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Final Report

ISO 9000's Effects on Accident
Reduction in the U.S. Motor Carrier
Industry



Research



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16. Abstract (Limit: 200 words) <p>This report aims at establishing a correlation between the voluntary ISO 9000 certification by motor carriers and traffic safety. The report shows that improvement of operating and quality performance improved safety performance. As part of the analysis, several ISO 9000 certified and non-certified motor carrier companies were compared based on their social and financial performance prior to, during and after the certification process. The authors have shown that there is a positive increase in performance during and after the certification process. The number of motor carrier companies certified by ISO 9000 is limited and unique. The uniqueness arises from the fact that the certified organizations haul specialized products such as automobiles and hazardous materials. That shows that most organizations are certified due to mandatory reasons.</p> <p>In conclusion, the observations and results have thrown light in a new direction that indicates that there exists a significant relationship between the quality assurance and safety performance of a motor carrier organization. The authors feel that further research is necessary to investigate of the circumstances under which ISO 9000 and other programs for upgrading motor carrier performance help lead to increase in safety.</p>			
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ISO 9000's Effects on Accident Reduction in the U.S. Motor Carrier Industry

Final Report

Eitan Naveh
William Davidson Faculty of Industrial Engineering and Management
Technion – Israel Institute of Technology
Haifa, Israel

Alfred Marcus
Department of Strategic Management and Organization
University of Minnesota
Minneapolis, Minnesota

Gove Allen
School of Business
Tulane University
New Orleans, Louisiana

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Office of Research Services
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Table of Contents

Chapter 1: Introduction	1
Chapter 2: The Case Study	4
Chapter 3: Literature Review	6
3.1: Organizational Safety	7
3.2: Corporate Social Responsibility	7
Chapter 4: The Statistical Study	12
4.1: Measures	12
4.2: Creating the Matched Samples	13
4.3: Analyses	14
Chapter 5: Conclusion.....	17
References:.....	18

List of Figures

Figure 1.1: Purpose of Research.....	1
Figure 1.2: What is ISO 9000?.....	2
Figure 1.3: Methods	3
Figure 2.1: Case Study	4
Figure 2.2: Case Study Interview Guide	5
Figure 3.1: A Theory of Safety From the Literature	6
Figure 3.2: A Model of Fatalities Based on 1999 Minnesota Statistics	6
Figure 3.3: The Conditions for Successful ISO 9000 Implementations From the Literature	10
Figure 3.4: Effects of ISO 9000 on Organizational Performance From the Literature	10
Figure 3.5: Research Model for Statistical Analysis.....	11
Appendix A: List of Tables.....	20
Table 4.1: Financial and Safety Performance of Five Best Matched Samples Prior to and after ISO 9000 Implementation	A-1
Table 4.2: Preimplementation and Postimplementation Periods Mean, Standard Deviation and Correlations	A-11
Table 4.3: Result of Hierarchical Models Testing the Effect of Financial and Standardization on Safety Performance	A-12

Executive Summary

In a typical year, more than 400,000 large trucks (gross vehicle weight rating greater than 10,000 pounds) are involved in traffic crashes in the U.S. and about 5,000 of these crashes are fatal ones in which up to 5,000 people die (U.S. Department of Transportation, NHTSA, Traffic Safety Facts, 1997). These fatalities constitute about 13 percent of all traffic fatalities in the U.S. More than 125,000 people typically are injured in these crashes. Unlike other types of accidents, those involving large trucks did not decrease in the 1990s. It is generally acknowledged that federal motor carrier safety regulations and/or available resources to enforce trucking regulations may be inadequate to regulate the many different kinds and number of operators in the industry.

- Can voluntary ISO 9000 certification serve to alleviate the regulatory burden and improve motor carrier safety?

Certification might have a positive effect on safety depending upon the post-certification actions a company takes. For example, a company may introduce driver training, follow particular maintenance practices and learn from mishaps and other types of near misses through the corrective action procedure that ISO 9000 mandates.

During the last several years, there has been a mammoth campaign for organizations to obtain ISO 9000 certification (see page 2 for a brief explanation of ISO 9000). Over 300,000 organizations around the world have been certified and another 300,000 are in the process of doing so. For the purpose of this analysis, we identified 40 certified U.S. motor carriers and compared their safety performance to a group of motor carriers that had similar characteristics, but were not certified. We found that

- The safety performance of the ISO 9000-certified carriers was significantly better than the non-certified carriers.

These results advance our knowledge of the conditions that lead to improved safety in the motor carrier industry. They provide the first solidly based empirical evidence that suggests that ISO 9000 has a positive effect. By showing the link between certification and safety, this study performs a number of useful purposes, including assisting shippers in selecting carriers and providing regulators with an early warning system that tells them on which carriers to concentrate. With such a system in place, regulators can better focus their activities.

Based on these results, we would say that voluntary ISO 9000 certification does have the potential to alleviate the regulatory burden and improve overall motor carrier safety. However, certification is relatively new in this industry, and our research suggests that companies that have been certified may be unique in the following ways:

- Certified truckers are generally found among carriers who haul for the automotive industry, which requires certification of all its carriers.
- In addition, they can be found among carriers that haul hazardous substances or highly flammable liquids and other dangerous chemicals.
- Certified truckers were also very early adopters of the ISO 9000 standard in an industry which, as a whole, has been a very late adopter of the ISO 9000 standard. They are

exceptions to the rule; we could identify in total just 40 ISO 9000-certified carriers at the time we carried out our research.

In our quantitative analyses, we found that

- The attribute most highly correlated with a good safety record was a carrier's profitability, or its Return on Assets (ROA).
- ISO 9000-certified firms were not among the leaders on ROA before they were certified, but after they were certified both their profitability and safety improved.

A case study we did prior to the quantitative analysis suggests that ISO-certified truckers had safety-related problems which they were reacting to when they became certified. In other words, they were in the midst of trying to make improvements and the certification process was part of this attempt.

The policy implications, therefore, are fairly clear.

- To improve motor carrier safety, regulatory authorities must encourage motor carriers to engage in improvement efforts that both enhance their financial viability and improve their safety.

The reason to encourage financial viability as well as safety is that the strongest predictor of a good safety record is sound economic performance on the critical indicator Return on Assets.

In the end, we would argue that whether or not ISO 9000 is likely to have a positive effect on safety depends on a variety of factors—the reason a company becomes certified, the auditors and consultants it engages, the process and the content of its certification. Size and visibility of the company also are likely to be important. The effects of ISO 9000 on the next round of certified companies may not be nearly as great as on the first round, since these companies may not be doing it for the same reasons. For instance, we would be concerned that if truckers were compelled to be ISO 9000 certified by regulatory authorities, because they might comply in a nominal way with less impact.

With this caveat in mind, we repeat our main finding: certification can have a positive effect on safety. However, we hold that the conditions under which this positive impact exists need further investigation. The reasons certification enhances safety requires further specification. To what extent, for instance, does the introduction of new internal auditing procedures that accompany certification affect safety? The driving factors may be those resulting from any serious improvement effort by a motor carrier and not ISO 9000 per se.

Therefore we recommend further investigation of the circumstances under which safety is improved by ISO 9000 and other programs for upgrading motor carrier performance.

