National Center for Intermodal Transportation

Effects of Safety Culture & Leadership on Accident Rates Among Transportation Workers

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Abstract

Workplace accidents have a devastating effect on the transportation industry. Corporate safety culture has inspired interest because it is thought to influence the performance of employees. However, the implementation and measurement of safety culture interventions are challenged by a lack of theoretically supported measures. The purpose of this project was to discuss the design and validation of the Safety Culture Scale (SCS) and its utility in improving transportation safety through assessment and feedback. The SCS was developed by creating items consistent with the three themes (values, meaning, and behavioral expectations). The survey instrument was administered to a sample of employees from a large public transportation agency (N=1909). Confirmatory factor analysis (CFA) was used to validate the underlaying model of cultural components of safety culture. One-way between groups analysis of variance, and post hoc tests provided initial evidence in support of the validity and reliability of the SCS. Results of analyses revealed significant differences ($p<.05$) between persons who had been involved in more accidents and safety violations thus demonstrating the relationship between safety culture and accident rates on scales included in the instrument. Implications of these findings are that the safety culture survey could be used to assess safety awareness and safety culture of trucking or transport companies, small communities, and other organizations involved in transport. By carefully monitoring scores on the SCS efforts could be made in various organizations to improve attitudes and behaviors towards safety and ultimately to reduce accidents and improve safety.

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Introduction

Workplace accidents, (DiBerardinis, 1999), significantly impact organizations operating within the mining, agriculture, construction and transportation industries. In the transportation sector, safety has garnered particular interest as greater than 41% of work-place accidents, across all industries, occur during periods of transportation (U.S. Department of Labor, 2010). The high rate of accidents in transportation is alarming because it limits productivity, and negatively influences the physical and psychological health of employees.

The combined set of a corporation's safety-related attitudes, shared meanings, behaviors, practices, and beliefs, can be labeled the corporation's safety culture. Safety culture is important as it reduces the prevalence of what Reason (2000) called active failures and latent conditions. When safety becomes a priority over productivity, companies with strong safety cultures are believed to be the most protected and safe organizations. Approximately 25 years ago, the concept of corporate culture became significant to investigators working in safety management, because it was believed to be a significant moderator of employee behavior. This focus on culture as a predictor of corporate safety was prompted, in large part, by the 1986 nuclear catastrophe at Chernobyl. After this tragic accident, and several other significant work-place calamities involving chemical plants, commuter boats, oil tankers, freight trains and commercial aircraft, investigators observed that commonalities existed in the conditions surrounding each accident. Hopfl (1994) explained that "despite the obvious differences in the industries involved and their technologies,….at a contextual level, there [were] many common characteristics (Reason, 1990, cited in Hopfl, 1994). As researchers identified circumstantial similarities, they began to emphasize social and organizational factors in their evaluations of work place accidents (Hopfl,1994). This amended focus was shown in the International Atomic Energy Agency's (IAEA) updated safety report on the accident at Chernobyl. The IAEA report explained that "the accident … flowed from a deficient safety culture, not only at the Chernobyl plant, but throughout the Soviet design, operating and regulatory organizations for nuclear power that existed at that time" (International Safety Advisory Group, 1991).

The impact of corporate culture was also revealed after the 2003 Challenger Space Shuttle disaster. This tragedy was caused by a combination of latent conditions that, though foreseeable, were not corrected prior to the shuttle launch. In 2003, the National Aeronautics and Space

Administration (NASA) had a history of success. The organization had not experienced an in-flight accident in the 17 years prior the 2003 tragedy. Though engineers were aware of structural problems, the glitches were ignored and considered acceptable risks for the Challenger exploration (National Aeronautics and Space Administration, 2003). NASA had a culture focused more on success than safety. As a consequence, when the Challenger space shuttle reentered the earth's atmosphere, a crack in the thermal protection system led to a major catastrophe (National Aeronautics and Space Administration, 2003).

Given the influence of corporate culture on safety, it is no surprise that investigators have started evaluating the culture at BP (previously known as British Petroleum) in the aftermath of the Deep Water Horizon blowout and gas explosion. As a result of the accident, 11 BP employees were presumed dead, and over 1 billion gallons of oil have leaked into the Gulf of Mexico. This is not the only accident associated with BP. In 2005, a BP refinery located in Texas exploded, killing 15 employees and injuring 180 additional people. The company was also associated with the 1989 Exxon Valdez oil spill in Alaska. BP held a controlling interest in the Alaskan oil consortium, which was largely responsible for the cleanup effort, and heavily criticized for errors. In reference to BP's accident record, Rep. Joe Barton stated that BP has created a "corporate culture of seeming indifference to safety and environmental issues" (Mauer, 2010).

The concept of corporate culture as a predictor of corporate safety was prompted, in large part, by the 1986 nuclear catastrophe at Chernobyl. Although interest increased the relevance and study of corporate culture, it did not allow for the development of a systematic examination of the construct. Today, the literature remains theoretically disorganized and inconsistent (Pidgeon, 1998; Schien, 2004).

Defining Corporate Culture

The difficulty inherent in describing corporate culture lies in the need to honor the breadth of the topic while upholding a level of specificity that maintains the construct's significance (Coffey, 2010). Definitions that are too broad run the risk of missing the particular characteristics of culture while those that are too narrow miss the larger picture. Thus, there are many attempts to provide an accurate explanation of corporate culture.

When reviewing the different conceptualizations of corporate culture, and corporate safety culture it is clear that commonalities exist throughout. Specifically, the terms 'thoughts,' 'beliefs,' 'meaning,' 'values,' 'learning,' and 'behavior' are repeatedly mentioned. Many focus on behavior and norms, while others center on personal ideals. Each characterization describes an aspect of culture, but there is no single description that combines the critical components of each definition.

In common managerial jargon, the terms culture and climate are often misused and misinterpreted. Executives frequently refer to *culture* in reference to an organization's environment, mood, or feel, yet these organizational factors are more closely related to *climate* than culture. Organizational culture references an underlying quality that impacts productivity, structure, strategy and climate within an organization. Despite its recent surge in popularity, culture is an elusive construct that is rarely considered. For example, many managers in high risk industries hope to enhance the safety of their organizations. They proactively work to modify their facilities, guidelines, mission statements and reward programs. However, very few consider how cultural assumptions about individual success, responsibility, and masculinity may be thwarting their efforts toward a safer work environment (Schein, 2004). It is clear that defining culture and climate, and understanding the difference between the two concepts is critical to any evaluation of corporate culture. The following section discusses the etiology and definition of each construct.

Corporate Culture and Corporate Climate

Climate

The notion of corporate climate was first identified in the 1950's and 1960's as school researchers considered the psychological effects of diverse educational settings (Hoy, 1990). They were particularly interested in uncovering the educational benefits of different teaching environments, and worked to define and measure different aspects of educational atmospheres (Halpin & Croft, 1963). This initial interest in environments was appreciated by investigators working in large businesses, that believed climate could explain the long-term characteristics of any work environment (Hoy, 1990). In 1964, Forehand and Gilmer defined corporate climate as "a set of characteristics that describe an organization and that (a) distinguish the organization from other organizations, (b) are relatively enduring over time, and (c) influence the behavior of people in the organization." Similarly, Taguiri (1968) drew a connection between personality traits and an organization's climate. The author explained that "a particular configuration of enduring characteristics of the ecology, milieu, social system and culture would constitute a climate, as much as a particular configuration of personal characteristics constitute a personality" (Taguiri 1968 p. 23, cited in Hoy, 1990).

Culture vs. Climate

Research on corporate climate proliferated because it was understood to be a critical construct that could influence employee behavior (James & Jones, 1974). As the concept matured through research, investigators began to identify a distinction between the characteristics, behaviors and feelings that are universally supported by an organization's workforce, and the values and beliefs held by most of an organization's employees (Ekvall, 1983). This recognition of difference led to the identification of corporate culture as opposed to corporate climate. Globally, corporate climate refers to the overt characteristics of an organization's environment,

while corporate culture references the underlying values and beliefs of a given organization (Guldenmund, 2000). It is clear that the constructs of corporate culture and corporate climate are not mutually exclusive. In fact, they are inter-connected, influencing one another as a company grows and works through challenges (Schien, 2004).

Culture

With the identification of culture as an important construct, corporate leaders, researchers, managers, and the general public began to develop an interest in the possibility of creating an organizational culture that influenced employees to behave in a desired manner. This fascination with culture was fueled by the publication of *Theory Z: How American Business Can Meet the Japanese Challenge* (Ouchi, 1981). This well-received management work suggested that American corporations could increase productivity by adopting Japanese management practices. Specifically, the author referred to an organizational shift that would carry a more collectivistic culture, characterized by long-term job security, responsibility, group work, and cautious promotion and evaluation practices (Ouchi, 1981).

Similarly, Peters and Waterman's work, *In Search of Excellence: Lessons from American's best run companies* (1982) became a seminal management book that discussed business from a more flexible perspective. As opposed to focusing on productivity alone, the authors suggested that managers ought to reduce bureaucratic control, focus on customers, facilitate entrepreneurship, value low-paid employees, centralize company values and maintain a committed management team (Peters & Waterman, 1982).

As the construct of corporate culture entered the awareness of the general population, research on the topic proliferated. Investigators with different occupational and theoretical backgrounds began exploring the impact of culture, finding that positive cultures correlate with positive financial outcomes (Kotter & Heskett, 1992; Denison, 1990). Although researchers agreed on the value of culture, their fundamental theoretical differences led to variant definitions of the construct. As a result, the burgeoning research continued to expand without a solid theoretical foundation. Today, the literature remains theoretically disorganized (Schien, 2004; Pidgeon, 1998). In an effort to describe the unsystematic mass of literature, several investigators have created large, all-inclusive, models of corporate culture.

Schein, (2004) worked to condense the literature by describing culture in three interacting levels. The first level, *Artifacts* refers to the observable characteristics of an organization. This includes the language used, the facilities, the dress code, and any other tangible quality that can be quickly observed. The second level, *espoused beliefs and values*, describes shared ideas of people

working within the organization. As a company grows and overcomes challenges, its employees learn from the growth and develop long lasting values and beliefs. The third level, labeled u*nderlying assumptions*, refers to core assumptions that are universally supported within a corporation. Schein explained that these assumptions are supported so often that employees are unable to consider a different thinking pattern (Schein, 2004).

The models proposed by Keesing, Allaire and Firsirotu, and Schein are important in understanding the challenge of describing corporate culture. Each author struggled to provide an all-inclusive explanation of culture, while simultaneously providing specific details that maintain the integrity of the construct. The difficulty inherent in describing corporate culture lies in the need to honor the breadth of the topic while upholding a level of specificity that maintains the construct's significance (Coffey, 2010). Definitions that are too broad run the risk of missing the particular characteristics of culture. Examinations that are too narrow miss the larger picture. Many researchers have attempted to produce an accurate explanation of corporate culture. However, it is clear that limitations can be found in each proposed definition. For a review of recent definitions of corporate culture please see Table 1.

