AN ABSTRACT OF THE DISSERTATION OF

Mohammed Nooruldeen Azeez for the degree of Doctor of Philosophy in Civil Engineering presented on February 19, 2020.

Title: Risk and Reward Perception and Risk-Taking: Applicability, Relationship, and Implication in Construction Safety.

Abstract approved: ____
John A. Gambatese

While safety improvements have been made in the construction industry, construction still experiences one of the highest numbers of fatalities annually compared to other industries in the United States with over 970 fatalities in 2016 alone. This number of fatalities drives researchers and safety managers to improve safety measures and practices, and to gain a better understanding of why accidents happen. One of the main hurdles facing safety managers across the United States is workers' risk taking.

While risk perception and risk taking have been studied extensively in construction, there is a general lack of research that factors in the impact of risk taking or the biases in risk perception. Most prior studies have considered workers' risk perception of the hazards present in their work as an accurate assessment of safety risk. Biases in risk perception were rarely examined. Furthermore, the factors influencing workers' risk perception were often studied individually. While that approach might provide an explanation of the impact of a certain factor (e.g., the amount and quality of training) on safety risk perception, this approach often fails to examine the bigger picture and does not give a clear transition for the implications of that single factor on overall risk taking. Therefore, a need for a holistic approach directed at a worker's risk taking has risen. This study addresses this knowledge gap by conducting an all-inclusive approach to safety risk perception, the factors influencing it, and how it impacts a worker's decision making.

By conducting a very detailed literature review in construction safety, occupational safety, and decision-making literature, the main factors influencing perception and risk

taking were highlighted. This study utilized multiple forms of data collection, both at the national level and at the state level, to conduct the various analyses that were carried out in the research. Throughout the four manuscripts of this dissertation, new and unstudied biases in workers' risk perception are presented and discussed, occupational rewards are defined, the connections between the perception of risk and reward are established, and the implications of all of those issues on worker's risk taking are investigated and outlined.

The findings of this study indicate that workers' risk perception is influenced by many factors that have not been examined in prior studies. Workers were found to assess the same risk differently depending on the person that might be impacted by that risk. This bias has not previously been studied in construction safety research. Furthermore, this study presents a modern definition of occupational rewards that reflects what workers perceive as being a reward in their job. The study also presents the perceived rewards as indicated by the construction workers in four different categories (financial, developmental, social, and personal) and illustrates the impact of the rewards on attracting new workers to the industry, as well as retaining and motivating the existing workforce. The study also establishes the presence of a connection between the perceptions of risk and reward in construction workers' assessment even though workers failed to directly identify the connection. Finally, the study utilized a mixed methods approach to examine construction workers' risk taking that took into consideration multiple factors highlighted throughout the previous steps. The findings of this study provide the foundation for future research in this field, and can have a great impact on improving safety outcomes in practice if addressed properly in a company's safety plan.

Risk and Reward Perception and Risk-Taking: Applicability, Relationship, and Implication in Construction Safety

by
Mohammed Nooruldeen Azeez

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Mohammed Nooruldeen Azeez, Author

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CONTRIBUTION OF AUTHORS

Dr. John Gambatese was involved with the reviewing of all the dissertation Chapters. Dr. Salvador Hernandez was involved with the reviewing and analysis of Chapters 3 and 4.

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DEDICATION

To the loving memory of my late father, Nooruldeen, and my grandmother, Sabeeha.

1 INTRODUCTION

1.1 Research Motivation

Safety risk is one of many risks that contractors deal with when executing a project, but the only one that has human loss consequences. While great strides have been made to improve safety on construction worksites, the industry still has one of the highest accident and fatality rates when compared to other industries, both in the United States and abroad. While safety risk is one of many risks that contractors address on a project, to the on-site workers, safety risk might be the primary risk that they keep in mind when they go about doing their jobs.

To improve safety in the industry, a clearer and more comprehensive understanding of how accidents occur was needed. Therefore, many accident causation models have been developed over the years, and their level of sophistication has ranged from attributing accidents in construction to worker behavior as in the accident proneness theory, all the way to multi-factor systems in accident causation models (e.g., Swiss Cheese theory, Chain of Events theory) (Hinze 1997).

With the help of the Bureau of Labor Statistics (BLS) and through the Injury, Illnesses, and Fatalities (IIF) program, the industry now has the information needed about the hazards that cause most of jobsite accidents, the most common diseases in each industry, and through the Occupational Health and Safety Administration (OSHA), a baseline level of how to safely execute an activity on each job. While that information is present, accidents still occur at a very high rate in construction. Researchers have traced the reasons for accidents in construction to three main root causes to: 1) worker inability to identify hazards, 2) identifying hazards and disregarding their impacts, and 3) workers' disregard for the safety conditions in their worksites (Abdelhamid and Everett 2000). Other studies examined this issue at a broader aspect, where it has been found that the main root causes of accidents in construction are related to lapses of judgement (mistake/error, absent-minded/forgetful, uncaring/indifferent, ignorance, poor risk management, and high-risk tolerance) whether by the policy and decision makers when assessing risk or by those who are in charge of following that safety system and controlling it (Gambatese et al. 2016).

The reliance on judgement in construction safety is not a coincidence and it is not a sign of a lack of effort on behalf of the construction industry and its constructors. The reliance on personal judgement is due to the industry's dynamic nature (Seo et al. 2015), uniqueness of its projects, variety in site conditions, and extensive human involvement as a result of the large percentage of man-hours needed to construct a project. Simply, the industry lacks a task specific safety metric, and that reason is why the reliance on assessments of safety risk by both professional safety practitioners as well as on the ground by workers is integral to establishing a safe worksite and improving safety for future work.

Workers' personal judgment, informed by safety training, is often used to assess the risk levels in an activity, risk factors in a certain condition, and what is considered as acceptable risk to take. For construction workers, safety risk may be a function of their perception based on knowledge, previous experiences, personal influences, and preconceptions, as is the case for the general public's perception of risks (Slovic 1997). Workers, however, are not supposed to have just a layman's view of risk, especially in their work. They are trained and educated about the risk that their work includes, and they are expected to take measures to mitigate that risk. One of the early studies of workers' perception of risk was conducted by Rundmo (1996) Rundmo (1996) where the researcher studied the relationship between risk perception and risk behavior. Although Rundmo (1996) did not find risk perception to be an indicator of risk behavior, the researcher found that perception and behavior are positively correlated. Furthermore, the researcher found risk behavior to have an impact on near-misses and accidents. The fact that risk perception by itself is not a predictor of risk behavior is not surprising; risk perception is only one part of the story. Situational awareness has been considered to be a prominent model in understanding human behavior for over 20 years (Endsley 2015). Though it has been improved over the years, the situational awareness model divides the decision-making process into three main components: perception, comprehension, and projection, as shown in Figure 1.1. These three steps lead to a decision that a person/worker makes. The situational awareness model also notes that there are many factors that impact the decision-making steps. These factors are either environmental such as system capacity and stress, or individual such as goals, preconceptions, and experience.

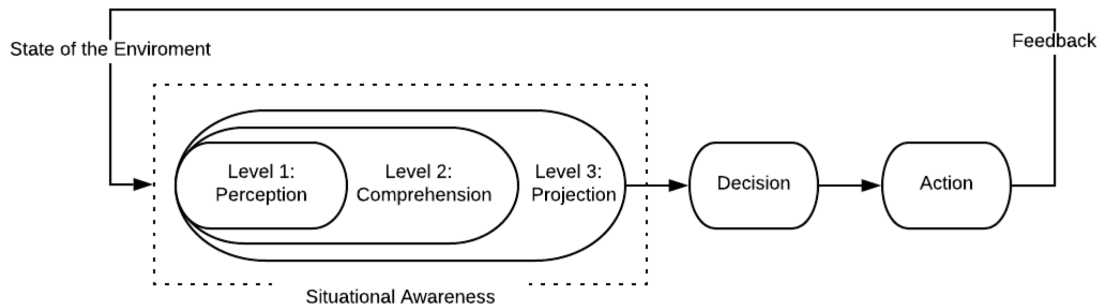

Figure 1.1: Endsley's Situational Model (Endsley 1995)

In construction, early research examining safety risk perception has been viewed within safety culture (Dedobbeleer and Béland 1991). That viewpoint is not surprising given that risk perception is generally influenced by psychological, social, cultural, and political factors (Slovic 1997).

Initial work dedicated to workers' perception of safety risk was conducted in the early 1990's where it was found that construction workers underestimate their work hazards (Helander 1991). Later research by Hallowell (2008) indicated that workers are able to adequately assess the risk in their own work. Similarly, Schafer et al. (2008) argued that management personnel usually overestimate the safety of their worksites, while Hallowell (2010) revealed that management personnel complain about the workers' violations of safety standards, and that construction workers tolerate 5 times the acceptable level of safety.

Risk perception has been frequently studied in the field of construction safety, with three main ways of calculating risk: 1) Frequency * Severity, where the researcher asks workers to assess the frequency of an accident as well as the severity of that accident (Hallowell 2008); 2) Asking workers to identify hazards in a work scenario (Vahed 2015); and 3) Asking workers to self-assess safety risk using a Likert scale (Rodríguez-Garzón et al. 2014). While each method has been used multiple times in different studies, based on a review of published psychology risk perception methods, it was found that the third method involving self-assessment of safety risk is the most commonly used method (Visschers and Meertens 2010).

Examples of risk perception studies include studying the relationship between risk perception and training. Rodríguez-Garzón et al. (2014) found that training impacts the level of risk perception. Moreover, Namian et al. (2016) indicated that the training format also impacts workers' risk perception where interactive and worker-oriented training yields a higher level of safety risk perception. Chen and Jin (2015) conducted a comparison between the risk perception of general contractors' workers and subcontractors' workers. The results of the study indicated a higher level of safety risk perception among the general contractors' workers when compared to subcontractors' workers. In another study, Zou and Zhang (2009) conducted a comparison between construction workers' perception in China and Australia. Finally, Choe and Leite (2016) focused on construction workers' risk perception across different trades where it was found that each occupation has it is own unique characteristics.

That, unsurprisingly, is the reason why early studies focused on proving that construction workers are capable of and reliable in assessing safety risk in their jobs.

1.2 Problem Statement

While, as described above, many studies have focused on safety risk and how to decrease it by addressing workers' risk perception and risk taking in construction, there are still many problems that need to be addressed and investigated. These problems can be grouped into eight main issues as follows:

1. While there have been many studies that focused on the validity of worker's risk perception, there is a general lack of research that addresses the biases and influencing factors that impact construction workers' risk perception.
2. Prior studies have addressed risk perception of construction workers, but ignored the impact of reward perception and how it might impact the assessment of risk, even though evidence of a relationship between risk and reward has been shown in studies conducted in other fields.
3. There is a general lack of understanding of how workers view rewards, where usually rewards and compensations are addressed from management's point of view, rather than the workers' point of view.

4. There are still issues and vulnerabilities related to worker recognition of risk and adequate safety assessment present in the construction industry.
5. Risk taking and risk taking for rewards has not been studied holistically with the perception, comprehension, and projection of risk, especially when other factors are present.
6. Risk taking is still an issue in construction that is impacting safety outcomes negatively, and research and practice still have a long way to effectively reduce unnecessary risk taking in construction.
7. While knowledge of prior events and statistics of accidents and the main hazards in construction are now readily available more than previously, the industry still lacks a task-specific safety metric that worker assessments can be compared against and governed by.
8. While safety regulations and enforcement have evolved and companies have now understood the importance of focusing on safety, the industry still lacks a system that functions as an early warning sign of unsafe workers and workers who tend to take high risks.

This research addresses some of the key issues that have perturbed the construction industry in an effort to improve the safety outcomes of events and to serve as base knowledge for future studies that will further drive improved safety of workers.