- Future research could lead to the creation of a quality assurance standard specific to the motor carrier industry, one that is more appropriate than the generic ISO 9000 standard which is designed for all industries.

- It also could lead to changes in regulation, wherein regulators relied on voluntary ISO 9000 implementation or the adoption of other programs to upgrade carrier performance in place of or as a complement to actions they currently take.

Regulatory authorities already encourage motor carriers to upgrade their operations and make improvements. Our research, in short, suggests that there is likely to be a payoff for these efforts.

Chapter 1 Introduction

One hundred and fourteen people are killed every day in traffic accidents in the U.S. This is equivalent to a daily crash of a mid-sized commercial jetliner. Motor carriers suffer disproportionately from such accidents. They experience devastating loss of life, injuries, and property damage. Motor vehicles with a rating of over 10,000 pounds constituted 7 percent of the miles traveled in the U.S. in 1999, but they represented 13 percent of the fatal crashes and 23 percent of the injuries (1). In a country where the number of people killed daily in traffic accidents is equivalent to the number of fatalities in the crash of a mid-size passenger jet, few would dispute that more should be done to improve safety. This study's purpose is to examine and compare the safety results and other performance results of ISO 9000-certified and non-certified motor carriers before and after certification.

Purpose of Research

- Increase safety & decrease motor carrier crashes & fatalities
 - 400,000 accidents/yr
 - 5,000 fatalities (13% of U.S. total)
 - 125,000 injuries
- Can voluntary ISO 9000 certification alleviate regulatory burden & improve safety?
 - Positive effect on carriers' other performance results?



Figure 1.1 Purpose of Research

Based on Hendricks and Singhal, we matched ISO 9000 trucking companies with a similar group of non-certified companies (2). The main measure of safety we used is accident data. The main limitation of this data is that it does not report causation and thus excludes the effects of other drivers and vehicles. Nonetheless, we found that the ISO 9000-certified operators indeed have significantly fewer accidents than the non-certified carriers. They have fewer accidents of all sorts—accidents involving fatalities and injuries as well as accidents where towing is required.

What is ISO 9000?

- most commonly implemented quality innovation by U.S. and European organizations in the last decade.
- requires that organizations have verifiable routines and procedures in place for product design, manufacture, delivery, service, and support.
- organization must strictly monitor the sequence of steps it takes for the completion of a job and must follow process documentation.
- no shortcuts are supposed to take place.
- third party auditor site visits take place twice a year to verify compliance.
- aim to get organizations to satisfy customer needs at each stage in the value chain.
- managers set up essential business processes for training, skills, procedures, policies, etc.
- built-in mechanisms for continuous improvement including corrective action system.

Figure 1.2 What is ISO 9000?

The potential benefits of this research are:

1. Developing new regulatory procedures and methods based on an understanding of the ISO 9000 process.
2. Gaining an ability to identify motor carriers that already are performing at a high level of safety and quality and therefore reducing the need to spend public resources on such motor carriers.
3. Creating a mechanism to help leverage public resources on those motor carriers most in need of attention.
4. Focusing safety issues and analysis upstream in the process rather than downstream where only non-compliance issues arise.
5. Enhancing awareness of ISO 9000 certified companies' performance improvements as a possible means to reform regulation.

Methods. In carrying out the research, we did a case study, literature review, and statistical analysis. The statistical analysis compared the safety and other performance results of ISO 9000 certified and non-certified commercial motor vehicle companies and motor carriers before and after certification.

Methods

- Case study
- Literature review
- Statistical analysis
 - compare the safety and other performance results of ISO 9000 certified and non-certified commercial motor vehicle companies and motor carriers before and after certification.



Figure 1.3 Methods

Organization of the Report.

Chapter 2 presents the results of the case study. Chapter 3 is our literature review on organizational safety and corporate social responsibility. Chapter 4 is a description of the statistical study. It includes measures, how we created the matched samples, and the analysis. The conclusion is found in Chapter 5.

Chapter 2 The Case Study

The case study pre-interview protocol and selected questions from the interview guide are presented on the next page. The company where we did the case study was a large bulk transporter, mainly of chemicals, gases, and industrial wastes. It had 120 employees of which 90 were drivers. It owned its own fleet, however, 12 percent of its hauls were subcontracted. It sold logistic services and storage as well as hauling. It started its ISO certification process in December of 1999 and expected to be certified by September 2000. Thus, we conducted our site visit and interviews in the midst of the certification process.

The company where we did the case study had had lots of accidents, one very severe, and it was under pressure from its insurer to reduce accidents or face higher rates. It already had made many safety changes prior to starting the certification process. These included additional background checks on drivers, training that involved the use of scenarios, performance monitoring using accident statistics, the establishment of safety goals, and the analysis of accidents and their causes by a safety committee composed of high level managers who met regularly each Friday. Drivers were being graded first for safety, then for timeliness, pleasing customers, personal appearance, and upkeep of their trucks. To become certified, the company's management, with participation from drivers and other employees, was writing an operations manual with a full set of company procedures that the firm expected all employees to follow at all times. The firm's employees wrote the manual themselves with very little input from a consultant, who mostly was hired for his expertise in the area of safety. The consultant was hired mainly because of past safety problems and pressure from the firm's insurer. The company claimed that the changes it had made were having an effect on its safety record and overall performance.

Case Study

Pre-interview
(find out before interviews)

<p>Company information</p> <ul style="list-style-type: none"> -Business description -Business history -ISO 9000 process <p>With regard to ISO certification: Where is certification held? Collect papers on ISO history in company Tour the company</p>	<p>Try to determine:</p> <ul style="list-style-type: none"> -Certification chronology -Was there a consultant? To what extent was he/she helpful? -Who was the auditor?
--	--



Figure 2.1 Case Study

Case Study

Interview Guide

(Selected Questions)

What is special about this company? Tell us a little about the culture.

Why in your opinion did your company get certified?

What aspects of the internal and external audit activity were the most, and the least, helpful?

In what ways has ISO 9000 served to make your company better?

To what extent is ISO 9000 part of the overall approach being adopted to improve the performance of your company?

How is it linked with other quality initiatives?

To what extent has ISO 9000 motivated the company to re-think the way it does business?

How do you use ISO 9000 in every day practice?

What are the biggest barriers preventing you from deriving greater benefit from ISO 9000?

Figure 2.2 Case Study Interview Guide

Chapter 3 Literature Review

While the management literature commonly examines reasons for business success, it pays little attention to highway safety. Most traffic safety studies focus on the individual driver. Typically these studies claim that a combination of road conditions and the decisions that the individual driver makes interact to cause accidents and affect the severity of the accidents that occur, as shown below.