Table 1 Definitions of corporate culture.

Author(s)	Definition
(Aceves & King, 1978)	'the totality of the learned and shared patterns of belief and behavior of a human group.'
(Steadman, 1982)	'learned behavior copied from one another.'
(Deal and Kennedy, 1982)	'the way we do things around here.'
(Murphy, 1986)	'means that total body of tradition borne by a society and transmitted from generation to generation. It thus refers to the norms, values and standards by which the people act, and it includes the way distinctive in each society of ordering the world and making it intelligible.
(Whitten, & Hunter, 1987)	'the patterned behavior and mental constructs that individuals learn, are taught, and share within the context of the group to which they belong.'
(Haviland, 1993)	'a set of shared ideals, values, and standards of behavior; it is the common denominator that makes the actions of individuals intelligible to the group.'
(Cunningham & Greso, 1994)	'in its most basic form is an understanding of "the way we do things around here." Culture is the powerful yet ill-defined conceptual thinking within the organization that expresses organizational values, ideals, attitudes and beliefs.'
(D'Andrade, 1996)	'consists of "learned systems of meaning, communicated by means of natural language and other symbol systems, having representational, directive, and affective functions, and capable of creating cultural entities and particular senses of reality."'
(Harris, 2004)	'the learned patterns of behavior and thought characteristic of a societal group.'
(Kessing & Strathern, 1998)	'We will restrict the term *culture* to an ideational system. Cultures in this sense comprise systems of shared ideas, systems of concepts and rules and meanings that underlie and are expressed in the ways that humans live. Culture, so defined, refers to what humans learn, not what they do and make.'
(Ember & Ember, 2001)	'the set of learned behaviors, beliefs, attitudes, values, and ideals that are characteristic of a particular society or population.'
(Jurmain et al., 2000)	'All aspects of human adaptation, including technology, traditions, language, and social roles. Culture is learned and transmitted from one generation to the next by nonbiological means.'

(adapted from Coffey, 2006)

When reviewing the different conceptualizations of corporate culture, it is clear that commonalities exist throughout. Specifically, the terms 'thoughts,' 'beliefs,' 'meaning,' 'values,' 'learning,' and 'behavior' are repeatedly mentioned. However, the definitions undoubtedly hold distinct differences. Many focus on behavior and norms, while others center on personal ideals. Each characterization describes an aspect of culture, but there is no single description that combines the critical components of each definition.

Hypothesized Model of Corporate Safety Culture

In an attempt to fill this gap in the literature, the current project aspired to develop a measure of corporate culture that combined major themes of previous instruments. Specifically, culture was described as the sum of the *Values*, *Meaning systems* and *Behavioral expectations* that exist within a corporation. Each domain was hypothesized to hold an equal role in the assessment of corporate culture. (See Figure 1)

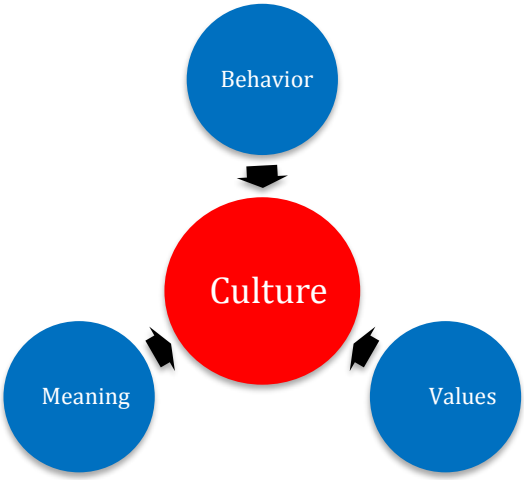

Figure 1. Hypothesized model of corporate culture.

The unique characteristic of the proposed model was the integration of shared meaning systems. To the authors' knowledge, meaning systems have been considered by numerous researchers (D'Andrade, 1996; Geertz 1973; Kessing & Strathern, 1998), but never considered as a component factor of full model of corporate safety culture alongside values and behavioral expectations. Typically, meaning (D'Andrade, 1996; Geertz 1973; Kessing & Strathern, 1998) and values (Aceves & King, 1978; Cunningham & Gresso, 1994; Murphy, 1986) are considered together as a single factor. It is possible that researchers have rejected the simultaneous inclusion of both

constructs in an effort to avoid redundancy. This was seen as a critical mistake. Though meaning and values are related, they refer to distinct human experiences. The present model hypothesizes meaning systems, values and behavioral expectations as a more complete model of corporate safety culture, and therefore more comprehensive than earlier conceptualizations of culture. To be complete, the three domains of values, meaning and behavior would likely be further defined by specific sub components that would make up the domains.

Measures of Corporate Safety Culture

Literature consistently demonstrates a relationship between corporate culture and organizational growth and performance (Miron, Erez, & Naheh, 2004; Prather, & Turrell, 2002; Ogbonna & Harris, 2000; Deshpande, Farley, & Webster, 1993). However, the various theoretical positions of different investigators limit the interpretability of these findings. It becomes challenging to comprehend the results of any given assessment of corporate culture because every measure takes a different perspective. Moreover, common quantitative measures of corporate culture deviate from the construct of culture and unintentionally assesses corporate climate.

The creation of a single measurement tool that is built on a solid theoretical foundation, and pointedly assesses corporate culture would be extremely valuable. The corporate executive could then use the measure to gain a comprehensive understanding of the state of his/her company's culture. This would be especially be important in the measurement of safety culture, as the repercussions of a poor safety culture can be dire (Hopfl, 1994; Reason, 1990).

By unifying the research into a single, comprehensive measure, this study will enable executives to predict and avoid company disasters. As opposed to identifying culture problems after the occurrence of large-scale accidents, as has been shown in the case of BP and Compania Minera San Esteban, companies will have the ability to identify problems in safety culture prior to accidents. The use of a valid and reliable comprehensive measure of safety culture could save the lives of employees and increase productivity.

Empirical research validates an interest in safety culture, as investigators have shown repeatedly that a robust culture of safety significantly reduces the overall risk of workplace accidents. For example, in 1997 Judith Erikson completed a nationwide study on the impact of corporate culture on safety performance. Using a survey to evaluate the perceptions of employees, Erikson showed that when an organization's management team works to implement a culture of safety, safety performance and employee health improve (Erickson, 1997).

These results were corroborated by Shannon, Mayr and Haines, (1997) who reviewed the conclusions of ten studies that evaluated the connection between safety and workplace factors.

The authors' analysis was comprehensive, as each study included in the review had assessed at least 20 separate occupational settings. Shannon, Mayr and Haines identified work place factors that were significantly correlated with injury rates. The significant factors fell under the following 4 headings: 1) Joint health and safety committees, 2) Management style and culture, 3) Organizational philosophy, and 4) workforce characteristics. The authors synthesized the results by identifying variables that were significantly correlated with injury rates in at least 66% of the reviewed studies. Safety culture and management style, though influential in each of the assessed factors, was explicitly shown to be a significant predictor of reduced injury rates in 100% of the studies evaluating this relationship.

Non Quantitative Approaches to Safety Culture Assessment

Despite the advantages of quantitative measurement, many corporate culture experts support the use of qualitative assessments (Guldenmund, 2007; Denison, 1996). Guldenmund (2007) explained that the use of surveys is problematic because corporate culture is a construct that is shared by employees. The author noted that

> "in survey research, one is caught between the theoretical demands of statistics (heterogeneous normally distributed variables around a single mean obtained from a large population) and the theoretical requirements of culture ([strong] convictions shared by groups or categories of people, which are small enough to interact and create a culture about safety or any other related topic)" (Guldenmund,2007).

More simply stated, statistical theory requires a large and diverse sample that comes in opposition to corporate culture, which is created in smaller, homogeneous populations.

Guldenmund's reservations about the use of quantitative methods have been echoed by other investigators, who believe quantitative surveys do not accurately assess the culture. These researchers argue that surveys usually address characteristics, behaviors, and feelings associated with an organization. However, they do not consider the participant's underlying values and meaning systems. Essentially, most current culture assessments measure climate, as opposed to culture (Mearns, Whitaker, and Flin, 2001; Denison, 1996).

A report from the Health and Safety Executive office of the Her Majesty's Railway Inspectorate (HMRI) reviewed various pragmatic approaches to the assessment of safety culture. (HME, 2005) Based on the work of Cooper (2000) who argued that safety culture be defined as "what people do" and the situational factors that contribute to shaping behavior "what the organization promotes." Cooper differentiates safety climate as "how people feel" about safety and the corresponding values attitudes and perceptions of employees. These factors were

combined to create the HMRI Safety Culture Inspection Toolkit, a qualitative approach to determining safety culture in the UK.

The HMRI review of the literature identified several key indicators of corporate safety culture in including:

- Leadership,
- Two-way communication,
- Involvement of the staff in identifying safety practices,
- Learning culture that promotes a continuous improvement
- Assessment instruments and questionnaires
- Health and safety managed techniques to promote safety.

The report also included a number of measures that showed promise for use in the field. The **Aberdeen University Offshore Safety Questionnaire (OSQ99)** (HSE, 1999) was designed to provides companies with information about their current safety climate, and highlights areas of strength and of weakness. The OSQ99 was includes scales designed to assess a seven factor model of safety culture including: 1) Policy awareness 2) involvement 3) communication 4) Perceived supervisor competence, 5) management commitment 6) General safety behavior and 7) Job satisfaction. The questionnaire contains 80 items requiring answers on a three or five point Likert-type scale. The tool was designed for usage in the offshore, gas, as well as power generating industries. (RSSB, 2003, pg. 50-56).

The **HSE Health and Safety Climate Survey Tool (CST)** has been ranked the best safety climate tool in a review of safety climate/culture tools (RSSB, 20032, page 41). The questionnaire was designed to assess employee involvement in health and safety culture in their organization. Questions on the asks employees about aspects of their existing health and safety climate. The CST is a 71-item computer administered questionnaire using a standard 5 point rating scale designed to asses a 10 factor model of safety culture including: 1) Organizational commitment and communication 2) Line management commitment 3) Supervisor's role 4) Personal role 5) Workmates influence 6) Competence 7) Risk taking behavior 8) Obstacles to safe behavior 9) Permit-to-work systems and 10) Reporting of accidents and near misses. The CST has been used to assess safety climate across a range of industry sectors, including oil and gas companies. It is used to assess managers, supervisors and the workforce. (RSSB, 20032, page 41).

