. Liechtung (2018) discusses the lack of regulatory framework surrounding AVs the challenge that this poses to AV adoption. Some of this lack of regulation is by design, as Congress does not want to enact legislation that may stymie the growth of a new technology (Geistfield 2018). An interesting legal and ethical dilemma is the so-called “forced choice” scenario, in which a vehicle operator must choose an action that will harm another individual versus an action that will harm themselves (Fleetwood 2019). For instance, if a child were to run out into the road and a driver was faced with the choice of hitting the child or hitting an object like a parked truck with the possibility of seriously injuring themselves or other persons, which would they pick? Which would the AV pick?

**Autonomous Truck Adoption**

A handful of companies have run autonomous truck pilot projects. Rio Tinto, an international mining company based in London, has successfully used autonomous trucks off-road in some of their locations (Fagnant and Kockelman 2015). Anheuser-Busch partnered with Uber to run a successful over-the-road semi-shipment of beer under Uber’s “Otto” autonomous truck program (Fitzpatrick 2016). Embark, a
technology-based trucking company, has successfully operated self-driving trucks over a 650 mile route between California and Texas since 2017 (Davies 2017). A common trait among Uber’s “Otto” and Embark projects was that a human driver remained on the trucks in case a need arose to override the autonomous feature and operate the vehicle manually.

Additionally, several quantitative studies (Zhang et al. 2018, Young 2017, and Kavakeb et al. 2015), attempted to model the effects of AV use.

There exists, however, a lack of basic understanding of the ‘how’s and why’s’ of AV use. What will drive autonomous vehicle adoption from a commercial perspective? How are transportation professionals influenced when making a decision to adopt disruptive technologies such as autonomous vehicles? This research seeks to shine a light into that darkness!

Adoption of Related Technology

Several studies addressed topics that are tangential to the adoption of autonomous commercial vehicles. This literature was included in the review because it may provide input for preliminary models of commercial AV adoption and use. Topics reviewed included truck platooning, automated warehouse operation, autonomous oceanographic vehicles, private vehicle marketing and alternative-fuel vehicles.

Truck Platooning

Truck platooning is a concept in which a lead truck is followed by multiple driverless trucks. Platooning benefits include increased fuel efficiency and the possibility of lower traffic congestion, but there is a debate on how platoons could most effectively be formed as well as if they will actually lower traffic congestion (Boophalam et al.)
2018). Bernard Bracy et al. (2019) discuss infrastructure changes that are necessary for Decentralized Platooning, in which a “highly autonomous truck,” to mate up with other autonomous trucks while enroute. This is similar to Boophalam, et al.’s (2018) concept of “Opportunistic Platooning,” in which trucks that happen to be underway within a certain proximity of one another link up to form a platoon when they encounter one another by chance. The other platooning operations that Boophalam et al. (2018) describe are Scheduled Platooning, in which platoons are orchestrated in advance and truck departures are scheduled to facilitate the platoon; and “Real-Time Platooning,” in which trucks announce their departures to surrounding trucks to present platooning opportunities. While Boophalam et al. (2018) discuss truck platooning as a means to decrease costs and emissions for trucking, Bernard-Bracy, et al. (2019) identify autonomous truck platooning as a way to increase roadway safety, and to provide a cost justification for the necessary infrastructure modifications using crash data from Missouri.

Other Related Technologies

Automated warehouse operation is another tangential avenue of autonomous vehicle research. In this setting the autonomous vehicles are material handling equipment that operate within a facility, off of public roads in a defined grid system.

The field of oceanography also provides input for preliminary models of commercial AV use, since autonomous underwater vehicles have been proposed to perform oceanographic research duties that are impractical for humans (Brito, et al. 2019). Research in this area provided some constructs for some preliminary speculation, such as the expense of technology, and legal uncertainty (Brito, et al. 2019). Brito, et
al., also provided support to this study’s methodology, citing a lack of Grounded Theory research as a limitation to their study due to a lack of understanding of some respondents’ answers to their questions (2019).

Private vehicle marketing refers to the ability of automakers to quickly develop and market innovative technological features in automobiles as a competitive advantage in the area of product differentiation (Maniak et al. 2014). In a conceptual paper, Geller (2015) explained the adoption of vehicle-to-vehicle (V2V) connected technology as a driver’s aid and identified the benefits of this technology. Public opposition was found to be one of the challenges to V2V deployment. Alternative-fuel vehicles, while still an evolution of the conventional automobile, may offer some insight into consumer adoption habits. Lane (2007) evaluated fuel-efficient vehicle adoption in the United Kingdom and focused largely on consumer preferences and fleet vehicle purchases. Corporate culture was identified as one of the driving forces behind fleet vehicle purchases.

Post-Review Studies

Several studies identified after the conclusion of the SLR are pertinent and are included here to enhance the veracity of the literature review. These studies were either missed within the search engine and were identified through conversations with the dissertation committee and industry practitioners or were published after the conclusion of the literature review. Bernard Bracy’s et al. (2019) study was identified after the literature review, but it was included in the section on truck platooning since it was determined to be pertinent to that section.
Raj et al. (2020) published an enlightening paper on barriers to autonomous vehicle adoption after the conclusion of the SLR. The authors used a Grey Decision-Making Trial and Evaluation Laboratory (Grey-DEMATEL) model to identify ten barriers to AV adoption, based on a literature and the opinions of 18 subject matter experts. Of these experts, 14 were academics and only four were practitioners. Sixteen of the subject matter experts held PhD’s, and two held Master’s degrees. The analysis focused on private autonomous vehicles, but the authors’ influence model bolstered findings from the Development Study outlined in Chapter 3: Methodology, of this dissertation. The relevant barriers identified were: Absence of Regulation & Certification, Obscure Accountability, Inadequate Infrastructure, Lack of Customer Acceptance, and Manufacturing Cost (Raj et al. 2020). These barriers are similar to the concepts of legal risk, government regulation, public opinion, and cost that were identified in the aforementioned Development Study.

Conclusions

Autonomous vehicle use is a popular topic in the popular press. Much of the research addresses the technical aspects of autonomous vehicles. Qualitative research is focused on consumer adoption of autonomous cars, with little emphasis being placed upon the adoption patterns of transportation professionals such as transportation vehicles and trucks more specifically. As Konig and Neumayr (2017) observed their research on AV adoption, individual purchase patterns will drive market penetration. This also holds true for transportation professionals, and if the full benefits of commercial AVs are to be realized, it is important to understand what motivates transportation professionals to adopt and use AVs. The goal of this study is to use
rigorous qualitative research to better understand the motivating factors that will drive the adopt vs. do-not-adopt decision when transportation professionals are faced with the choice of whether or not to employ autonomous trucks, thus filling the knowledge gap that lies between the ability to physically engineer an autonomous truck, and the effects of those autonomous trucks’ widespread use.

The next chapter will describe this study’s chosen research methodology.
Chapter 3: Methodology

Chapter 3 describes the methodology that will be employed in this research. First, an introduction provides an overview of the research goals and questions, the differences between deductive and inductive research, and why a Grounded Theory methodology was selected for this research. Second, a brief discussion of the history, the theoretical underpinnings and schools of thoughts of the Grounded Theory methodology will be presented. The chapter will conclude with a description of the research design and how the methodology will be executed.

Introduction

The objective of this study is to develop a conceptual model that explains the phenomenon of adoption of autonomous vehicles from the perspective of commercial users. This study therefore poses the following Research Questions:

- How do transportation professionals choose a method of transportation or carrier for their business?
- Why would transportation professionals choose to adopt autonomous vehicles versus other transportation methods?
- How do transportation professionals expect their businesses to be affected by autonomous vehicles?

This study will use an inductive research design to address the Research Questions. Inductive research begins with data and makes generalizations about patterns that
emerge through analysis of the data (Gabriel 2013). The Research Questions in this study begin with “how,” or “why,” and Yin (2003) recommends an inductive research approach when examining those types of questions. Yin (2003) writes primarily about case studies, but asserts that inductive research methodologies allow for the complexities of real-world phenomena to remain intact, and do not require the researcher to have the ability to manipulate the participants behavior. Yin (2003) writes, “an experiment… deliberately divorces a phenomenon from its context,” (p 13), but that inductive methodologies allow for the effects of the phenomenon’s natural environment to remain intact during the research. Suaro (2015), gives a summary of several qualitative, inductive research methodologies. Among them are,

- Ethnography – An anthropologically based methodology in which researchers immerse themselves in a culture in order to gain a deep-rooted understanding of the symbology inherent in a culture or cultural phenomenon. Ethnography requires that the researcher be a participant in the culture, rather than simply a data collector.

- Phenomenology – A research methodology that seeks to understand a specific event or phenomenon from the perspective of those who experience it directly. In phenomenology, the researcher collects data from multiple sources in order to build an understanding of the phenomenon of interest. Since Phenomenology seeks to understand a topic from the perspective of the participant, this places it in Burrell and Morgan’s (1983) “Interpretive” paradigm.
• **Narrative** – A methodology that, rather than evaluating a single event or phenomenon, connects a series of events together in order to gain a thorough understanding or some sort of story. The Narrative methodology usually relies on a very small sample size, and an intimate rapport with the elements being of the population in the sample.

• **Grounded Theory** – An inductive methodology that is similar to Phenomenology in that it seeks to build a thorough understanding of a single event or phenomenon, but it differs from Phenomenology in that it tries to construct a positivist theory from the data (Glaser and Strauss 1999), rather than an understanding of the participant experience.

Deductive methodologies are another approach to academic research. In deductive research, a priori hypotheses are tested through data collection (Gabriel 2013). Statistical hypothesis testing is a type of deductive research, in which a null and alternative hypothesis statement are generated, and data are evaluated to determine if the alternative hypothesis is statistically supported (Anderson, et al. 2008). Deductive methodologies are not appropriate for the types of Research Questions posed in this research study. Research question 1, for instance, seeks to describe a decision-making process. In terms of selecting an autonomous truck as a result of that decision-making process, no prior research was identified, as shown in the literature review chapter. Conversely, inductive research begins with observations and then creates theoretical generalizations from those observations (DeCarlo 2018).
Grounded Theory serves as the methodology for this study. It retains the inductive approach that is beneficial to the Research Questions, but it operates under a positivist research approach (Charmaz et al. 1996). It also allows for the exploration of new constructs that emerge during the course of the study (Glaser and Strauss 1999).

Positivist approaches to knowledge, or epistemologies, mirror the scientific approach used in the natural sciences (Burrell and Morgan 1983). Positivist research assumes the existence of, and seeks to identify, predictable causal relationships involving the phenomenon of interest (Burrell and Morgan 1983). The positivist assumptions of reproducibility, and the separation of the researcher from the research subject (Darman, et al. 2017) are desirable in research evaluating factors affecting decision-making. Without predictable cause and effect relationships, the conceptual model of factors affecting the decision to use, or not to use, autonomous vehicles loses its value as a means of guiding further research and public policy!

Grounded Theory allows for theory to flow naturally from the data gathered (Glaser and Strauss 1999). Constant comparison - one of the key features of Grounded Theory (GT) methodology - makes GT valuable in the study of emerging phenomena such as autonomous vehicles. Constant comparison means that data are collected and analyzed in iterative rounds, rather than in a single round of data collection and a single analysis phase (Glaser and Strauss 1999). It allows later data collection activities to be tailored to examine emerging constructs. Such customizability is beneficial to exploratory research, where the objective is to gain an understanding of a phenomenon that is not supported by a large volume of existing research.
Origins of Grounded Theory

Barney Glaser and Anselm Strauss laid the groundwork for what would become Grounded Theory while working together on a study of the experiences of terminally ill patients (Chun Tie et al. 2019). Glaser and Strauss published their original constant comparative method in the study of the patients’ experiences in 1965, and they went on to publish guidelines for others that wished to use their research approach as the 1967 book, The Discovery of Grounded Theory: Strategies for Qualitative Research (Chun Tie et al. 2019).

Eventually Glaser and Strauss developed diverging views on how Grounded Theory is best applied to research which led to two different approaches. Glaser's approach is the original, or “classic,” Grounded Theory and is meant to explain behavior patterns. That approach is a middle ground between empiricism and true relativism (Suddaby 2006). Strauss and Corbin’s approach is more interpretive, and it focuses on the subjective meaning that the researcher attributes to the topic of study (Chun Tie et al. 2019). The more interpretive approach, referred to by Charmaz (1996) as “symbolic interactionism,” is concerned with uncovering the sociological meanings that participants in a phenomenon ascribe to the events – what the events symbolize to them. Interpretive Grounded Theory resembles the phenomenology method described in the introduction (Chun Tie et al. 2019). This allows the interpretive Grounded Theory to serve as a bridge between positivist research and strictly
interpretive research that is concerned with a subject’s experience (Charmaz et al. 1996).

Ralph, et al. (2015) describe Grounded Theory as a “dynamic” methodology that can be epistemologically adapted to the time and situation at hand; however, they note that the “essential methods,” of Grounded Theory – namely the inductive orientation and the constant comparative method – are present in all versions. This research study employs traditional Grounded Theory as first developed by Glaser and Strauss, with a more positivist epistemological background. However, this research acknowledges the beneficial attributes of all schools of Grounded Theory methodology.

**Research Approach**

The examination of an emerging phenomenon such as autonomous trucks deserves a research methodology that is flexible in order to examine compelling information that comes to light during the research process. The methodology should provide an in-depth data collection method that gives the researcher the ability to establish a rich conceptualization of the phenomenon. Grounded Theory meets these requirements: The researcher develops theory that is “grounded” in the data which means that the researcher generates the theory directly from analysis of the data rather than from deduction or “speculation,” (Glaser 1965). It employs in-depth data collection processes such as interviews (Suaro 2015) and relies in what its creators, Barney Glaser and Anselm Strauss (1999), refer to as the “constant comparison” method. Constant comparison means that the researcher collects and analyzes data in an
iterative fashion, rather than collecting a study’s entire volume of data and then performing the analysis (Glaser and Strauss 1999). Examination of emerging constructs and data patterns occurs as the study moves forward, and findings from earlier rounds of data comparisons are used to tune the sampling and data collection techniques for later rounds (Chun Tie et al. 2019 and Glaser 1965). Grounded Theory is a flexible methodology that is well-suited to an emerging phenomenon, for which there is not a large volume of background research that can be used to guide the study. These attributes make Grounded Theory the chosen methodology for this research project.

The remainder of this section describes a generalized approach to Grounded Theory research. It is not intended to represent the precise design employed in this study, but is an overview of a typical Grounded Theory project. Once it is identified as the proper methodology to address a set of research objectives, grounded theory begins with purposeful sampling, in which a participant is chosen for the initial round of data collection specifically because it is representative of the phenomenon of study, (Patton 2002 and Chun Tie et al. 2019). As the research progresses a theoretical sampling scheme is used, in which participants are chosen with the explicit goal of exploring certain constructs, as theories and patterns emerge from the data (Chun Tie et al. 2019). Data are collected using an instrument such as surveys or interviews (Chun Tie et al. 2019). Analysis occurs concurrently with data collection. The researcher keeps memos while analyzing the data, which Chun Tie (2019) describes as an “audit trail,” for the researcher’s thoughts.
Coding is a key qualitative data analysis feature of Grounded Theory. It is used to capture units of meaning that emerge from the data (Charmaz et al. 1996). Codes in Grounded Theory are words or phrases that describe certain actions or ideas that occur in the data (Chun Tie et al. 2019). Analysis and coding continue in an iterative fashion, and the researcher makes comparisons of new data patterns to data patterns from previous rounds (Glaser 1965). This process continues until saturation, which means that new theories do not emerge from additional data collection and analyses (Glaser 1965).

The next phase is Intermediate Coding, in which more abstract codes are allowed to flow from the initial codes and memos (Glaser 1965 and Chun Tie et al. 2019). Intermediate Coding combines Initial codes that have interrelated meaning into higher level categories (Chun Tie et al. 2019). Memo-writing is an integral part of the intermediate coding process, according to Charmaz (1996), since the memos record the researcher’s thought about each specific code in the data. The researcher uses the memos to make comparisons between the initial codes, allowing them to flow into categories that become the intermediate codes (Charmaz et al. 1996).

The final stage is Advanced Coding (Chun Tie et al.). The researcher identifies relationships among the Intermediate codes. Chun Tie (2019) cites Birks and Mills (2015) advice to employ a storyline as a tool for the advanced coding. A storyline connects the categories developed in the Intermediate Coding and describes their relationships (Chun Tie et al. 2019). Charmaz (1996) describes this as writing the first draft of the final data analysis and recommends that the researcher continue to use their memos to aid in the writing. In the final stage of the analysis, the researcher
should be able to relate the abstract concepts developed from the codes to one another and describe how their relationships influence the overall phenomenon of study.

Figure 6, adapted from Chun Tie (2019), provides a graphical representation of a typical Grounded Theory research project. The figure includes the project tasks described in this section: purposive sampling, data collection, initial coding, Intermediate coding, and advanced coding.

![Figure 6 - Example of Grounded Theory methodology (Chun Tie et al. 2019)](image)

**Validity of the Findings**

Validity refers to the academic rigor or quality of research. Quality is expressed through the research’s ability to pass the scrutiny of logical tests (Yin 2003).

Assurance of academic rigor is especially important in qualitative research because of the level of subjectivity inherent in qualitative data (Enz 2009). Yin (2003) proposes...
four tests of validity for qualitative research; while Glaser and Strauss (1999) did not
directly address these validity concepts, researchers such as Charmaz (1996) and
validity checks, and their Grounded Theory counterparts, are:

- **Construct Validity** – ensures that the constructs that emerge from the analysis
  appropriately capture the phenomenon of interest. Construct validity also
  ensures that the researcher’s analysis accurately reflects the opinions of the
  participants (Enz 2009). In order to increase construct validity, Yin (2003)
  recommends the use of multiple sources for data collection and multiple
  rounds of data collection with different participants. Yin (2003) also states
  that researchers should keep a “chain of evidence,” which is accomplished
  through memo keeping in Grounded Theory studies (Chun Tie et al 2019).
  Lockstrom (2009) recommends that researchers use discussions with industry
  practitioners and other academics to guide question development.