1.3 Research Goals and Objectives

The overarching goal of this study is to improve safety outcomes by reducing unnecessary risk taken by construction workers, and to remove personal biases and external influences from the process of safety related decision making. To fill the knowledge gaps identified and answer the research questions posed, this study aims to undertake four main objectives:

1. Explore workers' perception of risk for potential biases that impact their assessment of safety risk, and assess the impact of the biases when present.
2. Establish a clear understanding of reward perception, and workers' needs in the construction industry.

3. Illustrate the relationship between safety risk and occupational rewards as perceived by construction workers.
4. Investigate the influencing factors that impact risk and reward perception.
5. Present the influence of biases and compromises of risk perception on workers' willingness to take safety risk in an in-depth manner.

To fulfill each of the objectives listed above, this dissertation is divided into four different chapters that addresses the objectives. The following section explains the research design in further detail.

1.4 Research Design

To fulfill the five research objectives, the research is divided into four separate manuscripts, Manuscripts 1-4. Manuscripts 1, 2, and 3 are the basis for developing the fifth chapter, Manuscript 4. Additionally, Manuscript 2 is designed to support the work in Manuscript 3. Figure 1.2 presents a graphical representation of the content in each of the manuscripts, and how the manuscripts are connected.

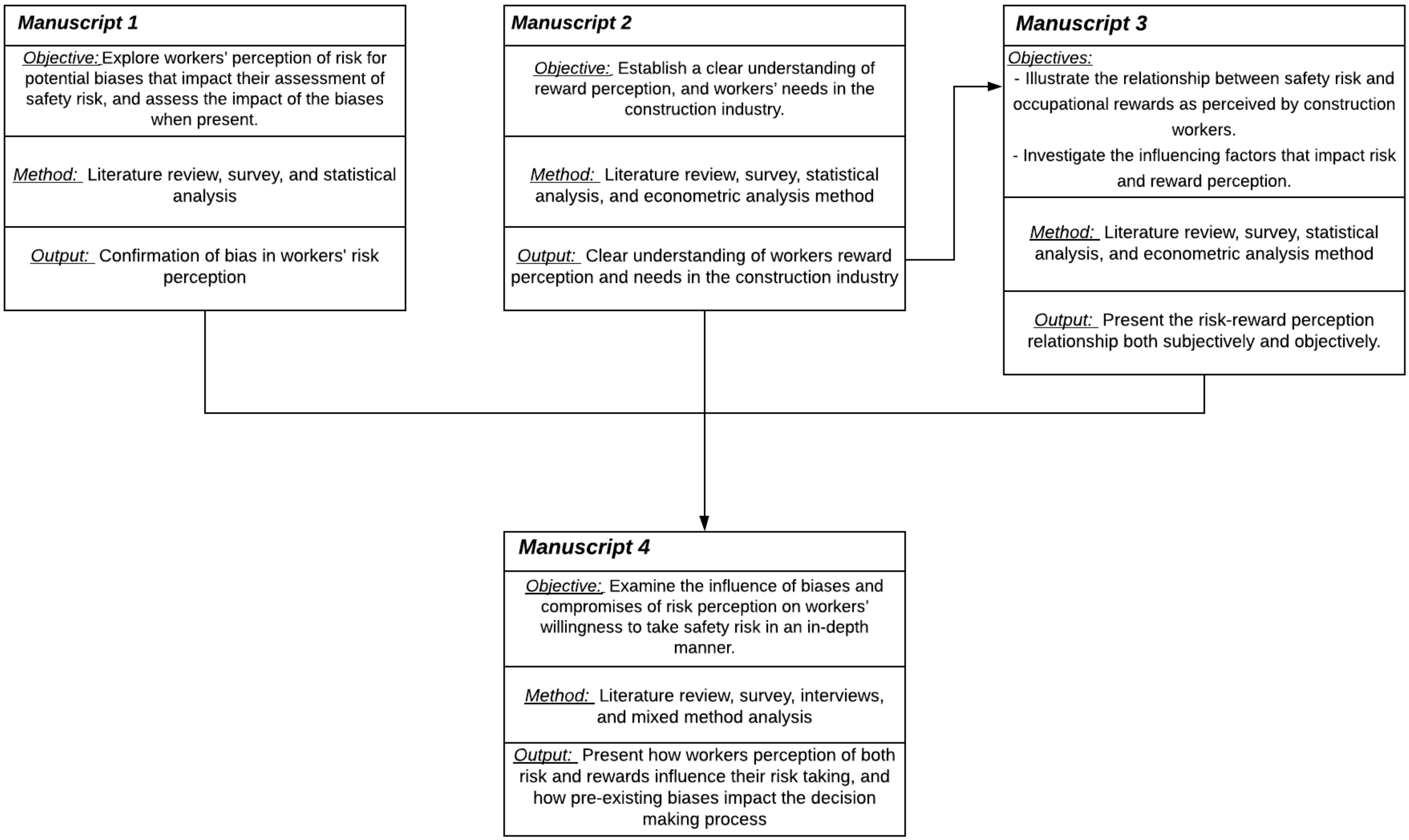

Figure 1.2: Graphical Representation of the Research Design

1.5 Definitions

This section presents a list of the key terms and concepts that occur frequently throughout this dissertation. Some of the terms listed here are commonly used by safety researchers, few of the terms listed have different definitions depending on the context that that they are used for. A full understanding of these concepts and key terms is essential to fully understand the structure, methodology, and the results of this dissertation.

1. Safety risk unit is calculated by multiplying the frequency of an injury incident occurring due to a hazard by the severity of the injury incident (Hallowell and Gambatese, 2009).
2. Risk perception is the individual assessment of the hazards a person faces day-to-day" (Sjöberg, 2000)
3. Occupational reward can be anything of value (tangible or intangible) that an employer or an organization delivers to its employees whether intentionally or unintentionally in contemplation of the employee's work contributions (Henderson, 2003, Shields et al., 2016), "and to which employees as individuals attach a positive value as a satisfier of certain self-defined needs."(Shields et al., 2016).
4. Reward perception is the worker's valuation of the total returns received from working in their job whether the returns are provided by the employer or not.
5. Risk-reward relationship is the worker's perception of the relationship between risk and reward in their daily work. The correlation between risk and reward is perceived to be either positive, negative, or absent.

MANUSCRIPT 1

USING THE RISK TARGET CONCEPT TO INVESTIGATE CONSTRUCTION WORKERS' POTENTIAL BIASES IN ASSIGNING/ASSUMING SAFETY RISK

Mohammed Azeez, and John Gambatese

American Society of Civil Engineers (ASCE), *Construction Research Congress (CRC) 2018*, pp. 324-333.

2 USING THE RISK TARGET CONCEPT TO INVESTIGATE CONSTRUCTION WORKERS' POTENTIAL BIASES IN ASSIGNING/ASSUMING SAFETY RISK

The contents of this chapter are an extended version of work published in the proceedings of the 2018 American Society of Civil Engineers (ASCE) *Construction Research Congress* (CRC), presented at the conference in New Orleans, LA (April, 2018)[1].

2.1 Summary

The construction industry must plan, manage, and mitigate the safety risk that is passed down to the contractor from the owner and/or designer. Such risk is often referred to as residual risk. After the project managers and safety managers identify the safety hazards, assess their impact, and design a safety plan that addresses the hazards, the on-site personnel (foremen, crew leaders, laborers, etc.) will eventually face the risk and execute the project accordingly. This process, however does address the construction worker's assessment of safety risk for their fellow workers. Will the process of assigning tasks and/or executing tasks lead to another type or amount of residual risk that is being assumed or passed on through the chain of command? Previous research has compared the safety risk perception of construction workers and safety experts. However, an unanswered question is, how do construction personnel perceive the safety risk associated with the work at hand for workers other than themselves who may have more or less training and experience? To investigate this question, the researcher conducted a survey of more than 200 construction workers from different states. The analysis of the survey responses shows that construction workers gave different values of safety risk associated with the same task when they were asked to assess the level of risk to themselves, to their fellow workers with less training and experience, and to those who have more training and experience. Furthermore, the primary theory that comparative risk is associated with the perceived control was found to be unsuitable for construction.

[1] Azeez, M. and Gambatese, J. (2018). "Using the Risk Target Concept to Investigate Construction Workers' Potential Biases in Assigning/Assuming Safety Risk," *Construction Research Congress 2018*, ASCE, pp. 324-333.

2.2 Introduction

Lack of construction knowledge, lack of safety training and liability concerns lead to designers' recusal from efforts to address construction workers safety (Karakhan and Gambatese 2017), leaving construction companies responsible for the residual risk created by designers. With their employees' health and safety in mind, as well as the direct and indirect cost of accidents, construction firms have been improving their safety practices by aiming for higher standards than those set by OSHA (Hinze, Hallowell et al. 2013). In some cases, contractors are also implementing new technologies, like Building Information Modeling (BIM), that may help improve their safety performance. In addition, contractors are working toward lowering their recordable incident rate (RIR) and Experience Modification Rating (EMR) in order to gain the ability to compete at a lower bid price (Hinze 1997). Despite the extra efforts, accidents still occur and the industry remains one of the most dangerous in the United States (BLS, 2015), claiming more than 900 fatal work injuries annually.

Many accident causation theories have been formed over the past years, mostly which attribute accidents to either human failure or system failure. In construction, Abdelhamid and Everett (2000) identified three root causes of accidents: (1) worker's failure to identify hazards, (2) proceeding with hazardous activity after diagnosing its riskiness, and (3) acting unsafely despite the worksite conditions. As for system failures, the case can be made that the process failure is partially a human failure since accidents may occur if, for example, the original assessment of the work conditions outlined within the safety plan was flawed (Gambatese et al. 2016). Injury incidents may also occur because risk assessment is still a subjective measure (Tolbert 2005). The subjectivity attributed to the personal opinions and decisions of what is acceptable risk and what is high risk, may also be factors that lead to injury incidents (Visschers and Meertens 2010).

2.3 Risk Perception

Risk perception is one of the main components used in the assessment of the risk associated with a process or condition. Sjöberg (2000) defined risk perception as "a phenomenon in search of an explanation". In simple terms, risk perception can be defined as the personal evaluation of the daily encountered hazards. The justifications for using worker's risk perception are: a) worker's risk perception can be considered as an actual measure of the safety risk that they are exposed to (Weyman and Clarke 2003); and b) risk perception is influenced by the same factors that influence the worker's safety in the real world (Visschers and Meertens 2010).

A worker's perception of safety risk has been used as a measure of safety risk in many studies. Rodríguez-Garzón et al. (2015) listed more than five different studies in various fields that focus on worker's risk perception. In construction, Hallowell (2008) found that construction workers have a practical capability in identifying and evaluating occupational safety risk in their work. Rodríguez-Garzón et al. (2015) explored the effect of various work and sociodemographic variables on worker's risk perception. Other studies measured the risk perception between: subcontractor's and contractor's workers; Latinos and other workers; and visual training and other types of training. However, the question remains: is risk perception without bias?

2.4 Risk Target

The importance of studying risk target lies in its unknown nature (Sjöberg 2000), where people assess risk differently for themselves compared to their families, countrymen, or other people in general (Sjöberg 2000, Hermand et al. 2003). In a survey of over a thousand respondents from the general population of Sweden, Sjöberg (2000) asked respondents to rate 15 types of hazards using a scale from 0 to 6 (0 being no risk to 6 being extremely large risk) for themselves, their families, and their fellow citizens. For all of the hazards examined, risk assessed for self was drastically different from that assessed for family or people in general. Figure 2.1 shows the results of the study for 27 types of hazards for different targets, where independent groups rated each target. "Risk denial" is what Sjöberg (2000) called the result of subtracting the difference in risk assessed for people in general from that assessed for self, which the researcher associated with unrealistic optimistic bias.