The **Occupational Psychology Centre Safety Culture Questionnaire (SafeCQ)** was developed to assess safety culture in rail companies. The questionnaire is based on a twelve-factor model of safety culture and includes the following factors: 1) Communications about safety 2)

Profile of safety within the organization 3) Access to safety information 4) Management involvement in safety 5) Recognition and openness about safety issues 6) Control over safety 7) Attitudes to safety 8) Safety information 9) Learning from safety issues 10) Perceptions of safety performance 11) Investment in safety and 12) Other factors (e.g. concern over minor incidents and attitudes to short cuts). The questionnaire was developed based on the rail industry, however, according the HSE (2005) report, this tool has not been widely used. It has only been applied within one UK, and one US organization. (RSSB, 20032, page 145)

Quest Evaluations and Databases Ltd Safety Climate Questionnaire (QSCQ). The questionnaire provides methods for measuring attitudes, values and beliefs of individual workers. It can be used for the assessment of behaviors, working practices and perceptions of safety, and identification of root causes of potential problems. It can also be used to define proposed industry norms for error potential on critical drilling activities, together with norms for safety climate. The tool is useful because it allows companies to identify where improvement efforts need to be focused. (HSE, 1999, pages 30-34).

The Safety Climate Survey (SCS). This instrument was developed based on a review of accidents and incidents in the oil and gas industry. The factors identified from the 88 factors were grouped into 12 categories to structure the questionnaire. The twelve factors included: 1) Safety priorities 2) Communication 3) Training 4) Environment 5) Individual - Procedures 6) Design of work/people 7) Design of things/equipment 8) Management/structural 9) Investigation/evaluation 10) Emergencies and 11) Maintenance. The questionnaire consists of 319 items that make up the 12 categories using responses on a 7-point Likert-type scale. The survey can be limited to specific sections of area of concern, e.g. management and training. The tool was developed specifically for the offshore drilling environment. (RSSB, 2003).

The Rail Safety and Standards Board (RSSB) Safety Culture Tool (RSSBSCT). The RSSB Safety Culture Tool was designed to assess the safety culture of any rail company. The instrument is a 66-item self-assessment questionnaire using a response format ranging from strongly agree to strongly disagree. The items comprise a nine factor model of safety culture that includes: 1) Positive organizational attributes 2) Management commitment to safety 3) Strategic flexibility 4) Participation and involvement 5) Training 6) Communication 7) Reinforcement and incentives 8) Individual ownership and 9) Individual perceptions. The this tool has been highly rated by UK rail professionals. (RSSB, 2003).

The Robert Gordon University Computerized Questionnaire (CSCQ). The questionnaire provides offshore rigs/facilities and companies with information about their safety climate and may highlight areas of strength and weakness. The CSCQ was developed as a version

of the (Aberdeen University Offshore Safety Questionnaire, OSQ v1.0) also used with offshore operating and contracting companies themselves. The tool is administered through a Microsoft Excel-based software package, consisting of the questionnaire and analysis macros. The questionnaire has 49 items which comprises adapted from the Aberdeen instrument which are organized into the following areas: (RSSB, 20032, page 122): 1) General information 2) Risk taking behavior) 3) Safety attitudes 4) confidence in safety management 5) pressure for production 6) supervision and management 7) rules and regulations and 8) Safety in operations. Responses are recorded using a five-point rating scale. HSE, 1999, page 27).

The Loughborough University Safety Climate Assessment Toolkit (LSCAT). The safety climate assessment toolkit contains several procedures, including a questionnaire designed to assess safety culture in and safety climate in offshore operations. The instrument consists of 47 items comprising the following model of safety culture: 1) Organizational content 2) Social environment 3) Individual appreciation 4) Work environment 5) Organization specific factors. (Cox & Cheyne, 2000; HSE, 1999, page 30).

The LSCAT based on information provided in the HME (2005) report was designed to be administered as a standalone self-report questionnaire. However, some of the assessment questionnaires were intended as components of a larger more comprehensive qualitative review of the organization. Unfortunately, the HME (2005) did not provide information on the psychometric qualities and characteristics of the instruments including such constructs as: reliability, validity, utility and effectiveness at differentiation safe vs. unsafe cultures.

Another general consideration is that most of the tools reported on in the HME (2005) report were designed specifically for, and applied within a particular industry, such as the oil and gas, nuclear, or rail industry. Only the oil and gas industry seems to have a consistent record of using the same instrument and items repeatedly which would allow for benchmarking and standardization of the instruments. There is also some interchangeable use of the factors of safety culture and safety climate.

An additional review of US based measures that assess corporate culture in a quantitative fashion was also conducted. Five published instruments (see Table 2) that measured on corporate culture, only two of which included safety culture, were identified. Overall, these measures are still quite limited in the depth to which it addresses culture. The measures identified were limited in their overall conceptual framework and point to the need for an empirically supported measure of corporate safety culture.

The Organizational Culture Inventory (OCI) is a measure designed to assess a corporate culture. A total of 120 items are used to assess the a twelve factor model: 1) humanistic-

encouraging, 2) affinitive 3) approval, 4) conventional, 5) dependent 6), avoidance, 7) oppositional, 8) power, 9) competitive, 10) perfectionistic, 11) achievement, and 12) self-actualizing" (Alexander, 1990). The OCI is considered a unique test because it purports to measure a participant's interpretation of their company's culture, as opposed to the participant's own thoughts and behaviors. This difference in focus is believed to decrease personal bias and thus make the measure more valid. In addition to evaluating the style characteristics of the assessed corporation, the OCI also identifies the corporation's culture across the following culture categories: 1) Constructive, 2) Passive/defensive, and 3) Aggressive/Defensive. The conclusions of the measure are cataloged in a culture profile that is easy for a consumer to review and understand (Alexander, 1990). The validity of these outcomes, with respect to organizational safety, are indeed unknown (Alexander, 1990). Unfortunately, the OCI appears to have not published any clear findings associated with the reliability or validity of the measure. This lack of statistical support drastically limits the value of the measure. Similarly, no explanation is provided regarding the selection of the three culture clusters or the 12 style categories. It is unknown if these groupings have theoretical underpinnings.

The Denison Organizational Culture Survey (DOCS) was developed by Denison, a consulting firm based in Ann Arbor Michigan. The foundation for all of Denison's work is the "Denison Model," a conceptual model of consisting of 1) Mission, 2) Adaptability, 3) Involvement and 4) Consistency (Denison, 2010). The four factors are assessed via 60 items. The DOCS has been used with over 1000 organizations operating in numerous industries. Although the Denison Model completely describes organizational characteristics, only one of the indices (values) addresses corporate culture. With this foundation, the DOCS seem to be more of a climate survey than a culture survey. It is also important to note that, to this author's knowledge, Denison has not published any data regarding the DOCS's reliability or validity.

The Safety Culture Survey (SCS) was designed by Safety Performance Solutions (SPS), a consulting organization that specializes in helping other companies acquire a "Total Safety Culture." The SCS is specifically designed to evaluate employee's perceptions of a reviewed company's safety culture. It is a 93-item measure, which questions employees about numerous aspects of the 14-factors model of safety culture: 1) management support for safety, 2) peer support for safety, 3) personal responsibility, 4) discipline, 5) incident reporting and analysis, 6) safety rules, regulations, and procedures, 7) training, 8) safety suggestions and concerns, 9) rewards and recognition, 10) safety audits and inspections, 11) communication, 12) employee engagement, 13) safety meetings and committees, 14) miscellaneous (Safety Performance Solutions, 2010). With 14 separate domains, this test considers a large range of company characteristics. The extensive domain list is designed to assess a company's current safety

environment, which best fits the definition of climate. There are no domains that directly address meaning or values.

The *Safety Culture Values and Practices Questionnaire (QCS)* QCS is an intricate measure that uses a double-pronged approach to assess corporate safety culture. First, QSC uses a competing values framework to describe a reviewed organization's orientation towards safety. This process ranks the organization across the following values: human relation or support, open system or innovation, internal process or rules, and rational goal or goal models. The test creators explain that each of these orientations exist within all companies, but the different degrees of their presences can provide insight into the safety of the organization (Diaz-Cabrera, Hernandez-Fernaud, & Esla-Diaz, 2007). The seven dimensions of safety culture are: 1) training program content, 2) incident and accident reporting systems, 3) orientation of safety rules and procedure, 4) performance appraisal and safety promotion strategies, 5) motivation patterns used, 6) information and communication systems, and 7) leadership styles (Diaz-Cabrera, Hernandez-Fernaud, & Esla-Diaz, 2007).The limitation of this measure is found in the specific categories of culture. The QCS's competing values framework provides insight into the level of value within an organization. However, the specific categories do not present a full picture of culture. The domains are very specific, ignoring the role of meaning and focusing largely on tangible aspects of the corporate climate.

The Safety Culture Indicator Scale Measurement System (SCISMS) is a safety culture survey designed for use in high risk industries. Most recently, the test has been widely used in the aviation industry. The test uses a four-factor model, including: 1) organizational commitment, 2) formal safety indicators, 3) operations interactions, and 4) informal safety indicators. Combined, each of these factors purports to identify the strengths and weaknesses of an evaluated organization. In an effort to increase the measurability of the modes, each factor is composed of three concrete dimensions. Specifically, organizational commitment is composed of: a) safety values, b) safety commitment, and c) going beyond compliance. Formal safety indicators include the following: a) reporting system, b) response and feedback, and c) safety personnel. Operations interactions consist of: a) supervisors/foremen, b) operations control/ancillary operations, and c) instructors/training. Finally, informal safety indicators incorporates constructs such as: a) accountability, b) employee authority, and c) professionalism (Thaden, & Gibbons, 2008).

In addition to the previously noted factors of safety culture, the SCISMS also carries a correlated factor labeled Safety Behaviors/Outcomes composed of two dimensions: a) perceived personal risk/safety behavior, and b) perceived organizational risk, as an outcome measure. The test creators believe safety culture influences both corporate safety behavior, and perceptions of risk (Thaden, & Gibbons, 2008). This survey has a high degree of internal reliability, however,

it only evaluates the concrete categories of safety, but it is not a measure of culture includes behaviors, values and meaning. The SCISMS does not measure these aspects of a reviewed corporation.

Need for a new survey

When reviewing the available measures of corporate culture and corporate safety culture, it is clear that the current measures are deficient. Only two of the identified measures also include a major domain of corporate culture that assesses meaning, values or behavior. These measures, the Safety Culture Values and Practices Questionnaire, and the Denison Organizational Culture Survey, are still limited in the depth at which it addresses culture. This review highlights the need for an empirically supported measure of corporate safety culture. A review of the evaluated measures can be found in Table 2.