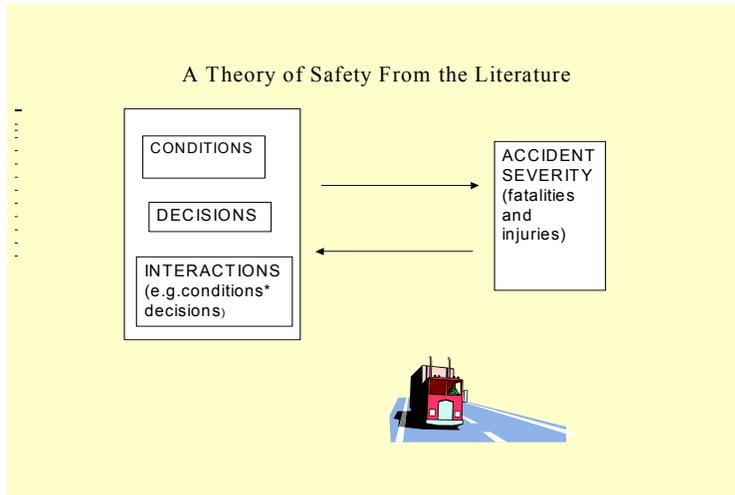


Figure 3.1 A Theory of Safety From the Literature

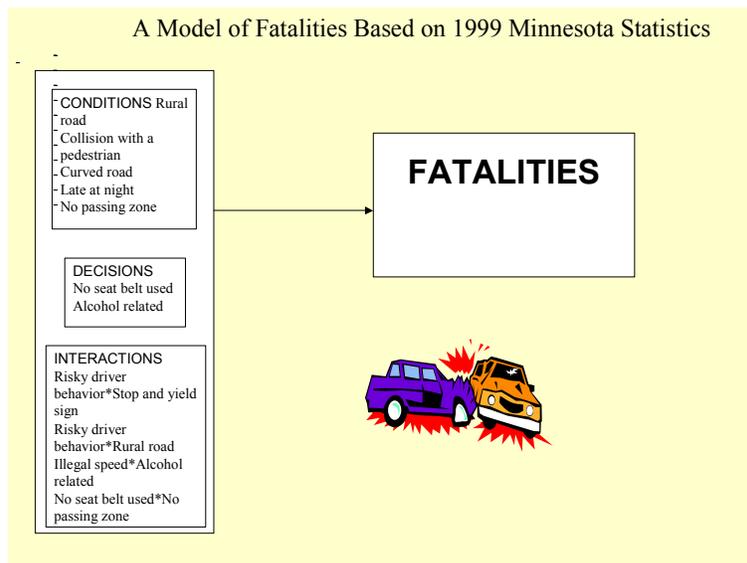


Figure 3.2 A Model of Fatalities Based on 1999 Minnesota Statistics

This paper takes a different approach. We analyze performance at the organizational level, a topic not generally addressed in the literature on traffic safety. At the organizational level, two relevant theories can be applied—theories of organizational safety and theories of

corporate social responsibility (CSR) (3)(4)(5)(6). Based on the hypotheses we developed from these theories, we analyzed longitudinal data from U.S. trucking firms.

3.1: Organizational Safety

With respect to industrial accidents where the unit of analysis is the organization, Perrow maintains that minor incidents are nearly “*normal*,” that is they occur regularly and on a continuous basis (3). At the typical industrial facility, there is likely to be more than one such incident per day, but incidents that involve injuries are far less common, perhaps taking place only once every two to three months, and very serious accidents involving major loss of life are exceedingly rare (3). Though events with fatalities are rare, Perrow considers them normal, that is, he believes they are inevitable and that little can be done to prevent them (3).

Following normal accident theory, one would not expect systematic variation in the number and severity of traffic accidents in organizations. Unlike normal accident theory, however, there is another approach to safety. Referred to as reliability theory, it suggests that though not all critical points of exposure and of vulnerability can be eliminated, safety varies systematically in organizations (4). We, therefore, hypothesize that

Hypothesis 1: *There are systematic differences in the safety performance of motor carriers.*

3.2: Corporate Social Responsibility

Various arguments have been made regarding the relationships between a firm’s social responsibility and its financial performance. One view is that firms face a trade off between social responsibility and financial performance since social responsibility costs are high. In support of this view, Marcus and Nichols argue that the level of safety an organization achieves is not the highest technically and humanly possible but depends on the resources it has available (7). The level of risk tolerated depends on a

...utilitarian calculus that safety is desirable but costly and that organization choose a level of safety by balancing the benefits of safety reduction against the costs of safety improvement.(7).

In other words, well-to-do companies achieve their financial health at the expense of society (5). Another way of saying this is that well to do motor carriers are likely to have a poor safety record.

The contrasting point of view is that firms benefit from social responsibility, for instance employee morale is high and they are more productive. They benefit in other ways as well, for instance, a reputation for social responsibility helps in customer relations. Social responsibility breeds a higher level of financial performance. A higher level of financial performance then breeds more social responsibility because firms can afford to be “good.” Indeed, McGuire, Sundgren, and Schneeweis maintain that financial performance is more likely to influence social responsibility than the reverse (6).

Thus, there may be a virtuous circle of good social responsibility leading to good financial performance leading to good social performance. Of course, the opposite also takes place, a vicious circle of poor social performance leading to bad financial performance leading to poor social performance. The practical implications for motor carriers would be that a good

safety record contributes to good financial results, which in turn allows a firm to achieve a good safety record.

There is still a third possibility. A U-shape correlation may prevail, which would suggest that there is an optimal level of social responsibility and that corresponding allocations of resources above this amount can have a negative effect. Up to a point motor carrier safety has a positive effect on financial performance but beyond that point the effect is negative.

Based on the CSR literature, we hypothesize that

Hypothesis 2: *Correlations exist between financial performance and safety performance.*

Management standards, such as ISO 9000, are a subset of a broader category of voluntary management practices, often referred to as administrative innovations (8). Whether their implementation is helpful to organizations, is not known with certainty. However, recent studies suggest that there is likely to be some gain to operating performance from the implementation of administrative innovations like the ISO 9000 standard (9)(10)(11). A number of studies have investigated the effects of resources on the implementation of administrative innovations, which find that available resources positively affect the success of implementation (12). Financial performance, as an indicator of resource availability, represents success, experience gained, and know how. As argued by Dierickx and Cool, the implementation of management practices can lead to asset stock accumulation and the development of a sustainable advantage (13). Thus, we hypothesize that implementation of management practices partially mediates between financial performance and social behavior.

Hypothesis 3: *The implementation of management practices partially mediates the effects of financial performance on social behavior.*

New models for quality have continually evolved and been refined over time. Cole maintains that quality standards have become a competitive factor in industry after industry (14). ISO 9000 is a quality standard that requires that firms have set routines and procedures and that they demonstrate adherence to these routines. By having these routines and demonstrating that they adhere to them, their quality is expected to increase. The motivation for being registered to the ISO 9000 standard combines the need to satisfy customer requirements with the need to make quality improvements (9). The International Standards Organizations in Geneva published ISO 9000 in 1987 but its origins are in earlier U.S. (1960s - MIL-Q-9858A and MIL-I 45208A) and British standards (BS 5750). Over 100 countries have adopted ISO 9000. As of 2000 more than 300,000 facilities were certified worldwide (IQNet, 2000).

ISO 9000 provides customers with assurance that registered suppliers have a quality system to which they must adhere. To guarantee compliance, independent, third party auditors evaluate the suppliers' procedures and carry out site visits. Twice a year they return to the facility to re-verify that it is in compliance. In the U.S., the American National Standards Institute's (ANSI) and American Society of Quality (ASQ) administer ISO 9000. ANSI with ASQ have a separate affiliate, the Registrar Accreditation Board (RAB), which accredits third party auditors. Many organizations report tangible and intangible improvements in different types of organizational performance due to ISO 9000 implementation.