- **Internal Validity** – ensures the quality of conclusions related to causal
  relationships among constructs. Glaser and Strauss (1999) refer to this as
  “fit,” meaning that the theory generated through the research must be,
  “applicable to and indicated by the data under study,” and that the theory must
  be able to explain the examined behavior pattern in such a way that another
  researcher could understand the theory (p 3). Chun Tie (2019) suggests that
  memo writing helps in ensuring internal validity in a Grounded Theory study.
  Data comparisons to literature from similar fields can also aid in ensuring
  internal validity (Lockstrom et al. 2009). Predicted relationships among
constructs, based on earlier data collection, were compared to observed relationships as recommended by Enz (2009).

- **External Validity** – determines if the findings of the study are generalizable beyond the immediate study’s sample. The concepts, “relevance,” and, “work,” describe External Validity in Grounded Theory (Lomborg and Kirkevold 2003). “Relevance,” means that the theory should have a high-quality relationship to the phenomenon that it attempts to explain, and “work,” means that the theories generated should have predictive power regarding the phenomenon of study (Lomborg and Kirkevold 2003). Yin (2003) recommends replication as a means of ensuring external validity. This means that newly collected data about a concept should exhibit similar patterns to previously collected data about the same concept (Enz 2009). Lockstrom (2009) used multiple case studies to allow for intra- and inter-case validation to achieve replication logic.

- **Reliability** – describes a study’s ability to reproduce similar results if presented with similar data. Chun Tie (2019) admits that a challenge inherent in Grounded Theory research arises from the fact that much of the quality of a study depends upon the capabilities of the researcher. Charmaz (1996) suggests that a researcher should compare the findings of their Grounded Theory analysis with existing literature to see if patterns discovered in their analysis resemble existent patterns. Charmaz (1996), Glaser and Strauss (1999), and Chun Tie (2019), all recommend extensive use of memos as a means of ensuring methodological rigor of a study. Glaser and Strauss (1999)
say of memos, “Memo writing on the field note provides an immediate illustration for an idea,” (p 108). Chun Tie (2019) writes, “Procedural precision requires careful attention to maintaining a detailed audit trail… and procedural logic recorded using memos,” (p 7). Sound memo writing explains the researcher’s thought processes as they evaluate their data and should allow other researchers using the logical framework from the memos to arrive at similar conclusions.

Considering the nature of the research goals of this study, and the lack of theories from the literature involving commercial use of autonomous trucks, this study employs Grounded Theory methodology in order to generate a conceptual model of factors affecting commercial autonomous vehicle use. The next section describes how Grounded Theory methodology was employed and how the tactics suggested by Charmaz (1996), Glaser and Strauss (1999), and Chun Tie (2019) were used to satisfy the four measurements of research validity.

**Research Design**

This section describes how the Grounded Theory methodology was applied in this study. Grounded Theory guidelines from the literature were followed as closely as possible, but some customizations were made for this specific study. The Research Design section describes the specific research protocol used to execute this study. This section outlines how Yin’s (2003) four validity checks were implemented in this study. A discussion devoted to the study’s execution follows after the validity
checks. The Research Design finishes with an account of the author’s experiences conducting the research.

Research Protocol

A research protocol includes the research goals the research design, and the blueprint for conducting the research (UCSF 2017). The research protocol serves as a manual for conducting the research project, and as a guarantee of the study’s quality to academicians and practitioners (Silverman and Kwiatkowski 1998).

The steps performed during this study were: 1) Initial Questionnaire Development; 2) Development Study Execution; 3) Questionnaire Adjustment; 4) Final Sample Selection; 5) Questionnaire Refinement; 6) Data Collection and 7) Data Analysis. These steps are described next.

Initial Questionnaire Development

The initial questionnaire, shown in Appendix 4: Interview Guide from Development Study, was developed through consideration of the Research Questions and through casual discussion with industry participants involved in the Council of Supply Chain Management Professionals (CSCMP) over the span of many months. The questions were kept open to allow for discussion and for the opportunity to ask more specific follow-up questions of the interview participants, as recommended by Seidman (2013). The questions were intended to assess the background of the participants, the decision-making process(es) at the organizations for which the participants work, the participants knowledge level concerning autonomous vehicles, and the participants’ interpretations of the future of commercial autonomous vehicle use in their industry.
Development Interview Execution

Seidman (2013) recommends the use of semi-structured pilot interviews to test the interview structure with a small number of participants. Semi-structured interviews employ an interview guide containing questions for the participant to answer, but the questions are broad and open-ended in order to allow for follow-up questions to explore intriguing answers (Seidman 2013). The interview guide can then be modified based upon the findings of the pilot study to better serve the research objectives (Seidman 2013).

This study employed a development study sample size of three. The development study was performed for internal purposes to demonstrate efficacy of the study concept, and to allow the author to refine the interview instruments and coding methods. The participants selected all worked at Third Party Logistics firms. The participants included in the pilot study are representative of transportation decision-makers who would adopt autonomous trucks. Two of the development study participants were known to the author through the Council of Supply Chain Management Professionals. The third participant was referred to the author through an UMSL faculty member. All three participants were eager to participate in the research and expressed interest in the study’s results.

As stated above, the development study interview guide, in Appendix 4: Interview Guide from Development Study, was designed as a broad questionnaire that could be readily tuned in order to explore constructs that emerged through the development interviews. Respondents were first asked to give a basic profile of themselves, including their position within their company and years of experience in their
industry. Participants were then asked to discuss the typical decision-making model that they use to make transportation decisions. They were then asked to describe the relative importance to the factors identified and to discuss how that approach was developed. Participants then responded to questions relating to their knowledge of autonomous vehicles and the effect that they thought AVs would have on their industry and company. The next question focused on how their company evaluated and deployed new innovations. After that, questions focused on challenges related to AV adoption and cost changes associated with AV adoption. A question about the effects of insurance and liability laws on AV adoption followed, and the interview questionnaire concluded with a question about the respondent’s personal views on autonomous vehicles.

Development study interviews were conducted via telephone and recorded with Apple’s Garageband software. Interview audio were transcribed verbatim using WReally software. Transcripts generated automatically from WReally and were edited against the original audio files for accuracy. Completed interview transcripts were imported into MAXQDA for coding. An example of MAXQDA is shown in Appendix 6: MAXQDA Screenshot.

Interviews were coded line-by-line as suggested by Charmaz (1996). Memos that detailed the author’s thoughts about the codes, constructs, unique attributes of the interviewee, and other relevant factors were kept both in MAXQDA and as a separate Microsoft Word document. The memo-writing was performed to fulfill validity checks as outlined in the previous section by Charmaz (1996) and Chun Tie (2019). Codes were allowed to emerge from the data. Categories were kept open so that
many passages dealing with the subject matter could be included, but codes were not restricted to any predetermined number. If a passage did not fit well into one of the previously developed codes, a new code was created, and a memo was written for that code. The coded sections and memos from all interviews were compared to one another in order to identify similarities and differences between the responses given by the interviewees.

The pilot interviews demonstrated the efficacy of the study and provided input to refine the Interview guide. The development interviews prompted the addition of questions relating to insurance and legal liability to the guide. The final analysis of the study includes full formal interviews of the development study participants.

The next section will discuss how validity checks were assured during both the pilot interviews and the primary data collection interviews.

Validity of Findings

Recommendations from the literature informed methods to increase validity of the study, as discussed in the previous section, Validity of the Findings. Concepts explicitly described as “validity checks,” were not discussed by Glaser and Strauss (1999), but Glaser and Strauss (1999) did describe methods to ensure high quality in grounded theory studies. Charmaz (1996) and Chun Tie (2019) also made several suggestions to ensure quality of the study. These suggestions were matched with Yin’s (2003) concepts of construct validity, external validity, internal validity, and reliability.
• **Construct Validity** – Yin (2003) suggests using multiple sources of evidence to establish construct validity. This study used multiple industry professionals from different positions of the trucking industry and in companies related to the trucking industry (such as transportation managers in manufacturing and retail companies) to triangulate its findings. Enz (2009) recommends establishing a “chain of evidence,” and “allowing key informants” to review the study results. The author kept memos in accordance with recommendations from Charmaz (1996) and Chun Tie (2019) and offered all research participants the opportunity to review the study prior to its presentation. Key informants who were trusted by the author were also asked to review the study for this reason.

• **Internal Validity** – results obtained from this study were compared to existing patterns from supply chain management literature (Lockstrom et al. 2009). This study employed pattern matching, where the researcher compares expected data patterns to empirically observed patterns, as another method of ensuring internal validity (Enz 2009). Lockstrom’s (2009) recommendation to discuss findings with academic peers was adhered to as further means of establishing internal validity.

• **External Validity** – This study establishes external validity through replication logic (Yin 2003). Data patterns from different participants in different firms within and connected to the trucking industry were compared to one another to check for consistency and predictability. Additionally, respondents were recruited from different geographic regions of the continental United States to
minimize any geographic bias in the data. Enz (2009) also employed replication logic to ensure external validity in a Grounded Theory study about buyer-supplier relationships. This study assured external validity through the coding process. During the move from Initial Coding, to Intermediate Coding, and then to Theory Development, codes for constructs and the relationships between those constructs became more general and abstract (Charmaz et al. 1996 and Chun Tie et al. 2019). This satisfies Yin’s (2003) guidelines for External Validity of ensuring that a study’s results are generalizable over a broader spectrum of data than just the sample data.

- Reliability – Per the methodology of Lockstrom (2009) this study followed the guidelines defined in the research protocol and interview guide. Due to scheduling concerns and the COVID-19 pandemic, this study’s interviews took place remotely, either over phone or over the Zoom video calling application. The author recorded interviews using Apple Garageband or the Zoom software and generated transcriptions from the recordings to follow Lockstrom’s (2009) guidance for data traceability. Enz (2009) recommends that the researcher create a research database in order to ensure reliability. This study used MaxQDA’s qualitative data analysis software to curate transcripts, codes, and memos.

In addition to the checks shown above, the author kept memos at all stages of the study: during interviews, during transcription, during coding, and during comparison of responses, in accordance with recommendations from Chun Tie (2019). Memos included such concepts as thoughts and impressions about the interview participants.
and their responses, explanations of codes, why certain passages were coded the way that they were, methods to improve the interview guide, and comparative notes, among others. These memos comprised validity checks for reliability and internal validity, by providing an audit trail of the researcher’s logical arguments made during the study. The memos also documented the constant comparison method. The constant comparison method ensured internal validity by triangulating causal relationships developed through interviews with several participants. Constructs and relationships were refined until theorized relationships between constructs that were coded in one interview were compatible with the constructs and relationships identified in the other interviews.

Next is a discussion of the execution of the primary analysis of this research study.

Research Execution

Full Data Collection

Interviewees were recruited following the conclusion of the refinements from the Development Study. Participants were recruited and interviewed. The interviews were recorded, transcribed, and analyzed. Further discussion of each of these activities follows below. The results of the analysis are presented in Chapter 4: Findings.

Participant Recruitment

Participants were recruited in several ways. The primary means of interview recruitment was through cold calling. The author employed LinkedIn’s search
function to identify participants within set geographical areas to make contact with through LinkedIn’s messaging feature. The geographic areas were deliberately manipulated to provide location diversity among the interview pool. Candidates were evaluated based upon the following minimum criteria:

- Recruit prospects must be employed in a transportation function at their firm or must work in a management or executive capacity at a firm that specializes in transportation.
- Recruit prospects must have at least three years of industry experience, or commensurate background education, in order to provide a relevant baseline level of knowledge of the transportation industry.

Prospects who responded to the initial message were asked for an email address and a consent form was sent to that email. Interviews were scheduled upon confirmation of receipt of the consent form.

Snowball sampling was also employed on a limited scale. Interviewees were asked if they knew anyone meeting the criteria that might be willing to participate and were asked to forward the author’s contact information to prospects. The author ascertained the suitability of snowball prospects through email and described the nature of the study to snowball prospects. If snowball prospects were interested in participating and were determined to have met the interview criteria, they received a copy of the consent form and the author scheduled an interview upon confirmation of consent form receipt.
Twelve participants were interviewed in total. The generalized backgrounds of the participants are shown below in Table 5. Their combined experience covers a wide range of the freight transportation industry. Their domain knowledge includes: brick and mortar retailing, online retailing, inbound and outbound transportation, asset-based trucking, non-asset based trucking, third party logistics operations, supply chain consulting, and freight forwarding. Additionally, the sample is geographically diverse and includes transportation professionals from across the Continental United States.
<table>
<thead>
<tr>
<th>Participant</th>
<th>Position</th>
<th>Background</th>
<th>Description of Current Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manager</td>
<td>LTL shipments and brokerage - 20 years of experience</td>
<td>Third Party Logistics</td>
</tr>
<tr>
<td>2</td>
<td>President</td>
<td>Worked in third party logistics as well as transportation consulting</td>
<td>Supply Chain Consulting / 3PL</td>
</tr>
<tr>
<td>3</td>
<td>President</td>
<td>Extensive experience in freight forwarding, LTL shipping, and third party logistics operations</td>
<td>Supply Chain Consulting / 3PL</td>
</tr>
<tr>
<td>4</td>
<td>Outbound Transportation</td>
<td>Experience managing inbound and outbound transportation, as well as yard operations</td>
<td>Online Retailer</td>
</tr>
<tr>
<td>5</td>
<td>Transportation Analyst</td>
<td>Twenty years of experience in transportation, including pharmaceuticals</td>
<td>Pharmaceutical</td>
</tr>
<tr>
<td>6</td>
<td>President</td>
<td>President of trucking company and involved in trucking company association</td>
<td>Trucking</td>
</tr>
<tr>
<td>7</td>
<td>Driver</td>
<td>Experienced mid-career truck driver for a large logistics company</td>
<td>Logistics and Transportation</td>
</tr>
<tr>
<td>8</td>
<td>Distribution Manager</td>
<td>Experience with distribution network design and transportation innovation research</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>9</td>
<td>Chief Strategy Officer</td>
<td>Worked as an industrial engineer before working at a 3PL startup, left to join another logistics provider</td>
<td>Logistics and Transportation</td>
</tr>
<tr>
<td>10</td>
<td>Solutions Specialist</td>
<td>Has extensive background within information management and consulting as it relates to transportation</td>
<td>Logistics and Transportation</td>
</tr>
<tr>
<td>11</td>
<td>Transportation Procurement</td>
<td>Twenty years of experience with private fleet management and transportation procurement</td>
<td>National retail company</td>
</tr>
<tr>
<td>12</td>
<td>Operations Coordinator</td>
<td>Has experience working as a logistics specialist and in multiple positions within a 3PL company</td>
<td>Third Party Logistics</td>
</tr>
</tbody>
</table>

Table 5: Summary of Participants

Interviews and Transcription

Interviews were conducted via telephone and Zoom. Telephone interviews were recorded using Apple’s GarageBand software and then converted to mp3 recordings. Zoom interviews were recorded via Zoom’s audio recording.
Interviews followed a semi-structured outline. The author utilized an interview guide with several topics to be touched upon in the interview. However, the questioning was not rigid and certain topics were explored in greater detail according to new information that presented itself or to take advantage of unique expertise of the participant. Each interview took approximately 45 minutes, with some variation among the interviewees.

The interviews were uploaded to WReally for transcription. The automated transcription process returned a text block that was copied into Microsoft Word for reference against the original recording. Interview accuracy was evaluated manually, and corrections to the automated transcript were made as necessary. The author estimates that the WReally transcripts were approximately 85 percent accurate, though no measurement was taken of the transcript accuracy.

**Analysis**

Finalized transcripts were imported into MaxQDA for analysis and coding. Memos were kept during coding, with memos describing new codes created as well as thoughts on coded passages.

Codes were initially created with broad constructs identified from literature, such as Cost, Service Level, Customer Service, and Safety. New codes were added to address topics that did not fit well within the existing code structure, though the author did try to fit concepts in the interviews into the existing code structure.
wherever possible to keep the coding scheme succinct. As the number of codes and coded segments grew, some codes were nested within others that they shared a common theme with.

New interview transcripts were compared with older transcripts and emerging patterns became apparent early on. Successive interviews were informed by the emerging patterns and the gaps in those patterns that became apparent through the data analysis process.

Construction of the Model and Propositions

Recruitment, Interviewing, and Analysis occurred concurrently during the project. Recruitment was an ongoing activity in order to prevent the available interviewee pool from going empty. Interviews were scheduled in order to allow for the author to analyze the previous interview and inform future interview guides prior to beginning new interviews. The process was, for the most part, orderly, and it was iterative. Interviews continued until theoretical replication was reached. This concept is described earlier in this chapter. Based upon similar studies that the author had read prior to beginning this analysis, the author estimated that theoretical saturation would be reached at approximately 15 participants. The final sample size included 12 participants at the time of saturation. It should be noted that the development study participants were officially recruited and interviewed for this study using the updated interview guide.
A conceptual model and nine propositions are discussed in Chapter 4: Findings. The conceptual model is related to Research Questions 1 and 2, and the propositions are related to Research Question 3. The model and propositions were developed based upon the relationship of constructs identified through the coding activities, and their relationships to the Research Questions were drawn through analysis of the coded segments relating to those constructs.
Chapter 4: Findings

Chapter 4 presents the outcomes of the qualitative data analysis and addresses the three Research Questions: (1) how do transportation professionals choose a transportation method or carrier for their business, (2) why would transportation professionals choose to adopt autonomous vehicles versus other transportation methods, and (3) how do transportation professionals expect their businesses to be affected by autonomous vehicles. The chapter starts with Figure 7, which provides a graphical depiction of the conceptual model that emerged from the analysis of the interviews with professionals. This model is developed to address Research Questions 1 and 2 together. It is intended to serve as a visual reference of the constructs that were identified and the relationships among them. The constructs are numbered to facilitate their identification in the text.