A second major concern about the existing measures of corporate safety culture that were available for review is the fact that there is limited or no evidence to suggest that the measures were created through the use of currently accepted standards of psychometric instrument construction including: factor analysis, reliability and validity analysis, as well as criterion validity techniques. Thus, the available instruments appear to fall short of current accepted psychometric standards and call for the construction of a new instrument.

A review of the literature did not uncover a complete or comprehensive measure of corporate culture or corporate safety culture. A perfect measure would include an evaluation of each global domain of culture. To ensure validity, these overarching domains would be empirically supported. In an effort fill the gaps in the literature, the current project is designed to develop a measure of corporate safety culture that considers the overarching domains of culture. These domains have been identified as: meaning systems, values, and behavioral expectations. In addition, such a measure would also provide useful information on the subcomponents reflected in the three domains. To satisfy the need for an empirically validated measure, the aforementioned domains will be subjected to statistical tests of reliability and validity.

In addition to developing a measure of corporate safety culture, this study also endeavored to evaluate the value and importance of the survey. To assess the relationship between the measure and safety behavior, behavioral frequency was assessed. Without a validated, preexisting test, the most efficient way to measure behavioral frequency as an outcome variable was to assess a single behavioral frequency items with high face validity. The use of untested items to assess an outcome raised some methodological questions. It was possible that the assed question was invalid, thus limiting the accuracy of the outcome assessment. The existing measures have very different conceptual frameworks and only one provided evidence of adequate scientific reliability.

Table 2. List of Measures of Corporate Safety Culture.

Measure	Components of Culture	Weakness	Evidence
Organizational Culture Inventory (Cooke & Lafferty)	(a) Constructive (b) Passive/Defensive (c)Aggressive/Defensive	1) Theory 2)statistical support	No reliability or validity data
Denison Organizational Culture Survey (Denison & Neale)	(a) Mission (b) Adaptability (c) Involvement (d) Consistency	1) Theory 2) No psychometrics	No reliability or validity data
Safety Culture Survey (Safety Performance Solutions)	a) Management support b) Peer Support for Safety c) Personal Responsibility d) Discipline, e) Incident Reporting Analysis f) Safety Rules, Regulations, and Procedures g) Training h) Safety Suggestions and Concerns i) Rewards and Recognition j) Safety Audits & Inspections k) Communication l) Employee Engagement m) Safety Committees n) Miscellaneous	1) Theory (measures climate)	Absent of any reliability or validity data
Safety Culture Values and Practices (Diaz-Cabrera, Hernandez-Fernaud, & Esla-Diaz)	(a) Human Relation or Support, (b) Open system or Innovation (c) Internal Process or Rules (d) Rational Goal or Goal Models	1) Theory (measures values, but no other aspect of culture)	Absent of any reliability or validity data
Safety Culture Indicator Scale Measurement System (Thaden & Gibbons)	(a)Organizational Commitment (b) Formal Safety Indicators (c) Operations Interactions (d) Informal Safety Indicators	1) Theory (measures climate)	Alfa coefficients =.81-.95

Method

Participants

The experimental survey was administered to all of the employees of a state transportation agency. All employees at all levels of management and labor were invited to participate. The final version of the survey was electronically distributed to all 3,349 CDOT employees.

Construction

With the goal of creating a more well-rounded and inclusive instrument, the investigator attempted to connect the theories by organizing the research into overarching thematic categories. The following three groupings were identified as comprising a comprehensive model of safety culture: 1) shared meaning systems, 2) values, and 3) behavioral expectations. The recognition of three global themes led to the hypothesis that corporate culture is a large construct that is composed of the previously mentioned three themes, or factors. The factors described above are further defined in Table 3.

Table 3. Domains of Corporate Culture

Factors	**Explanation**
Meaning Systems:	Meaning Systems are underlying mental constructions that allow for the interpretation and understanding of how daily events fall into an individual's personal narrative.
Values:	Values represent the fundamental moral expectations that an individual uses to appraise daily events.
Behavioral Expectations:	Behavioral Expectations refers to the activities that are anticipated within the course of an individual's employment responsibilities.

Potential items of the CSCS were developed conceptually, following an attempt to create items consistent with the three themes. The author generated approximately 10 items per theme. Then, in conjunction with the dissertation chair the investigator reduced the item pool by eliminating unnecessary items. In total 25 new items were retained, with at least 8 items in each domain. All items were given a six option Likert response format with a continuum ranging from strongly agree to strongly disagree.

Cognitive Interviews

As was recommended by DeVellis (1991), the investigators met with several subject matter experts from a local transportation organization and its safety committee to ensure that the survey items had face and content validity. Members of this committee held expertise in safety, culture, risk, survey development, within the transportation industry. In total, the measure held twenty-four items. To further improve the validity of the items, the survey was evaluated by 23 graduate students at the University of Denver who rated the extent to which each proposed survey item addressed the intended culture domains. Items were rated for relevance to the anticipated domains that were defined on the rating form. The resulting questionnaire had 18 items, with at least 5 items predicted to load on each proposed domain.

Data Analysis

Factor analysis and structural equation modeling were used to design and evaluate the CSCS. Exploratory factor analysis (EFA) was used to develop an empirical model. Confirmatory factor analysis (CFA) was employed to present the theoretical model, containing the predicted components: shared meaning systems, values, and behavioral expectations. The model fit of each developed model was assessed and compared. After identifying the model with best fit, the researcher used a one-way between groups analysis of variance to appraise the relationship between safety behavior and scores on the CSCS.

Procedures

The survey was administered electronically to all eligible employees of a large transportation organization in a large western state. Study participants received the survey and the consent form approved describing participant anonymity by the IRB. The resulting data set was randomly divided into two equal samples identified as group "A" or "B".

A principle components analysis conducted on group "A" with factors selected based on Communalities, Eigen values, the pattern matrix, and the Scree Plot. In the second analysis, with group B, CFA was used to evaluate the model fit of the empirical model and the experimental model, composed of the originally theorized items and domain**s.** The final model was adjusted only with theoretically supported modifications to improve model fit. Model fit was evaluated and compared using the following fit indices: Chi-squared (χ^2), Root-mean-square error of approximation (RMSEA), Bentler comparative fit index (CFI), and Expected cross-validation index (ECVI). Finally, after identifying the model with the best fit. The full sample was submitted to an analysis of variance and the relationship between scores on the CSCS and scores on a self-report behavioral frequency item were evaluated.

Results

Participants

The final version of the survey was electronically distributed to all 3,349 agency employees. The survey received a strong response rate of approximately 57%. In total 1909 surveys were fully completed. For analysis purposes only responses provided by participants working in high risk positions were evaluated. Specifically, this included employees working in divisions of transit and rail, and the maintenance division. In addition, participants did not hold managerial positions within their organizations. This requirement was intended to reduce respondent bias. It was believed that higher-ranking employees would be more invested in the outcomes of the study and more aware of efforts made to implement a culture of safety. Lower ranking employees were thought to be less familiar with executive mandates, and thus more likely to accurately describe the safety culture of CDOT. Finally, all evaluated participants were between the ages of 18 and 65. This age limitation was important as it allowed the researcher to assess the most typical segment of employees working in high-risk industries.

Consideration was also given to the participant's tenure as CDOT employees. It was believed that employees who had been employed for longer periods of time would have a better understanding of the corporate safety culture. However, due to sample size necessities, the investigator was unable to exclude employees with limited tenure at CDOT. Please see Table 4 for tenure statistics.

Table 4. Tenure of study participants.

Years of Tenure	N
0-5	413
6-10	203
11-15	130
21+	64

Prior to commencement of this project, the researcher anticipated measuring the effects of demographic differences amongst the participants. However the agency safety committee was unwilling to record demographic information because they deemed the information to be unnecessary. Specifically, they did not allow for the inclusion of questions associated with race, ethnicity, gender, age, SES, or education level. The researcher was forced to accept this limitation. With this restriction, the results must be interpreted with care. They likely only generalize to similar state departments of transportation.

Tests of Assumptions

The assumptions for large sample size (N=1907), factorability of the correlation matrix (r=> .30), Sphericity (p<.001), and Linearity were met. Seventy cases were removed due to high values on the Mahalanobis distance. The Kolmogorov-Smirnov value was evaluated and (p<.001) revealed a violation of the normality assumption. However, square root, inverse, reflect, and logarithmic transformations did not improve normality within the variables. Accordingly, the original data was retained.

Test of the Domain Model

This section provides an explanation of theoretical factor structure, and compares its fit with empirically derived models. Exploratory factor analysis was used to obtain the empirical factor structure. Confirmatory factor analysis was used to test the theoretical model, along with the empirical model and a modified empirical model. CFA was used to compare the model fit of each of the aforementioned models. This fit was identified using the criteria discussed in chapter three.

Exploratory Factor Analysis

By exploring the independent variance carried by the variables, Exploratory Factor Analysis (EFA) enabled the researcher to identify the empirical model. In the segment below, the steps taken to uncover the empirical structure are identified. The discussion starts by presenting an explanation of Principle Components Analysis, the data reduction technique selected for this project. The conclusions of the analysis are presented with an evaluation of communalities, Eigen values pattern matrices, structural matrices, the scree plot, and correlations of identified components. At each step, the decision making process is explained.

Principle Components Analysis

Principle components analysis (PCA) was identified as the optimal analysis for the purposes of this project. PCA is a data reduction technique that accounts for the greatest amount of data variance with the fewest of factors. PCA is different from other factor analytic techniques because it evaluates the shared, unique, and error variance of each factor. As a result, the variability accounted by each factor is maximized. Moreover, the identified factors are independent, and do not correlate with one another.

Communalities

Communalities are important as they reveal the extent to which an item's variance is explained by the extracted factors. With this data, essentially a correlation coefficient, the investigator was able to identify items that did fit well with the extracted items. Costello & Osborne, (2005) reported that items with low values, less than .4, needed to be removed, or

accommodated, through the creation of additional factors. Because no items in this project held commonalities values below .4, all items were retained.

Eigen values

Eigen values describe the amount of variance that is accounted by each factor. The Kaiser criterion (Kaiser, 1960), suggested that Eigen values greater than or equal to one can be considered stable. The Principal components analysis revealed four factors carrying Eigen values that met this standard. These four factors accounted for 65.14% of variance. The Eigen values attributed to each identified factor, and their claimed variance can be seen in Table 5.

Table 5. Total Variance Explained.

Component	Eigen values	% Variance	Cumulative Variance
1	6.709	35.312	35.312
2	3.565	18.764	54.076
3	1.086	5.717	59.793
4	1.016	5.348	65.141

However, after evaluating the pattern matrix, and eliminating items that were cross loaded, two factors were identified. The specified factors were submitted to Oblimin rotation, which allows for the correlation of factors and leads to greater eigenvalues. The rotation resulted in a between factors correlation of .25. When evaluating the "elbow" depicted in the scree plot, the decision to select 2 factors was confirmed. The amount of variance explained by the first two components was much greater than the variance explain by the last ten components. The scree plot can be seen below in Figure 2.