ISO 9000 is based on the assumption that high organizational performance is gained by quality processes carried out before-the-fact and preventive in nature and not those carried out after-the fact and corrected only because of inspection. Naveh and Halevy have developed a mechanism to assess the cost that is associated with poor quality. This cost is a motivation for companies to improve their quality assurance systems.

Though ISO 9000 implementation should not be treated as a discrete, homogenous phenomenon, and variations in implementation needed to be considered, each ISO 9000 implementation does include practices that safety experts claim would have a positive impact on safety (15)(11). In the motor carrier industry, these practices include those related to driver hiring, licensing procedures, working hours, training, safety programs, instructions about limited access roads (roads with fewer intersections), and monitoring of both drivers and their vehicles. Because ISO 9000 certification is designed to improve both a carrier's internal auditing and corrective action procedures, it can have a positive impact on safety. In research for the Nuclear Regulatory Commission (NRC) Marcus and Nichols found that organizations often drift to a safety border, but what makes a difference in terms of determining whether they go over this border and have serious accidents is various organizational processes they have in place for alerting them to the danger and to take corrective action (7). While a gap might exist between the rhetoric of a quality program like ISO 9000 and the reality, a semblance of conformance to ISO 9000 guidelines is likely to apply if a firm is certified (16)(17). The reason is that certification requires bi-annual third party audits in which implementation of practices called for in ISO 9000 guidelines is checked. For instance, though there is great variety in how ISO 9000 is implemented, the external audit verifies that a company has established and uses a system for identifying and learning from its mistakes. We therefore hypothesize that

Hypothesis 4: *Implementing management practices like ISO 9000 can lead to better safety performance.*

By April of 1998, based on a search of the ABI Inform Index search, there were 1,012 journal papers and articles about ISO 9000. This literature suggests that ISO 9000 is a powerful tool for organizational improvement, but only under specific conditions such as: (1) the existence of internal *organizational motivation* for implementation; (2) the ISO standard being *customized* to the specific context, needs, and conditions of an organization; (3) the standard being *routinely used*; (4) the certified company developing *effective learning* processes based on ISO 9000 mandates (such as learning from mistakes and internal auditing to prevent mistakes) and; (5) a policy of going *beyond the rules* being implemented.

Full implementation of a standard like ISO 9000 is needed. By full implementation, we mean that the standard is thoroughly assimilated and used as a catalyst for change, as shown in the diagram below.

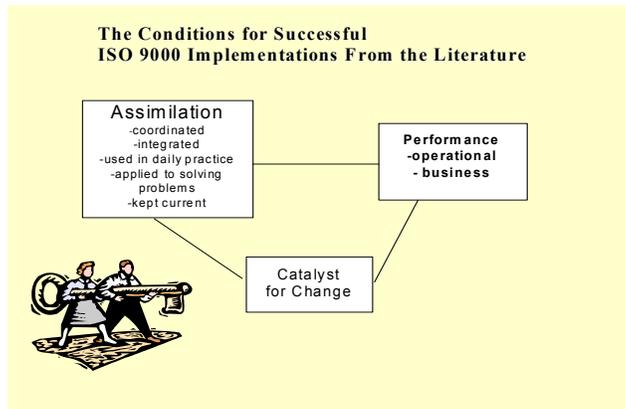


Figure 3.3 The Conditions for Successful ISO 9000 Implementations From the Literature

ISO 9000 also is likely to have a greater effect on performance if there is learning from experience with ISO 9000 and learning from the experience of other firms with the standard (social learning), as shown in the next diagram. It is not just a matter of the motivations for certification whether they are external pressure or technical efficiency that affects performance. It also is the learning that takes place.

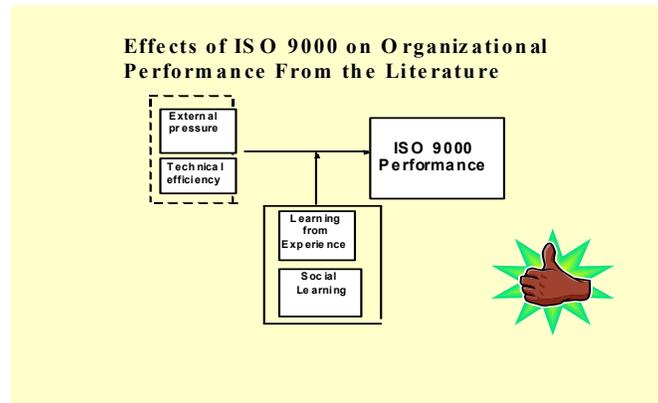


Figure 3.4 Effects of ISO 9000 on Organizational Performance From the Literature

It is probably the case that the effects on safety in the motor carrier industry depend on the degree to which risks are better identified and priorities are established for dealing with these risks. Some of the factors needed for successful ISO 9000 certification also include the role of the certification body, management attitudes and commitment, and the role of the external consultants. Undoubtedly these factors influence whether certification has an impact on safety enhancement.

A summary of our four hypotheses is presented in the next diagram.