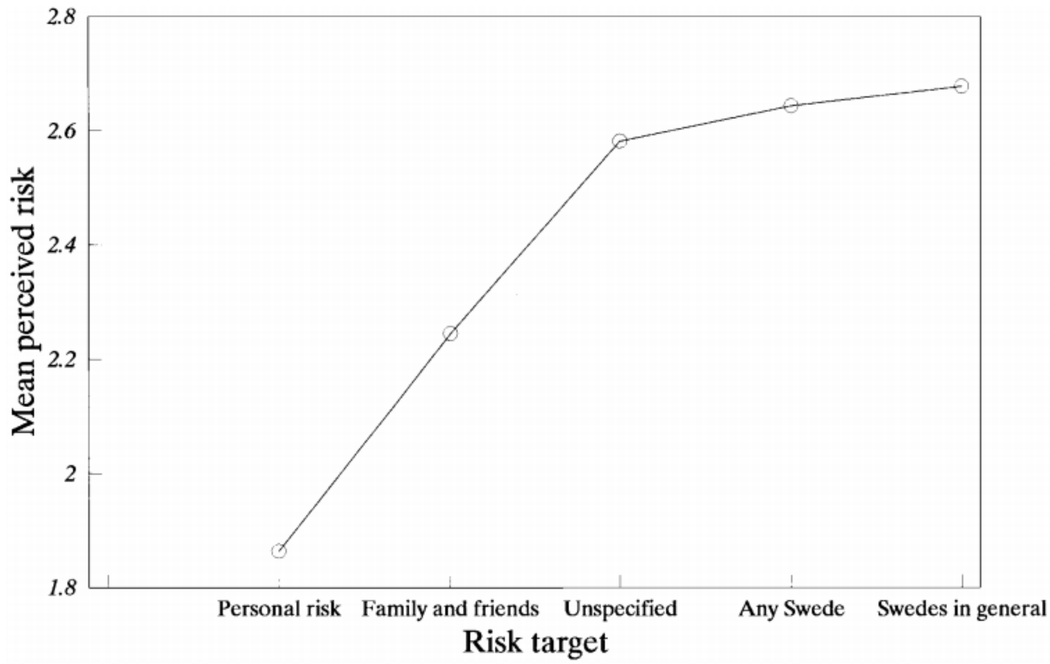

Figure 2.1: Mean perceived risk for different targets (Sjöberg 2000)

As for the cause, the researcher pointed to the perception of control that the respondent felt they had over that risk. Figure 2.2 shows the resulting relationship between the perceived control and risk denial. As shown in the figure, the relationship is positively correlated, i.e., as perceived control increases, the amount of risk denial also increases.

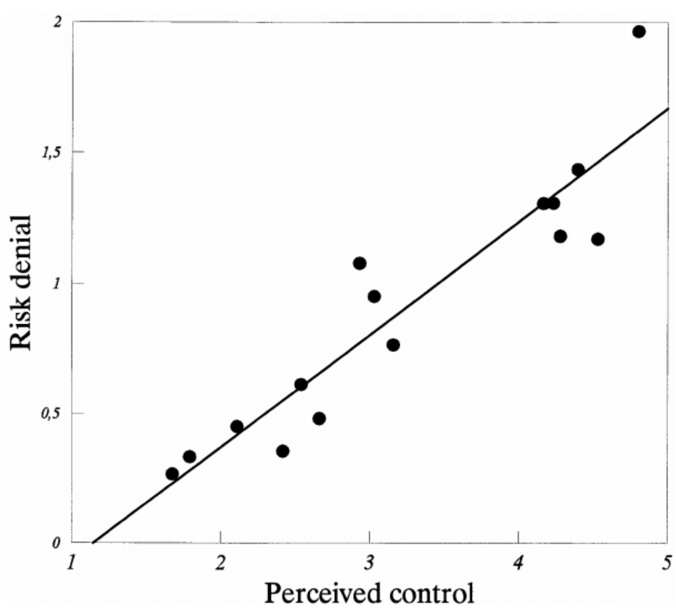

Figure 2.2: Plot of mean rating of various hazards for risk denial against perceived control (Sjöberg 2000)

Given that personal perception of risk has a significant impact in construction coupled with the fact that workers are often asked by their supervisors, crew leaders, and fellow workers to perform tasks, the need to investigate biases in risk perception arises. This manuscript presents research that aims to investigate the potential bias in safety risk assessment that can influence a construction worker's judgement to underestimate or overestimate the risk that they or their fellow workers encounter in their daily tasks.

2.5 Research Methodology

Of interest to this research are three aspects that relate to the concept of risk target. The first point of interest is the assessment of safety risk for the workers themselves. Secondly, the related aspect of interest is the assessment of safety risk for others (family, and people in general). Since construction sites are usually restricted to people who work there, the assessment of safety risk for others was, therefore, directed to workers with more or less experience and/or safety training. The final point of interest is the aspect of control of the work. In prior studies on this topic, the researcher asked respondents about their perceived control over a certain hazard. In construction, workers might have three types of control: control over construction safety, control over how to execute the work at hand, and job title control where supervisors and crew leaders have supervision control over other workers.

2.6 Survey Design and Data Collection

A survey was designed to assess construction worker safety risk perception, risk perception biases, and hazard identification. Survey questions relevant to this study asked workers to:

1- Assess the level of safety risk in their work using a five-point scale (very low, moderately low, average, moderately high, and very high).

2- Assess their work safety risk for a worker with more training or experience, using a five-point scale (much safer, safer, same level of risk, riskier, and much riskier).

3- Assess their work safety risk for a worker with less training or experience, based on a five-point scale (much safer, safer, same level of risk, riskier, and much riskier)

4- Assess the extent that the respondent can intervene to control (prevent or mitigate) the damage/injury that the safety hazards in their work might cause. This question was adopted from the nine attributes of safety risk perception presented by Rodríguez-Garzón et al. (2015). The assessment scale ranged from 1 to 7 (1 = extremely controllable, 4 = moderate control, and 7 = extremely uncontrollable).

5- Indicate whether they follow a procedure at work or execute the work as they see fit.

6- Indicate their job title (helper, tradesman, journeyman, crew leader, foreman, or superintendent).

The Qualtrics platform was used to format and disseminate the survey. Multiple quality checks (attention check, speed check, and "straight-liner" check) were implemented in the survey. Participation was voluntary and all respondents were over the age of 18. The targeted pool was construction workers in the United States. For this study, 208 completed survey responses from workers in 37 different states were collected and used to create the sample.

2.7 Statistical Analysis

The goals of this research, as mentioned previously, are to investigate the existence of comparative bias and to check for association between biases in risk perception and control. Given that workers were not assigned into groups at random (i.e., there was no "control and treatment" group separation), causal inference cannot be made (Ramsey and Schafer 2012). Therefore, association inferences were examined using odds ratio analysis. Odds ratio is a non-parametric method that measures the independence between two groups, using the Chi-square test to establish a 5% significance level. The Chi-square test has been used previously to analyze survey data in construction safety (e.g., Tymvios and Gambatese 2015, Karakhan and Gambatese 2017). Given that the questions asked in the survey were in a scale format, and the Chi-square test requires 2x2 tables, data truncation was conducted to compile explanatory variables as well as the response variables into the required form.

The explanatory variable selected was the type of control in question. Since there are three types of controls to be examined (control over construction safety, control over how to execute the work at hand, and job title control), three different explanatory variables were tested. The truncation of the job title control was made by grouping all of the workers at the crew leader or higher level together as being the in-control group, and by grouping all workers at the tradesman or lower level together into the not-in-control group. Truncation of the safety risk perceived control was made by grouping all of the workers who assessed safety risk being controllable or higher together, while respondents who assessed safety risk being uncontrollable to extremely uncontrollable were grouped together.

The response variables in the analysis were the assessment of risk for workers with more experience and the assessment of risk for workers with less experience. Each explanatory response data was truncated based on the respondent assessment of safety risk for the group in question being the same as it is for themselves, or being different (regardless of the direction of the assessment). The process of grouping answers has been successfully implemented in prior construction safety analyses (e.g., Tymvios and Gambatese 2015, Karakhan and Gambatese 2017). Figure 2.3 shows the calculation procedure for the odds ratio and the Chi-square test of independence.

Regarding the correlation coefficient, tetrachoric correlation was used since this type of correlation is appropriate when both variables are binary. Tetrachoric correlation, calculated as shown in Equation 2.1, considers variables as being continuous-nominal variables (Hinkle et al. 2003).

$$r_{tet} = \cos \frac{180^\circ}{1+\sqrt{\frac{n_{12}n_{21}}{n_{11}n_{22}}}} \qquad (2.1)$$

In Equation 2.1, r_{tet} is the tetrachoric correlation coefficient, and $n_{(i,j)}$ represents the observed cell count in the corresponding position for the data in the 2x2 table.

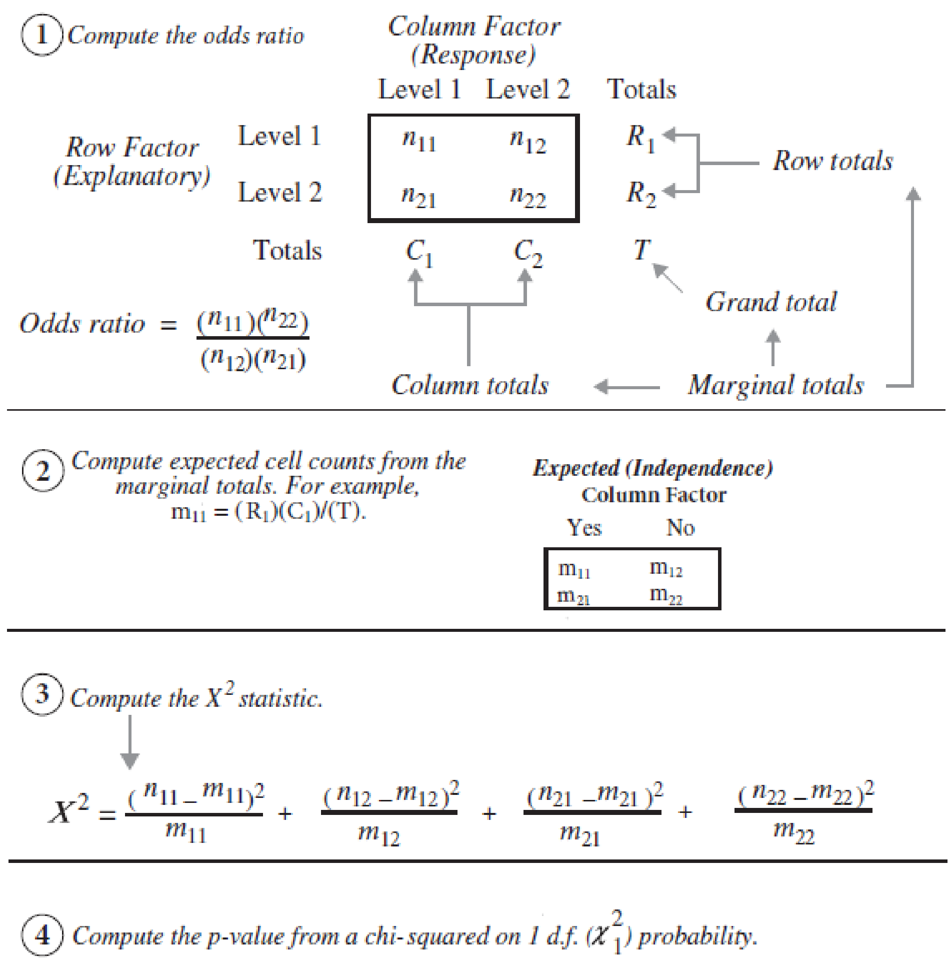

Figure 2.3: Calculations of odds ratio and Chi-squared test of independence. (Adapted from Ramsey and Schafer 2012).

2.8 Analysis and Results

The assessment of the safety risk for the workers themselves was close to being normally distributed, as shown in Figure 2.4. More than 40% of the respondents assessed their work as being average in safety risk, and about 10% assessed their work as being very risky.