The model is explained after the figure is presented. Each construct is addressed individually first, providing a definition and explaining its relationships with other connected constructs. Quotations from the interviews are included to support and illustrate the findings. Appendix 7: Construct Code Frequencies contains statistics about the constructs’ code frequencies and relative frequencies as they appeared during the qualitative data analysis. Question 3 is addressed in a separate section with a set of propositions that capture how transportation professionals expect their businesses to be affected by autonomous vehicles. This chapter leads to Chapter 5, which provides the conclusions about the findings and the research as a whole.
Research Question 1: How do transportation professionals choose a transportation method or carrier for their business; and Research Question 2: Why would transportation professionals choose to adopt autonomous vehicles versus other transportation methods?

This section presents the analysis of the data relating to Research Question 1 and Research Question 2. A conceptual model, and its description, are presented first. A discussion of the constructs outlined in the conceptual model, and their relationships, follows.

**Conceptual Model**

Figure 7 shows the conceptual model developed from the qualitative data analysis procedure, and addresses Research Questions 1 and 2. The center construct is “Adoption,” (0), which represents the result of interest. Twelve other constructs influence Adoption, and in some cases, influence each other. These relationships are depicted by arrows between the constructs. A relationship that is theorized to have a positive influence on the affected construct has a (+) sign. A relationship that is theorized to have a negative influence on the affected construct has a (-) sign. Relationships presented without a (+) or (-) did not have a direction of the effect that could be ascertained with certainty. The relationship is theorized to exist, but to not be strongly positive or negative.
Figure 7 the conceptual model displaying constructs relevant to Research Questions 1 and 2.

The next section of the chapter explains the elements in Figure 7 starting with Cost (1) as a basis to answer Research Question 1: How do transportation professionals choose a transportation method or carrier for their business, and Research Question 2: Why would transportation professionals choose to adopt autonomous vehicles versus other transportation methods?
Cost (1)

Cost was used to code segments of the interviews that addressed monetary expenditures owing to procurement and use of a transportation solution. Several sources of cost were discussed in the interviews, including the price of equipment, maintenance, insurance, fuel, and labor. However, the most frequent types of cost mentioned were direct operational costs such as labor and fuel. Cost was found to be related to adoption as described next.

Relationship of Cost (1) to Adoption (0)

The cost of a transportation solution was found to be negatively related to adoption. Cost was mentioned by all respondents as being a key performance metric to consider when selecting a transportation solution. For example, professionals said:

- “Probably, the two main [decision factors of transportation adoption] are cost and time of delivery.” - Interviewee 2

- “What really mattered [when choosing transportation] was the financial aspect and service.” - Interviewee 11

- “Cost is a major decision factor [for] the federal government that we work with. Even though they get [criticized] for not really caring about cost, they actually do quite a bit.” - Interviewee 10

- “They offered a cost to us that was comparable to what [we were] paying, but there was not a savings. So in this particular case, we didn’t make a move [to the new carrier] because it didn’t save us any money.” - Interviewee 11

Professionals perceived that autonomous trucks could be more expensive or less expensive in terms of total cost of ownership than traditional trucks. Driver wages
and benefits represent 44 percent of the operating cost of trucking (Robinson 2020). Eliminating that operating cost is theorized to lower the operating cost of autonomous trucks. However, interviewees keyed in on the possibility that the autonomous trucks might be more expensive to purchase and maintain, and that those added expenses could offset some of the savings. The following quotes illustrate the divergence in opinions:

- “I would figure that the cost [of trucking] would go down [with autonomous trucks]. Although it's probably [going to be offset by] the cost of the initial investment in the vehicle. You know, again, you have trouble right now with trucking companies that do not want to update their fleets just because it is cost prohibitive to sink several million dollars into upgrading their fleet of vehicles.” -Interviewee 3

- “It is just like any new technology, right? The cost to build - the cost to deploy [the technology]- is going to be the initial big cost once we move over to a system like that. The other cost will be maintaining those [autonomous] vehicles. How do you do that?” -Interviewee 4

- “There is going to be a large cost savings for wages and benefits [from autonomous trucks].” -Interviewee 11

- “There is going to be a large cost savings for wages and benefits [with autonomous trucks]” -Interviewee 11

It is theorized that if autonomous trucks can provide the same service levels as human operated trucks, but at a lower cost, then autonomous trucks will have an advantage.
over human operated trucks. This proposition is expanded further later in the chapter when research question 3 is covered.

**Service Level (2)**

The term Service Level was used to code segments of the interviews related to effectively meeting customers’ wishes. Like Cost, Service Level was a common topic of discussion in the interviews. The most common aspects of service level that the interviews referred to were transportation responsiveness and dependability, which were modeled as sub-codes (child nodes) of service level. The responsiveness of a transportation service was viewed primarily in terms of transportation velocity. Dependability refers to the ability for a transportation solution to routinely meet a stated performance level. A combination of Cost and Service level was found to be a commonly used metric in the evaluation of supply chain performance. Service level was found to be related to autonomous truck adoption as described next.

**Relationship Service Level (2) to Adoption (0)**

Service level is theorized to be positively related to adoption. For some executives, this construct was more important than the cost of a transportation solution. The first component of Service Level, Responsiveness, is a concern to shippers whose markets require rapid delivery of products. These companies may place a premium on service velocity as a necessary means of creating a competitive advantage. Innovative products – generally those products that have high profit margins and low sales
volumes – benefit from faster, more responsive supply chains (Fisher 1997). This was supported in the interviews, especially with Interviewee 5 who is a transportation manager at a pharmaceutical company.

- “Typically, I like to look at service and cost, and for instance different industries are going to value cost [more]… A grocer, for example, [has] razor-thin margins. So, they are going to take the lowest cost carrier. But in pharma, if you have one pallet of product, that might be two years’ worth of inventory at temp control [so] it is service first and foremost.” -Interviewee 5. The interviewee described their company’s need for customized, responsive shipping services several times during the interview.

- “One of the two main [decision-making] factors is how quickly do they [the customer] need it to get from point A to point B? That is probably 1-A.” -Interviewee 2. The interviewee was discussing the prioritization of metrics involved in selecting a truck to move a customer’s shipment. 1-A refers to the top priority.

Dependability emerged as a component of Service Level that measures the ability of a solution to consistently meet customer desires and expectations. Whether the objective of the distribution system was rapid response or efficiency, professionals placed a high priority on the ability of transportation solutions to consistently meet expectations. Dependability was seen as an integral part of service level by professionals whose businesses deal primarily with functional products and by professionals whose businesses deal primarily with innovative products.
• “Let's say you have a critical [pick-up] time of three o'clock. The drivers must pick that [load] up at that time. They cannot be late. There is very little time for them to miss.” -Interviewee 4

• “I think one thing we struggle the most with [in] the current [trucking] industry is the on-time [aspect] of things like reliability and commitment; pick up and drop off.” -Interviewee 8

Autonomous trucks are not limited by hours-of-service regulations that apply to human drivers, which is expected to drive autonomous truck adoption in companies that prioritize service levels, as explained by these professionals:

• “Sometimes we have things coming off of our production lines on a Sunday at 11:00 p.m. when there is no one that is going to pick up a load on Sunday at 11:00 p.m. [The load] has to sit and [be held in] inventory and not get to its destination.” -Interviewee 8. The interviewee was discussing how an autonomous truck could operate 24 hours a day, which might match up to a production schedule better than a traditional truck.

• “You are not having a driver that gets tired [or has] to stop for hours of service and things like that [with an autonomous truck]. I would think the autonomous vehicles would be able to keep going whereas drivers are restricted to a certain number of hours per day of activity.” -Interviewee 5

• “[The] truck [itself] can run 24 hours a day, 7 days a week. Because of DOT rules [it can] only run for 10 hours a day, [because] that's all the driver can do.” -Interviewee 2
The section on Cost (1) discusses the uncertainty of whether or not autonomous trucks will provide cost savings over traditional trucks. This uncertainty is largely due to the difficulty of predicting how the purchase price of an autonomous truck will compare to a traditional truck once autonomous trucks become widely available. Autonomous trucks may be more expensive than traditional trucks because of the technological systems. It is theorized that even if there is not a sufficient cost savings from autonomous trucks, they could still have an advantage over traditional trucks if they can provide a better service level. This is discussed further in the following section on Profit Contribution.

Profit Contribution (3)

Cost (1) and service level (2) are related to the concept of profit contribution (3), which is the ability for an activity to generate profit for a company after the costs of that activity are subtracted from its revenue. In this study, Profit Contribution refers to profits generated by a shipping company or a non-asset-based transportation company. It was found to be directly related to autonomous truck adoption.

Relationship Profit Contribution (3) to Adoption (0)

Either cost or service level may take precedent as the primary metric for transportation adoption, depending on the nature of the firm. For example, the pharmaceutical transportation manager said that their industry concentrates on service
level first and then on cost, whereas a business such as a grocery company that has lower margins would focus on cost first. However, cost was the more-commonly observed primary focus among the professionals interviewed. One interviewee indicated that some customers tend to view transportation as a “commodity” as the participant put it.

- “It was the ability to say we are not a commodity. We are not buying at this rate [and] selling at this rate. We are providing a back-end service through our technology, providing accounting visibility through the freight bill audit and pay system, or creating value within your organization to limit dead-heads to create efficiencies on the dock and routing efficiencies integration with your system. It takes us out of the commodity bucket. And we have always said we try to keep the carrier out of the commodity bucket because they do not like it. Carriers themselves do not like it, but they always throw themselves back into it… like I said, they report their operating relationships.” -Interviewee 3. The Interviewee was discussing how the openness of truck carriers to report their operating margins puts them in a more competitive market, because customers know the carriers profit margins and tend not to view the carrier as a means to create value in their own organizations. The Interviewee said that they tell their clients not to treat their firm as a commodity, because their software platform can represent a value-added service for the client.

- “The trucking industry, from my experience, has always been almost too transparent about what their operating ratios and their margins [are]. You could get on almost any one of the LTL calls of the shareholder monthly calls
where they go over the numbers, and they will talk about their operating ratio that basically says, we are operating at a percent of 96 meaning we are making four cents on the dollar.” -Interviewee 3

The priority for shippers and shipping companies is the profit margin that a solution provides. Thus, the Profit Contribution of a transportation decision is theorized to have a positive relationship with transportation adoption.

- “[If] you are making eight percent on the primary [freight], but you are getting an opportunity to get a lot of spot freight where you're making fifteen percent margins, you might be willing to accept a little bit more primary freight to ensure you get that spot freight, because you are making more money on the spot freight.” -Interviewee 1. In this passage the respondent was discussing how a transportation provider might be willing to accept a lower margin bid for a primary load if it allowed them to pick up spot freight, which is a load that is bid on outside of normal freight contracts.

- “Does that cheaper rate you're getting paid… is your margin the same, is what I am trying to say. If you make a 4% margin at the end of the day, if you have drivers you might make 4%, and what if you don't have a driver? You can't prove that cost to your customer why you need ‘x’ amount. It might still be 4%.” -Interviewee 1. In this passage the respondent was discussing why shipping companies might not see a financial benefit from autonomous trucks because the profit rates for trucking firms are fairly well-known to their customers, and if trucking firms and 3PL’s realized a savings from
autonomous trucks that their customers would want that savings for themselves.

- “We did a very large move for one of our big customers on the air freight import side just last week, where we had to charter an Antonov, which is one of the world's largest cargo planes, to bring product from Germany into Atlanta. The price tag on that was pretty steep, but [the customer] made that decision that [the aircraft was] what they needed to hit certain dates for their marketing and [product] release.” -Interviewee 3

Insurance (4)

Insurance was a construct used to code interview passages that expressed a contractual relationship by which an insurance firm guarantees a second party against loss. The Insurance construct, as it relates to the Research Questions, refers to the power of insurance companies and their ability to affect the decisions of firms. Insurance was found to have a primary direct effect on adoption and an effect mediated by Cost (1).

Relationship of Insurance (4) to Adoption (0)

The power of Insurance companies to affect transportation decisions was found to be the primary effect of Insurance on Adoption. Insurance companies can dictate the decisions that their insured firms make. Interviewees 2 and 5 explained this:
• “From the trucking company’s standpoint - the insurance companies run our industry. They truly are more powerful than our customers, [The Department of Transportation] themselves, and our own internal people. The insurance companies basically dictate who you hire, your type of equipment, whether you are going to still be in business. They are that much of an influence to the success of your trucking company.” -Interviewee 2

• “We work with our Risk Management Group, and when we have a contract with a carrier, it is usually a red line in the contract as far as what amount of insurance they are going to carry and things like that.” -Interviewee 5

Insurance was also found to affect adoption indirectly through Cost.

Relationship of Insurance (4) to Cost (1)

Insurance has an effect on indirect cost. This is because cost is one of the ways that insurance companies can incentivize or disincentivize certain activities. The relationship of Insurance to Cost is complex. One interviewee indicated that many large asset-based firms self-insure. Other firms use insurance providers, and the insurance providers can use insurance pricing to heavily leverage firm behavior.

• “That's essentially [what] we do, not with autonomous [trucks] but [with] 360 [degree] cameras, telematics, accelerometers and key controls - make sure that we can limit any sort of liability from an accident or something that was caused by our own vehicles. So, I could see [autonomous trucks] being [a] benefit [to] insurance costs, in liability costs.” -Interviewee 8. In this instance the interviewee was directly discussing how autonomous trucks would have
an effect on insurance rates. The interviewee mentioned that truck data logging technology is onboard trucks in order to limit the company from liability in case the truck is involved in an accident, and that lowering of liability translates to improved insurance rates.

- “Most of the companies I have worked for and managed are self-insured. [My current employer] is self-insured. Once you get so big it would just be cost prohibitive to insure. We have got over a million pieces of equipment, not counting airplanes.” -Interviewee 7 was discussing how the trucking firms that they have worked for in the past have dealt with insurance.

- “Our industry as a whole will listen to [insurance companies]. They will say, ‘no, we are not [telling you how to operate], we are just making suggestions.’ But you know, they are one of the biggest costs [that] a trucking company has.” -Interviewee 2. The interviewee was discussing how insurance companies can use the cost of coverage as a means to make trucking companies behave in ways that the insurance company’s management wants them to.

If insurance companies support the use of autonomous trucks, then it is theorized that trucking companies that use those insurance companies will be more likely to adopt them. Similarly, if the autonomous trucks lower the payout risk for a self-insured trucking firm, it is theorized that those companies will be more likely to adopt autonomous trucks. This suggests that Insurance and Liability, which is addressed next, are related constructs.
**Liability (5)**

“Liability,” was used to capture sections of the interview related to the concept of being held culpable in the event of a mishap such as an accident. Liability was derived from a constructed called “Legal Issues,” which was used early in the study as a general code for passages about legal liability, contractual obligations, and corporate relationships. However, over the course of the study it became apparent that much of the discussion of legal issues in the trucking industry related to liability in the event of personal injury or property damage. Liability was found related to insurance (4), adoption (0) and cost (1).

**Relationship of Liability (5) to Insurance (4)**

Liability has an effect on Insurance because a key priority of insurance companies is to shield themselves from liability. Interviewees indicated that since the trucking industry is litigious, if management thinks that a technology such as AVs will lower their liability level and potential payouts, they will incentivize its use. They said:

- “Unfortunately, we live in a time where lawyers drive much too large [of a] percentage of decision making [through] your liability.” -Interviewee 3

- “I would imagine that the insurance companies, at least initially, would be a bit reticent [to insure autonomous trucks]. They would want a lot of things in place to cover it. The prices are going to be high while we figure [autonomous trucks] out as a new technology. But over time, I think it would
really drop the rates because I think we could potentially have less incidents over time.” -Interviewee 5.

- “They [the insurance companies] love the cameras all over the trucks inside and out. All the safety things you can put on your truck, the insurance company is very much for.” -Interviewee 2.

**Relationship of Liability (5) to Adoption (0)**

Liability presents a potential challenge to transportation adoption. There is a question surrounding who holds the legal responsibility for an autonomous truck. According to Interviewee 7, the trucking companies generally guarantee the operation of the trucks that they own, as long as the driver of a truck involved in an incident was operating within the confines of the law. When asked if drivers are typically indemnified in the event of a crash, interviewee 7 responded:

- “Yes, unless they fail the drug test or [it is a] DWI situation. Then they would still be criminally negligent, and [my employer] would just fire the driver. And ultimately, we would just write a check for whatever covered our part [of the settlement] and [the driver] would be out on their own, but if there was no illegal substance [involved] then the driver would be covered by the company.” -Interviewee 7

Interviewees indicated that in the case of autonomous trucks, the vehicle manufacturers would likely hold the liability for the operation of their equipment. This is because the trucking firms themselves would not be able to dictate *how* the
programming in the autonomous truck’s computer system drive the truck, like they can with a driver that they employ. Mann (2020) discusses this in terms of autonomous cars, and cites the CEO of Volvo, who asserts that manufacturers would bear that responsibility. He also urges caution in regard to that idea, since burdening manufacturers with the legal liability for the safe operation of these vehicles could stymy manufacturers’ enthusiasm for developing the technology (Mann 2020). This is an issue in general aviation, because aviation equipment manufacturers are often sued by passengers, their relatives, and pilots in the event of a crash. Kolczynski (2001) blamed poorly written product liability laws for some of the lawsuits that have had a detrimental effect on the production of general aviation aircraft. Interviewees mentioned that it is possibility that litigation will be directed towards the company that has the best ability to pay:

- “I do not know [what] the exact [liability] mix is going to be, but it might come down to questions of, ‘was [the accident] a result of poor maintenance or was it the result of a poor design, with the design [issue] being more faulted towards the manufacturer.” -Interviewee 10

- “It will be a whole new set [of legal issues]. Most of the lawsuits now have to do with hours of service and whether the driver [is] liable. So, it is going to change. I think it is going to change what these lawsuits are about because you do not have that person in the [driver’s] seat to blame.” -Interviewee 1

- “The lawyers go after the people with the deepest pockets. So, I think they would certainly go after the trucking companies and eventually after the manufacturer [of the autonomous truck], especially if they could prove there
was some sort of malfunction or misuse or something like that.”