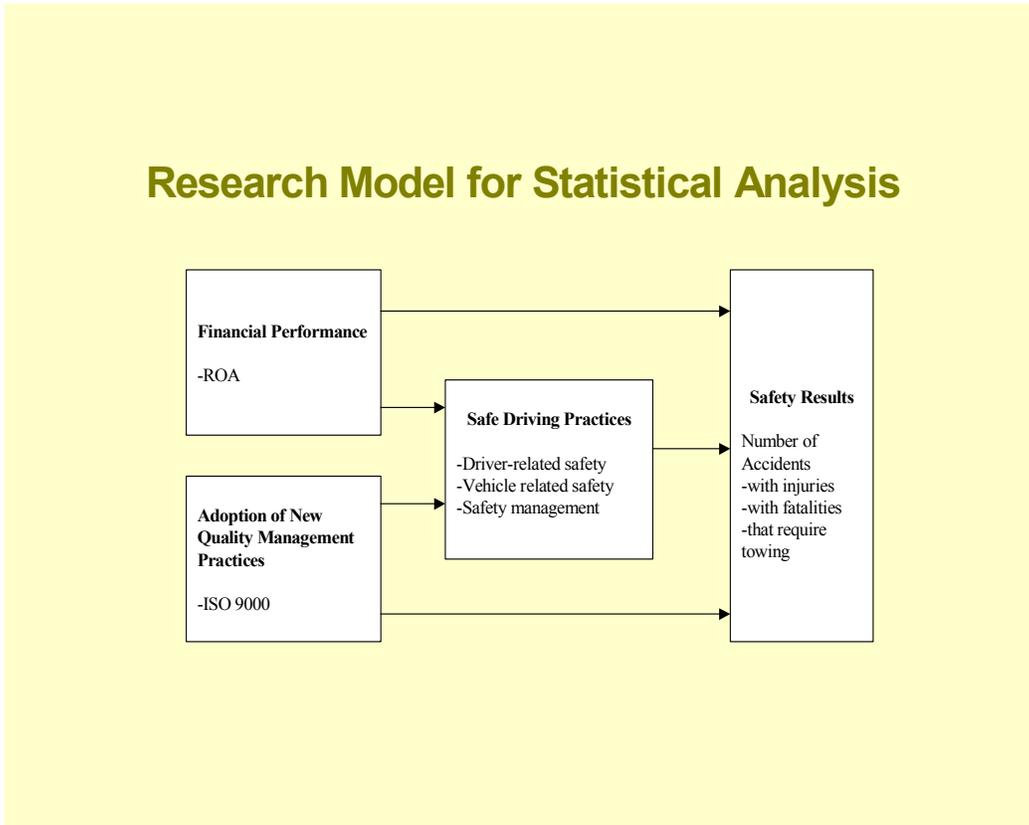


Figure 3.5 Research Model for Statistical Analysis

Chapter 4

The Statistical Study

We included all U.S. motor carriers with large trucks in our sample. Our definition of motor carriers is that their trucks are over 10,000 pounds gross vehicle weight rating. Thus, we are restricting our study to carriers that have large trucks. Three data sets were used to do the analyses. One is the American Trucking Association (ATA) foundation data set, which includes financial data on all U.S. motor carriers. The second is the federal government's Department of Transportation (DOT) SAFER data set, which includes safety performance data on all U.S. carriers. The third data set comes from McGraw-Hill. It names all ISO 9000 registered companies in the U.S. and gives their year of registration.

Comparing the ATA data with the McGraw Hill, we were able to identify 40 ISO 9000 registered companies out of 1742 additional non-registered carriers. As indicated, being registered means that an external auditor checks for compliance with the ISO standard twice a year. Only a small percentage of carriers can afford to be registered. They are found mainly in the automotive industry, where major manufactures require that suppliers be certified and among carriers that transport hazardous chemicals, where great care has to be taken in the transport of goods.

4.1: Measures

The main financial measure we used as an independent variable was return on assets (net income/total assets). We used other financial measures (total assets, total operating revenue, total insurance expenses, and net operating income) in alternative runs of our analyses and had similar results. The safety measures that we used as dependent variables were the number of injury, fatal, and tow accidents the carrier had as recorded in the SAFER database. Mediating variables came from SafeStat, which calculates a score to rank carriers in descending order by their safety status. A carrier with the highest SafeStat score is the worst in terms of safety. A score with a value 75-100 is considered deficient. Detailed explanation of the measures is available in the U.S. Department of Transportation, Federal Motor Carrier Safety Administration's Internet site <http://ai.volpe.dot.gov>, where the SafeStat data can be found. We used three of SafeStat Safety Evaluation Areas (SEAs) as indicators: driver, vehicle, and management.

- 1) Within the Driver SEA, SafeStat evaluates a carrier's driver-related safety performance and compliance. The Driver SEA Value reflects a carrier's driver safety posture relative to its peers. SafeStat calculates the Driver SEA Value based on the Driver Inspections Indicator (DII), the Driver Review Indicator (DRI), and the Moving Violations Indicator (MVI). The DII is based on driver roadside out-of-service (OOS) inspection violations. The DRI is based on the violations of driver-related acute and critical regulations discovered during a compliance review. The MVI is based on serious moving violations recorded in conjunction with roadside inspections.

- 2) Within the Vehicle SEA, SafeStat evaluates a carrier's vehicle-related safety performance and compliance. The Vehicle SEA Value reflects a carrier's vehicle safety posture relative to its peers. SafeStat calculates the Vehicle SEA Value based on the Vehicle Inspections Indicator (VII) and the Vehicle Review Indicator (VRI). The VII is based on vehicle roadside OOS inspection violations. The VRI is based on the vehicle-related violations of acute and critical regulations discovered during compliance reviews.
- 3) The Safety Management SEA Value reflects the carrier's safety management posture relative to its peers. The Safety Management SEA Value is based on the Enforcement History Indicator (EHI), the Hazardous Material Review Indicator (HMRI), and the Safety Management Review Indicator (SMRI). The EHI uses the Enforcement Severity Measure (ESM) based on the results of violations cited in closed enforcement cases. The HMRI and the SMRI use violations of hazardous material-related acute and critical regulations and violations of safety management-related acute and critical regulations, respectively, that were discovered during a compliance review.

4.2: Creating the Matched Samples

There is no single, agreed upon approach in the literature for how to create matched samples and then test for the long-term performance effects on companies resulting from their adoption of different management practices (2). Following the approach of Hendricks and Singhal, we developed a series of matched samples with which to compare the 40 ISO 9000 certified carriers with the 1742 non-certified carriers (2).

How did we create these matched samples? We started with each ISO certified company and gave each non-certified company an index value based on the similarity of the goods shipped (Goods Index). We compared certified and non-certified companies with respect to each of the 29 categories of goods hauled (general freight, household goods, metals, etc.). When they were different (the certified company hauled a particular category of goods and the non-registered company did not--or vice versa), we added a one to the index. Thus, the index's range, as first conceived, was 0 to 29. A perfect match was 0 while complete difference between carriers was 29/

We also did a calculation of the difference in highway miles traveled between certified and non-certified companies, a process that we repeated for each non-certified company. The measure of size was highway miles traveled in a particular year. We considered it the best indicator of size. The Size Index expressed a relative size comparison between certified and non-certified carriers. Simply put, it was the percent of the smaller company's size in proportion to the larger company.

The non-certified companies then were sorted using both Goods Index and the Size Index. The goodness of fit index ranged from 0 to 100. It was the weighted average of the two indexes, first the Goods Index, scaled to be a 0 to 100, and second the Size Index, also scaled in this fashion. The main Goodness of Fit Index was the "weighted" average of the two indices. We assumed that if carriers were similar in the types of goods hauled and the amount of miles traveled, then they would be similar in other variables (driver experience, turnover rates, crash types, age of trucks, maintenance policies, technologies of the trucks, time of driving – day, night or working 24 hours, etc.). The top 20 non-registered companies that

were the 20 best matches for each certified company were used in the analyses that were carried out. The mean main index (Goodness of Fit) for the 20th matched sample was 77 with a standard deviation (S.D.) of 12, the mean Goods Index was 91 with a S.D. of 6, and the mean Size Index was 50 with a S.D. of 38. This mean dropped below 50 for the 21st best sample.

The ISO 9000 registered companies financial and safety annual measures were taken for two years before registration, one year before registration, the year of registration, the first year after registration, and the second year after registration. For each matched company, financial and safety measures were taken for the same calendar years as for the company that was ISO 9000 certified (i.e. if 1998 was the certification year, financial and safety measures both for the ISO 9000 registered company and for its 20 matched companies were taken from 1996 and up to 2000).

4.3: Analyses

We first analyzed our data following the statistical procedure used by Hendricks and Singhal (2). Differences were compared for each of the 20 matched samples paired with each of the 40 ISO 9000 registered companies. These differences were calculated as the differences between the certified company's measure and the non-certified, but paired, company's measure. Following Hendricks and Singhal, this analysis was done using a t-statistic to determine if these differences were significant (2). The t test was run after a test was carried out to see if the measures were normally distributed.