Figure 2. Scree Plot of Hypothesized Factor Structure.

During the analysis of the Pattern Matrix, the following six items were dropped from the scale because they were shown to load on at least two factors.

Table 6. List of key items deleted due to factor overlap.

Q16 =I know how to avoid safety hazards
Q43 CDOT personnel usually follow safety guidelines
Q47= I would rather be a safe employee than a productive employee
Q49 I can prevent and avoid accidents through my personal actions
Q52=My coworkers see me as a safe worker
Q53=Safe employees should be rewarded

Based on the suggestions of Tabachnick & Fidell, (2001) and Costello & Osborne (2005) factors with loadings of .40 or greater were extracted and identified. Items loading on factor one addressed behavioral and performance and expectations. Accordingly, this factor was identified as "Behavior." The second identified factor held items created to measure the values/beliefs held by employees. This factor was labeled "Values." One item, (Q51=*The best employees are usually the safest employees*) was removed because it carried a factor loading below .4 and could not be extracted. The resulting pattern matrix can be seen below in Table 7. The means and standard deviations of the identified factors is shown in Table 8.

Table 7. Items in proposed domains.

ID	Component		Item	Proposed Domain
	1	2		
Q6	.770		Employees feel free to report safety hazards	Behavior
Q8	.840		Employee safety is not sacrificed for production during a job	Behavior
Q18	.787		Employees are encouraged to fix safety hazards	Behavior
Q20	.871		Employee safety is not sacrificed for speed during a job	Behavior
Q22	.483		My coworkers look out for my safety	Behavior
Q30	.794		I am encouraged to raise safety concern	Behavior
Q32	.876		Employee safety is not sacrificed for quality during a job	Behavior
Q40		.825	I pride myself on my ability to work safely	Values
Q41		.781	Safety is more important than productivity	Values
Q42		.864	I hope to be known as a safe worker	Values
Q44		.833	Safety at work is as important as safety at home	Values
Q46		.849	The most important part of completing a job is being safe	Values

Table 8. Means of proposed factors.

Factors	1	2
1 Behavior	1	
2Values	.214**	1
Mean	31.54	37.84
SD	3	7

Test of Reliability

To ensure that the developed scale was consistent and dependable, the reliability of the scale defined in the empirical model was tested prior to further evaluation. Items with low item-total correlations were removed from the scale. Question 22 was eliminated from the Behavior scale, (r=.53). No items were dropped from the Values scale, as they all had item-total correlations greater than .60. An appraisal of the two domains and the full scale's reliability is depicted below in Table 9. DeVellis, (2003) suggested that Cronbach's Alpha values above .7 are acceptable.

Table 9. Internal consistency and reliability estimates of proposed two factors.

	Number of Items	Alpha
Behavior Domain	6	.915
Values Domain	5	.88
Full CSCS	11	.885

Principal Components Analysis and Identification of Safety Culture Sub-components

Results of the principle components analysis (PCA) identified ten factors carrying Eigen values greater than one and accounting for 65.14% of variance. After evaluating the pattern matrix, and eliminating items that were cross loaded, two factors were identified.

Test of Reliability

To ensure that the developed scale was consistent and dependable, the reliability of the scale defined in the empirical model was tested prior to further evaluation. Items with low item-total correlations were removed from the scale. One question was eliminated from the Behavior scale, (r=.53). No items were dropped from the Values scale, as they all had item-total correlations greater than .60.

Confirmatory Factor Analysis: Empirical Model

The model developed though the Exploratory Factor Analysis (EFA) (Model One – Empirical Model (see Figure 8)), on data set Group "A" was tested through Confirmatory Factor Analysis (CFA) on data set Group "B". The resulting fit indices were ($\chi^2 = 307.5$, df = 43, p<.0001) which showed that significant discrepancy existed between the two data sets. In order to test the initially Hypothesized model (see Figure 9), the nineteen items initially submitted for the composition of the CSCS were analyzed. The initially Hypothesized model, which consisted of the items comprising the Meaning, Values and Behavioral Expectations factors, also did not have a good a fit (see Model One in Table 10).

Because the Hypothesized and Empirical (EFA) models did not have an adequate fit, a third model, the Modified Empirical Model (Model Three in Table 10 and Figure 10) was developed using modification indices to improve model fit. Through this process, three suggested modifications that had both large modification index values and conceptual support. Controlling the relationship between error terms of the correlated items produced model with an overall acceptable model fit. The chi-squared value of ($\chi^2 = 126.54$ df = 40, p<.001) was overlooked due to the large sample size. The RMSEA value (.071) suggested a strong fit, the CFI (.978) confirmed an adequate fit, and the ECVI score showed that Model Three had the best fit. (see Figure 10 and Table 10).

Table 10. Comparison of fit indices.

	Fit Indices					
Tested Models	χ^2	DF	Sig	RMSEA	CFI	ECVI
Model One (EFA-Empirical Model)	307.5	43	<.001	.119	.917	.813
Model Two (Hypothesized)	683.04	149	<.001	.091	.888	1.76
Model Three (Modified Empirical)	126.54	40	<.001	.071	.973	.410

Validation of the Modified Empirical Model

After identifying a reliable model, the Modified empirical Model (Model Three), the validity of the CSCS was evaluated by demonstrating a relationship between each identified component of the measure to a criterion measure of related safety behavior. This assessment was completed with the use of a single behavioral rating of job performance related to supervisor acknowledgement of safe work behavior (Item 61 – "I received a performance documentation form for using good safety practices during the past 12 months.") Based on their responses respondents were classified as either "Safe" "Not Safe" or "Un Sure".

A one-way analysis of variance between groups revealed that for the full scale, and each of the identified domains, the "Safe" group was shown to have a higher mean score than the "Not Safe" and "Un Sure" group. (see Table 11) This finding suggests that high scorers on the CSCS are safer employees than those who score lower.

Table 11. Validity of safety culture scales and accident data.

Full CSCS				
	Safe	**Not Safe**	**Un Sure**	**Sig.**
Mean	65.36	62.62	63.36	Safe> Not Safe & Un Sure
N	233	504	100	
SD	7.39	8.36	7.2	
Behavior Domain				Safe> Not Safe & Un Sure
Mean	65.36	62.63	63.36	
N	233	504	100	
SD	7.39	8.36	7.2	
Values Domain				
Mean	31.92	31.39	31.23	Safe> Not Safe & Un Sure
N	233	504	100	
SD	2.7	3.03	3.34	

Analysis of Subcomponents of the Modified Empirical Model

To further understand the nature of safety culture and to also develop a useful and instructive tool the items in the scale were subjected to further analysis and review. Using the set of items derived it was decided that an additional set of scales, based on face valid selection and structure, and building upon the information gathered from previous reviews would be useful. Accordingly, after inspecting the eigenvalues of the exploratory factor analysis, a 12 factor solution was extracted from the data set in which the factors had eigenvalues over 1.00. (Costello & Osborne, 2005). However, at least five of these factors were single item factors and thus did not lend themselves to easy interpretation. A second factor analysis, omitting these single item factors, was conducted that extracted 10 factors with eight of the eigenvalues over 1.00 and two very close to 1.00. These factors were deemed interpretable, were given names, and are presented in Table 12. As can be seen, Factor 1, the factor that accounted for the largest percentage of the variance, was labeled *Supervisor Commitment*. The items in this scale are generally referencing the activities of the respondents immediate supervisor. This was followed by Factor 2, *Safety Over Productivity*. Factor 2 was comprised of items that addressed a belief, on the part of the respondent that the safe performance of the job was more important than the job itself. Next, Factor 3 was comprised of items dealing with *Peer Commitment* or Co-Worker commitment to safety. Interestingly, Factor 4, *Senior Management Commitment*, accounted for the fourth largest percentage of the variance (3.24%). The first four factors then, accounted for 56% of the total variance. The remaining factors, which accounted for only 10% of the variance remaining include awareness and usefulness of safety staff such as trainers and safety managers, respondent knowledge of safety hazards and procedures, perception of safety being rewarded, knowledge of safety policies, and perception of safe employees. Overall, the total factor model, and the ten scales that comprise it accounted for a cumulative 69% of the variance in the items analyzed. Taken together these items and scales then suggest a fairly robust accounting of the components that comprise corporate safety culture in a large state department of transportation.

Table 12. Factor components and percent of variance accounted for.

Component	Total	% of Variance	Cumulative %
1. Supervisor Commitment	21.176	39.955	39.955
2. Safety Over Productive	4.727	8.919	48.874
3. Peer Commitment	2.181	4.116	52.99
4. Senior Mgmt Commitment	1.717	3.24	56.23
5. Safe Work Environ	1.515	2.859	59.088
6. Safety Staff	1.369	2.584	61.672
7. Safety Knowledge	1.104	2.083	63.755
8. Safety Rewarded	0.992	1.872	65.627
9. Safety Policies	0.958	1.807	67.434
10. Safe Employees	0.878	1.656	69.09

Importance of Factors

The ten factor structure that was derived from the data may be more clearly understood by arranging the relative magnitude of the variance accounted for in a hierarchical format. While a total of 31% of the variance is unaccounted for and unknown, the largest amount of variance is from the supervisor commitment factor (40% - see Figure 3). The next largest contributors are Safety Over Productivity (9%), Peer Commitment to Safety (4%) and Senior Management Commitment (3%). Thus, the relative magnitude of the variance accounted for by the various components may lead to some prioritization of areas for intervention.