-Interviewee 3

This should serve as a warning to stakeholders of autonomous trucking. If autonomous truck manufacturers were allowed to be held strictly liable for crashes involving their equipment, it is possible a similarly deleterious effect would be seen in the autonomous truck manufacturing industry, reducing the probability of AV adoption

Relationship of Liability (5) to Cost (1)

Interviewees indicated that in the event of a crash, plaintiffs’ attorneys sued as many parties as possible, hoping to find where the biggest payoff would come from, leading to increased cost.

- “Everyone in line gets sued. I mean everyone. It does not matter if I brokered it… they literally now just sue everybody in line. [The] carrier will be first.”

-Interviewee 1. The interview was discussing the fact that plaintiffs broadly sue as many parties as possible in the event of trucking mishaps to see where they can get a payout.

- “The attorney is going to look at everybody to say, ‘Okay not only was it the carrier's fault... we think everybody else involved is [responsible].’ If there is a third party in there, then they brokered the load to this truck and why did that [accident] happen?” -Interviewee 3
• “Based on previous law, I [would] treat it like somebody flies out of a roller coaster. Is it the amusement park’s fault, or was it the company that manufactured the roller coaster? The plaintiff will sue both and it is going to come down to whether there was a malfunction that was caused by the park not maintaining the ride properly or whether this was an engineering design flaw. Then the park can now blame whoever made the roller coaster.”
  -Interviewee 7. The interviewee was discussing how multiple parties can get sued in the event of a crash.
• “Whether it’s the driver’s fault or not does not matter. That [is] the initial stuff that they saw where it was going.” -Interviewee 2 was discussing a seminar on autonomous trucks that they had attended where an insurance company representative discussed the safety and liability improvements to be had from autonomous trucks.

Safety (6)

Safety is a construct that captures interview passages associated with a cause of hurt, injury, loss, accidents, accident likelihood, bodily injury, fatalities, safety to pedestrians, and property damage. It was found to be related directly to autonomous truck adoption (0), Insurance (5) and public acceptance of autonomous trucks (7).
**Relationship of Safety (6) to Adoption (0)**

Safety is believed to have an impact on a company’s likelihood of adopting a transportation solution. This effect is theorized to be primarily through other constructs such as Liability (3), Insurance (2), and Public Acceptance (6), but there is also a direct link between safety and adoption of a transportation solution. Interviewees indicated that they value safety in transportation, and that they are receptive to adopting new safety technologies as long as the technologies fit their operational models. For example:

- “It is not like [the trucking industry is] luddites. We want to continue the adoption of safety technologies and increase [their] utilization. We are totally on board with [driver assist features].” -Interviewee 6. The interviewee was discussing a question about whether or not the trucking industry was resistant to change, and if that resistance includes reluctance to adopt safety technologies such as driver aids, and developments such as autonomous trucks.
- “Safety is a big part of how we make our decisions.” -Interviewee 8

Autonomous trucks may present some distinct advantages to shippers and trucking companies when compared to human driven trucks when considering safety, which could increase their attractiveness to transportation professionals. The National Highway Traffic Safety Administration (NHTSA 2015) estimates that over 90 percent of crashes are caused by driver error. A fully autonomous vehicle would remove the
driver from the equation and would have the potential to remove many of the errors that lead to traffic crashes.

- “[The speaker] said all their initial studies [about autonomous trucks] were with trucking insurance companies, [and that] autonomous trucks will kill [fewer] people than trucks with drivers [in] them.” -Interviewee 2. The interviewee was discussing a conference that they attended, and a speaker was giving a talk about early studies of autonomous truck safety.

- “Everything I have heard is [that the researchers] believe that there will be less accidents [and] less fatalities with autonomous trucks.” -Interviewee 1

- “It is almost like the airplane [automation] argument. Airplanes… do not [have] very many accidents. When they do [have accidents] they can be catastrophic, but fatalities [in airplanes] are much lower. If you can design autonomous vehicles essentially to take out a lot of human error, they can get to something like a Six Sigma level of quality where there are very few errors, and even if those errors are really bad when they happen you can still save lives [with autonomous trucks].” -Interviewee 10

It is worth noting that not all of the respondents agreed that autonomous trucks would be safer in the immediate future. Interviewee 7, an experienced mid-career truck driver, had an interesting take on a potential safety challenge facing autonomous trucks.

- “[What about] with road rage and [when] people just generally get aggravated? These [autonomous trucks] are going to have safety sensors on
them. They are not going to like [other drivers] getting near them. So, I am thinking, ‘how many people are going to pull up and deliberately get too close to these [autonomous trucks] to see if they will drive off on the shoulder?’” - Interviewee 7. The interviewee was discussing how in their job as a truck driver they occasionally have to deal with angry drivers who act out of road rage. The interviewee was not certain how an autonomous truck would handle another driver deliberately driving dangerously in its vicinity.

Relationship of Safety (6) to Insurance (4)

Safety is believed to affect cost through Insurance (4), since trucking companies can be sued for safety problems. It is theorized, therefore, that safer trucks are a source of savings for insurance companies since their payout likelihood is lowered. The data that supports this proposition corresponds the following passages of the interviews:

- “[The insurance companies] were encouraged with the [safety] statistics and the numbers, since there would be less fatalities.” -Interviewee 2. The interviewee was discussing a presentation on autonomous trucks that they attended, where insurance company representatives were talking about their anticipations for autonomous truck use.
- “There is going to be [a savings with] liability insurance. It is going to be a safer solution over time.” -Interviewee 11. This segment also deals directly with autonomous trucks, since the interviewee was discussing cost changes that they thought would happen with autonomous truck implementation.
• “The [insurance] prices [on autonomous trucks] are going to be high while we are figuring this out as a new technology. But over time, I think it would really drop the rates because I am thinking we could potentially [have] less incidents over time.” -Interviewee 5. The interviewee thought that insurance rates on autonomous trucks might initially be higher than human driven trucks because of a lack of actuarial data regarding autonomous trucks, but that over time the trucks could potentially offer a savings on insurance premiums if they prove to be a safer solution than human driven trucks.

**Relationship of Safety (6) to Public Acceptance (7)**

Safety is also theorized to affect public acceptance (7). The construct public acceptance is defined and addressed later in the chapter, but in order to keep consistency with how the predecessor-successor relationships are covered in the chapter, its relationship with safety is discussed here. Interviewees indicated that the public tends to have poor views of trucks, and that perceived safety problems are part of that negative view. Interviewees suggested that members of the general public tend to see tractor trailer trucks as dangerous obstacles on the roadway that are likely to cause a crash, rather than systems that are useful and necessary for the economy. For example, professionals said:

• “Outside of the industry, people in general have a poor view of these large trucks. [They say] trucks need to be safer and trucks are causing all these accidents, when in reality, when you look at the data trucks have become [safer]. Drivers have things in the cab to help them be [safer].” -Interviewee 5
• “I think the common public has… the perception that trucks are dangerous and [that] they get in the way of something, and they cause accidents [that are] really devastating, and so there is always a sort of… acceptance of them being there, but also concerns about [whether trucks are] being safe enough or the drivers alert enough.” -Interviewee 10

Some respondents had concerns about the effect of safety on the public acceptance of autonomous trucks and thought that a single bad incident could overshadow an otherwise positive rollout. Others felt that the public would begin to embrace autonomous trucks if their safety record was empirically proven. A third opinion was that the general public would not have strong feelings one way or another, so long as their goods continued to arrive on time.

• “Well, the downside [of an autonomous truck failure] is big. The consequences of a 75-foot tractor trailer weighing 80,000 pounds including payload is a pretty big deal. That is a difference from between that and… many other science projects [this was a sarcastic comment on the part of the interviewee]. The guys who want to push for [autonomous trucks] hard…. okay, fine. Just have your 12-year-old ride his or her bike in front of the truck going 70 miles an hour.” -Interviewee 6. The interviewee was discussing the potential consequences of a computer or safety systems failure in an autonomous truck. The interviewee was concerned with the damage potential of a large truck being out of control because of an equipment failure. This
comment illustrates the potential for a high-profile accident to sour public opinion on autonomous trucks.

- “I think it is [approximately] 60% of people would spend more money for a product that was produced and managed sustainably. Right now, I think [autonomous truck companies should] brand a lot of this as an opportunity to be safe and sustainable and to start to get more consumer benefits.” - Interviewee 8. The interviewee suggested that if autonomous truck use is marketed as something to increase safety and sustainability, that the public might be more accepting of it.

- “I do not know [if] I think people would be concerned a great deal about safety, because they are not going to stop ordering [goods]. They want the pills to be at the pharmacy. They want the clothes [to be] in the store when they go shopping. They want the food [to be] in the grocery store. They are going to continue to spend that money, so they want the freight there.” - Interviewee 5. This is an illustration of the opinion that the public would not have strong opinions about autonomous trucks, as long as the delivery of goods was not interrupted.

It is theorized that adopters of autonomous trucks could improve Public Acceptance through presentation of safety data regarding autonomous trucks, based on conversational implications from the interviews. A demonstrated increase in Safety might sway Public Acceptance in favor of autonomous truck adoption.
• “I think the public has to embrace [autonomous truck use] and I think that process is [demonstrating] the right tests that are executed in that shows how safe the technology really is. Assuming it is safe, you can kind of prove that and there are measures [in place to] keep the public safe.” -Interviewee 9. The interviewee was discussing how safety data might be helpful in gaining public acceptance.

• “Some people just do not like change, so getting them to adopt this entirely new idea for the industry… I just think some people might be hesitant at first until they see research or maybe other companies start to [use autonomous trucks].” -Interviewee 12

Public Acceptance (7)

Public Acceptance represents the opinions of the public at large regarding a transportation solution. Interview segments assigned to this code include topics such as willingness to share a roadway with trucks, perception of the safety of trucks, and the view of the public on whether trucks are a benefit or a detriment to society. The construct was found associated with Regulation.

Relationship of Public Acceptance (7) to Regulation (8)

Public Acceptance is believed to influence transportation solution adoption through the construct Regulation (8), which is defined in more detail later in this section. This relationship is theorized to be inverse and be a manifestation of political pressure. Elected officials need to satisfy their constituents in order to secure reelection, and so
a lack of public acceptance to a transportation solution is believed to foster restrictive regulations upon the transportation solution. Additionally, layoffs and job loss connected with a transportation solution might pressure elected officials to create regulations against that solution. In this regard, professionals commented:

- “What governor wants to be first in line to have the big accident in his state if he approves [autonomous truck use]? Then that is where I think if you get the general public that thinks this is a horrible idea and they are vocal about it, then I think the politicians of course will turn around and say, ‘we don't want autonomous trucks in our state.’” -Interviewee 2. The interviewee was talking specifically about government regulation of autonomous trucks, but it is an excellent example of the link between public acceptance, regulation, and adoption of a transportation solution.

- “There is going to be a lot of angst because people are going to be losing jobs. And that is immediately going to prompt the folks that are looking for votes to create artificial barriers to entry.” -Interviewee 11. This interviewee also identified that public opinion could sway policymakers.

**Regulation (8)**

Regulation represents rulings by government agencies that dictate procedures or methods. The construct regulation was used to code passages that discussed governmental limitations on the experimentation with or use of a transportation solution. Regulation can also involve incentivization of a behavior, but that aspect was not mentioned by any of the interviewees.
Regulation is theorized to have both a direct and an indirect impact on transportation solution Adoption (0). An example of a direct influence on adoption would be a prohibition on the use of a transportation solution. Regulation’s indirect effect on transportation adoption was found to be related to how the regulation affects the Profit Contribution (3) of the solution in question. This indirect influence was the more common effect of Regulation (8) that was discussed in the interviews.

\textit{Relationship of Regulation (8) to Adoption (0)}

Regulations pose a challenge to autonomous truck adoption. Charlie Mann (2020) discussed regulatory barriers in the Cornell Policy Review, noting that traffic laws vary from state to state, and differences in laws regarding autonomous vehicles could hamper deployment efforts. Interviewees were split on whether or not a laissez-faire regulatory environment or a more rigid regulatory environment would be more likely to foster autonomous truck adoption. Generally, the sentiment leaned towards a laissez-faire approach, with six interviewees explicitly stating a preference for a laissez-faire regulatory approach. However, two of interviewees thought that a firm existing regulatory environment would be more enticing to transportation firms by offering a legal roadmap to using autonomous trucks.

- “I think people and companies need some sort of guide rails to work within.”
  - Interviewee 8. The interviewee was discussing a need for a regulatory framework that describes what states would and would not allow in terms of autonomous truck use.
• “With [autonomous trucks] being a brand-new part of the industry, [I] think that [manufacturers and autonomous trucking companies] would want some kind of structure and being told how it works, and then maybe down the line saying okay, this this is not working like we originally thought and then making changes. I feel like if it were a free-for-all from the beginning things could get messy.” -Interviewee 12

• “A laissez-faire approach and some freedom to do this [is better] in my view. Once the government gets involved, there are just going to be more and more barriers to entry.” -Interviewee 11

• “I think the new up and coming [autonomous trucking] firms that want to get in that space would prefer [a] more laissez-faire space in which they can really experiment more freely.” -Interviewee 10

The interviewees agreed that regulation would lag behind technological development.

• “It is going to be a while before the regulations can adapt and people get comfortable with autonomous 40-ton trucks driving up and down the highway.” -Interviewee 9

• “Marijuana, for example, [has] had an impact on our industry over the last few years because if you are a driver in Colorado you can have [marijuana] at home on your time off, but because of federal regulations, even if you are only driving in Colorado, you cannot have it or have it in your system at any time. So, the [transportation regulation] is lagging behind.” -Interviewee 5. In this
instance the interviewee was discussing how regulations tend to lag technological and social changes.

- “A few years ago, Amazon wanted to start delivering packages with drones. They cannot do that in the United States because of those [FAA] regulations [placing limits on drone flights]. That could be one of those things - because we have such strict regulations in the United States - that will be a barrier [to entry] for years.” -Interviewee 4. The interviewee was discussing how lagging aviation regulations have limited a company’s ability to experiment with flying drone deliveries.

**Relationship of Regulation (8) to Profit Contribution (3)**

Regulation can affect Profit Contribution through an influence on asset productivity. Transportation regulations limit the number of hours that a driver may work in a certain period, and some of the interviewees identified this as a limitation on the service level of a solo driver operation.

- “Every time [the Federal Motor Carrier Safety Administration] wants to tweak hours of service, or something changes that impacts productivity, the argument is keeping the highways safer.” -Interviewee 9. This passage is part of a discussion about the pros and cons of a more highly regulated autonomous vehicle deployment versus a more laissez-faire autonomous vehicle deployment, but the interviewee identifies that government regulations on hours of service impact the productivity of truckers.
“In the industry in general most operations are single driver operations. So [in a] long haul if you think about it, you can only drive a max of 11 hours a day. Well, that’s 13 hours a day that the asset is sitting, and it is so capital intensive… a tractor-trailer can cost anywhere from 200 to 350 [thousand dollars]. So, the utilization is, as I am sure you are aware, extraordinarily low.” -Interviewee 6. The interviewee is discussing the amount of time out of every day that trucks have to sit idle so that drivers can rest. While the truck sits idle, it cannot transport customers’ goods or earn revenue for the shipping company.

This plays into the favor of autonomous trucks. Without a driver, an autonomous truck should be able to operate 24 hours a day. Providers of transportation services would see higher productivity from their trucks, and purchasers of transportation services would see faster service thanks to 24 hour a day operation.

A team driver operation is a workaround that addresses the effects of hours-of-service regulations on service levels is the implementation of team driver operations. However, the addition of another driver increases the cost of the transportation. Regulations also govern certification of drivers and equipment. Specialized Commercial Driver’s License certifications, such as those required to transport tanker trailers and hazardous material, place a monetary premium on the cost of those services (Matthews 2020). To this point, Interviewee 8 said:
• “A larger fleet purchase in terms of capacity, and weight, and size can impact the type of licensing you need and [the] type of driver you need to train.”

-Interviewee 8. The interview is discussing decision-making processes when purchasing transportation assets. Different sizes of vehicles, and different types of cargo, require different classifications of Commercial Driver’s Licenses (CDL) and endorsements (“CDL Classifications,” n.d.).

A single autonomous truck may be able to transport a variety of loads, and to provide productive operations for its owner and customers 24 hours a day.

Labor (9)

Labor represents an exchange of work for compensation, or a collective bargaining organization that represents laborers in the market. It was used to code interview segments that discussed topics related to truck drivers, dock workers, and workers’ unions. Labor was found to be directly associated to Adoption (0) and Dependability (10).

Relationship of Labor (9) to Adoption (0)

Labor is theorized to have an effect on the use of a transportation solution, but according to the respondents this effect is manifested through the ongoing driver shortage. The driver shortage in the trucking industry is affecting the dynamic between labor providers and purchasers in the trucking industry and would encourage the adoption is driverless vehicles. The interviewees said:
• “There is a nationwide driver shortage. It is only getting worse and the older, established, experienced drivers are… it is an aging workforce and they are retiring, and young people do not want to [drive trucks] for a living.”  
  -Interviewee 11

• “We have right now… our impediment to growth in our business is a shortage of professional truck drivers. If we could hire a hundred drivers today, we could put them to work. That is really frustrating. It is not an equipment shortfall. It is a skilled labor force shortfall.”  -Interviewee 6

Labor unions was a subtopic of the labor construct. The effect of unionized labor was no longer viewed a strong force in the trucking industry. Respondents reported that drivers’ unions no longer enjoy the bargaining power in the trucking industry that they once did. A minority of trucking firms are still unionized, according to interviewees. Even if those unions took exception to adoption of a transportation solution such as autonomous trucks, the majority of firms could still adopt that solution. It is also possible that autonomous trucks would initially be used to satisfy the unfilled demand for truck drivers caused by the driver shortage, and that it would be some time before any drivers were laid off because of autonomous truck adoption. Interview passages that exemplify these points are:

• “Unfortunately for the unions only about 10% of [drivers] are in the union anymore.”  -Interviewee 4
- “I think, in my opinion, the lack of drivers is becoming real… To me, it has always been a bit of a smokescreen that, ‘oh, there are no drivers out there, so we have to keep our rates up.’ Stuff like that. But I think that [the driver shortage is] actually becoming a little bit real.” -Interviewee 1 was discussing a lack of qualified truck drivers, and that in the past they had viewed it as a way to justify keeping transportation rates up but that recently they are beginning to believe that qualified drivers are becoming hard to find.