Going beyond Hendricks and Singhal's methods, we then relied on a multi-level approach and used Hierarchical Linear Models to test our hypotheses (2). Hierarchical Linear Models (HLM) for analyzing the data were built taking into to consideration 1) the 40 ISO 9000 registered companies as regard to their financial and safety performance before and after registration, and 2) each ISO 9000 registered 20 matched companies as regards to their financial and safety performance in similar years. Twenty times 40 yielded 800 non-certified companies, with the addition of the 40 certified carriers the N was 840.

According to the mediation model called for by our hypotheses (Figure 3.5), financial performance (ROA) and new management practices (ISO 9000) should have a significant effect on safe driving practices and result in fewer accidents. Safe driving practices also should yield fewer accidents, but to a lesser extent than financial performance and the management practice. If mediation holds, then ISO 9000 should lessen the effect of the financial variable on safety.

Results. Table 4.1 presents descriptive statistics, which compare the ISO 9000 registered companies and the 5 best matched samples. The first part of the table presents the pre-implementation and the post-implementation period for financial performance. The table shows how similar the ISO certified and the non-ISO certified carriers are. The goodness of fit indices are close to 90 percent or more.

In the pre-implementation period, there are no significant different means (no significant t tests among the paired comparisons). In the post-implementation period, there are a number of significantly different means, which show improved financial performance after the carriers become ISO certified. For example in comparison to sample 1, the ISO certified carriers have significantly more income.

The second part of the table presents the pre-implementation and the post-implementation period for safety performance. In the first period, there are no cases of significant differences between the ISO certified and non-ISO certified carriers with regard to their safety performance, but in the second period the ISO certified carriers begin to show instances of significantly better safety records. For example in comparison to samples 1 and 2, the ISO certified carriers have significantly fewer tow accidents. In particular, with regard to simple accidents involving towing, as opposed to more severe accidents involving loss of life or injuries, the ISO certified carriers do significantly better in the second, post-implementation period.

These results provide support for the first hypothesis that the safety performance of the carriers is likely to vary. Carriers that are similar in most other ways seem to diverge when it comes to their safety performance depending on whether they have introduced ISO 9000 or not.

Table 4.2 presents pre-implementation and post-implementation periods means, standard deviation, and correlations of the ISO 9000 registered companies and the best twenty matched samples. This table provides additional evidence that suggests that ISO 9000 has a positive effect on safety. After implementation (see the correlations above the diagonal), there are significant relationships between ISO 9000 and fatal, injury, and tow accidents. Carriers that have implemented the standard have fewer of these kinds of crashes. Before implementation (see the correlations below the diagonal), these relationships do not hold. There are no significant relationships between the carriers that become ISO 9000 certified and the safety indicators. In contrast, ROA is significantly related to safety in both the pre and post implementation periods. The higher the ROA of a carrier, the fewer fatal, injury, and tow crashes it has.

Table 4.3 presents the results of hierarchical models, which test for the effects of financial performance and the adoption of the management practice, ISO 9000, on safety performance. As expected with regard to the control variable, the more total highway miles, the worse a carrier's safety (models 1-12). This result is uniform across the safety indicators. Hypotheses 2 is strongly supported in that the carriers with better financial performance, that is higher ROA, have significantly better safety records. This result is uniform across all of the safety indicators (models 1-12). The better a carrier's financial performance, the better the driving practices and the fewer the accidents.

Hypothesis 3 receives some support in the analyses. ISO 9000's presence in the model reduces the effect on ROA on safety, but just slightly (models 5-6, 8-9, & 11-12). ROA is more predictive of fatal and injury accidents than ISO 9000 (models 5-6 & 8-9). However, ISO 9000 is more predictive of tow accidents (models 11-12). What adds weight to the partial mediation (see Figure 3.5) is that both ROA and ISO 9000, as predicted, significantly impact safe driving practices (models 1,2, & 3).

Hypothesis 4 is fully supported in that in each model, ISO 9000 is significantly related to safer driving (models 1-3) and fewer accidents (models 5-6, 8-9, & 11-12), and this holds even in models where ROA and the safe driving practices are both present (models 6,9, & 12). In all of the regressions, ISO 9000 continues to have a significant effect in reducing accidents, whether they are fatal, injury, or tow accidents. Controlling for the other variables in our models, the adoption of this management standard has a positive effect on the safety of motor carriers.

Chapter 5 Conclusion

In this study, we have found that the traffic safety performance of the motor carriers differed and that management practices and tools commonly used for improving operating and quality performance helped improve safety performance. Financially well-to-do organizations were safer, yet whether an organization was financially well off or not, it could achieve a better safety record if it adopted a management practice like ISO 9000. Our analysis suggests that the effects of financial performance on safety are partially mediated by the management practices an organization adopts. Management practices implemented because organizations have better financial performance result in companies that have better safety records. Because evidence for this relationship has not been previously established in the literature, we believe that our study makes an important contribution.

While many studies deal with traffic safety performance at the national, state, and individual driver levels, only a few studies deal with traffic safety performance of organizations. The main contribution of this study is showing that a management practice, a quality standard such as ISO 9000, can lead to better traffic safety performance. Such an argument has not been supported previously in the organizational literature and it brings a fresh point of view to the study of traffic safety. Our study suggests that organizations with better financial results have a higher tendency to implement management practices that lead to better social performance. The same management practices have an effect on financial performance, which suggests that organizations can doubly benefit from implementing management practices like ISO 9000.

Implications. The overriding implication of this study is in order to improve motor carrier safety and reliability and avoid traffic accidents that can cause deaths and injuries, quality standards like ISO 9000 are useful. This study is the first solidly based research exploring and comparing the safety and financial performance of ISO 9000-certified and non-certified motor carriers companies before and after certification. In it we examined and identified the conditions under which ISO 9000 is likely to have a positive effect on carrier safety. Understanding the connection between a better quality assurance system and safety performance in this industry should provide guidance to regulators, shippers, and firms in the industry. The ISO 9000 quality assurance standard can have a positive effect on both financial and safety performance. With ISO 9000 in place, motor carrier regulators can feel more confident that a carrier is likely to exhibit good driving practices and have fewer accidents. This study also can serve to develop shipper awareness of the link between certification and safety. Inasmuch as this study helps to define a modern quality assurance system for the trucking industry as a tool for increasing safety, its implications are very broad.