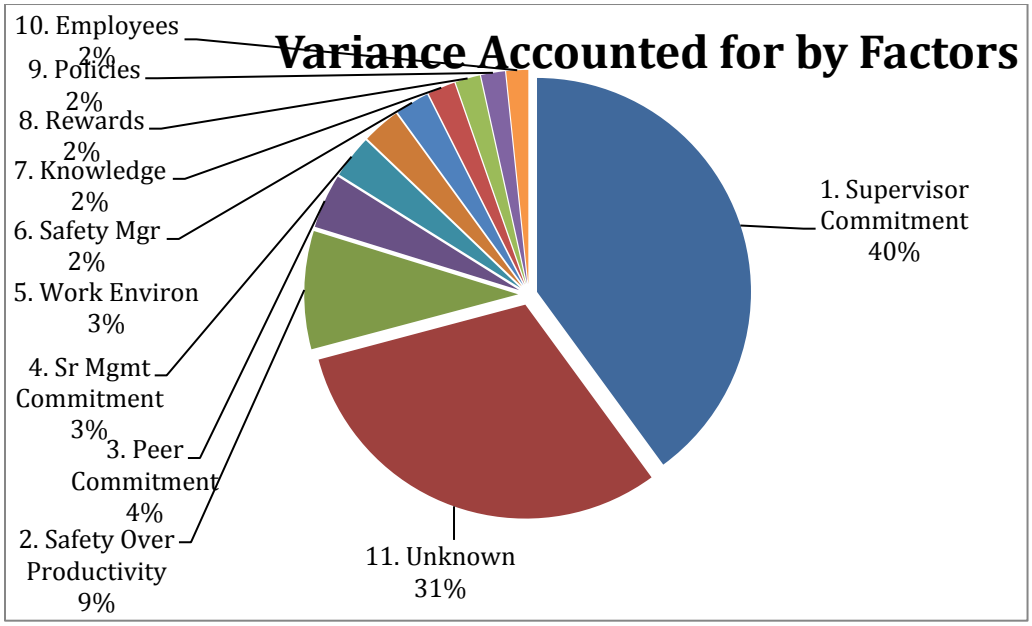

Figure 3. Breakdown of variance associated with factor components.

Reliability of Extracted Scales

These scales were then subjected to additional analysis using Cronbach's alpha to determine their internal consistency. As can be seen from Table 13, the ten scales demonstrated adequate reliability and internal consistency from the standpoint of the Cronbach's alpha.

Table 13. Means, standard deviations, and alpha's of factor components.

	Scale Mean	Scale STD	Cronbach's Alpha	Cronbach's Alpha STD	N items
1. Supervisor Commitment	53.92	11.39	0.946	.946	10
2. Safety Over Productive	66.33	7.354	0.902	0.913	11
3. Peer Commitment	39.43	6.027	0.873	0.877	7
4. Senior Mgmt Commitment	27.42	5.876	0.924	0.925	5
5. Safe Work Environ	25.96	5.45	0.830	0.837	5
6. Safety Staff	14.59	4.667	0.944	0.944	3
7. Safety Knowledge	17.77	2.162	0.807	0.816	3
8. Safety Rewarded	12.58	3.813	0.791	0.792	3
9. Safety policies	17.85	2.291	0.653	0.680	3
10. Safe Employees	11.14	2.083	0.586	0.592	2

Note: Based on N=1909.

Validity

The validity of the various scales was determined by demonstrating that there was a significant difference between persons who were identified, based on their responses respondents as either "Safe" "Not Safe" or "Un Sure". This assessment was completed with the use of a single item behavioral self-rating of job performance related to supervisor acknowledgement of safe work behavior (Item 61 – "*I received a performance documentation form for using good safety practices during the past 12 months*." And Item 62 – "*I received a performance documentation of unsafe safety practices from my supervisor I the past 12 months*.") The rationale for this approach was the notion that a person's internalization of the safety culture would be associated with their behavior and performance on the actual job. Furthermore, since there were limited sources of data available, and confidential responses to the survey questionnaire were deemed to be necessary in order to ensure completion of the survey, these were likely the best data available.

The first set of analyses compared those who had received a rating of "Safe" to those who had not. As can be seen in Figure 4 there was a significant difference in perception of the safety

culture between the two groups. Those who received a "Safe" rating had higher scores on all of the safety culture scales than those who did not.

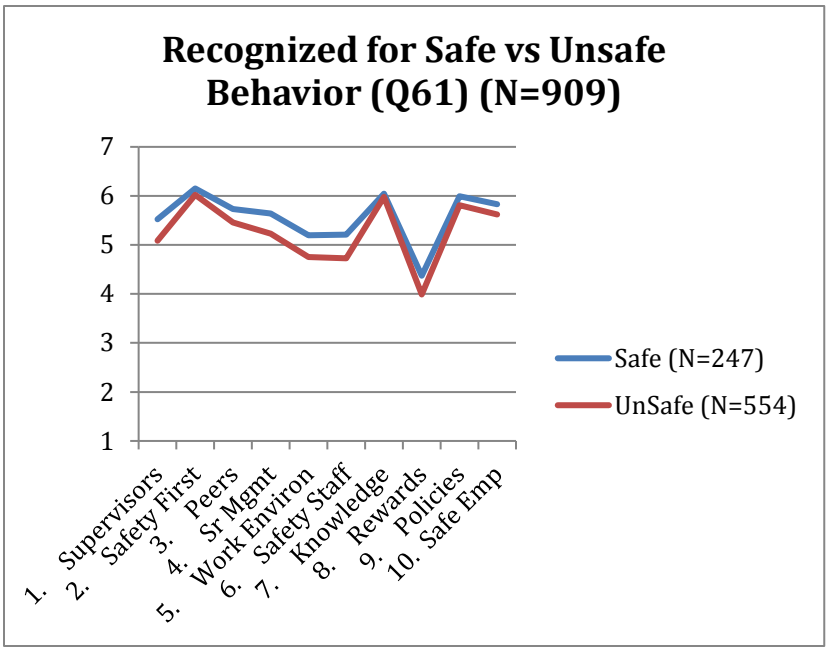

Figure 4. Documentation for "Safe" work behavior.

Similarly, respondents also rated themselves on whether they had received performance documentation for "Unsafe" work practices from their supervisors. Results of a series of one-way analyses of variance revealed that those persons who had received performance documentation from their supervisors regarding "Unsafe" work practices were also significantly different in their perceptions of the safety culture as is shown in Figure 5. Interestingly, there

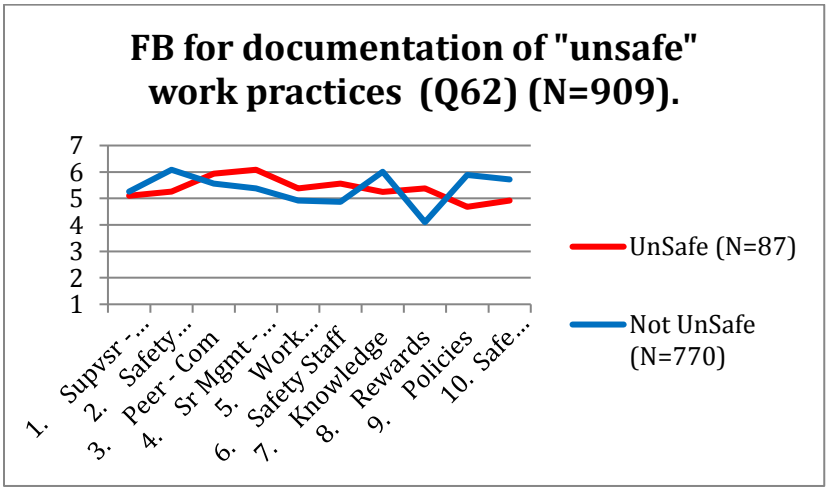

Figure 5. Feedback (FB) Documentation for "Unsafe" work practices.

were statistically significant differences between those workers who did not receive documentation scored higher on "F7- Knowledge of Safety Hazards" and "F9 – Awareness of Safety Policies" and also on "F2 – Safety First Attitude."

A final comparison was conducted between those who were rated as "Safe" on item Q61 "documentation of safe work practices" and those who were rated as "receiving documentation for "Unsafe" work practices. This comparison was felt to be somewhat of a confirmation of both ratings and more statistically defensible due to a sample size that was more comparable in size. A one-way analysis of variance was conducted results of which are presented in Table 14.

Table 14. Oneway ANOVA compariosn of Q61 vs Q62 Safe vs Unsafe practices.

ANOVA				
Subscale	**Mean UnSafe (N=87)**	**Mean Not UnSafe (N=213)**	**F(2,904)**	**p<.01**
1. Supervisor – Commitment	5.11	5.58	11.87	0.001
2. Safety First	5.94	6.21	8.21	0.001
3. Peer – Commitment	5.38	5.80	12.26	0.001
4. Sr Management – Commitment	5.25	5.71	13.00	0.001
5. Work Environment	4.68	5.22	12.39	0.001
6. Safety Staff	4.97	5.24	8.26	0.001
7. Knowledge	5.85	6.08	4.19	0.001
8. Rewards	4.25	4.42	8.30	0.001
9. Policies	5.69	6.03	7.96	0.001
10. Safe Employees	5.64	5.88	5.51	0.001

As can be seen in Figure 6 the comparison of Q61 with Q62 reveals that all of the ten factors were significantly different with the Unsafe group scoring lower on all of the factors. Thus, the sub-scales of the Safety Culture measure appear to reflect differences in perceptions of safety culture within the organization.

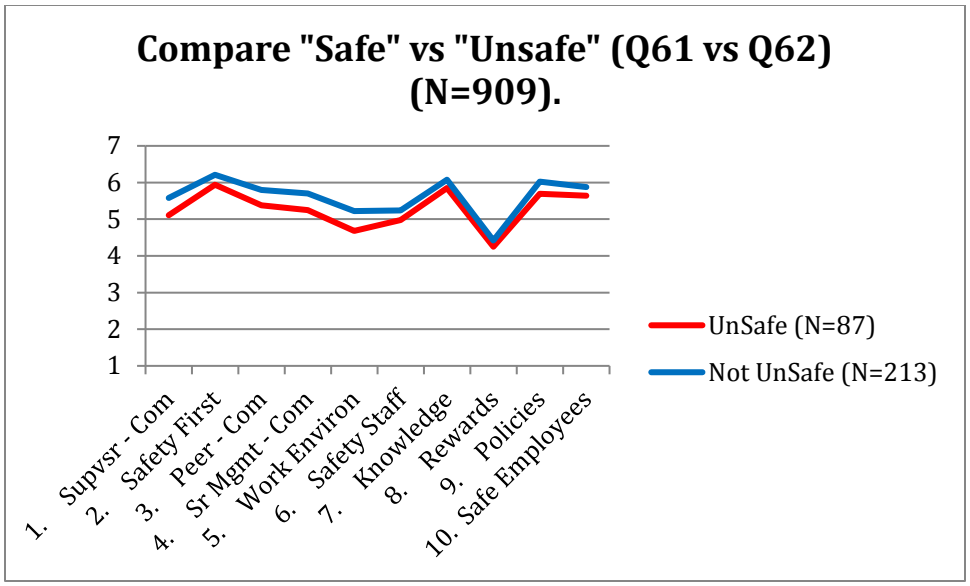

Figure 6. Comparions of "Safe" versus "Unsafe" documentation for work practices.

These data clearly suggest that the measure of safety culture is capable of differentiating between members of an organization who are likely to receive recognition, versus no recognition for safety practices. Thus, there is some correlation between the perception of safety culture and safety behavior within an organization.