- “We are losing almost ten thousand drivers a year at [my employer]. Everybody is now approaching [retirement]. All the [older] drivers are now retiring. So they are not going to run us out of work by [getting autonomous trucks]. That would work. If they could get that technology, it would be fine.” -Interviewee 7 was describing the loss of truck drivers as the labor force begins to retire and younger people are not entering the driver workforce. They said that at the rate their company replaces equipment, they would probably not lay off drivers by beginning to adopt autonomous trucks. The autonomous trucks would initially take the place of drivers that retired.

Interviewee 3 pointed out that unionized labor representing workers in other industries could have an effect on transportation adoption through friendly relationships among trade unions, but this effect was not deemed important by other interviewees.

- “Any union has a significant lobby and I think they would try to protect, as a group, any job that they could protect as far as keeping people in those jobs.”
Interviewee 3 was discussing the power of unions in the trucking industry, and that organized labor might engage in protectionist behavior and lobbying activities even if it is not their particular union being affected.

Respondents believe that human drivers will still be needed for some operations, or that existing drivers will be retrained and moved to other functions for the remainder of their careers. This could help to alleviate fears of layoffs among unionized workers and might lead to less union opposition of autonomous truck usage.

- “Take another industry like the coal industry where they said, ‘We will retrain you for renewable energy jobs if you are willing to quit [the coal industry] now.’ I think they will have to do something similar to that.” -Interviewee 4

- “Companies would have to prove to its employee base, ‘While you were an over-the-road driver, we are going down to 50 percent of that because we have these self-driving vehicles, but we've got a better job for you that is going to keep you home and [you will] be able to see your family every night. You are going to be doing more local deliveries or all package deliveries and you will still need your CDL.’ Or retrain them to do a warehouse job where they are driving a forklift or something like that.” -Interviewee 3

- “I think even if they did start to adopt autonomous vehicles and autonomous trucks within the next 10 years, [those vehicles are] not going to be widely used in every state or in every trucking company.” -Interviewee 12. The interviewee was discussing the fact that widespread use of autonomous trucks
would not happen overnight, and that it would be some time before autonomous trucks had a large detrimental effect to truck drivers’ job security.

Relationship of Labor (9) to Dependability (10)

As it is defined later in the chapter, dependability is the quality of a physical system reliably delivering results. Several interviewees reported that the truck drivers represent one of the largest sources of variability in their service times. Complaints included drivers not keeping regular schedules, not respecting requested pickup or drop-off times, and not dropping loads at the requested dock. This affects dependability by causing increased variability in delivery times, and by causing extra work for yard workers and administrative workers.

- “[One of] the challenges that we have face a lot of the time is [that] drivers do not listen to where we need something on a door or [in] a yard, or they drop [the load] and just go, and we have no idea where they have dropped it until we go out and actually physically look [for the load].” -Interviewee 4. The interviewee was describing a challenging problem where drivers do not deliver a load to a requested yard location or dock. This causes the dock or yard workers to have to go look for the load instead of doing their normal work.

- “Some of these drivers like to work on their own clock. I would not say [that] they are always super reliable. Some are great and they do exactly what they are asked to, but some kind of like to take their time and do not really
understand the importance of appointment times and things like that.”

-Interviewee 12

Autonomous trucks could help to alleviate these problems. Even if an autonomous truck could not deliver a load to a specific location at a yard or a dock, it could drop the load off in a pre-specified location and this would make finding that load easier for the yard workers. Autonomous trucks could also be much more dependable in terms of making scheduled appointments.

- “With autonomous vehicles you are telling [the vehicle] through its programming where to go, and I think that that would be amazing.”

-Interviewee 4. The interviewee was discussing the problems that their company has with drivers not dropping loads where they are asked to, and then the yard workers have to search for the load. The interviewee said that autonomous vehicles could solve this problem by consistently delivering loads to the desired location.

Performance dependability could be a strength of autonomous trucks. Labor is considered to be a factor in this, because many of the respondents tied service dependability to issues with the drivers themselves. Most respondents agreed that performance dependability could be improved with autonomous trucks.
• “Reliability\(^4\) would probably be the number one [attraction of an autonomous truck], and then also cost. Reliability [is important] because some of these drivers like to work on their own clock. I would not say [that] they are always super reliable. Some are great and they do exactly what they are asked to, but some like to take their time and do not really understand the importance of appointment times and things like that.” -Interviewee 12

• “We have had incidents where we had drivers who had a load… and [the driver] just took off. They had a bad day and decided they were not going to deliver the load. Instead of going to Los Angeles, they went to Phoenix, parked their truck and got out. They were done.” -Interviewee 3

• “My biggest issue is human error. I do not have direct contact with drivers except for the ones that I see that come in to pick up or drop stuff off. Getting hold of a driver that has been sitting somewhere in the middle of nowhere for 10 hours for no reason is a huge challenge” -Interviewee 4

**Dependability (10)**

Dependability is the quality of being able to be trusted. The construct was used in this study to describe reliability of systems such as machinery or networks, or the consistency of workers in delivering promised results. It was found to be related directly to Adoption (0) and indirectly through Service Level (2).

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\(^4\) Although interviewees referred to this as “Reliability,” it is referred to here as “Dependability” to avoid confusion with another construct.
Relationship of Dependability (10) to Adoption (0)

Dependability can be applied to autonomous trucks in two ways. First, users must consider the physical dependability of the vehicle systems. Some interviewees expressed concern over the autonomous trucks themselves. Concerns included both software and hardware issues.

- “Because the [autonomous] vehicles have not been around long enough to say when things [are likely to] break and when they [are likely to] fail, there is [a question of], how do I manage [maintenance]… Can you look at autonomous vehicles and make sure you have people that understand the software and systems and [that] you have the components [to repair them] which I am sure have a different price tag [compared to normal trucks].” -Interviewee 8

- “I think the simple things like a wiring harness can be [an] impediment to [autonomous vehicle] effectiveness if you are in a corrosive environment.” - Interviewee 6. The interviewee was discussing the dependability of a highly computerized vehicle that was made to operate in environments that are hostile to electronic components, such as salty areas near the coasts and places that use corrosive road treatments in the winter.

It is theorized that companies will be less likely to adopt autonomous trucks if their physical systems in autonomous trucks prove to be undependable. A lack of dependability would increase the downtime of the truck, and it would also be likely to incur repair costs which might not be present in a traditional truck.
Dependability (10) and Service Level (2)

It is theorized that Dependability (10) is positively related to Service Level (2). For example, Interviewee 7 mentioned that the loads that their company transports are time critical, and that if they have a truck break down their dispatcher will automatically call a tow vehicle no matter what the suspected problem is:

- “With [my employer] everything is time sensitive because we guarantee how fast we get there. [The company] will call a tow truck automatically [in case of a breakdown].” -Interviewee 7

- “[If] I can turn around and commit to the receiver – the customer that is getting the trailer load – and say, ‘[the truck is] going to be here within this two hour time window,’ a few days in advance [then that] is huge.” -Interviewee 8. The interviewee was saying how greater dependability would allow them to better serve their customers by giving the customers more accurate anticipated delivery times. The interviewee said that they currently cannot do that because of the variability of driver schedules and the availability of equipment during high demand periods.

- “If you did not have those laws where [drivers] had to take 30 minutes breaks, or [that] they can only drive for 10 hours at a time and you just could just ship that [load] right to a hub or another location to be sorted without stopping that would be amazing. Our errors and our mis sorts would go down astronomically.” -Interviewee 4
It is theorized that manufacturers would need to demonstrate that the physical dependability of autonomous trucks was at least as good as traditional trucks in order to make them attractive to trucking firms and shippers. However, autonomous trucks have the potential to offer greater consistency in terms of service dependability, which might give them a competitive edge over human-operated trucks.

Security (11)

Security (11) was defined as a safeguard against criminal activity. The construct was brought to attention by a comment made by Interviewee 7, who believed that autonomous vehicles being vulnerable to communications infrastructure damage. The code Security (11) had a low frequency of appearance in the analysis (in 5 instances). But the concept adds interesting insight to the discussion of autonomous truck use thus it was included in the model. It was used to capture comments about system security, such as a system’s ability to thwart cyber-attacks, and physical security, such as the theft of products from a truck. The construct is related to Dependability (10).

Relationship of Security (11) to Dependability (10)

Security is believed to have an effect on dependability. Interviewee 7 expressed concern over the ability of attacks on communications infrastructure to negatively impact connected and autonomous vehicles.

- “What happens if somebody [destroys] a satellite [or other infrastructure] and then all of a sudden we [have] got no trucks moving?” -Interviewee 7
“My concern was, what if [an organization] took out our cell network somehow.” -Interviewee 7

According to Interviewee 7, security is a key concern in the trucking industry. Security is also a priority in other industries that rely on connected technologies. A bomb attack of downtown Nashville, TN on the morning of December 25, 2020 disrupted cellular service across several states (Jeong and Allison 2020). In May 2021, the Colonial Pipeline in the Eastern United States was hacked, which disrupted the gasoline supply in that region of the country (Egan 2021). These incidents highlight the susceptibility of highly connected systems such as autonomous vehicles to malicious activity.

Interviewee 7 also indicated that trucking firms tend to view the drivers as a potential security threat. According to the Interviewee, shippers worry about the drivers pilfering items from the truck.

• “Usually [the trucking firm is] afraid of the driver itself taking stuff. [The load] would be sealed when [the driver] picked it up and unsealed when [the driver] got it there.” -Interviewee 7

Customer Requirements (12)

Customer Requirements is a concept representing a service level or capability that a customer needs in order to consider adopting a transportation solution. To an extent, the construct “Customer Requirements,” is similar to service level, but it represents a
condition set by the buyer of transportation services that the provider must be able to meet. Service Level (2) is desirable, but Customer Requirements (12) are mandatory.

**Customer Requirements (12) to Service Level (2)**

Customer Requirements (12) was found to be directly related to the likelihood of transportation solution adoption through the concept of Service Level (2). This relationship is conditional: if a transportation solution is capable of meeting the customer’s requirements, then it can be adopted by the customer; otherwise, the solution cannot be adopted.

- “[The customer will] tell us what exactly or what date that product needs to be at their warehouse, and it is up to us to make sure that that happens, assuming we are given enough notice to be able to plan [our work].” -Interviewee 12

- “This [trucking manager] literally said, ‘You gave my business away for five cents a mile and I called you on it. And you said, if you come down five cents, you can have the business back,’ and [then] the [manager] said, ‘in the same breath you are telling me to go spend an extra $15,000 per truck for security enhancements, but you are not paying me for that, and [the customer said] ‘yeah.”’ -Interviewee 2. The interviewee was describing a panel discussion that a major company had with its transportation vendors. A manager from a transportation company pointed out that the customer had switched transportation vendors away from them for a marginal savings, while simultaneously telling all of its transportation vendors that if they wanted to
haul the customer’s products, that they would need to install certain equipment on their trucks which the customer would not pay for.

- “Before we would put [a transportation vendor] into place, we would do a scope of work [evaluation] where I [would] talk to the plant site [personnel]. I would ask them what their needs are, and any concerns they might have [what vendors] they are using today.” -Interviewee 5

Customer Requirements could be leveraged to positively impact the adoption of autonomous trucks if the trucks could better satisfy the specific needs of transportation customers. Fast service and increased visibility are two ways that autonomous trucks could potentially better satisfy customer requirements.

- “[We] need the thermal packaging [and] quick distribution for those materials. It really [depends on] what carriers have those capabilities and can protect our material and keep us updated all along the way.” -Interviewee 5. The interviewee was discussing how their company evaluates transportation vendors. Vendors must have the capability to handle cold storage loads and provide extensive tracking data.

- “Anyone who does autonomous [trucking] will have the technology to allow you to track the location of the trunk, versus some other [vendor who] might not give you that access.” -Interviewee 1

This section presented the results of the qualitative data analysis for Research Questions 1 and 2. A table of the codes used, a brief description of each, and their
frequencies are shown in Appendix 8: Codebook. The analysis for Research Question 3 is presented next. Some of the findings for Research Questions 1 and 2 provide insights for Research Question 3.

**Research Question 3: How do transportation professionals expect their businesses to be affected by autonomous trucks?**

This section addresses Research Question 3, providing an analysis about the effect that autonomous truck adoption is expected to have on industry. The outcomes of the analysis are presented as a set of propositions about the effect of autonomous truck adoption on different transportation professionals such as trucking companies, third party logistics firms, business transportation departments, truck drivers, and ancillary firms that serve the transportation industry. Research Question 3 also presents the propositions in regard to the effect of autonomous truck adoption on businesses at a macro industry level, rather than at the level of the individual firm.

**Proposition 1: Direct operating costs for a given service level will decrease across the trucking industry.**

The American Transportation Research Institute defines operational costs as a combination of the costs of fuel, asset acquisition costs, maintenance costs, licensing costs, road use fees, insurance, driver wages, and driver benefits (Williams and Murray 2020). For the purpose of this proposition, direct operating costs are
considered to be the cost to transport a load from a given origin to a given destination. When referring to these costs, interviewees typically mentioned driver wages, driver benefits, and fuel for the truck. It is theorized that direct operating costs will decrease with autonomous truck adoption. An interviewee indicated that approximately one third of direct costs of truck transportation are incurred due to driver wages and benefits. One interviewee also suggested that autonomous trucks would have better fuel economy than human driven trucks because their programming would make them less likely to execute hard braking and acceleration events. Another interviewee suggested that shipping rates could decrease because of greater resource productivity to the trucking firms, owing from an autonomous truck’s ability to operate 24 hours a day. Some of the interview passages that support this proposition are:

- “Driver wages and benefits are about thirty-five to forty percent of the overall cost of transport. That goes away practically overnight [with autonomous trucks].” -Interviewee 11
- “It seems like over time it would be a less expensive option to not have to pay these drivers for their time.” -Interviewee 12
- “Once they have the programming perfected, you are going to have better fuel economy versus a human driver. You are not going to get those hard brake [events] unless it is an outside influence like a wild animal or another driver coming into [the truck’s] lane.” -Interviewee 5
- “It can lower cost. [An autonomous truck] can lower that shipping cost because that truck can run 24 hours a day 7 days a week.” -Interviewee 2. The interviewee was discussing how an autonomous truck could lower direct
shipping costs on long haul routes because of greater productivity when compared to a human driver with hours-of-service regulations.

Proposition 2: Fixed costs of trucking are expected to increase

The increase in fixed costs is theorized to be due to higher purchasing costs of the autonomous power unit, owing to the technology of their power units, as well as the maintenance of that power unit. The professionals said:

- “Total cost of ownership of different types of fleets and what upgrades have come out by providers has been another key piece of this. For [a truck] to be maintained that is 15 years old versus one-year-old is pretty major.”
  - Interviewee 8. The interviewee was expressing concern over the acquisition cost and maintenance cost of technologically-advanced trucks.

- “Like any new technology, the cost to build and the cost to deploy [it] is going to be the initial big cost once we move over to a system like [autonomous trucks]. The other cost will be maintaining those vehicles. How do you do that? The software engineers [and] the programmers needed to maintain those and the updates that come through as well. You are going to have a whole new set of costs.” -Interviewee 4

One noteworthy exception was an interviewee who thought that the autonomous truck power unit not needing a cab for a driver could keep the costs down due to fewer materials in the power unit chassis.
● “I know that 60 to 80 percent of the metal material in a truck is there to support the human being piloting that truck. [If you] no longer need a human being is the cost of a power unit - a Class A power unit – [going to] drop materially?” -Interviewee 9. This interviewee thought that a decrease in the material required to build a fully-autonomous tractor might cause the price of that tractor to drop. This supposition was an outlier, as other interviewees thought that the price of trucks would increase.

Proposition 3: Autonomous trucks will offer a Competitive Advantage to those firms that adopt them.

In business literature, a Competitive Advantage is a feature of a business that allows it to attract greater sales or market share than its competitors (Twin 2021). It is theorized that autonomous truck use will offer a competitive advantage to firms that use them.

Four of the respondents thought that autonomous trucks might allow for companies to leverage better transportation availability, lower operating costs, or economies of scale to gain a sustainable competitive advantage in their marketplaces. For example:

● “There is going to be that firm that realizes, ‘we are running this truck cheaper [than our competitors].’ They are going to go to the customer and say, ‘listen, we really want that lane.’ Somebody is going to undercut [your firm] all the time, and you just have to keep up [with competitive pricing]. It is going to
drive [shipping] costs down. I think a lot of the thought is, if my competition has these [autonomous] trucks and their cost of driving is cheaper, I have to be cheaper to [keep] my customer.” -Interviewee 1. The interviewee was discussing how if autonomous trucks are cheaper to operate, that it could lead to a price war which might force other firms to adopt autonomous trucks just so that their competitors do not have a competitive advantage from the cheaper operations.

- “[If] somehow someone gets an early mover advantage, they are able to enjoy some period of time where no one else has [autonomous trucks] and they can you exploit higher than Market margins until the rest of the industry catches up.” -Interviewee 9.