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Appendix A

List of Tables

Table 4.1
Financial and Safety Performance of 5 Best Matched Samples Prior to and after ISO 9000 Implementation

	ISO 9000 Certified	Non ISO 9000 Certified Matched Sample				
		1	2	3	4	5
Sample size	40	40	40	40	40	40
<i>Mean Goodness of fit Indexes (SD)</i>						
Main Index		93.87 (6.38)	92.62 (6.93)	91.79 (7.44)	90.59 (7.62)	89.81 (7.72)
Goods		94.69 (5.18)	92.57 (6.94)	92.96 (5.8)	91.37 (8.17)	90.71 (6.87)
Size Percent		92.23 (15.74)	92.74 (17.44)	89.43 (16.18)	89.02 (19.04)	88 (17.34)

Financial Results

Pre-Implementation period (Event Month): -24 to 0

Mean financial measures (SD)

Total miles on Highway	35,728,943 (12,641,955)	37,043,347 (11,655,983)	42,840,340 (14,626,167)	32,476,444 (15,086,467)	30,408,421 (8,717,405)	33,078,251 (11,092,638)
Total Assets	30,463,262 (11,639,518)	47,192,961 (21,162,419)	43,144,428 (16,012,863)	31,952,010 (10,620,695)	36,025,732 (11,332,018)	24,592,349 (7,603,969)
Total Operating Revenue	56,902,724 (23,384,875)	43,084,074 (44,915,390)	51,905,662 (27,292,017)	49,248,047 (16,727,104)	55,747,302 (15,119,451)	56,079,629 (19,257,635)
Total Insurance Expenses	1,900,703 (699,697)	1,003,649 (1,071,865)	2,286,337 (767,802)	1,100,668 (281,944)	1,737,900 (465,447)	2,710,541 (928,085)
Net Operating Income	2,579,035 (1,109,842)	1,853,628 (4,350,536)	2,115,496 (2,709,200)	3,910,769 (2,050,691)	3,834,515 (1,325,029)	3,516,384 (1,357,180)

Net Income	3,724,732 (806,658)	3,179,080 (2,668,894)	4,113,244 (1,777,926)	3,519,563 (2,014,210)	1,230,884 (843,859)	1,556,496 (1,078,504)
<i>Mean of the paired difference (SD)</i>						
Total miles on Highway		5,067,230 (3,543,454)	-7,111,397 (7,058,228)	3,252,498 (6,076,606)	5,320,522 (5,001,881)	2,650,692 (1,004,124)
Total Assets		-3,548,906 (9,982,928)	-12,681,166 (1,319,412)	-1,488,748 (2,425,185)	-556,270 (7,914,838)	5,870,867 (5,920,235)
Total Operating Revenue		-3,461,721 (5,126,425)	-5,002,937 (7,556,223)	7,654,677 (11,946,882)	7,155,422 (3,775,495)	823,095 (2,526,473)
Total Insurance Expenses		-874,985 (408,423)	-385,633 (806,542)	800,035 (540,432)	162,803 (420,388)	-809,837 (313,635)
Net Operating Income		1,438,154 (3,765,403)	1,536,460 (2,081,450)	-1,331,734 (1,945,365)	-1,255,479 (1,090,204)	-937,348 (950,581)
Net Income		1,398,877 (2,403,005)	-2,705,640 (1,485,588)	-2,111,958 (1,894,933)	823,280 (791,332)	1,148,891 (935,346)

Paired differences that are positive (%)

Total miles on Highway	47.5	40	40	50	57.5
Total Assets	57.5	40	52.2	50	47.5
Total Operating Revenue	50	37.5	32.5	40	40
Total Insurance Expenses	60	47.5	32.5	37.5	57.5
Net Operating Income	57.5	32.5	40	65	57.5

Net Income	60	47.5	47.5	57.5	47.5
<i>T statistic for the paired difference</i>					
Total miles on Highway	1.11	-1	.53	1.06	.26
Total Assets	-1.35	-1.12	-.11	-.7	.99
Total Operating Revenue	-1.21	-.85	1.47	.8	.08
Total Insurance Expenses	-1.14	-.47	1.48	.38	-1.28
Net Operating Income	1.24	1.49	-.68	-1.15	-.98
Net Income	1.24	-1.42	-1.11	1.04	1.22

† p<.1 *p<.05 ** p< .01 ***p< .001

Table 4.1 Cont.

	ISO 9000 Certified	Non ISO 9000 Certified Matched Sample				
		1	2	3	4	5
Financial Results						
Post-implementation period (Event Month): 1 to 24						
<i>Mean financial measures (SD)</i>						
Total miles on Highway	42,519,155 (16,014,200)	43,239,012 (21,204,275)	46,918,357 (16,238,027)	39,202,413 (13,359,479)	36,875,816 (11,952,472)	41,840,262 (15,160,286)
Total Assets	40,109,933 (15,882,261)	50,234,611 (8,588,970)	53,808,507 (20,953,295)	41,212,382 (14,071,849)	43,891,172 (11,384,003)	34,525,192 (13,919,583)
Total Operating Revenue	61,056,020 (26,060,946)	44,727,965 (55,461,692)	59,535,259 (21,785,862)	51,613,089 (22,096,792)	62,410,240 (9,526,928)	52,535,189 (11,661,095)
Total Insurance Expenses	2,037,007 (721,540)	1,170,794 (1,583,002)	2,198,465 (741,324)	1,579,631 (558,727)	1,917,004 (598,122)	3,077,005 (2,119,802)
Net Operating Income	3,651,034 (1,230,195)	2,120,954 (5,571,084)	3,742,408 (3,743,997)	3,993,570 (2,198,494)	3,170,283 (2,226,211)	2,270,846 (1,507,438)
Net Income	4,165,508 (518,577)	3,502,067 (3,445,518)	4,300,891 (2,547,624)	3,733,140 (2,241,822)	1,995,236 (1,132,696)	1,801,192 (1,741,309)
<i>Mean of the paired difference (SD)</i>						

Total miles on Highway	5,542,592 (1,212,740)	-4,399,202 (3,543,202)	3,316,742 (3,510,459)	5,643,339 (6,321,801)	678,893 (4,136,514)
Total Assets	5,033,913 (2,829,007)	-3,698,573 (2,525,609)	-1,102,448 (7,751,658)	-3,781,238 (5,731,910)	3,584,741 (7,020,546)
Total Operating Revenue	5,082,171 (6,159,716)	-3,479,238 (4,865,136)	4,442,931 (9,368,759)	-6,354,219 (3,751,459)	-6,479,168 (6,090,145)
Total Insurance Expenses	1,833,342 (845,552)	-161,457 (722,196)	457,376 (385,151)	120,003 (321,981)	2,039,997 (1,477,297)
Net Operating Income	2,353,564 (4,775,401)	1,091,373 (2,869,723)	-1,342,535 (2,063,965)	2,519,248 (1,463,713)	980,188 (1,958,261)
Net Income	1,818,512 (3,065,727)	1,135,382 (2,161,042)	-2,567,631 (207,6618)	-829,728 (1,042,356)	1,266,700 (2,055,255)

Paired differences that are positive (%)

Total miles on Highway	65	46	50	46	65
Total Assets	65	42	50	42	50
Total Operating Revenue	50	34	34	42	38
Total Insurance Expenses	50	34	34	46	53
Net Operating Income	57	50	46	50	53
Net Income	57	50	53	50	38

T statistic for the paired difference

Total miles on Highway	1.72†	-1.24	.94	.89	.16
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Total Assets	2.08*	-1.09	-.06	-.92	.42
Total Operating Revenue	1.95†	-.71	.74	-.46	-.78
Total Insurance Expenses	2.16*	-.22	1.86†	.37	1.68†
Net Operating Income	2.16*	1.77†	-.65	1.72†	.19
Net Income	2.22*	1.91†	-1.2	-.79	.61

† p<.1 *p<.05 ** p< .01 ***p< .001

Table 4.1 Cont.