Discussion

An attempt to define and measure culture as the sum of an organization's meaning systems, values, and behavioral expectations, was intended to provide a more complete assessment of corporate safety culture. The data did not support the proposed model of safety culture. Contrary to prediction, the data from the empirical analyses point to the superiority of the two factor model, containing only a Behavior and a Values domain. This conclusion fits research suggesting that, at its core, safety culture consists of only behavior and values (Cooper, 2000). If this premise is accepted, culture may be explained as values and their behavioral indicators alone. More clearly, an organization's safety culture might be recognized simply as the values held by members of the organization, and reflected in the member's behavioral choices or perceptions. With this perspective, future investigations of safety culture could focus entirely on values, and how those values are revealed through behavior.

However, additional analyses resulted in a modified empirical model that adequate fit the data and show that the assessment of corporate safety culture from the point of view of a two main factors including values and behaviors was a viable approach. Moreover, utilizing a face validity approach, the items that comprised the model that adequately fit the data were further analyzed and forced to produce a ten factor solution which then resulted in a ten scale instrument.

The ten scale instrument was determined to have adequate psychometric reliability and validity. The scales are stable and internally consistent and measure many of the factors that were previously found in other safety culture and safety climate measures. Thus, the instrument would seem to be useful in other transportation settings.

Further, if corporate culture can be recognized as those values held by its members, and the resulting behavioral decisions, then culture may be most efficiently addressed through the measurement of behavior. If one assumes that behavior is the result of values, it may be considered a strong indicator of the underlying culture.

The measurement of values and behavior is not unique to the CSCS. In fact, nearly every measure of corporate safety culture includes an assessment of values, and behaviors (Denison, 2010; Diaz-Cabrera, Hernandez-Fernaud, & Esla-Diaz, 2007; Safety Performance Solutions, 2010; Thaden & Gibbons, 2008). However, the CSCS is unique because it explicitly and parsimoniously addresses the two constructs. The other evaluated measures assess the domains through the evaluation of disparate organizational characteristics that relate to values and behaviors. To view a list of previously developed measures, please see Table 2.

Recommendations for Practice

The results of this study clearly have implications for practice and the improvement of Safety Culture. As seen in the model in Figure 3 the most important component of safety culture appears to be the commitment of the immediate supervisor which accounts for 40% of the variance. Thus, a model of intervention for the improvement of safety culture would need to address the organizational issues, structures and policies that impact these components depicted in Figure 7. In particular, dealing with and influencing Senior Management commitment as a driver of immediate supervisor commitment would likely be the first step. As most people know, the immediate supervisor will respond to the most pressing demands and expectations placed on him or her by senior management.

Once the Senior Managers have demonstrated their commitment a focus on the first line supervisor can be undertaken. This can take the form of training for first line supervisors on how to show commitment, knowledge of safety practices, problem solving to address safety concerns, and other important matters. Additional training sessions will need to be provided to ensure that first line supervisors are well situated and prepared to address the culture. Bu, most importantly, senior leaders must engage in meaningful activity and behaviors that will reinforce the immediate supervisors role. This is an important component and should not be underestimated in the development of safety culture. Culture evolves from shared experiences and shared belief systems. Typically, examples of how senior leaders act or behave, relative to immediate supervisors and others in the organization. The shared memory of a landmark or bellwether event where the senior leader actually acts to reinforce the stated beliefs of the safety culture is what serves as the precursor to and the eventual reinforcement of the culture. Members of the culture point to the shared moment in time and use it to guide present and future actions.

Another important aspect of improving the safety culture is to ensure that high quality and professional Safety Staff are available to the organization to provide expert guidance, training, and consultation. Safety managers with appropriate background and training provide an invaluable resource, demonstrate a commitment to safety and ensure that state of the art best practices are available to the supervisors and managers. Moreover, they can assist in ensuring the Work Environment is properly prepared, hazards identified, and appropriate safety equipment provided. Improving safety culture will depend upon demonstrating both commitment as well as providing the technical guidance and expertise as well. These professionals must be very well versed in the current rules and regulations relative to the specific industry (e.g. Federal Transit Administration, Federal Railroad Administration, etc.) as well as being up-to-date on the Occupational Safety & Health Administration (OSHA).

Equally, if not more important, is the endorsement and promotion of the overall corporate value of ensuring safety versus productivity. This value, in our terminology, should be reflected in the overall corporate values and mission statements. The promotion of this value in all of the corporate endeavors is the second most important contributor to a strong Safety Culture. It should be clearly visible and obvious to all members of the corporate environment. Again, there must be shared examples and events which demonstrate to all that safety is more important than productivity. Examples of managers at all levels making decisions to halt production or movement in favor of safety will be repeated and discussed throughout the organization many times over. These events send a powerful message and will do much more for the organization than a list of rules or values.

Lastly, to improve safety culture there is a need for continued emphasis on developing a detailed and specific knowledge of safety hazards, and best practices for promoting safety. This includes developing and publishing key corporate policies, rules and requires. It also means that safe work behaviors will be rewarded in the corporation. These rewards can take the form of any sort of recognition. Monetary rewards are discouraged lest they become confused with salary and wages.

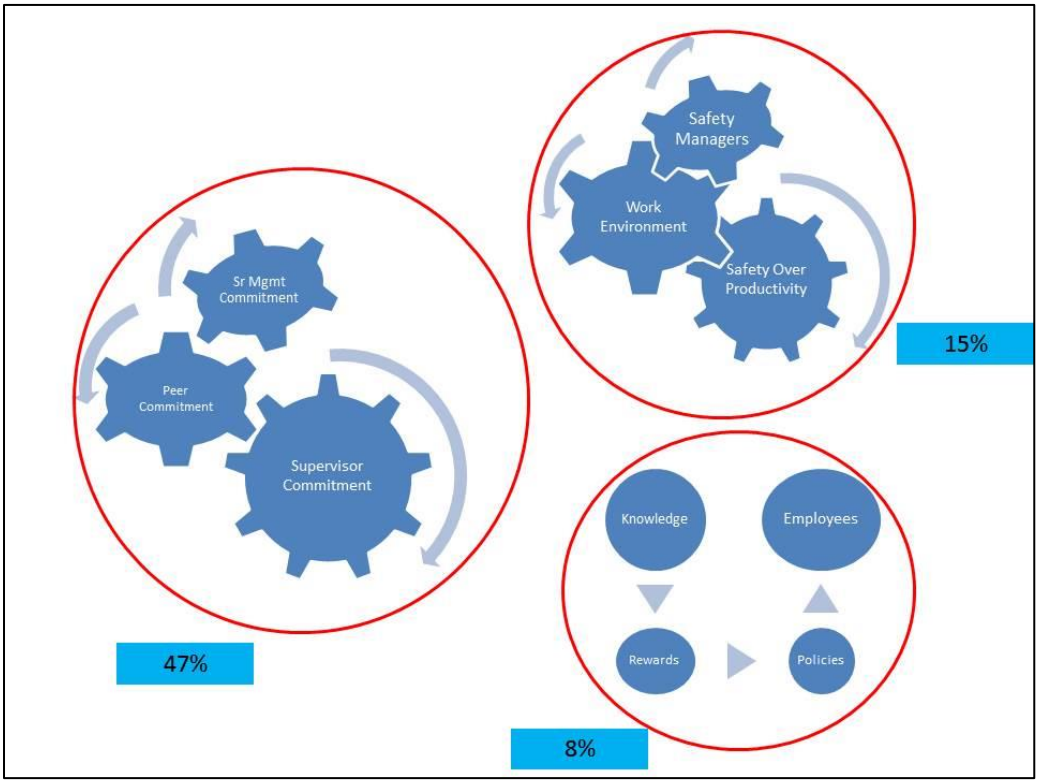

Figure 7. Components of Safety Culture.

Last, but not least, is the realization, based on the se empirical findings that employees are key to the development and maintenance of a strong safety culture. The employees must also be

of high quality, committed to safety and willing to learn and work towards having and maintaining a strong safety culture.

Conclusion

In conclusion, this study has described the development and potential use of a measure of corporate safety culture. The instrument can be used in any corporate environment, but has most technical relevance for transportation focused entity. The instrument has demonstrated psychometric properties of reliability and validity. Moreover, it has been show to measure characteristics of corporate culture which differentiate employees who have received recognition for safe work behaviors or accidents and those who have not.

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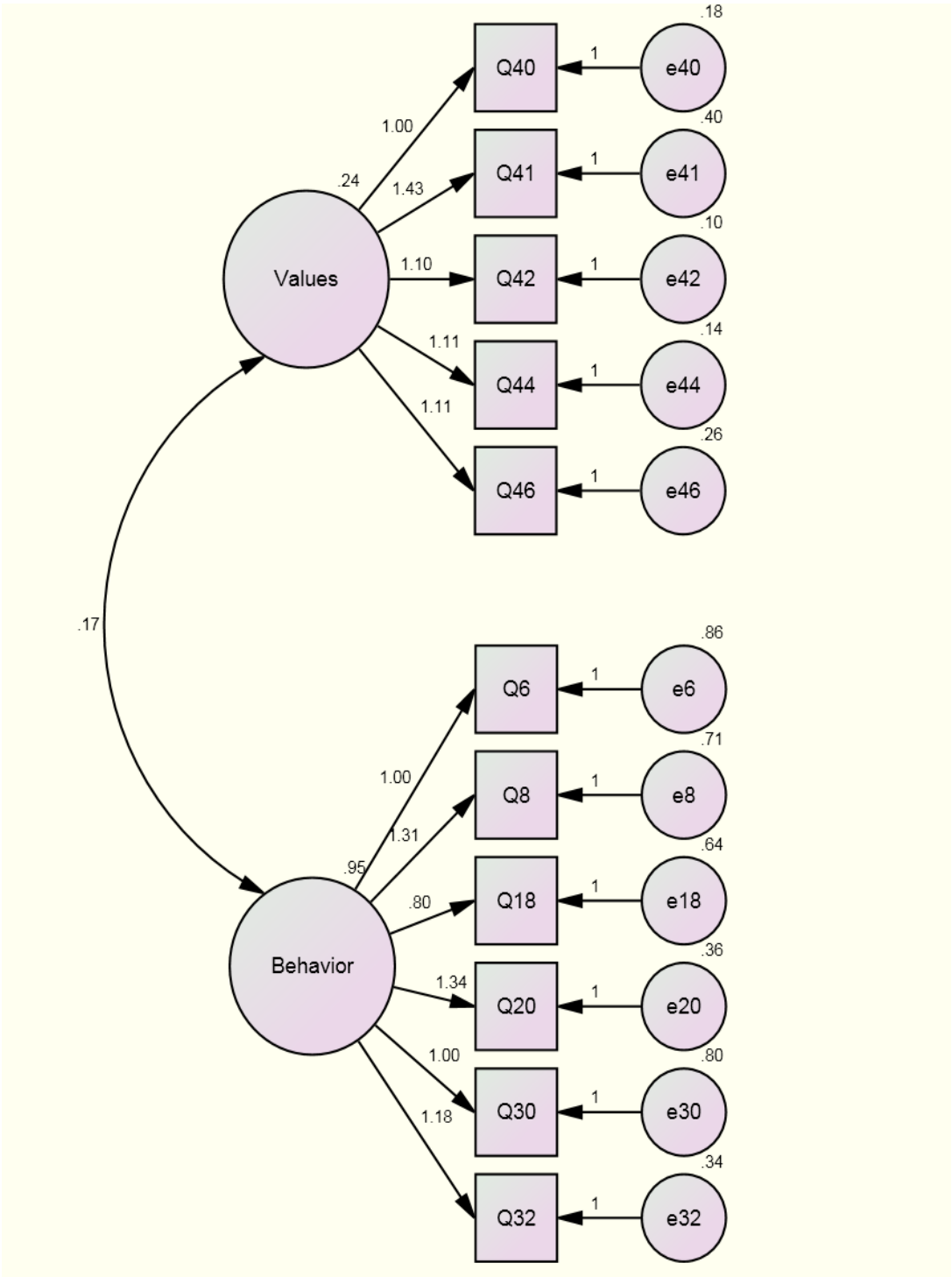

Figure 8. EFA – Empirical Model.