Two interviewees said that the advantage possessed by firms who adopt autonomous trucks would force other companies to adopt autonomous trucks in order to remain competitive in their markets.

- “If my competition has these trucks and their cost of [shipping] is cheaper, I [need] to be cheaper to [keep] my customer.” -Interviewee 1

- “I think if this autonomous [trucking] would get momentum, it would be, ‘my competition - it has an advantage now because they are doing this so I am [also] going to do it.” -Interviewee 2
Proposition 4: Job security of truck drivers will not be heavily impacted by autonomous truck adoption, but non-driver transportation positions may be eliminated.

Job security refers to the safety of employment against actions such as layoffs. Most interviewees agreed that a scenario of widespread joblessness is unlikely. Even if autonomous trucks suddenly became a viable transportation solution, it would take years before the majority of trucks on the roadway in the United States were autonomous. In the meantime, AVs would alleviate the driver shortage mentioned earlier in the document. Interviewee 7 offered some very interesting insight into the length of time that it would take for autonomous trucks to become common, and also suggested that since truck drivers are not entering the industry at a replacement rate, that the autonomous trucks would largely offset the retiring workforce.

- “I do not think that it is going to have too much of an impact. We are losing almost ten thousand drivers a year at [my employer]. All of the original drivers are now retiring. They are not going to run us out of work by [buying autonomous trucks]. If [my employer] could get that technology, it would be fine… [My employer has] over a million pieces of equipment not counting airplanes. We are probably [replacing] 5,000 trucks a year, and [we] have been on that pace for about five years” -Interviewee 7 was discussing attrition of truck drivers in their company, and how autonomous trucks might simply fill the unmet demand for drivers. It is assumed that the million-power-unit figure quoted includes power units other than over-the-road tractors, but even
if only a fraction of those power units were tractor-trailer power units, it would still take many years for the entire fleet of trucks to be replaced with autonomous trucks at a rate of 5,000 trucks per year.

- “I think [truck drivers will still be needed]. I might just put it a little differently based on how autonomous continues to evolve, and [if] we have these Hub and spoke models that [become dominant], and as a result and the nature of truck driving changes, but I do not think human beings are going away in a material way anytime soon. And, by that, I mean 10 years.”

-Interviewee 9. The interviewee was discussing an operational model such as those employed by Embark (Ohnsman 2019) where autonomous trucks perform long distance shipping of loads between hubs, and a human driver performs last mile delivery.

Most other interviewees also did not think that drivers would be put out of a job by autonomous trucks. They agreed that there would still be a need for drivers, but that their responsibilities might change. Rather than performing over-the-road functions, drivers might perform local deliveries in areas that were difficult for autonomous trucks to access. Other drivers might perform switch yard duties or short-haul deliveries that would allow them to return home every night.

- “I think that doomsday scenario where suddenly you have millions of truck drivers trying to find something else to do is probably not likely.”

-Interviewee 9. The interviewee was discussing an autonomous truck pilot project that was unable to maintain operations but mentioned that the pilot
project had CDL drivers on staff to operate the trucks remotely from a control center. This led to the discussion about still needing human drivers for the near future while autonomous truck technology develops and becomes more capable of handling challenging driving situations such as bad weather and urban environments.

- “Maybe [companies will] retrain some of their current drivers into different types of roles in order to support the autonomous side. You are still going to need people who can monitor [the vehicles], who can dispatch [vehicles], and can maybe navigate [vehicles] remotely in more challenging scenarios.” -Interviewee 8

- “Drivers are aging out and the younger drivers do not want to leave families and go over the road… There is not a lot of appeal for young people to go into the [trucking] industry. If you can keep people closer to home and have the [autonomous] trucks take the high mileage [routes], it is a win from a drivers’ perspective.” -Interviewee 5. The interviewee was saying that drivers might see a situation where autonomous trucks took long haul routes and human drivers did local deliveries as a net benefit, since the human drivers could stay close to their homes.

- “Maybe instead of having [a human] deliver it from point A to point B, there will be an increase in those people who understand how to operate the vehicle once it gets to its dock [and to] making sure if any maintenance that needs to be done [gets done].” -Interviewee 10
One interviewee suggested that some non-driver positions and firms within the trucking industry would be eliminated. These indirect labor positions consist of those whose responsibilities are to find and retain skilled labor will be in less demand.

- “What I do is going to become less and less relevant as autonomous vehicles come to the forefront because I have been recruiting, training and managing drivers. That is a big part of my responsibility, and then [so is] all the regulatory compliance goes along with it.” -Interviewee 11

**Proposition 5: Business Operations will change to take advantage of autonomous trucks’ strengths.**

Business Operations refer to the design and function of business activities that a firm engages in to generate revenue. It is theorized that autonomous trucks will make operational processes more efficient. This could help organizations implement lean operations through the reduction of inventory levels. One interviewee suggested that this effect could be so pronounced that it prompts the redesign of physical distribution networks.

- “I think that [autonomous trucking] definitely has some hidden benefits of a more consistent industry - down to the hour of receipt and shipment.”
  -Interviewee 8. The interviewee was describing how autonomous trucks could be more consistent and flexible in terms of their pickup and delivery times than human driven trucks, which would allow for a decrease in safety stock in many organizations.
“Right now, to put things in perspective, we spend hundreds of millions of dollars in our logistics business, and a lot of that is just moving [product] around. [Our autonomous truck research] really changed how we look at the costs of production right now. We would go and outfit some of our production lines to produce a specific product because it is cheaper to spend the 30 million dollars on a production line [in New York] than it is to ship from LA to New York. So we will outfit New York with this new 30 million dollar production line just so they can ship [the product] from New York instead. [Autonomous trucks will] definitely shake everything up… You [will] probably start to see a very interesting kind of new [distribution] hub opening and [old hubs] closing. With [electronic logging devices] and driver hour tracking a lot the [current] hub cities and distribution centers make sense. But start to imagine a truck that can drive through the night and does not have to stop for breaks. Maybe we can use highways at times that may be [less safe] for humans but [are] safer for autonomous trucks, and [that] puts those key points of distribution and even production in different locations. It makes sense right now to produce and store things right in downtown Los Angeles, because to ship it is much more expensive compared to [producing and storing it]. Maybe there is some benefit of putting a facility in Kansas or Ohio [with autonomous trucks] - a place that is maybe not as exciting to live in – [but that has] talent to hire, and you can ship anywhere from [there] across the country.” -Interviewee 8. The interviewee was discussing the fact that their business currently builds manufacturing centers close to their demand. The
efficiencies of autonomous trucks might make it more optimal from a financial and operational perspective to locate manufacturing facilities further away from major population centers, where labor to operate the manufacturing centers is cheaper, and to use autonomous trucks to transport their goods to market.

- “What we hear [will change with autonomous trucks] is that today you think of a driver going to a warehouse to pick up [a load] and driving that [load] across country to another warehouse or to a retail location. What we are hearing is that model will potentially change where you might have a driver pick up from a warehouse – we will say it is going from St. Louis to Los Angeles – [with autonomous trucks] you might have a driver pick up [the load] in a suburb of St. Louis and drop it at a hub in St. Louis. An autonomous truck would take it cross-country on the major highways and then [there would be] a delivery driver that would pick up outside of L.A. and take it to its final destination. It would be more like [a Less-Than-Truckload] model with hubs and spokes.” -Interviewee 5

**Proposition 6: Autonomous truck adoption will cause a decrease in the number of road crashes.**

It is theorized that autonomous trucks will cause a lower number of road crashes than human-driven trucks do. A majority of crashes have human error as a causal factor (NHTSA 2015). An autonomous truck would remove that causal factor.
Interviewees agreed that autonomous trucks would likely be safer than human-driven trucks.

- “[From our autonomous truck research] I think what you see are very good use cases of ways to use this technology. I think the industry can look at growing this segment and really seeing the value in terms of [what autonomous truck use] provides in safety to the people driving the truck, but also people around the trucks.” -Interviewee 8. The interviewee was discussing internal conversations that their company had about autonomous truck pilot projects that they had witnessed, where a truck operated itself with a driver onboard as a backup in case something went wrong.

- “I think that merging [autonomous trucks] together [with human drivers] to make things safer, where you have got the truck driver being more like the airline pilot [overseeing a plane on autopilot], is a real possibility.” -Interviewee 7. The interviewee was discussing the possibility of having a truck driver onboard an autonomous truck as an administrator and backup system in case of an emergency.

- “Everything I have heard is [that insurance companies] believe that there will be [fewer] accidents [and fewer] fatalities with autonomous trucks.” -Interviewee 1.
Proposition 7: Infrastructure changes will be needed in order for the full benefit of autonomous trucks to be realized.

In this study’s context, Infrastructure refers to the United States’ roadway infrastructure such as roads and bridges. The American Society of Civil Engineers gave the American roadway infrastructure system a “D” grade in the first half of 2021 (ASCE 2021). This indicates that roadway repairs and upgrades are needed, and that viewpoint was echoed by one of the interviewees who suggested that infrastructure changes are needed regardless of whether or not autonomous truck use becomes widespread.

● “Infrastructure upgrades are going to be required regardless…”
  -Interviewee 11. The interviewee went on to say that they did not think autonomous vehicles would have any greater difficulty than a human driver in most roadway situations once the technology matured.

The general sentiment was that autonomous trucks would be better utilized if infrastructure was upgraded to aid the technology. Three interviewees specifically mentioned that dedicated autonomous vehicle lanes would help autonomous trucks reach their full potential, and Interviewee 7 even suggested a dedicated highway for autonomous trucks.

● “I think that [autonomous truck use will] bring some infrastructure changes in terms of dedicated lanes for autonomous vehicles or different speed limits, or [possibly] different types of road and asphalt configurations.” -Interviewee 8
• “I think that [autonomous vehicle lanes] would probably work better than [having] cars merging in front of the autonomous vehicle. There are so many factors that seem like something could go wrong where if [the autonomous vehicles] were in their own lane, you wouldn't necessarily have to worry about all of those factors.” -Interviewee 12

• “I think infrastructure wise, certainly, you would need to look at how in some cities you have the high-occupancy vehicle lanes, perhaps [we need] special lanes dedicated to those types of vehicles.” -Interviewee 3. Later in this same passage the interviewee brought up the challenge of fueling an autonomous truck, but that is discussed later in this section.

• “I think the [federal government] has been talking about making [highway] 69 an interstate from Laredo to Chicago. I do not see that as a big bonus for cars. Why not just build a strict autonomous truck lane?” -Interviewee 7

Proposition 8: Ancillary businesses that support the trucking industry will be affected by autonomous truck use.

The concept of the effects of autonomous truck use on support businesses grew organically out of conversations with the interviewees. Ancillary businesses are businesses such as mechanical service centers and fuel stations that exist to serve human-driven trucks. Even businesses such as fast-food franchises that earn part of their income from feeding long haul truck drivers could be negatively impacted.
These firms would need to adjust their business models in order to maintain their profitability.

- “I have a buddy whose family owned a truck repair company. They were the only game in town between Springfield, Missouri and St. Louis. For any tractor-trailer that had an issue or needed some sort of maintenance, they were the company that was called. So, they had a couple hundred mile radius that they were getting calls on. I do not know if they would, at least initially, be able to ramp up with staff or mechanics that could fix a lot of [problems with autonomous trucks] until they were it was proven that they were losing business by not having that [autonomous technician] on staff who can fix a different type of vehicle.” -Interviewee 3

- “I think you are going to have to [have] a huge increase in [mechanics’] capabilities. If you are a classic mechanic or a tow truck driver or a shop, you are going to have [to have] a pretty sizable component [of your workforce] that is going to be devoted to understanding machine code or software that has been written into the operation of that [autonomous truck] and being able to diagnose what is going on with the vehicle. It is going to be an increase in a lot of the specialty [expertise] you need inside those mechanic shops.”
  -Interviewee 10

One interviewee wondered about how autonomous vehicles would handle situations in which the driver traditionally served the vehicle. For instance, truck drivers often refuel their trucks, and drivers call for tow trucks in the event of a break-down. In the
case of a fuel station, the station might have to hire attendants to go out and perform service for the trucks – such as refueling the vehicle, checking the air in the tires, and other routine functions. In the case of a breakdown, a tow truck driver might have to perform field diagnostics on the vehicle or make an adjustment to allow the autonomous truck to be towed.

- “Does the [autonomous] truck go in and fuel itself or do the fueling providers come out and fuel the truck?” -Interviewee 6. The interviewee was posing a question about how refueling operations would be conducted for a truck without a driver.

- “What I mentioned in terms of breakdowns – we would like to think that is an infrequent occurrence, but it is not. Currently, if you break down you can typically limp to the next exit or at least to the side of the road. Would an autonomous tractor-trailer be able to do that? Because, if one does is not able to do that if they sense that there is a malfunction, it shuts down immediately.” -Interviewee 6. This was from later in the interview. The interviewee was discussing how a driver can provide some support in the event of an equipment problem, and wondered how an autonomous vehicle would handle a malfunction. A driver could also find a service center to try and quickly get the truck back on the road.
Proposition 9: Widespread autonomous truck usage will change the market makeup of the trucking industry.

It is theorized that the market conditions – the state of the trucking industry and the firms that operate with it – will be affected by autonomous truck adoption. For example, one interviewee thought that the increased visibility offered from the technology that made autonomous trucking possible would be detrimental to non-asset based third party logistics firms that primarily match available loads with available equipment and drivers.

- “[Shippers are] going to know [where trucks are] if trucks go autonomous, especially with the [Electronic Logging Devices]. As soon as ELD’s become common information, everybody is going to know where the trucks are at. If that technology goes commercial, and it will, it will… near eliminate the third party logistics world. That whole mystery of where is the capacity – trucks - all that is going to go away.” -Interviewee 2. The interviewee was discussing the effects of increasing visibility on the trucking industry. The interviewee surmised that autonomous trucks’ ELD’s would broadcast their location to regulatory bodies and to their owners as soon as the truck was activated. The interviewee also believed that the location information provided by the ELD’s would eventually become publicly accessible, which would do away with much of the need for third party freight scheduling firms.
Another interviewee who is involved in the non-asset Third Party Logistics industry shared a similar sentiment. The interviewee said that even though customers had the option to go direct to carriers, that they often used 3PL firms to have a human touch to the freight solution. The interviewee said that the dynamic in their industry could greatly change if autonomous trucks offered a direct-to-consumer technology solution for freight scheduling.

- “From a 3PL standpoint, autonomous in what sense? That there does not have to be a driver in there? Then it is really to make this 3PL space technology based, because you have a lot of carriers going direct to customers but up until now customers still want that interaction with a person, if that makes sense. They still… I think that is why companies like Uber Trucking [have not] taken off as much as everyone thought it would. But I think it could have a big impact on the relationship from a 3PL standpoint that [the customers] have with these carriers once the autonomous vehicles really hit.” -Interviewee 1

Interviewee 9 suggested that autonomous trucking might lower barriers to entry in trucking their statement about the lack of a driver interface potentially decreasing the cost of a power unit.

- “I know that 60 to 80 percent of the metal material in a truck is there to support the human being piloting that truck. [If you] no longer need a human being is the cost of a power unit - a Class A power unit – [going to] drop materially? And, if the price of power units drops materially does that
actually lower the barriers of entry and make it cheaper for new participants to come in?” -Interviewee 9

The interviewee also speculated that larger firms might be early adopters of autonomous trucking technology and could use economies of scale to force smaller carriers out of the industry.

- “Does the licensing [and regulations] around who is able to operate autonomously… become so prohibitively expensive that only the largest, most well-funded national carriers are able to take that first step and become early adopters? And, if they become early adopters, does that give them such an instrumental cost advantage that it wipes out the rest of the industry that are comprised by [small] sub-6-truck fleet carriers?” -Interviewee 9. The interviewee also suggested that elimination of smaller carriers would probably not be an immediate effect.

Either of these two scenarios regarding barriers to entry would have a marked effect on the trucking industry’s competitive landscape through an affectation of the barriers to entry and threat of new entrants into the industry. A further discussion of these two possible outcomes follows in Chapter 5.
Chapter 5 – Conclusion

This chapter provides a summary of the goals and questions that were posited for this research, the methodology used, and the findings obtained. It also includes a reflection about the theoretical and practical contributions, the research limitations, and opportunities for further research.

Research Objectives and Questions

This study evaluated factors that influence business’ transportation decisions and addressed a shortcoming in autonomous vehicle research: factors that will affect autonomous truck adoption and how autonomous truck adoption might, in turn, affect transportation.

This research grew out of a need to understand the decision-making procedures used in selecting business transportation solutions. This was necessary because of the expected growth in autonomous vehicle use; specifically, that of autonomous trucks. Since autonomous truck adoption will be market driven, it is important to understand what business professionals’ transportation priorities are so that autonomous trucks can leverage these priorities. Additionally, trucking firms, their customers, and corporate transportation departments are not the only stakeholders in autonomous truck use. Truck drivers, ancillary businesses, and the general public will also be affected by autonomous truck adoption. Therefore, researchers and practitioners must be able to anticipate the effects that autonomous truck adoption could have on the
other stakeholders affected by this phenomenon. The three Research Questions posited were:

1. How do transportation professionals choose a transportation method or carrier for their business?
2. Why would transportation professionals choose to adopt autonomous vehicles versus other transportation methods?
3. How do transportation professionals expect their businesses to be affected by autonomous vehicles?

Methodology

Based on the research goals, an inductive methodology was selected because of a lack of research about this topic and a corresponding lack of existing hypotheses related to the Research Questions. Inductive methodologies allow for generalizable statements to flow from the data, and this attribute matched the research goals of this dissertation. The inductive approach used was Grounded Theory methodology (Glaser and Strauss 1999), which enables an iterative data collection and analysis process to address new findings and to take advantage of the unique expertise of a diverse sample of research participants.