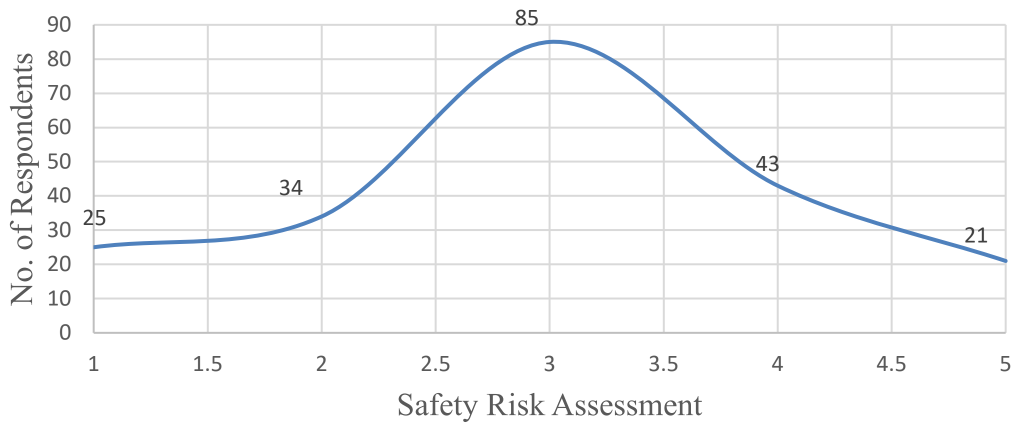

Figure 2.4: Respondent assessment of their work safety risk (n = 208): (1) very safe, (2) safe, (3) average safety risk, (4) risky, and (5) very risky

The initial analysis revealed that comparable bias exists in a construction worker's risk perception. Only 34 out of 208 respondents assessed the safety risk level as being the same for them as for both workers with more experience and/or training, and for workers with less experience and/or training. As for each target assessment, respondents assessed the safety risk for workers with more experience and/or training to be mostly safer than the level of risk associated with themselves. In comparison, respondents deemed their work to be riskier for those with less experience and/or training. Figure 2.5 shows the results for the respondents' assessments for each risk level.

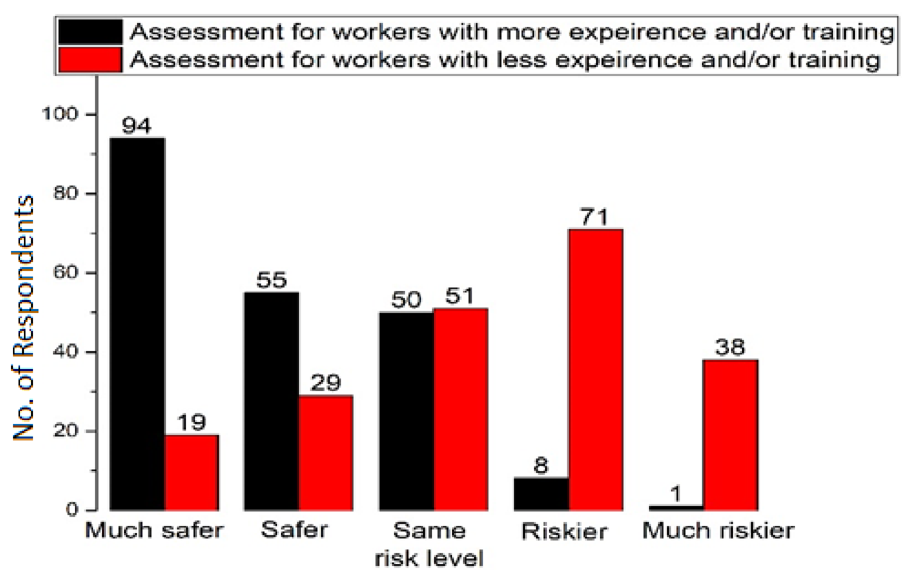

Figure 2.5: Respondent assessments of their work safety risk for others (n = 208)

The worker's personal safety risk was used as a reference for the calculations of safety risk for other workers. For example, if a worker assessed their safety risk as being 3 (average) on a scale of 1 to 5, and assessed the risk for their fellow worker being safer, 1 point of risk value was deducted. If the worker assessed the risk for their fellow worker as riskier, 1 point of risk is added. Figure 2.6 contains the average rating of safety risk per targeted group. On average, workers with more experience were assessed to have the lowest safety risk level and workers with less experience were assessed to have the highest safety risk level, while maintaining personal safety risk in between these two assessments.

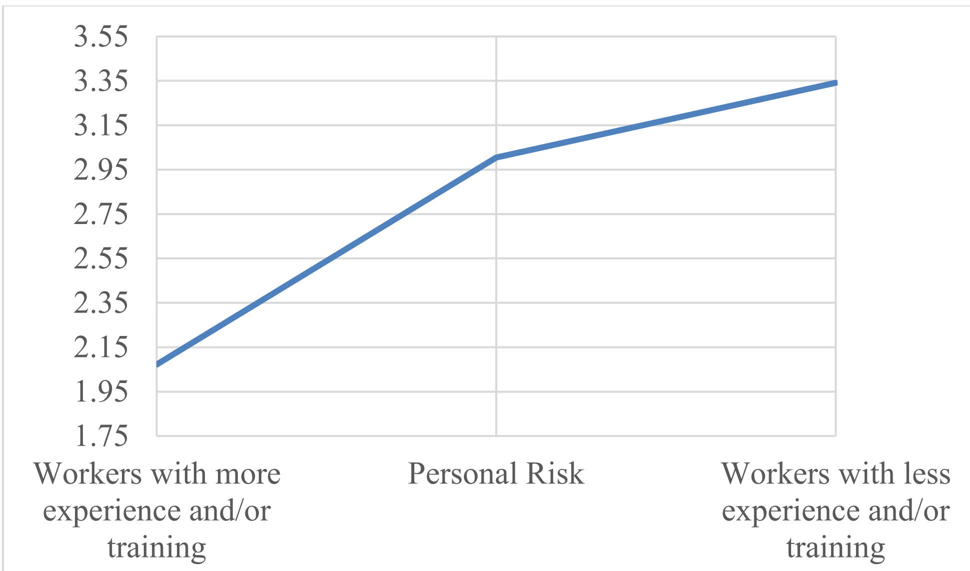

Figure 2.6: Average rating of safety risk for different target

The last step of the analysis involved using the statistical methods proposed for this data (described above) to evaluate the correlation between the chosen variables. All of the assessments were placed into 2x2 tables to be used in the analysis. For extra thoroughness, the assessments of the two response variables were combined to create an overarching response variable for the comparative bias variable. For this added variable, respondents who assessed risk for all other workers to be the same value as for themselves were combined and listed against each type of control. Table 2.1 contains the final count in each group.

Table 2.1: Respondent assessments (number of respondents) grouped by category

Control Type		Assessment for workers with more experience		Assessment for workers with less experience		Assessment for all workers	
		Same risk level	Different risk level	Same risk level	Different risk level	Same risk level	Different risk level
Procedural	Follow a procedure	27	98	27	98	18	107
	Work as see fit	23	60	24	59	16	67
Job title	In control	30	97	32	95	24	103
	Not in control	20	61	19	62	10	71
Safety risk	Controllable	44	139	48	135	31	152
	Not controllable	6	19	3	22	3	22

Although the initial analysis indicated the existence of bias in construction, the non-parametric analysis of the data revealed that control was not associated with that bias. The results of the analysis per control type are provided below.

2.8.1 Procedural Control as an Explanatory Variable

For workers who follow a procedure at work, and for those who execute as they see fit, the results show that the odds are almost equal, with a low p-value. The odds ratio of assessing safety risk for workers with more experience and/or training being the same or different was 0.72, with a p-value of 0.313. As for the assessment of workers with less experience and/or training being the same or different, the odds ratio was 0.67 (p-value of 0.23). As for the mentioned explanatory variables' tetrachoric correlation, the correlation coefficients for those workers with more and less experience and/or training with the procedural control were 0.129 and 0.152, respectively. A similar result was obtained from the combined table, where an odds ratio of 0.70 was obtained, and the p-value for the Chi-squared test was 0.35.

2.8.2 Job Title Control as an Explanatory Variable

Both the in-control group and not-in-control group had almost equal odds of assessing risk for workers with more experience being the same as their own or different (odds ratio = 0.94, Chi-square p-value = 0.86). Similar results were obtained for the assessment of the less experienced workers (odds ratio = 1.09, Chi-square p-value = 0.77). The correlation coefficients based on the tetrachoric correlation for the groups were 0.023 and 0.037 for workers with more and less training and/or experience, respectively. The combined assessment test revealed a similar result where the odds ratio was 1.65, and the Chi-square p-value was 0.212.

2.8.3 Safety Risk Control as an Explanatory Variable

The workers who assessed the safety risk as being controllable and those who assessed it as being uncontrollable had almost equal odds when assessing the risk for their peers to be the same or different. When assessing workers with more experience, the odds ratio was 1.0, and the Chi-square p-value was 0.99. As for the assessment of the less experienced workers, the odds ratio was 2.6, with the Chi-square p-value equal to 0.120. The groups' tetrachoric correlation values were 0.0009 and 0.361 for workers with more and less training and/or experience, respectively. For the combined assessment, the odds ratio was 1.64, and the Chi-square p-value was 0.53.

2.9 Discussion

From the results gathered, even though the odds were not always close to 1, there was no statistical evidence that control of any sort is associated with the assessment of safety risk for others. The overwhelming evidence shows that the two variables are independent. The Chi-square test values for procedural control and lower management control showed no statistical evidence of association between the two variables. As for safety risk control, only the assessment of risk for workers with less experience and/or training showed evidence of association between the two variables at the 85% confidence level, yet the evidence was found to be weak.

Similar outcomes were found while conducting the correlation analyses, where the assessment of safety risk for workers with less experience and the level of safety control had a correlation coefficient of 0.36. Other than that, the overall correlation was weak between any type of control and the assessment of risk.

By examining the combined assessment tables, the researcher did not find any statistical evidence of association between the two variables. Thus, it is safe to say that in construction, the risk target bias assessed is not associated or correlated with control when assessed for workers with more experience and/or training as well when assessed for those workers with less experience and/or training.

It is worth mentioning that the level of safety that can be controlled by the worker would be the least effective in the order of the hierarchy of controls (administration control and personal protective equipment). Safety control is most effective at the elimination level, followed by the substitution level and engineering control level (NIOSH 2014), therefore, workers have little if any control over safety risk and usually operate within the designed safety plan.

2.10 Conclusions and Recommendations

For safety managers, comparative bias needs to be addressed. Workers should be trained that safety risk, as a unit risk, is the multiplication of frequency and severity of the accident. Risk should be addressed as being equal for all workers regardless of their personal training and/or experience.

As for a cause(s) of the risk target bias, this research is limited to the original assumptions of the theory; therefore, the cause(s) of the bias was not explored and needs to be addressed in future research. Based on the outcome of the research presented, the researcher expects emotional factors such as worries, cognitive aspects such as previous experiences, or personal aspects such as trust, might be of importance to the causation of this bias (Morasso et al. 2000, Das and Teng 2001). Finally, a worker's perception of safety risk control should also be investigated for optimistic bias for the aforementioned reason.

MANUSCRIPT 2

WHAT DO CONSTRUCTION WORKERS REALLY WANT? A STUDY IN CONSTRUCTION OCCUPATIONAL REWARDS' REPRESENTATION, PERCEPTION, AND IMPORTANCE

Mohammed Azeez, John Gambatese, and Salvador Hernandez

Journal of Construction Engineering and Management

American Society of Civil Engineers (ASCE)

145(7), 04019040.