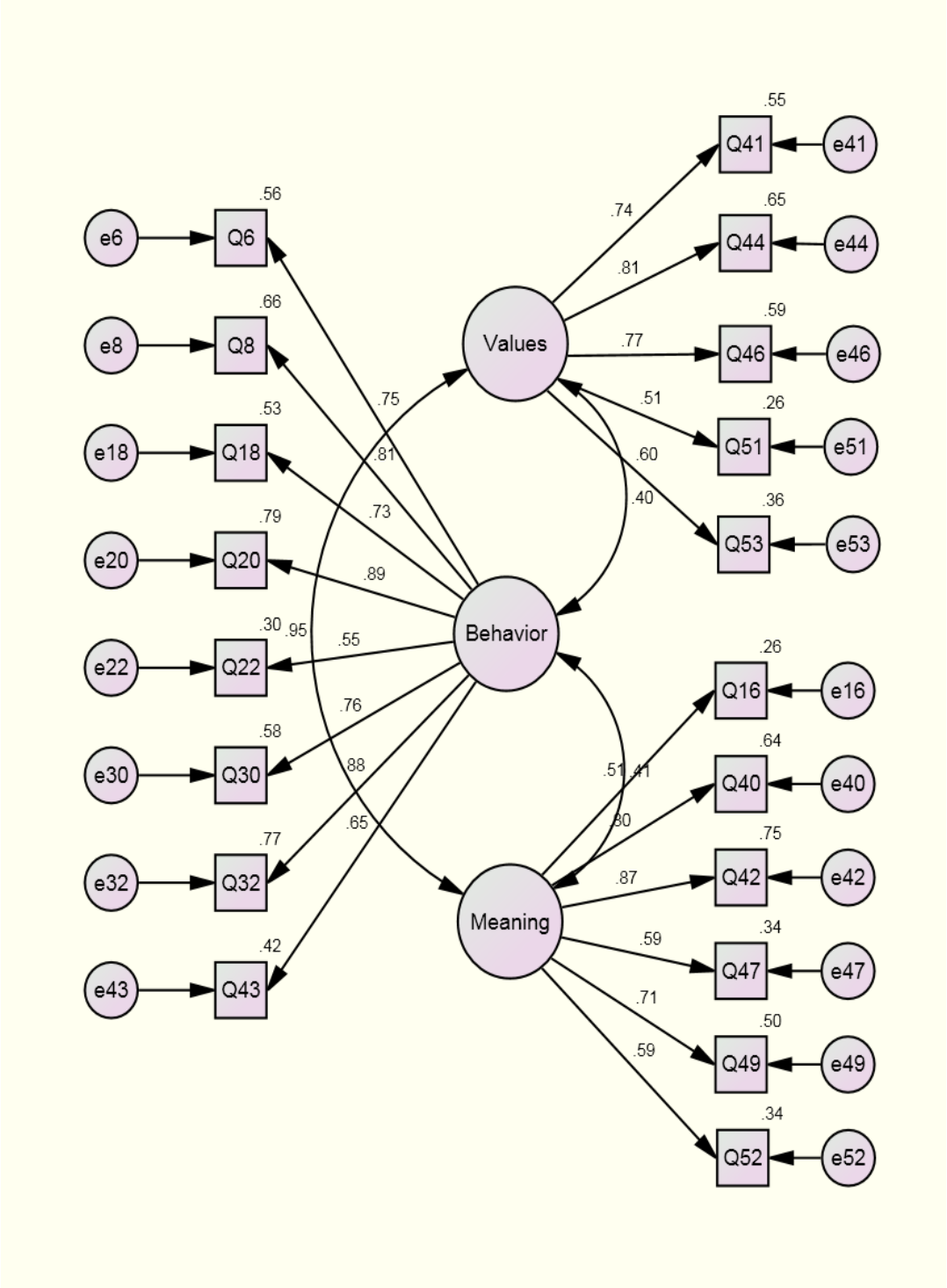

Figure 9. Hypothesized Theoretical Model.

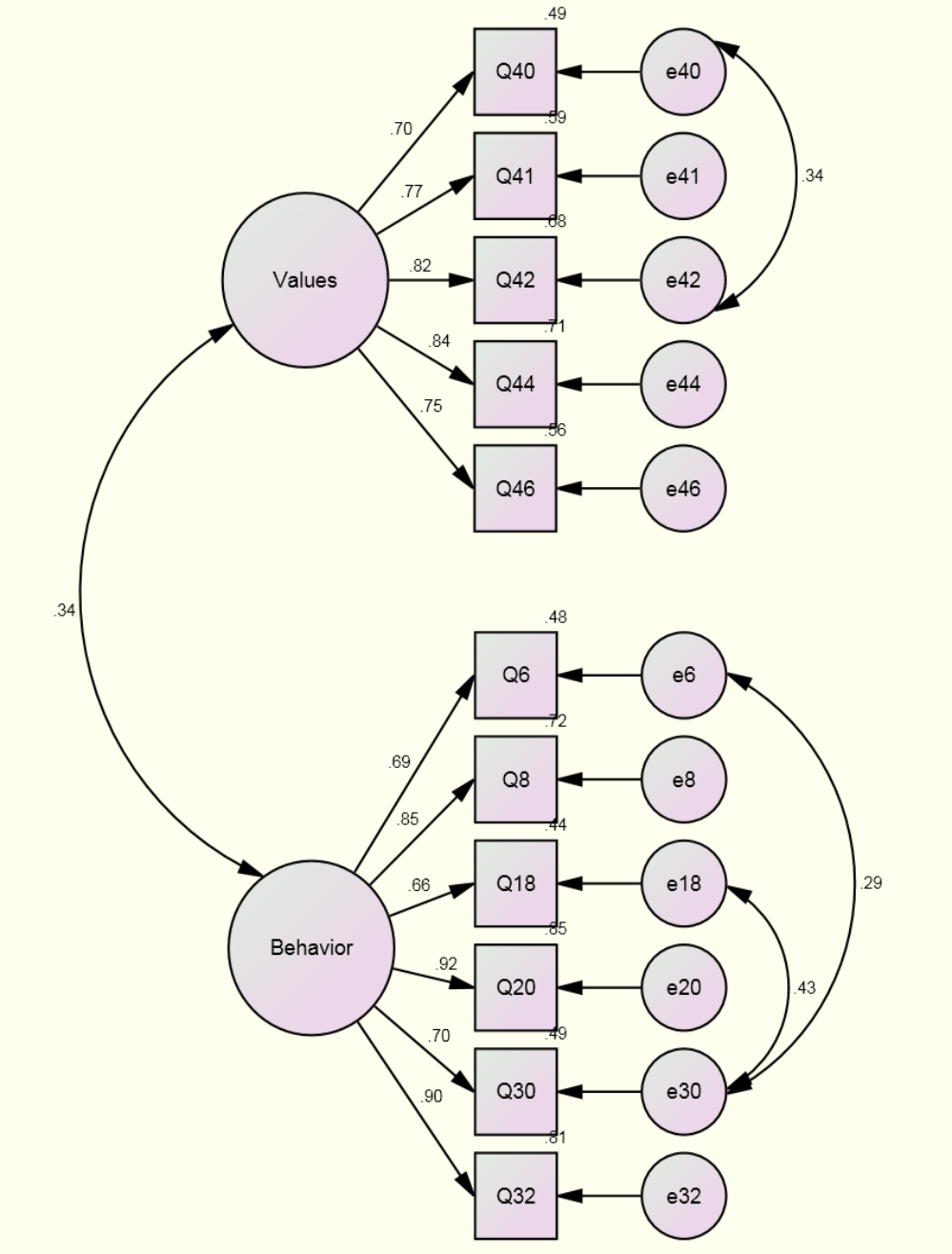

Figure 10. Modified Empirical Model.

Descriptions of Corporate Safety Culture Scales

F1 – Supervisor Commitment

- Assesses perceptions that supervisors are committed to safety as evidenced by the perception that they are encouraged to raise safety concerns and that supervisors are engaged in in and investing time in improving safety

F2 –Safety Over Productivity - Personal Responsibility

- Assesses perceptions that employees believe that safety is not sacrificed for productivity and that the work area has been made as safe as possible. Assesses perceptions that safety is a personal responsibility which can be can be prevented by personal actions.

F3 - Peer Commitment

- Assesses perceptions that co-workers are committed to personal safety contribute to making the workplace safe.

F4 – Senior Management Commitment – SR

- Assesses perceptions that the degree to which employees feel that senior mgmt. and the corporation is committed to employee safety.

F5 – Work Environment

- Assesses perceptions that employees believe that the work environment is safe and free of hazards.

F6 – Safety Managers

- Assesses perceptions regarding the extent to which the Safety professionals are seen as helpful and knowledgeable in providing safety training ing and information to assist with safety.

F7 – Safety Knowledge

- This scale assesses the extent to which employees understand and know how to address risks and hazards in the work environment.

F8 – Safety Rewards – (Inc)

- Assesses perceptions regarding the believe that safe work behaviors are rewarded in the organization through promotions and performance ratings.

F9 – Safety Policies

- Assesses the extent to which employees believe that safety policies have been publicized and that employees are held accountable for their safety actions.

F10 – Safe Employees

- Assesses the extent to which employees feel that safe employees are valued and rewarded by the organization.