A research protocol was developed which included guidelines for selecting participants, collecting data, and analyzing the accumulated data. Twelve professionals were interviewed from a diverse array of geographical and functional positions within the transportation industry. These interviews were recorded and transcribed, and coding analysis was conducted using MaxQDA. This led to a conceptual model that addressed Questions 1 and 2, and propositions that addressed
Question 3. Validity was assured by using recommendations from the literature. The findings of the research are summarized next.

Research Question 1: How do transportation professionals choose a transportation method or carrier for their business?

Research question 1 applied to transportation decision-making in a general sense that is not necessarily specific to autonomous vehicles. It is applicable to any trucking decision, such as choosing a traditional truck or a carrier for a specific load. Prior to beginning the research, the author expected that interviewees would favor the cost/service tradeoff aspect of a transportation solution as being the primary driving factor. Although the findings identified “Cost” as widely discussed contributing factor to transportation adoption, the true cost of a solution is a complex topic that goes beyond direct operating costs. The construct, “Cost,” was found to have several contributing constructs. For example, insurance companies and the effect of legal liability appear to play a large role in transportation solution cost.

The service level provided by a solution and the profit contribution generated by that service was found to play an important role in transportation selection. Interviewees indicated that cost and service and the general tradeoff that occurs between them, is often the primary decision-making factor. The prioritization of cost or service within that tradeoff depended upon the nature of the respondents’ respective businesses and the organizational objectives of those businesses.
An unexpected development was the importance of profit contribution to Third Party Logistics (3PL) companies. Interviewees from these companies indicated that they sought to maximize the profit margin on their transportation activities, rather than simply paying attention to the cost and service level of a solution. Responses from the interviewees suggest that due to customer knowledge of the trucking industry’s cost structure, the 3PL industry has a high bargaining power of buyers and that 3PL companies respond by opportunistically seeking bids which will yield higher profit margins.

Other constructs, such as Safety, Public Acceptance, and Regulation, are believed to have indirect effects on transportation adoption. That is, they primarily act through other constructs by means of their influence on those constructs, although respondents did indicate that Safety is a concern that is considered when making transportation decisions.

*Research Question 2: Why would transportation professionals choose to adopt autonomous vehicles versus other transportation methods?*

Interviewees indicated that autonomous trucks could enjoy a competitive advantage over human driven trucks in the areas of Cost and Service Level. Three scenarios were described in Chapter 4 that would give autonomous trucks an edge. They were: Same service level at a lower cost; higher service level at the same cost, or higher service level at a lower cost.
Dependability was identified as a concept that could have a positive or negative effect on autonomous trucks’ adoption. On one hand, transportation professionals expressed concern about the service dependability of human drivers and thought that autonomous trucks might operate at more regular schedules and be more flexible in terms of pickup and drop off times. On the other hand, some respondents expressed concern over the physical dependability of autonomous trucks’ system, especially in hostile environments such as salty winter roads.

Some interviewees also suggested that autonomous trucks could be safer than human driven trucks. This could lead insurance companies to incentivize the use of autonomous trucks. However, it is important to note that interviewees believed that autonomous trucks would become safer than current trucks only after the technology is stable and not immediately after their initial deployment. Demonstration of safe autonomous truck operation could help to alleviate the fears of transportation managers and of the general public. Further, safety and liability are tied to insurance. Therefore, a safer truck, which would hurt fewer people and result in less property damage, could lower an insurance company’s risk. Insurance companies appear to have a large influence in the trucking industry, and insurance companies’ support of a transportation solution is believed to be positively associated with the adoption of that solution.

Regulation could pose a challenge to autonomous truck adoption. Interviewees suggested that governors might choose to court a wary populace by disallowing use
of autonomous trucks. Current regulations have a large burden on the trucking industry, and that troublesome regulations relating to autonomous trucks could stymy their adoption.

Research Question 3: How do transportation professionals expect their businesses to be affected by autonomous vehicles?

Several interviewees indicated that if autonomous truck usage became widespread it would decrease the importance of non-asset based 3PL companies and corporate transportation managers. Non-asset based 3PL professionals believed that the load/truck matching services that they provide could be handled by an electronic autonomous truck shipping portal because the autonomous trucks would have to provide real-time location and activity data to their controlling agencies. Those agencies might be able to use their software to allow customers to schedule shipments. Transportation managers deal with hiring, training and retaining drivers. If autonomous trucks were common, then the need for that function would be diminished.

Questions remain about the effect of autonomous truck adoption on labor. For the most part, interviewees said that sudden mass layoffs were unlikely. Most seemed to think that autonomous trucks would initially augment the human driven truck fleet to offset the driver shortage. As drivers retired, their functions would simply be replaced by autonomous trucks. Some interviewees said that human drivers would probably still be needed in some capacity for a long time, even if they just performed
local delivery service, switchyard operations, or other activities which were impractical for autonomous trucks.

Transportation infrastructure and support industries will likely be affected by autonomous truck adoption. It was suggested that infrastructure upgrades are needed to make autonomous trucks widely feasible. The perceived need for infrastructure improvements was more common among interviewees in the northern parts of the country. One common infrastructure upgrade that was suggested was the addition of autonomous vehicle lanes to existing highways, but one interviewee went so far as to suggest that autonomous trucks might benefit from their own dedicated highways. Concerns about ancillary industries centered around companies such as service centers and fueling stations. Service stations might not be well-equipped to handle the complexity of an autonomous truck if it needed to be repaired. One interviewee very poignantly asked how an autonomous truck would be refueled if there was not a driver onboard the vehicle.

This technology might change the physical structure of outbound distribution networks. Less expensive road transportation or faster road transportation might present companies with a savings opportunity if they move distribution centers out of major cities and run more frequent shipments to retail centers in those cities. One interviewee described the system as a hub and spoke model. Less expensive long distance transportation options might also be a benefit to lean systems operations. Manufacturers could push safety stocks to lower levels and run more frequent
replenishments if trucking costs decreased and service levels simultaneously improved. Some of the safety stock held in inventory would essentially be shifted to inventory in transit, rather than being held at the point of manufacturing. A decrease in transportation cost with an improvement in service levels might also allow for fewer, more centralized production centers in a production and distribution network. Larger production centers could better realize scale economies, which would decrease per unit production costs. Companies that realized these scale economy benefits and effectively shared them with supply chain partners would make their supply chains more competitive in their markets.

The competitive landscape of the trucking industry might be affected as a result of changes of barriers to entry arising from autonomous truck use. Considering this concern in context with a suggestion about the effect that direct-to-customer scheduling technology based around autonomous trucks could have on the Third Party Logistics industry, it is theorized that one of two possible scenarios could become reality. The first scenario is that autonomous trucks, and technology such as direct-to-customer scheduling tools, could democratize the trucking industry. It would allow entrepreneurs who do not possess a Commercial Driver’s License to purchase an autonomous truck and put that truck to work transporting freight. The industry could see lower barriers to entry, and a proliferation of small carriers operating on a for-hire basis using direct-to-customer scheduling platforms to secure business.
Another possible scenario is the opposite of lowered barriers to entry. If liability for the operation of the truck falls on the truck’s owner, and autonomous trucks are highly regulated with expensive licensing and inspection procedures in place for autonomous operators, it could be that only large, well-funded carriers could afford to purchase autonomous trucks. Those carriers could then undercut smaller operators and force many of them out of business. With smaller carriers no longer taking up their parts of the market share, the trucking industry could become an oligopoly in which a small number of large firms dominate the market.

**Theoretical and Practical Contribution**

This study provides contributions to both theory and practice in the areas of transportation and supply chain management. In regard to theory, it addresses a need for future-oriented qualitative research in the logistics field that was described by Näslund (2002). The research also brings an empirical, practitioner-focused methodology to the problem of autonomous truck adoption, filling a gap identified in the literature review. The adopt vs. do not adopt decision from Rogers Diffusion of Innovation theory, which was described in Chapter 1, was applied in the trucking industry.

A vignette into how professionals in the transportation industry view innovation and their willingness or unwillingness to embrace that innovation is also presented. The research propositions and models developed in the dissertation examine practitioners’ decision-making priorities involving trucking. Research surrounding autonomous
vehicle benefits often assumes high market penetration rates as a prerequisite for realizing those benefits.

If society, as a whole, wishes to see this innovation adopted, an understanding of practitioners’ priorities and perceptions of autonomous trucks can be used to make the case for their adoption stronger from equipment, regulatory, and marketing perspectives. A parsimonious model can also help future researchers evaluate autonomous trucks and explain how transportation professionals prioritize constructs relating to their decisions, as well as how those constructs influence one another. The analysis demonstrated that there are different innovation curves at the individual, firm, and industry levels and gave a starting point for future research into this topic. Questions 1 and 2 evaluated the status quo of the phenomenon and then extrapolated trends uncovered in those questions to the future in Question 3.

In terms of practice, the findings are useful for industry professionals. Knowledge of the decision-making priorities of transportation professionals from a diverse array of firms and geographic locations can aid both transportation providers and customers in making more informed choices that can provide greater value to their organizations. Additionally, the results shed light on potential avenues to encourage a successful adoption of autonomous trucks. It is hoped that this insight will benefit all stakeholders of autonomous truck adoption. Researchers and companies developing autonomous trucks can use this framework to tailor their activities to design their products to provide maximum value in areas in which those products might best
exploit a competitive advantage. Companies interested in adopting autonomous trucks might use this information to see how to most effectively deploy these vehicles without a detrimental effect on their labor forces or firm reputations, all while maximizing the benefits that autonomous trucks might provide.

It is the author’s hope that this study will help to guide researchers, practitioners, policymakers, and the general public to live harmoniously with this new technology and with each other, rather than turning what could be a beneficial invention into a point of contention. Further, the author hopes that this study will demonstrate the benefit of industry and academic partnerships as a means of thoughtfully advancing the transportation, logistics, and supply chain management fields.

**Limitations and Future Research**

Being an inductive interview study, the conclusions and propositions reached in this research may not be generalizable. The goal was to perform an exploratory analysis of the phenomenon in question and identify relationships between constructs and the phenomenon of interest. A deductive research study is needed to test the generalizability of the conclusions reached in this study. The conclusions stated by the researcher are only based on theorizing about available information uncovered from the interviews with the study participants. A different methodological approach would be required to make deterministic predictions about future relationships among the constructs. Additionally, the views provided by the transportation professionals
in the interviews represent their opinions at the time that the interviews were conducted.

A geographically and functionally diverse sample was used in order to increase external validity. However, representatives from autonomous trucking companies, such as TuSimple and Embark, and manufacturers of autonomous trucks were not able to be included due to multiple failed contact attempts and owing to the fact that autonomous trucks are a new technology, not many of these firms exist yet.

The estimated required sample size for this study was 15 interviewees but theoretical saturation was reached at 12 interviewees. By the 12th interviewee, no new insights were being uncovered, and continued interviews served to validate what previous interviewees had said.

Qualitative research authorities such as Seidman (2013) and Chun Tie, et al. (2013) suggest that multiple authors should code interviews in order to increase the academic rigor of interview and Grounded Theory studies. Because this study was a doctoral dissertation, the researcher was unable to utilize a second author. Replicating this study with a second author and a different sample could provide new insights.

The researcher found that it was difficult to make directional conclusions about the relationships between the constructs because interviewees had different opinions on the relationships. When this was the case, an attempt was made to explain both
possible directions of the relationship in question. Future research could focus on the
directionality of the relationships between the constructs.

Only one professional from each firm was interviewed, which had the effect of
making the unit of analysis the individual interviewee rather than the firm. A case
study approach evaluating one company that has adopted or experimented with
autonomous trucks, and that allowed for participation from multiple representatives
from within that company, would be a valuable tool to gain greater insight into
perceptions and behavior at the firm level. However, since examples of autonomous
truck adoption are still rare, this was not practical for this study.

The moderating effect of the nature of the transportation professional’s company,
such as a Less-Than-Truckload (LTL) vs. a Truckload (TL) shipper, on the direction
of the relationships between constructs in the conceptual model, and upon the
precedence of the constructs in their effects on Adoption, was not evaluated in this
study. It is possible that different professionals from different types of firms
connected to the transportation industry would place different weights upon the
constructs. Additionally, the direction of the relationships between constructs may be
different, depending upon the type of firm that the transportation professional works
in.
Future Research

Some natural lines of inquiry present themselves for future research addressing and extending beyond what was mentioned in the discussion of Limitations. Research including representatives from autonomous trucking firms might provide new insight into the capabilities of these vehicles. Once more information about autonomous trucks is available, deductive research methodologies and statistical methods should be used to test the generalizability of the construct relationships proposed in this study’s conceptual model. The directions of the relationships between constructs is also a topic for future investigation.

Triangulation methodologies in which quantitative and qualitative research methods are brought to bear on the same phenomenon also offer a tantalizing research opportunity. The identification of Cost and Service Level as possible advantageous constructs of autonomous trucks lend themselves to simulation modeling as a means of evaluating the possible effects of autonomous truck adoption at the firm level, using differing autonomous truck penetration rates into a trucking firm’s fleet.

A network design project to examine the implications of autonomous truck deployment in a logistics network could shed light on the cost and service tradeoffs at play between transportation and warehousing costs. Cost and service level data for autonomous trucks would be needed for such a project. This project would also require metrics commonly used for network design such as: production data for the supply chain being evaluated, demand levels and locations, inventory policies,
available manufacturing and warehousing locations, and current transportation statistics. This project, if completed, could provide quantitative data to evaluate the network-wide benefits of autonomous truck use, and could be used to compare the effects of autonomous truck adoption on service times, inventory levels, and operational costs compared to current systems.

Research to address the weights of the constructs could be conducted using an expanded sample that segregates the participants by the type of firm that they work in. This type of study could allow for research into the moderating factor that the nature of the transportation professional’s firm plays in their perception of the direction of the relationships among constructs in the conceptual model, as well as the weights that professionals place on the constructs in the model.

A study of the effects on truck driving labor and on ancillary businesses that support the trucking industry would offer insight into the full effects of autonomous trucking on the ground transportation system in the United States. The findings regarding the displacement rather than replacement of truck drivers, as well as the affectation of support businesses such as fuel depots and service centers, were unexpected. Therefore, these propositions were not examined in great detail.

**Conclusion**

Autonomous trucks promise to be a transformative development in the ground transportation world. If and how the benefits of this innovation are realized is up to
market forces that will drive the adoption and deployment of the technology. An understanding of these market forces is necessary for autonomous trucks to be used to their full potential and in a way that is beneficial to the entire ground transportation industry. A technology such as this has the potential to benefit all stakeholders in the ground transportation industry, and its initial deployment should not be squandered for a lack of understanding of the true perceived benefits and drawbacks to different stakeholders within the industry.

This study identified relationships among constructs that affect transportation decisions and how those constructs may affect autonomous truck adoption. Additionally, several propositions about how the trucking industry could be affected by widespread autonomous truck adoption are offered. This dissertation should not be viewed as an end in itself. Rather, it should serve as a starting point that can be leveraged for academics and practitioners to make the best of this opportunity that is presented to us.
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Appendices

Appendix 1: Definitions from Structured Literature Review

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<tr>
<th>Topic</th>
<th>Description</th>
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<tbody>
<tr>
<td>Aerospace</td>
<td>Deals with aerospace engineering or operations</td>
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<tr>
<td>AV Adoption</td>
<td>Deals with using autonomous vehicles</td>
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<tr>
<td>Book Review</td>
<td>Reviews a book or article</td>
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<tr>
<td>Cinematography</td>
<td>Discusses filming or film production</td>
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<tr>
<td>Consumer Behavior</td>
<td>Discusses customer preferences or buying patterns</td>
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<td>Cyber Security</td>
<td>Discusses security of electronic media</td>
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<td>Data Analytics</td>
<td>Discusses data mining and analysis</td>
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<tr>
<td>Economics</td>
<td>Discusses economics and finance</td>
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<td>Engineering</td>
<td>Discusses physical or electronic product design</td>
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<td>Environmental</td>
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<td>Epistemology</td>
<td>Discusses research and knowledge</td>
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<td>Ethics</td>
<td>Discusses moral concerns</td>
</tr>
<tr>
<td>Gender Studies</td>
<td>Discusses gender social theory</td>
</tr>
<tr>
<td>Hospitality Management</td>
<td>Discusses hotel and service management</td>
</tr>
<tr>
<td>Human Factors</td>
<td>Discusses human behavior</td>
</tr>
<tr>
<td>Innovation Diffusion</td>
<td>Discusses innovation diffusion theory / marketing cycle</td>
</tr>
<tr>
<td>Insurance</td>
<td>Discusses insurance issues</td>
</tr>
<tr>
<td>Legal</td>
<td>Discusses laws, legal issues, and regulation</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Network Routing</td>
<td>Discusses physical / logistics network design</td>
</tr>
<tr>
<td>Operations Research</td>
<td>Discusses production and operations management</td>
</tr>
<tr>
<td>Organizational Behavior</td>
<td>Discusses organizational psychology / sociology</td>
</tr>
<tr>
<td>Parking / Road Use</td>
<td>Discusses parking and road design</td>
</tr>
<tr>
<td>Platooning</td>
<td>Discusses semi truck platoon operations</td>
</tr>
<tr>
<td>Public Perception</td>
<td>Discusses public view of products</td>
</tr>
<tr>
<td>Public Policy</td>
<td>Discusses public policy decisions</td>
</tr>
<tr>
<td>Retailing</td>
<td>Discusses selling and distribution of products</td>
</tr>
<tr>
<td>Risk Management</td>
<td>Discusses risk tradeoff decisions or mitigation</td>
</tr>
<tr>
<td>Safety</td>
<td>Discusses vehicle or road safety considerations</td>
</tr>
<tr>
<td>Unclear</td>
<td>Topic not clearly discernable / too broad</td>
</tr>
<tr>
<td>Vehicle Ops</td>
<td>Discusses vehicle operational concerns</td>
</tr>
<tr>
<td>Vehicle Purchase Decisions</td>
<td>Discusses consumer purchase choices</td>
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<table>
<thead>
<tr>
<th>Methodology</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Book Review</td>
<td>Discusses a book or article</td>
</tr>
<tr>
<td>Case Study</td>
<td>Discusses a specific case</td>
</tr>
<tr>
<td>Discussion of Study</td>
<td>Reviews a study</td>
</tr>
<tr>
<td>Editorial</td>
<td>Opinion / Editorial piece</td>
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<tr>
<td>Experimental</td>
<td>Controlled experimental design</td>
</tr>
<tr>
<td>Conceptual</td>
<td>Conceptual model</td>
</tr>
<tr>
<td>Mixed Methodology</td>
<td>Used triangulation or multiple methodologies</td>
</tr>
<tr>
<td>Qualitative</td>
<td>Unspecified qualitative study</td>
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<tr>
<td>--------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Quant Model</td>
<td>Mathematical modeling study</td>
</tr>
<tr>
<td>Survey</td>
<td>Survey-based research study</td>
</tr>
</tbody>
</table>
Appendix 2: Structured Literature Review Papers


Bert, Ray. "Driverless: Intelligent Cars and the Road Ahead." Civil Engineering 87, no. 2 (February 2017), 78.