3 WHAT DO CONSTRUCTION WORKERS REALLY WANT? A STUDY IN CONSTRUCTION OCCUPATIONAL REWARDS' REPRESENTATION, PERCEPTION, AND IMPORTANCE

The contents of this chapter are an extended version of work published in the American Society of Civil Engineers (ASCE), *Journal of Construction Engineering and Management*, published online (May, 2019)[2].

3.1 Summary

The construction industry in the United States employs thousands of workers in various jobs and accounts for over 645 billion of the United States' Gross Domestic Product in 2017. With the reported labor shortage, it has never been more important for the construction industry to have a sufficient and motivated workforce. To do so, the industry needs to understand the current status of occupational rewards and how are they being perceived by construction workers. This research aims to address this issue by investigating the workers' perspectives of occupational rewards in the construction industry. The study utilizes responses from 176 construction workers across different states, different job responsibilities, and different work conditions.

This research contributes to the construction industry by: a) presenting the types and frequency of rewards offered in the construction industry with emphasis on how the rewards impact reward satisfaction; b) investigating socio-demographic and occupational factors that impact rewards perception using econometric modeling; and c) studying the stated and the uncovered rewards importance. Findings of this research indicate that workers in general, are satisfied with the rewards that they are receiving, where job responsibility was found to be the reward that is received the most. However, their needs showed a commonality of financial urging. Furthermore, reward perception was found to be influenced by both occupational factors as well as socio-demographic factors. By understanding what workers have, how they perceive what they possess, and what's important to them, the industry will have a better chance of attracting and retaining the right workers for the needed job and motivating the available workforce

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[2] Azeez, M., Gambatese, J., and Hernandez, S. (2019). "What Do Construction Workers Really Want? A Study about Representation, Importance, and Perception of US Construction Occupational Rewards." *Journal of Construction Engineering and Management*, ASCE, 145(7), 04019040.

for the allocated tasks. This study would help both the industry, as well as academia, in understanding and better addressing worker rewards and needs.

Apart from the apparent worker's personal gain in a designed rewarding system that provides workers with what they value in exchange for their efforts, there are important stimuli for the construction industry as a whole to study and improve the personnel reward system in the industry. Among these motivations are: 1) attracting workers with the qualifications that match the industry needs at the suitable time; 2) retaining qualified workers; and 3) motivating workers to contribute and perform at their highest capabilities (Henderson, 2003, Kwon and Hein, 2013, Shields et al., 2016).

The construction industry has long expressed concern about a shortage of skilled labor through researchers (Burleson et al., 1998) and practitioners alike (AGC, 2017, NAHB, 2017). In 2017, the Associated General Contractors of America (AGC) surveyed over sixteen hundred construction companies about the current status of the industry. Seventy percent of the AGC survey respondents reported that they are "having a hard time filling some hourly craft position". In the same study, over 35% of respondents reported that they are "having a hard time filling some salaried position" (AGC, 2017). Similar answers were obtained from the National Association of Home Builders (NAHB) survey, where the shortages of specific trades ranged from 43% for building maintenance managers to 77% for framing crews (NAHB, 2017).

As for retaining workers, the AGC report also indicates that 20% of the respondents lost hourly craft professionals (such as carpenters, plumbers, laborers, etc.) and 14% of the respondents lost salary craft professionals to other industries (AGC, 2017). The surveyed companies also expected that the labor shortage, as wells as the competition for skill labor, will increase in the future (AGC, 2017). It is of vital importance to mention that the shortage of labor combined with the expected surge of construction work demand to rebuild after 2017's two major natural disasters (hurricanes Harvey and Irma) in two different states, might aggravate this problem to a new level.

Finally, the importance of a motivated workforce has been a subject of study for decades. The importance of motivation in construction has also been acknowledged by researchers, where it is considered one of the key factors for preventing accidents alongside training (Schafer et al., 2008). For this reason, unsurprisingly, various combinations of rewards are provided to workers by their employees in an attempt to satisfy their needs and to motivate them or to compensate them for a specified goal (Hewitt, 2012). Correspondingly, research has also pointed to the importance of understanding the impact of rewards on a worker's behavior in order for company management to attain a desired outcome (LaBelle, 2005). Yet, there is a lack of construction research in occupational rewards and research to identify factors that impact rewards perception. The combination of the aforementioned reasons associated with the impact of rewards on employee performance (Siegrist et al., 2004), stress management (Schafer et al., 2008), perception (Sims et al., 1976, Pessoa and Engelmann, 2010), and behavior (Henderson, 2003) are the inspiration for this study. This research focuses on matters related to rewards to help the industry understand how construction workers think and feel about rewards. Such understanding will enable industry practitioners to design a reward system that will help motivate and retain their existing workforce, as well as help attract new workers to the industry.

The next section presents a brief overview of reward literature and its evolution. Worker's needs and motivators are presented, and a prominent model of rewards selected for use in this study.

3.2 Literature Review

What is meant by rewards? An occupational reward can be anything of value (tangible or intangible) that an employer or an organization delivers to its employees whether intentionally or unintentionally in contemplation of the employee's work contributions (Henderson, 2003, Shields et al., 2016), "and to which employees as individuals attach a positive value as a satisfier of certain self-defined needs." (Shields et al., 2016). Though the researcher cannot identify the first manuscript that presents a study on rewards, research on the influence of motivating people to work by Herzberg et al. (1959) and Maslow et al. (1970) has an apparent impact on rewards in the reviewed literature.

The first known study of motivation theory was conducted by Maslow (1943), who introduced the hierarchy of needs. The hierarchy of needs includes five different levels of human needs which, starting from the lowest level of need, are: (1) physiological, that involves everything the body needs to function; (2) safety, which includes social, economic, and physical well-being; (3) belonging or love needs that include affection, and a sense of belonging to a community; (4) esteem or self-respect that comes from accomplishment and respect from others; and (5) self-actualization which Maslow associated with creativity and lack of prejudice among other similar factors. Accordingly, the premise of Maslow's theory was that one need cannot be fulfilled before fulfilling the previous pre-potent need.

Maslow's theory was later refined to be a seven-level hierarchy known as the theory of motivation (Maslow et al., 1970), as shown in Figure 3.1. The refined hierarchy introduced two extra levels: cognitive needs such as curiosity, exploration, and knowledge, and aesthetic needs such as appreciation and beauty. These two additional needs are ranked fifth and sixth, respectively, in the hierarchy, followed only by the need for self-actualization. Maslow also indicated that physiological, safety, belonging, and esteem needs are deficiency needs, meaning that without one of the needs being satisfied, a person would feel as if they are lacking something essential. On the other hand, cognitive, aesthetic, and self-actualization are growth needs which are associated with a person's desire to grow (Maslow et al., 1970). Importantly, to motivate an employee, a reward that addresses their needs should be provided. Moreover, a reward used for motivation should meet a need which the employee has not already achieved or fulfilled.

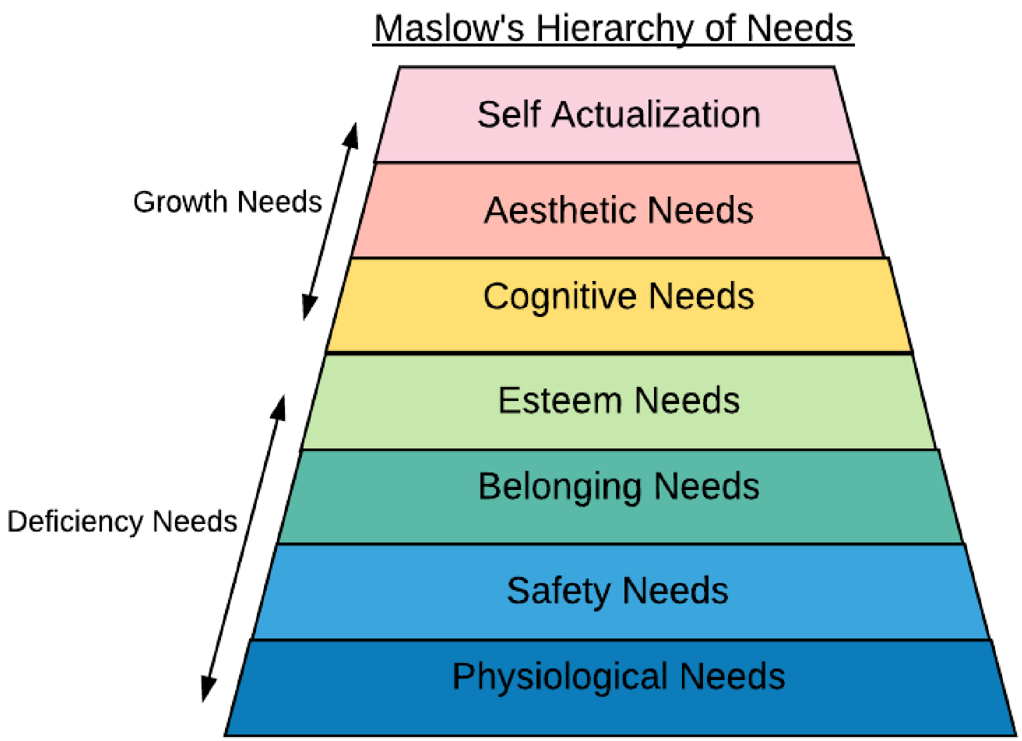

Figure 3.1: Maslow's Theory of Motivation (Maslow et al., 1970)

The second long-established theory of motivation was proposed by Herzberg et al. (1959), where the goal was to address some of the shortcomings of Maslow's theory in real life applications (Shields et al., 2016). Herzberg et al. (1959) investigated 16 factors, among which are: salary, interpersonal relations, working conditions, supervision, company policy, advancement, responsibility, work itself, recognition, and achievement for their impact on satisfaction. By surveying professionals working in the United States, Herzberg et al. (1959) found that these factors fall into two different categories in terms of their effect on satisfaction. The first category, called "hygiene factors", is where the presence of these factors will not cause motivation or satisfaction, but their absence will cause dissatisfaction. Hygiene factors are: salary, interpersonal relations, working conditions, supervision, and company policy. The remaining factors (advancement, responsibility, work itself, recognition, and achievement) were considered to be "motivator factors" and have an influence on the worker satisfaction. The absence of motivating factors does not cause dissatisfaction; rather, their absence causes lack of motivation.

The influence of the aforementioned studies on rewards research for many industries with different interests is clearly present in various subsequent studies. Among the later studies, Kalleberg (1977) aimed to develop job satisfaction by evaluating work valuation and rewards. Rewards included by Kalleberg were: intrinsic, convenience, financial, co-worker's valuation, career, and resource adequacy. House et al. (1979) conducted an occupational stress study on blue-collar workers. The researchers categorized the perceived rewards into four main types: (1) intrinsic rewards that included interesting and challenging work; (2) extrinsic rewards that included fringe benefits and working conditions; (3) importance rewards included work importance, prestige, and influence; and (4) control rewards which measure the control over the work pace.

Kalleberg and Van Buren (1996) investigated the relationship between organization size and job reward. The researchers categorized occupation rewards into four categories: (1) earnings, (2) fringe benefits, (3) promotion opportunities, and (4) autonomy. Siegrist et al. (2004) conducted a study on effort-reward imbalance, and categorized occupation reward into three main factors: (1) financial reward, (2) esteem reward, and (3) career prospects reward and job stability. Kouvonen et al. (2006) conducted an observational study of a large occupational group addressing the effort/reward imbalance and sedentary lifestyle in the Finnish public sector. The researchers categorized the rewards into three main measurements: (1) income and job benefits, (2) recognition and prestige, (3) and personal satisfaction. Lastly, Chiang and Birtch (2008) investigated the performance-reward relationship of the hotel industry in Hong Kong. The researchers counted ten rewards that were divided into two parts, financial reward and nonfinancial reward. Financial rewards included: basic pay, benefits, salary, and incentives (if available). As for the nonfinancial rewards, the researchers listed: recognition, power, time-off, responsibility, training and development, and promotions.