	ISO 9000 Certified	Non ISO 9000 Certified Matched Sample				
		1	2	3	4	5
Safety Results						
Post-implementation period (Event Month): -24 to 0						
<i>Mean safety measures (SD)</i>						
Fatal	.72 (.27)	.92 (.28)	.75 (.24)	.52 (.15)	.55 (.2)	.66 (.26)
Injury	8.2 (2.53)	11.13 (3.3)	11.52 (3.44)	7.44 (2.92)	7.9 (2.14)	11.27 (3.27)
Tow	6.7 (4.44)	6.4 (3.45)	3.97 (3.07)	6 (2.76)	5.91 (1.38)	4.16 (2.65)
<i>Mean of the paired difference (SD)</i>						
Fatal		.13 (.24)	-.02 (.16)	.19 (.24)	-.16 (.21)	.05 (.4)
Injury		-1.21 (1.87)	-3.3 (2.04)	.77 (1.6)	.3 (1.3)	-3.05 (2.28)
Tow		-2.47 (1.9)	-3.8 (1.76)	.83 (1.48)	.86 (1.21)	2.33 (2.2)
<i>Paired differences that are negative (%)</i>						
Fatal		25	27.5	37.5	30	27.5

Injury	30	40	32.5	25	30
Tow	37.5	35	30	40	40

T statistic for the paired difference

Fatal	.46	.6	.53	.53	.4
Injury	.53	.53	.4	.4	.53
Tow	.4	.4	.4	.4	.4

Table 4.1 Cont.

	ISO 9000 Certified	Non ISO 9000 Certified Matched Sample				
		1	2	3	4	5
Safety Results						
Post-implementation period (Event Month): 1 to 24						
<i>Mean safety measures (SD)</i>						
Fatal	.69 (.24)	.84 (.36)	.77 (.23)	.36 (.19)	.63 (.24)	.66 (.53)
Injury	7.27 (2.25)	9.86 (3.27)	8.69 (2.82)	7.69 (3.53)	6.63 (1.8)	7.97 (2.96)
Tow	6.05 (2.16)	7.94 (2.49)	7.11 (1.99)	5.69 (2.54)	5.77 (1.54)	4.3 (2.86)
<i>Mean of the paired difference (SD)</i>						
Fatal		-.1 (.34)	-.08 (.2)	-.33 (.24)	-.05 (.31)	.02 (.41)
Injury		-1.26 (1.26)	-1.4 (1.32)	-.41 (2.3)	-.63 (1.31)	-.69 (1.52)
Tow		-.57 (.9)	-.88 (.9)	-.52 (1.74)	-.44 (1.04)	2.08 (1.4)
<i>Paired differences that are negative (%)</i>						
Fatal		65	62.5	55	57.5	57.5
Injury		65	62.5	80	50	80
Tow		57.5	67.5	57.5	57.5	57.5

T statistic for the paired difference

Fatal	.11	-.43	-2.08†	-.1	1.84†
Injury	.29	-.63	-.9	-1.19	-.36
Tow	-2.25*	-2.23*	-.9	-1.76†	-.46

Table 4.2

Preimplementation and Postimplementation Periods Mean, Standard Deviation, and Correlations ^A

	N	Preimplementation		Postimplementation		1	2	3	4	5	6	7	8	9
		Mean	SD	Mean	SD									
1. Total miles on Highway	840	36,055,356	9,014,502	39,985,256	11,512,231		.12	.12	.2*	.22*	.05	.14	.07	.07
2. ROA ^C	840	.08	.12	.082	.18	.16		-.18*	-.23*	-.29*	.02	-.2*	-.15 [†]	-.14 [†]
3. Fatal	840	.75	.3	.72	.3	.16	-.21*		.45***	.58***	-.14 [†]	-.06	-.05	-.04
4. Injury	840	8.1	3.1	7.6	.25	.22*	-.26*	.5***		.6***	-.17*	-.08	-.09	-.1
5. Tow	840	6.2	2.6	5.9	2.8	.24*	-.3*	.6***	.56***		-.18*	-.05	-.15 [†]	-.06
6. ISO 9000	840	.05	.21	.05	.21	.03	.01	.05	.06	.06		-.15 [†]	-.14 [†]	-.13 [†]
7. Vehicle-related safety	840	40.1	23.2	40.5	23	.15	-.2*	-.06	-.08	-.05	-.05		.2*	.11
8. Safety Management	840	73.2	17.5	74.2	17.3	.06	-.15 [†]	-.05	-.09	-.15 [†]	-.06	.2*		.14 [†]
9. Driver-related safety	840	44.9	26.3	45.2	25.3	.07	-.14 [†]	-.04	-.1	-.06	-.08	.11	.14 [†]	

^A ISO 9000 registered companies and the best twenty matched samples

^B Pre-implementation correlations are below the diagonal, while post-implementation correlations are above the diagonal.

^C Net Income / Total Assets

† p<.1
 * p<.05
 ** p<.01
 *** p<.001

Table 4.3
Result of Hierarchical Models Testing the Effect of
Financial Performance and Standardization on Safety Performance

	Vehicle-related safety	Safety management	Driver-related safety	Fatal	Fatal	Fatal
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	5.2 (1.7) ***	5.2 (2.7) ***	5.3 (.6) ***	.49 (.03) ***	.49 (.03) ***	.49 (.03) ***
Total miles on Highway	.0000007 (.00000001)***	.0000007 (.00000001)***	.0000007 (.00000001)***	.00000001 (.000000001)***	.00000001 (.000000001)***	.00000001 (.000000001)***
ROA ^A	-16.6 (5.2) ***	-21.2 (6.1) ***	-14.2 (6.9) ***	-.32 (.18) ***	-.3 (.15) ***	-.27 (.15) ***
ISO 9000	-3.2 (1.3) ***	-5.3 (2.1) ***	-3.1 (2.3) ***		-.17 (.07) *	-.12 (.05) †
Vehicle-related safety		.59(.2) **	.13 (2.1) **			.05 (.05)
Safety management	.1 (.05) *		.04 (.02) *			.05 (.03)
Driver-related safety	.02 (.01)	.3 (.01) *				.06 (.004)
N	840	840	840	840	840	840
-2 Res Log Likelihood	3252	3428	3621	3719	3714	3708

	Injury	Injury	Injury	Tow	Tow	Tow
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Intercept	7.7 (1.2) ***	9.8 (1.2) ***	4.2 (1.2) ***	6.2 (1.3) ***	11.2 (2.5) ***	1.6 (1.8) ***
Total miles on Highway	.00000008 (.00000001)***	.00000009 (.00000001)***	.00000009 (.00000001)***	.000000011 (.00000001)***	.000000011 (.00000001)***	.000000011 (.00000001)***
ROA ^A	-3.6 (1.8) ***	-3.5 (1.8) ***	-2.4 (1.8) **	-4.2 (1.3) ***	-3.9 (1.2) ***	-2.9 (1.2) *
ISO 9000		-2.1 (.9) **	-1.4 (.5) **		-4.8 (2.2) ***	-3.2 (1.3) **

Vehicle-related safety			.01 (.1)			.1 (.06) **
Safety management			.01 (.02) *			.05 (.02) **
Driver-related safety			.008 (.003) †			.007 (.05)
N	840	840	840	840	840	840
-2 Res Log Likelihood	9672	9658	9650	9368	9358	9351

^A Net Income / Total Assets

Standard errors in parentheses

† p<.1, * p<.05, ** p<.01, *** p<.001