Hadad, Jon. "Paving the Way: CALIFORNIA LOOKS TO THE FUTURE WITH SELF-DRIVING CAR TECHNOLOGY." *The RMA Journal* 100, no. 7 (n.d.), 62-64.

Hadian, Mohammad, Thamer Altuwaiyan, Xiaohui Liang, and Haojin Zhu. "Privacy-Preserving Task Scheduling for Time-Sharing Services of

Hall, P., and JR Owen. "Will the Real Driver Please Step Out of the Car! Autonomous Vehicles Managed by AI - Coming to a Roadway Near You!" *Graziadio business review* 21, no. 1 (n.d.).


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Li, Sen, Hamidreza Tavafoghi, Kameshwar Poolla, and Pravin Varaiya. "Regulating TNCs: Should Uber and Lyft set their own rules?"


Meng, Xiaolin, Simon Roberts, Yijian Cui, Yang Gao, Quisen Chen, Chang Xu, Qiyi He, Sarah Sharples, and Paul Bhatia. "Required navigation performance for connected and autonomous vehicles: where are we now and where are we going?" Transportation Planning and Technology 41, no. 1 (2017), 104-118. doi:10.1080/03081060.2018.1402747.


Minh Ha, Quang, Yves Deville, Quang Dung Pham, and Minh Hoang Ha. "On the min-cost Traveling Salesman Problem with Drone." Transportation research. Part C, Emerging technologies 86 (January 2018).

Miwa, Tomio, and Michael G. Bell. "Efficiency of routing and scheduling system for small and medium size enterprises utilizing vehicle location data."


Paul, Nicholas, and ChanJin Chung. "Application of HDR algorithms to solve direct sunlight problems when autonomous vehicles using machine vision


<table>
<thead>
<tr>
<th>No</th>
<th>Author Title Methodology Topic Search Term Year Database Peer</th>
<th>Journal of Cleaner Production</th>
<th>The adoption of cleaner vehicles</th>
<th>Journal of Cleaner Production</th>
<th>The adoption of cleaner vehicles</th>
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</thead>
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<tr>
<td>1</td>
<td>Pisano, Alessandro Purchase decisions <em>snowballed</em> 2007 Snowballed Peer</td>
<td>Journal of Cleaner Production</td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 4: Interview Guide from Development Study

1) What is your position within the company, and your professional experience?
   - Ascertain interviewee’s professional background and role within the company

2) Describe how you typically make transportation decisions.
   - Offers follow-up opportunities to delve into constructs uncovered in answer
   - Can be used to draw a preliminary model for the company

3) Are there any metrics or factors that have precedence over others when it comes to making transportation decisions?
   - This allows for cross-reference to Question 2

4) How was this decision-making approach developed?
   - Organizational model or individual decision-making model?
   - Cross-reference Questions 2 and 3

5) Briefly describe your own knowledge of autonomous vehicles
   - Ascertain interviewee’s knowledge of AVs
   - Identify preconceived notions
6) What do you perceive the effect(s) of AVs to be on your industry?
   • Identifies how interviewee thinks AVs will fit into transportation model

7) Do you see AVs as a viable alternative to existing transportation methods that you currently use? Why or why not?

8) If not, what would make an AV more attractive?
   • Attempts to tie AV perceptions back to original decision making model

9) What kind of research has your company done up to now with autonomous vehicles?

10) Describe the general procedure for deploying new innovations.

11) What challenges do you foresee with autonomous vehicle adoption?

12) Do you anticipate cost changes from AV use?

13) How do insurance and liability factor in to your transportation decisions?

14) What are your personal feelings on AVs?
Appendix 5: Confidentiality Statement

Statement of Purpose

The goal of this interview is to understand transportation professionals’ perceptions of the factors that will drive autonomous truck adoption. I am a PhD candidate at the University of Missouri – St. Louis, and this interview is part of the data collection activities for my dissertation. Your name and your company’s name will remain anonymous.

Risks and Benefits

There are no direct benefits to you, the participant, for participating in this research. By participating in this research you do have the opportunity to provide data that can help to guide research and public policy in the transportation industry.

Risks to participation in this research are minimal, and present the interviewee with no hazards greater than would be experienced during their day to day lives. Participation is voluntary, and you may withdraw from the research at any time without fear of any reprisal from the researcher.

Data Collection and Recording
The participant will participate in a semi-structured interview, that is expected to be between 45 minutes and 1.5 hours long. The interview will be recorded using either Apple’s Garageband software, or through Zoom’s recording feature. Recordings will be sent to WReally for transcription. Recordings will be kept on an external hard drive and will be deleted at the conclusion of the study. De-identified transcripts will be stored on a laptop computer’s internal hard drive, on an external hard drive, and may be stored on Google cloud storage as an extra backup.

Use of Data

This data will be used in Christopher Mony’s doctoral dissertation. Block quotes from the interview may be used in the paper, but no identifiable information will be included. Publications may be produced from the dissertation after its defense. Participants will have the option to review or redact any of their data included in the dissertation, if desired.

Confidentiality

All data will be de-identified prior to analysis. Participant and company names will not be included on transcripts or in the final dissertation document. No identifiable information will be stored on cloud storage. Interview recordings will be transferred to an external hard drive after the upload to WReally. All attempts will be made to
protect the identities of research participants and suggested research contacts. It is, however, unlikely but possible that a research subject may be identified through the study.
Appendix 6: MAXQDA Screenshot

Menu of available data sources such as transcripts.

Code list and count showing coded segments.

Color-coded brackets showing coded segments.

Interview transcripts with coded segments.
### Appendix 7: Construct Code Frequencies

<table>
<thead>
<tr>
<th>Construct</th>
<th>Code Frequency</th>
<th>Relative Frequency</th>
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<tbody>
<tr>
<td>Cost</td>
<td>98</td>
<td>0.059</td>
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<tr>
<td>Service Level</td>
<td>41</td>
<td>0.025</td>
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<tr>
<td>Profit Contribution</td>
<td>36</td>
<td>0.022</td>
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<tr>
<td>Insurance</td>
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<td>Liability</td>
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<td>Public Acceptance</td>
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<td>Regulation</td>
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<td>0.045</td>
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<tr>
<td>Labor</td>
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<td>0.041</td>
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<tr>
<td>Dependability</td>
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<td>0.016</td>
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<tr>
<td>Security</td>
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<td>0.003</td>
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<tr>
<td>Customer Requirements</td>
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<td>0.028</td>
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</table>
## Appendix 8: Codebook

### Code System

<table>
<thead>
<tr>
<th>CODE NAME</th>
<th>Frequency</th>
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</thead>
<tbody>
<tr>
<td>1 Industry Effects</td>
<td>21</td>
</tr>
<tr>
<td>2 Proof of Concept</td>
<td>17</td>
</tr>
<tr>
<td>3 Transportation Selection</td>
<td>9</td>
</tr>
<tr>
<td>4 Other AT Uses</td>
<td>4</td>
</tr>
<tr>
<td>5 Capability</td>
<td>19</td>
</tr>
<tr>
<td>6 Adoption Timeframe</td>
<td>20</td>
</tr>
<tr>
<td>7 Data Analysis</td>
<td>13</td>
</tr>
<tr>
<td>8 Company preferences</td>
<td>4</td>
</tr>
<tr>
<td>9 Labor</td>
<td>68</td>
</tr>
<tr>
<td>10 Infrastructure</td>
<td>51</td>
</tr>
<tr>
<td>11 Risk</td>
<td>29</td>
</tr>
<tr>
<td>12 Incentives</td>
<td>14</td>
</tr>
<tr>
<td>13 Technology</td>
<td>47</td>
</tr>
<tr>
<td>14 Pilot</td>
<td>19</td>
</tr>
<tr>
<td>15 Legal Issues</td>
<td>48</td>
</tr>
<tr>
<td>15.1 Liability</td>
<td>33</td>
</tr>
<tr>
<td>16 Snowball suggestions</td>
<td>3</td>
</tr>
<tr>
<td>17 Industry Knowledge</td>
<td>8</td>
</tr>
<tr>
<td>18 Reliability</td>
<td>26</td>
</tr>
<tr>
<td>18.1 Security</td>
<td>5</td>
</tr>
<tr>
<td>19 Other Industry Comparisons</td>
<td>21</td>
</tr>
<tr>
<td>20 Industry Conditions</td>
<td>59</td>
</tr>
<tr>
<td>21 Nature of Company</td>
<td>40</td>
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<tr>
<td>22 Professional Experience</td>
<td>18</td>
</tr>
<tr>
<td>23 Business Relationships</td>
<td>14</td>
</tr>
<tr>
<td>24 Insurance</td>
<td>60</td>
</tr>
<tr>
<td>24.1 Insurance Companies</td>
<td>18</td>
</tr>
<tr>
<td>25 Innovation</td>
<td>69</td>
</tr>
<tr>
<td>25.1 Early Adopters</td>
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<tr>
<td>26 Environmental Concerns</td>
<td>13</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>27</td>
<td>Personal Experience</td>
</tr>
<tr>
<td>28</td>
<td>Risk Taking</td>
</tr>
<tr>
<td>29</td>
<td>Competitive Advantage</td>
</tr>
<tr>
<td>29.1</td>
<td>Marketing</td>
</tr>
<tr>
<td>29.1.1</td>
<td>Market Positioning</td>
</tr>
<tr>
<td>30</td>
<td>Safety</td>
</tr>
<tr>
<td>31</td>
<td>Public Acceptance</td>
</tr>
<tr>
<td>31.1</td>
<td>Social Culture</td>
</tr>
<tr>
<td>32</td>
<td>Regulation</td>
</tr>
<tr>
<td>33</td>
<td>Uncertainty</td>
</tr>
<tr>
<td>34</td>
<td>AV Perception</td>
</tr>
<tr>
<td>35</td>
<td>Familiarity Level</td>
</tr>
<tr>
<td>36</td>
<td>Flexibility</td>
</tr>
<tr>
<td>37</td>
<td>Market Conditions</td>
</tr>
<tr>
<td>38</td>
<td>Customer Service</td>
</tr>
<tr>
<td>38.1</td>
<td>Customer Requirements</td>
</tr>
<tr>
<td>38.2</td>
<td>Customer Relationship</td>
</tr>
<tr>
<td>39</td>
<td>Visibility</td>
</tr>
<tr>
<td>40</td>
<td>Operational Processes</td>
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<tr>
<td>40.1</td>
<td>Efficiency</td>
</tr>
<tr>
<td>41</td>
<td>Corporate Culture</td>
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<tr>
<td>42</td>
<td>Tradeoffs</td>
</tr>
<tr>
<td>43</td>
<td>Profitability</td>
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<tr>
<td>43.1</td>
<td>Cost</td>
</tr>
<tr>
<td>44</td>
<td>Service Level</td>
</tr>
<tr>
<td>45</td>
<td>Nature of Position</td>
</tr>
<tr>
<td><strong>1</strong></td>
<td><strong>Industry Effects</strong></td>
</tr>
<tr>
<td></td>
<td>Describes an effect that autonomous trucks have on the transportation industry</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td><strong>Proof of Concept</strong></td>
</tr>
<tr>
<td></td>
<td>Codes a passage that details what a respondent would want to see as proof of an autonomous truck's efficacy, safety, etc.</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td><strong>Transportation Selection</strong></td>
</tr>
<tr>
<td></td>
<td>This code describes a transportation selection process, such as freight bids</td>
</tr>
</tbody>
</table>

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4 Other AT Uses
Codes a section that references a use of an autonomous truck for a function OTHER than over-the-road driving.

5 Capability
This refers to a passage describing a capability of an autonomous truck, that is not necessarily strictly technological

6 Adoption Timeframe
This code identifies passages which discuss timeframes for adoption of autonomous trucks

7 Data Analysis
Indicates a passage that discusses analytics, data mining, etc.

8 Company preferences
This details needs and wants of trucking companies, shippers, etc.

9 Labor
This code identifies passages that discuss drivers or support crews.

10 Infrastructure
This describes physical technologies necessary to make autonomous vehicles operate

11 Risk
Risk identifies passages that describe risk exposure to shippers, carriers, insurance companies, etc. This can be physical, financial, or legal.

12 Incentives
Describe an incentive to adopt AVs

13 Technology
Indicates a passage that discusses the effect of Technology

14 Pilot
Refers to somebody serving as a pilot case for testing autonomous vehicles

15 Legal Issues
Used to code a segment that describes legal involvement such as liability, lawyers, etc, that do not fit well under the Regulation code.
15.1 Legal Issues >> Liability
This is a subset of Legal Issues that specifically deals with legal liability - who is responsible for an accident or mishap?

16 Snowball suggestions
This describes other people mentioned by the interviewee that may have AV knowledge.

17 Industry Knowledge
This code refers to a participant's knowledge of an industry trend or condition.

18 Reliability
Refers to the ability to deliver a product or service consistently as promised.

18.1 Reliability >> Security
This code describes security of the transportation system, national security, or security of a sensitive load.

19 Other Industry Comparisons
Signifies a comparison to another industry such as rail, aviation, etc.

20 Industry Conditions
Refers to things affecting the trucking industry as a whole, such as collective bargaining, inter-firm competition, etc.

21 Nature of Company
Describes the specifics of a company that are outside of culture, such as size, etc.

22 Professional Experience
Broad term to describe professional experience.

23 Business Relationships
Represents strategic partnerships, etc.

24 Insurance
Marks a passage that discusses insurance requirements

24.1 Insurance >> Insurance Companies
Deals with requirements from insurance companies

25 Innovation
Describes the creation of new technology or new ways of doing business.

25.1 Innovation >> Early Adopters
Used to code a segment discussing early users of technology

26 Environmental Concerns
Describes natural environment concerns such as green tech, etc.

27 Personal Experience
This describes the personal or professional work experience that an Interviewee has had.

28 Risk Taking
Represents a willingness to experiment and take chances.

29 Competitive Advantage
Used to code a segment that discusses an ability to capture greater market share than competitors.

29.1 Competitive Advantage >> Marketing
Used to code segments about marketing activities

29.1.1 Competitive Advantage >> Marketing >> Market Positioning
This code will describe how a company differentiates itself from its competitors

30 Safety
Used to code a segment dealing with risk of loss, injury, or damage.

31 Public Acceptance
Refers to perception of AVs of the public at large, not just the interviewee.

31.1 Public Acceptance >> Social Culture
Indicates a section that relates to cultural elements of a society such as morés.

32 Regulation
Refers to governmental regulations about AVs

33 Uncertainty
Code represents an expression of uncertainty about AVs

34 AV Perception
35 Familiarity Level
Coding for an interviewee's familiarity with AVs

36 Flexibility
This is a supply chain metric that refers to a supply chain's ability to adapt to new circumstances.

37 Market Conditions
Used to code a segment describing market trends.

38 Customer Service
Differs from "service level" which in logistics and SCM generally refers to things like throughput speed. Customer Service refers to taking care of a customer, keeping them up to date, etc.

38.1 Customer Service >> Customer Requirements
May be merged with customer service or service level. Refers to meeting customer desires.

38.2 Customer Service >> Customer Relationship
Describes the nature of a relationship with a customer, such as building rapport.

39 Visibility
This code denotes a passage that describes transportation visibility, such as knowledge of a route, location, ETA, etc.

40 Operational Processes
I mean for this code to deal with things like day-to-day workload. So Interviewee 1 mentioned "management by exception." This refers to their daily operation.

40.1 Operational Processes >> Efficiency
Efficiency refers to performing a function with few input resources. This can refer to an internal process or an external process. An internal process would be something like load scheduling. An "external" process would be defined here as something like saving fuel.

March 10, 2021 - I moved this to be a child code of Operational Processes, because the segments in Efficiency seem to be related to operational processes.

41 Corporate Culture
Used to code a segment describing the culture of a company

42 Tradeoffs
Tradeoffs refer to the nature in SCM that it is often beneficial from a performance standpoint to opt for a more expensive course of action - i.e. paying more for faster transportation.

43 Profitability
Refers to revenue generation capability

43.1 Profitability >> Cost
Refers to the cost of service

3/10/21 monetary expenditures related to the procurement and use of a transportation solution (Jacobs, et al. 2014)

I moved this to a child of "profitability." Cost shows up more than "profitability," in the interviews, but cost really drives profitability. This is discussed in some of the passages relating to the margins in the transportation industry. Really, being able to maintain an income level while decreasing cost results in increased profitability, which is what businesses are really looking for. In supply chain management terms this is the profit leverage effect. I can find a definition for this readily online.

44 Service Level
This code deals with the service level (i.e. delivery time, on-time delivery, etc)

3/10/21 Being Able to Effectively Service Customers' Demand (Schalit and Vermorel 2014)

I think that service level is related to customer service, but this is an important enough concept that I am reluctant to make it a child node. For now I will leave it as its own separate construct.

45 Nature of Position
Used to code a segment describing a participant's position