3.3 Total Reward Approach

Although the subject of reward is not new, as seen in previous research, the broadness of the reward definition might cause an ambiguous characterization and lack of consensus as to what is considered to be a reward. In order to narrow the focus and utilize a contemporary perspective of rewards, the present study will adopt the total reward approach as presented by Shields et al. (2016).

Under the total reward construct, rewards are comprised of two main categories: extrinsic and intrinsic. Extrinsic rewards are rewards are job-contextual and physically external to the work of the employee. Extrinsic rewards are branched into three types:

(1) Financial rewards or compensation include base pay, performance related pay, and cash benefits. Base pay is the fixed component of the compensation, whereas the performance-related pay depends on the worker's performance in a particular arrangement and the cash benefits includes the direct benefits provided by the employer to the employee, such as contributions to a pension or healthcare plan, and childcare.

(2) Developmental rewards include: learning, training, and development; succession planning; career progression; and other career growth rewards.

(3) Social rewards are non-monetary, indirect benefits that employees receive from their organization that relate to the entity's culture, climate, and performance support, or that promote work group affinity and work-life balance. Other examples can include: flexible timing arrangement and fitness and wellness programs.

The second category of rewards is intrinsic rewards. Intrinsic (personal) rewards are provided by the nature of the job at hand. Examples of these rewards include: job challenge, responsibility, task variety, job importance, and autonomy. An illustration of the total reward approach can be found in Figure 3.2.

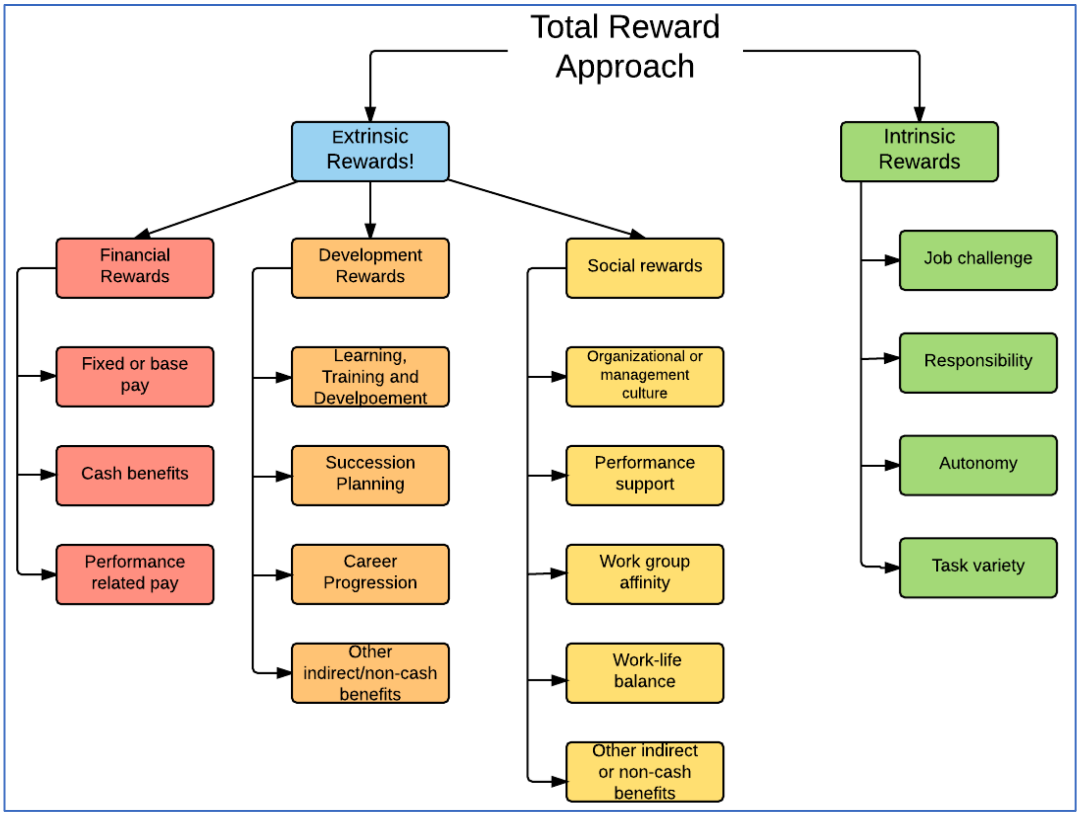

Figure 3.2: Total Reward Approach Components (Shields et al., 2016)

The total reward approach provides, in an organized and distinct manner, a clear understanding of rewards where there is no overlap between each category with a clear definition of each of its components. This approach also provides a clear answer to Maslow's proposed needs, as well as the two-factor theory proposed by Herzberg et al. (1959), in that it contains motivating factors along with hygienic factors that can satisfy and motivate workers. Table 3.1 shows a breakdown of how reward within the total reward construct relates to the aforementioned theories, and helps in motivating and retaining existing employees and attracting new employees. As shown in Table 3.1, financial and personal reward are mainly used for attracting new workers. Interestingly, what retain, and motivate existing workforce is the developmental and the social rewards.

Table 3.1: Relationship of Total Reward Approach to Maslow and Herzberg Models (Hewitt, 2012; Kwon and Hein, 2013)

Total Reward Approach	**Maslow's Motivation Theory**	**Herzberg's Two-Factor Model**	**Expected Outcome with respect to Employees**
Base pay	Physiological Need	Hygiene Factor	Attract
Cash benefits	Safety Need	Hygiene Factor	Attract
Performance-related pay	Esteem Need	Motivator Factor	Attract, Retain
Learning and Development	Cognitive Need	Motivator Factor	Motivate
Succession planning	Safety Need	Motivator Factor	Retain and Motivate
Career progression	Self-Actualization	Motivator Factor	Attract, Retain, and Motivate
Management culture	Belonging Need	Hygiene Factor	Attract, Retain
Performance support	Belonging Need	Hygiene Factor	Retain
Work group affinity	Belonging Need	Hygiene Factor	Retain, and Motivate
Work-life balance	Belonging Need	Hygiene Factor	Retain
Job challenge	Aesthetic Needs	Motivator Factor	Attract
Responsibility	Esteem Need	Hygiene Factor	Attract
Autonomy	Aesthetic Need	Motivator Factor	Attract
Task verity	Aesthetic Need	Motivator Factor	Attract

Though the researcher was not able to find an application of the total reward approach in construction reward research, it has been recommended to construction practitioners (CCQ, 2017) for salary paying positions. The CCQ report indicates that salaries are expected to increase by 3.6% on average for superintendents, project engineers, estimators, all the way to the senior management staff. However, the report also mentions that "it's complicated", that salary is not the only factor for employees, and that "novel benefits" must be considered by employers. Remarkably, the scope of the report did not include craft workers. It is of high importance to not neglect the perception of craft workers as they represent a larger portion of the construction workforce and they are the workers who are physically involved in constructing the work at hand.

It is important to note that the present study is about occupational rewards and what workers receive in exchange for their efforts. Performance related pay or incentives have been addressed in construction research and practice for safety and productivity purposes, yet occupational rewards have not received similar attention.

3.4 Point of Departure

Rewarding workers is not an easy task (LaBelle, 2005); it is dynamic in nature (Wiley, 1997) and its success relies on practice as well as theory (Hewitt-Associates, 1991). Rewards are especially important for a high physically demanding occupation such as many of those found in the construction industry (Choi, 2009), where low rewards have a significant negative impact on a worker's well-being (De Jonge et al., 2000). Furthermore, the productivity of a company is highly associated with that company's strategies and personnel (Tabassi and Bakar, 2009). Thus, by motivating a company's workforce, a competitive advantage can be gained by the company, and valued rewards and improved well-being can be gained by the company employees (Wiley, 1997).

As seen from the literature review, rewards significance is undeniable. Yet, there is a lack of research on this topic as it relates to the construction industry. This research aims to address this knowledge gap by providing the necessary tools to establish a worker reward system that accounts for and addresses their needs. The outcome of this research will enable creating a worker reward system that is based on perceived value to the employees, which is one of three methods of measuring the total value of compensation alongside actual cost to the company and actual value to the employee (Hewitt-Associates, 1991). To do so, the researcher will explore rewards representation, perception, and importance from the construction worker's perceptive. These three pieces of information, in combination, will provide industry decision-makers with a complete picture of what's essential to motivate workers.

3.5 Research Methodology

With the aim of providing a clear understanding of rewards and rewards importance, and how rewards and rewards importance are being perceived by construction workers, this study is comprised of a comprehensive literature review followed by a survey of construction workers and analysis of the survey results. The specific research methods that were undertaken, followed by the rewards analyses, discussion, conclusions, recommendations, and limitations, are described below.

A comprehensive literature review was conducted to document the variables to be targeted in the survey. The findings of the literature review guided the development of the survey conducted in the study. The survey was designed and developed to provide the optimal confidence level for an appropriate sample size. As for the reward perception, a list of all the variables selected and corresponding references where the variables are reported are provided. For the second part, various statistical methods relevant to the research are explained and utilized to create a clear understanding of the three vital aspects in designing a worker reward system. These three aspects are rewards representation, rewards perception, and rewards importance. After each analysis, results are presented and interpretations provided. In the discussion and recommendations section, the researcher introduces the overarching concepts that affect rewards or be affected by rewards. The researcher also discusses how to improve worker rewards in the best way possible in accordance with the findings of the study and the supporting literature. In the conclusions section, research contributions are presented and study limitations are listed.

3.6 Survey Design and Data Collection

With a better understanding of what rewards mean, the next step is to understand what workers feel that they are receiving from working in their construction position, how satisfied they are with the rewards received, and what types of rewards are more important. Thus, the survey was designed and developed to capture worker's insights through a self-assessment questionnaire. This method is the most common method found in conducting perception studies (Visschers and Meertens 2010).

In accordance with the topics of interest to this study, the survey contained three parts. The first part of the survey asked questions about the worker's socio-demographic information, such as gender, title, time in current position, etc. The second part aimed at capturing the occupational factors that impact the worker's rewards perception. An initial list of potential impacting factors was gathered through an intensive literature review of various studies in various fields. The variable selection section below provides more details about the factors identified.

The third part of the survey was dedicated to rewards. This part involved: 1) the participant selecting each type of reward from the total reward approach (individually) that they feel the construction industry offers; 2) an assessment of the worker's level of reward satisfaction in which the respondents answered the question by selecting the appropriate value from a seven point scale (from extremely dissatisfied [0] to extremely satisfied [6]); and finally, 3) the participants ranking rewards (financial, developmental, social, and personal) in terms of importance to the workers themselves, where [1] represents the most important reward and [4] represents the lease important reward.

To determine the optimal sample size for this study, the following formula was utilized (Lohr, 2008):

$$N = \frac{z^2 * \rho(1-\rho)}{e^2} \qquad (3.1)$$

where N is the estimated sample size, z is the z-score corresponding to the confidence level, ρ(1-ρ) is the responses variance, and e is the margin of error.

For this study, the confidence level selected was 95%, therefore, the z-score was 1.96. The expected value of the variance in responses used here was set as the maximum value (0.5), which is used for more conservative estimates (Lohr, 2008). The confidence interval, or the margin of error in the sample estimation selected, was 90%. Based on these values, using Equation 1 the recommended sample size is 97 responses. Similar consideration has been previously utilized and successfully implemented in construction and in perception research (Gambatese and Tymvios, 2012, Karakhan and

Gambatese, 2017). The researcher aimed to conduct a survey with a sample size twice as large as the extracted number above to add more confidence to the estimates.

3.7 Variable Selection

Due to lack of existing studies that discuss the underlying factors impacting reward perception, the researcher broadened the scope of variables to be examined. Socio-demographic and occupational factors that impact a person's perception and behavior were included for examination. Table 3.2 contains a list of all the variables selected, accompanied by a list of references documenting the variable as an impacting factor.

Table 3.2: Independent variables selected in this study

	Variable Name	**References**
Socio-demographic factors	Age	Cheng et al. 2012, Chen and Jin 2015, Siu et al. 2003, Byrnes et al. 1999, Rodríguez-Garzón et al. 2014, (Dong et al., 2017)
	Gender	Cheng et al. 2012, Weber et al. 2002, Fujishiro et al. 2017, Byrnes et al. 1999, Gaskell et al. 2004, Shan et al. 2016, Siegrist 2000, Frone 1998, Dong et al. 2017, Zhou et al. 2010
	Marital Status	Rodríguez-Garzón et al. 2014, Hallowell 2010
	Number of Children	(Rodríguez-Garzón et al., 2014), (Hallowell, 2010)
	Race	Fujishiro et al. 2017, Shan et al. 2016, Dong et al. 2017, Menzel and Gutierrez 2010
	US Region where located (East, South, Midwest, or West)	Demirkesen and Arditi 2015, Gangwar and Goodrum 2005, Dong et al. 2017, Fujishiro et al. 2017
Occupational factors	Years of Experience	(Cheng et al., 2012), (Rodríguez-Garzón et al., 2014), (Hallowell, 2010), (Shan et al., 2016), (Frone, 1998), (Wilkins, 2011), (Zhou et al., 2010)
	Job title (e.g., helper, journeyman, foreman, or superintendent)	Cheng et al. 2012, DePasquale and Geller 1999, Fujishiro et al. 2017, Rodríguez-Garzón et al. 2014, Shan et al. 2016, Dong et al. 2017, Weyman and Clarke 2003, Zhou et al. 2010

	Supervisor job title (e.g., helper, crew leader, foreman, or superintendent.	Wilbur et al. 1994, Aksorn and Hadikusumo 2008
	Method of payment (salary, by hour)	(Dong et al., 2017), (AGC, 2017)
	Skills and trades	Chen and Jin 2015, Rodríguez-Garzón et al. 2014, Dong et al. 2017, Aksorn and Hadikusumo 2008
	Stress	(Siu, 2001), DePasquale and Geller 1999, Hallowell 2010, Frone 1998, Dong et al. 2017 (De Jonge et al., 2000)
	Emotional involvement on the day of the study	(Aksorn and Hadikusumo, 2008), (Weller and Tikir, 2011), (Tixier et al., 2014), (Johnson and Tversky, 1983), (Magkos et al., 2006)
	Work familiarity	(Renn, 1998), (Weber et al., 2002), (Siu et al., 2003), (Choe and Leite, 2016), (Nathan, 2010), (Weyman and Clarke, 2003), (Helander, 1991)
	Work complexity	(Fujishiro et al., 2017)
	Job satisfaction	(Fernández-Muñiz et al., 2012), (Frone, 1998), (Kalleberg, 1977)
	Time spent working with the same employer (job tenure)	Chen and Jin 2015, Siu et al. 2003, DePasquale and Geller 1999, Hallowell 2010, Frone 1998, Dong et al. 2017
	Safety Training	(Demirkesen and Arditi, 2015), (DePasquale and Geller, 1999), (Saurin et al., 2008), (Namian et al., 2016), (Dong et al., 2017), (Menzel and Gutierrez, 2010), (Wilkins, 2011), Rodríguez-Garzón et al. 2014
	Type of employer (General contractor, subcontractor, or self-employed)	Cheng et al. 2012, Chen and Jin 2015, Fujishiro et al. 2017, Dong et al. 2017
	Number of projects worked on in the last three years	Chen, 2017
	Crew size and time with current crew	(Cox et al., 2006), (Son and Rojas, 2010)
	Accident involvement	(Sönmez and Graefe, 1998), (Rohrmann, 1999), (Carder and Ragan, 2016), (Hallowell, 2010), (Liu et al., 1998), (Leiter et al., 2009)
	Union Membership	(Demirkesen and Arditi, 2015), (Fernández-Muñiz et al., 2012)

	Trust	(Slovic, 1999, Siegrist, 2000, Siegrist and Cvetkovich, 2000, Siegrist et al., 2000, Das and Teng, 2001)

The researcher would like to highlight that one of the variables listed above (supervisor job title) is not explicitly mentioned in the cited references, but rather derived from the references. Supervisor job title was included as a factor to measure if the worker is being supervised by a peer worker, or by a higher-level worker, such as superintendent or a foreman. Previous research (Wilbur et al., 1994) indicates that peer feedback, peer review, and special insight are opportunities that within-group supervising offers. Supervisor relationship was also considered as a potential job stressor (Chen et al., 2017). Aksorn and Hadikusumo (2008) also indicated the importance of appropriate supervision and teamwork as critical success factors of safety programs.

3.8 Survey Results

This study utilized the Qualtrics platform to develop, disseminate, and collect the data. Participation in this study was for workers age 18 or older. For the 208 voluntary responses collected, three measures of quality checks were implemented: 1) straight-liner elimination, where those who answered multiple questions with the same value would be rejected; 2) distraction elimination, where respondents were asked to write a specific word in one of the check questions as an answer; and 3) speeders elimination, where respondent who answered in a third of the median response time would also be rejected. After implementing these three measures, 32 responses were removed from the analysis in this study due to incomplete responses, leaving a total of 176 responses for analysis. Please note that upper limit completion time was not set in this survey; therefore, responses should be considered as cognitive responses rather than associative responses (Visschers and Meertens 2010).

Survey participation was found to be distributed fairly equally to all of the four regions of the United States. Approximately 40% of the responding workers are from the southern region, and approximately 20% in each of the Northeast, Midwest, and West regions. Figure 3.3 illustrates the participation rate by state, where the darker colors indicate more worker responses were collected from that state.

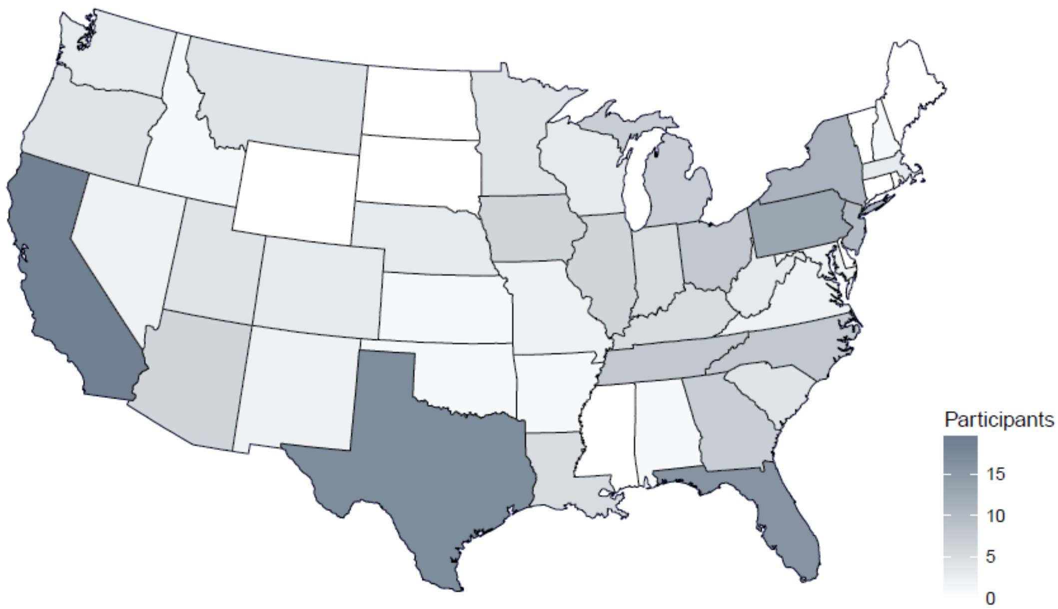

Figure 3.3: Survey participation rate per state

The average age of the participants was 38.24 years which is very close to the national average reported to be 41.8 years as of 2010 (CPWR, 2016). The respondents are mainly employed by general contractors (71% of respondents), while the remaining work for subcontractors, are self-employed, or a combination of both. Most of the responding workers are involved mainly in residential construction (45%), while 21% are involved in commercial construction, 10% in industrial construction, and the remainder in utility, roadway, or maintenance construction work. The average number of years of experience was 13.82 years, with 24% of the respondents at the level of foremen or higher, 25% working as crew leaders, and the rest of the respondents working as journeymen, tradesmen, or helpers. Finally, 78% of the respondents are not union members.

3.9 Rewards Analyses and Results

This section provides a comprehensive evaluation of occupational rewards in construction. The evaluation is conducted in three important segments. The first part focuses on rewards representation, where a portrait of what rewards workers receive and how each of the rewards impacts reward satisfaction is presented. The next part includes in-depth statistical analyses to obtain a deeper understanding of the underlying socio-demographic and occupational factors that impact a worker's reward perception. Finally, the third part investigates rewards importance where both the stated importance and the clustering predictor importance are discussed.

3.9.1 Rewards as seen by construction workers

To stay true to the definition of total rewards, the survey participants were asked to indicate which of the total reward approach components, listed in Figure 3.2, they receive while working in construction. The participants were also allowed to enter any other types of rewards that they might receive if not listed. The respondents where not asked whether their employer has a designed reward system or not. The survey questions allowed the researcher to capture the rewards that workers receive and the rewards that workers perceive, in addition to the rewards that workers intentionally or, equally as important, unintentionally receive from their employers, as mentioned previously in the definition of rewards. This decision was also made in accordance with Gee and Hanwell's (2014) remarks, where they state what motivates people can be stimulated and encouraged but cannot be produced or commanded.

With all responses in hand, the researcher performed a detailed analysis of all the individual types of rewards mentioned above, as they were selected by the respondents. Furthermore, the researcher calculated the mean job and reward satisfaction ratings for each type of reward, followed by a group summary that included correlation calculations between the number of rewards available to the worker, his/her job position, and reward satisfaction. The researcher believes that this analysis will provide a deeper understanding of the impact of each variable on a worker's job satisfaction and reward satisfaction, as well as how each reward type is represented in construction workers' minds. Table 3.3 provide a summary of the analysis results. Workers were asked to rank their job and reward satisfaction on a seven-point scale from extremely dissatisfied (0) to extremely satisfied (6).

Table 3.3:Statistical summary of total reward representation combined with correlation coefficients for job satisfaction and rewards satisfaction

Reward description	**Number of occurrences (Rate of occurrences)**	**Mean Job Satisfaction (Between 0 to 6)**	**Mean Rewards Satisfaction (Between 0 to 6)**
Fixed or base pay	66 (0.375)	5.30	5.23
Cash benefits	60 (0.34)	5.20	5.26
Performance-related pay	52 (0.295)	5.34	5.33
Financial Rewards summary	**Number of occurrences for at least one reward checked (Rate of occurrences)**	**Correlation between the number of rewards checked in this category and job satisfaction (p-value)**	**Correlation between the number of rewards checked in this category and reward satisfaction (p-value)**
	132 (0.75)	+0.226 (0.0142)	+0.324 (0.0002)
Learning, training, and development	64 (0.36)	5.36	5.27
Succession planning (plan for advancement)	29 (0.16)	5.55	5.31
Career progression	44 (0.25)	5.25	5.27
Development rewards summary	**Number of occurrences for at least one reward checked (Rate of occurrences)**	**Correlation between the number of rewards checked in this category and job satisfaction (p-value)**	**Correlation between the number of rewards checked in this category and reward satisfaction (p-value)**
	88 (0.50)	+0.180 (0.085) *	+0.203 (0.0069)
Organization and management culture	62 (0.35)	5.40	5.42
Performance support	40 (0.23)	5.63	5.55
Work group affinity (crew member closeness)	39 (0.22)	5.23	5.28
Work-life balance	46 (0.26)	5.22	5.48
Social rewards summary	**Number of occurrences for at least one reward checked (Rate of occurrences)**	**Correlation between the number of rewards checked in this category and job satisfaction (p-value)**	**Correlation between the number of rewards checked in this category and reward satisfaction (p-value)**
	102 (0.58)	+0.287 (0.0019)	+0.405 (0.0001)

Interesting/challenging work tasks	59 (0.34)	5.19	5.22
Responsibility	82 (0.47)	5.35	5.39
Autonomy	27 (0.15)	5.15	5.11
Task variety (diversity in work tasks)	44 (0.25)	5.30	5.27
Other indirect, non-cash benefits	2 (0.01)	6	6
Personal rewards summary	**Number of occurrences for at least one reward checked (Rate of occurrences)**	**Correlation between the number of rewards checked in this category and job satisfaction (p-value)**	**Correlation between the number of rewards checked in this category and reward satisfaction (p-value)**
	101 (0.57)	+0.163 (0.1199) *	+0.283 (0.0026)

As shown in Table 3.3, rewards representation is not equally spread throughout the four main categories. The financial rewards category had the highest presence in the responses, though the remaining rewards categories had nearly the same level of presence. Individually, a clearer picture can be seen as to where workers rewards are absent. In general, it can be seen that workers felt differently about the presence of various rewards even within the same category. The clearest example of this difference is the number of workers who selected responsibility and autonomy. Even though both fall under the personal reward characterization, their presence cannot be more different. Responsibility is received as a reward by 47% of the workers, the most of all rewards; while autonomy is received by only 15% of the workers, the least of all rewards excluding the “other” type. Financial rewards had the least variance in selection in individual rates, varying between 29.5% and 37.5% in performance-related pay and fixed pay, respectively.

Also, as seen in Table 3.3, the correlation between the individual reward selected, and the job and reward perception is almost constant. That is due to the nature of the question asked in the survey. Where workers were asked about their reward and job satisfaction only once; thus, their evaluation of both is not considered separately. Their evaluation encompassed all the various rewards that they might have selected.

Conversely, the correlations between the number of rewards selected in each category and their job satisfaction and reward satisfaction are a better indicator. The researcher found that for all categories, the more rewards the worker receives, the higher their reward and job satisfaction ratings. Furthermore, the results reveal that the reward satisfaction correlation factor is consistently higher than the job satisfaction correlation factor. Additionally, job satisfaction correlation was found to not be statistically significant for two of the four types of rewards mentioned - development and personal rewards - thus confirming that there might be other factors that come into play when assessing job satisfaction. Kalleberg (1977) indicated that job satisfaction includes reward satisfaction as well as work values, further demonstrating that work values has an independent effect on job satisfaction.

Finally, it is important to discuss that two respondents listed “other” rewards in their responses and the two workers maintained a strong conviction about their reward status, where they indicated that they are extremely satisfied with both their job and their rewards. The rewards that each of the workers indicated were work safety for one responding worker, and variety of locations for the other responding worker. Even though a generalization can be made by relegating that work safety under organization and management culture and a variety of locations can fall under personal rewards similar to task variety, these two respondents felt strongly about the reward that they had, which led to higher than average job and reward satisfactions. This finding conforms with what Gee and Hanwell (2014) indicated, and as mentioned earlier, that rewards can be stimulated but not mandated.

3.9.2 Reward Perception – A Deeper Understanding

The next step involved a statistical analysis of the underlying variables that impact workers rewards perception. For this analysis, workers rewards satisfaction is the dependent variable, and the variables selected in this study, as listed in Table 3.2, are the independent variables. Given that rewards perception was a measure of satisfaction based on a ranked scale, as is the case of many measures of perception, from extreme dissatisfaction to extreme satisfaction, an ordered probit model was chosen for the analysis. An ordered probit model has been successfully implemented in various fields of study when the response variable is in an ordered nature

3.9.2.1 Empirical Setting

Under the ordered probit model construct, the unobserved variable, y*, is defined as a linear function of explanatory variables, as seen in Equation 3.2 (Greene, 2003, Washington et al., 2010):

$$y^* = \beta x + \varepsilon \tag{3.2}$$

where:

- β is a vector of the estimable parameters which corresponds with x,
- x is, as mentioned previously, a vector of the explanatory variables (age, marital status, etc., as listed in Table 3.2), and
- ε is a random disturbance that is assumed to be normally distributed with a mean of 0 and variance of 1.

Using Equation (3.2), for each observation, ordinal data y can be represented as (Greene, 2003, Washington et al., 2010):

$$\begin{aligned} y &= 1 && \text{if } \mathrm{y}^* \le \mu_0 \\ y &= 2 && \text{if } \mu_0 \le \mathrm{y}^* \le \mu_1 \\ y &= 3 && \text{if } \mu_1 \le \mathrm{y}^* \le \mu_2 \\ &\vdots \\ y &= I && \text{if } \mathrm{y}^* \ge \mu_{I-1} \end{aligned} \tag{3.3}$$

where: μ is the threshold parameter used in the model to estimate the ranking, and I is the number of the highest possible ranking that the dependent variable has (in this case, up to a value of seven).

The probabilities are calculated as follows (Washington et al., 2010):

$$\begin{aligned} &P(y=1) = \Phi(-\beta\chi) \\ &P(y=2) = \Phi(\mu_1 - \beta\chi) - \Phi(\beta\chi) \\ &P(y=3) = \Phi(\mu_2 - \beta\chi) - \Phi(\mu_1 - \beta\chi) \\ &\vdots \\ &P(y=I) = 1 - \Phi(\mu_{I-2} - \beta\chi), \end{aligned} \tag{3.4}$$

where: $\Phi(.)$ is the cumulative normal distribution, with $0 < \mu_1 < \mu_2 < \mu_3 < \ldots \mu_{I-2}$.

Finally, marginal effects were used to better understand the probability change in an indicator variable from zero to one while keeping everything else constant (Greene, 2003, Washington et al., 2010). Equation 3.5 shows this relationship:

$$\text{Marginal effects} = \text{Prob}[\text{Y=1}|\overline{\text{x}}_{(d)}, d = 1] - \text{Prob}[\text{Y=1}|\overline{\text{x}}_{(d)}, d = 0] \qquad (3.5)$$

where: $\overline{\text{x}}_{(d)}$ is the mean of all the other model variables while the indicator variable, *d*, value changes from zero to one.

3.9.2.2 Model Results

After applying the ordered probit model to the sample size of 176 responding workers with the variables selected previously, nine variables were found to be statistically significant at the 5% level or lower and two variables were found to be statistically significant at the 10% significance level. A detailed list of all the variables that were found in the model is provided in Table 3.4, as well as the model fit values and threshold values. As for the computed marginal effects, the variable means are listed in Table 3.5.

Table 3.4: Estimated result for the best fit ordered probit model

Variable Description	Coefficient	T-stat.	P-value
Constant	3.71	9.31	< 0.0001
Marital Status (0 if married or never married, otherwise = 1)	-0.96	-3.84	0.0001
Race (1 if white, otherwise =0)	0.47	2.21	0.0270
Region (1 if South, otherwise =0)	-0.35	-1.89	0.0593
Method of Payment (1 if per hour, otherwise =0)	-0.49	-2.35	0.0187
Time with current employer (1 if 3 years or more, otherwise =0)	0.47	2.42	0.0156
Supervisor (1 if foreman or higher, otherwise =0)	-0.38	-1.99	0.0471
Job satisfaction (1 if low, otherwise =0)	-1.71	-6.87	<0.0001
Accident Involvement (1 if witnessed, otherwise =0)	-0.54	-2.85	0.0044
Number of trades (1 if the worker is skilled in 2 or 3, otherwise =0)	0.51	1.95	0.0513
Stress Level (from 1 being very low to 5being very high)	-0.28	-2.68	0.0073
No of Elements in training (1 to 7)	0.13	2.35	0.0186
Threshold Parameters:			
Threshold 1 Mu(01)	1.19	7.85	<0.0001
Threshold 2 Mu(02)	1.89	15.17	<0.0001
Threshold 3 Mu(03)	3.21	21.18	<0.0001
Number of variables: 11 Number of observations: 176 Log likelihood at convergence: -174.01100 Log likelihood at zero: -229.00878 Significance level: <0.00001 McFadden Pseudo R-squared: 0.2401558			

Table 3.5: Marginal effects of the variables in the best fit ordered probit model

Independent variables	**Reward satisfaction variable**				
	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Moderately satisfied	Extremely satisfied
Marital Status (1 if divorced, widowed, or separated; married or never married = 0)	0.0172	0.1370	0.1459	0.0071	-0.3072
Race (1 if white, otherwise =0)	-0.0042	-0.0504	-0.0729	-0.0428	0.1703
Region (1 if South, else =0)	0.0023	0.0321	0.0522	0.0449	-0.1316
Method of Payment (1 if per hour, else =0)	0.0024	0.0376	0.0678	0.0806	-0.1884
Time with current employer (1 if 3 years or more, otherwise=0)	-0.0033	-0.0437	-0.0695	-0.0580	0.1744
Supervisor Job title (1 if foreman or higher, otherwise =0)	0.0027	0.0359	0.0571	0.0462	-0.1418
Job satisfaction (1 if low, else =0)	0.0694	0.2977	0.1984	-0.1148	-0.4507
Accident Involvement (1 if witnessed, else =0)	0.0034	0.0475	0.0788	0.0758	-0.2055
Number of trades (1 if the worker is skilled in 2 or 3, otherwise =0)	-0.0019	-0.0334	-0.0661	-0.0991	0.2005
Stress Level (from 1 being *very* low to 5 being very high)	0.0016	0.0244	0.0416	0.0399	-0.1075
No of Elements in training (1 to 7)	-0.0008	-0.0116	-0.0197	-0.0189	0.0510

For social-demographic factors, three variables were found to be significant, as shown in Table 3.4 and the interpretation of the results found in Table 3.5. The three variables are: marital status, race, and region. Starting with marital status, respondents who are divorced, widowed, or separated had a 0.307 lower probability of being extremely satisfied in their occupational rewards compared to other workers. This lower level of satisfaction can be attributed to many reasons that might not be directly related to their occupational rewards. Work-life balance (one of the parts of the total reward system) is one factor that might have impacted the result. Shan et al. (2016) reviewed studies that also reported various satisfaction level for construction workers with different martial statuses.

As for the second variable, race, workers who identified themselves of being white, had a 0.17 higher probability of being extremely satisfied with their occupational rewards. While only a limited amount of research is available on the effect of race on rewards satisfaction, this finding conforms with the existing literature which emphasizes race and socioeconomic position are profoundly complex in the United States (Fujishiro et al., 2017). It is worth mentioning that Rowings et al. (1996) found, in their survey of construction workers in 2000, that Hispanic workers, compared to other workers, were more likely to be satisfied in their job. The researchers, however, reported that Hispanic workers had a higher percentage of participation in the study compared to other workers.

The last sociodemographic variable was region, where workers from the Southern region have a 0.13 lower probability of being extremely satisfied with their occupational rewards compared with their peers from other regions. Salaries, work conditions, and type of work varies by region. As for why workers in the south might have a lower probability of being extremely satisfied, Demirkesen and Arditi (2015) indicated that companies in the southern states often have a safety incentive program that rewards workers who complete safety training. Such programs have proven their diminished effectiveness overtime (Gangwar and Goodrum, 2005, LaBelle, 2005), and incentive programs are a controversial subject in construction safety literature (Hallowell et al., 2013). The differences in perspectives of incentive programs may be the underlying cause for why workers who receive an incentive might feel differently about their rewards.

For the occupational-related variables, seven of the eight variables were found to be statistically significant at the 95% level. Starting with method of payment, workers who indicated that they are being paid by the hour had a 0.18 lower probability of being extremely satisfied with their rewards. The method of payment variable is, in part, an indicator of job nature and position status. Workers who are at a supervisor or superintendent level are usually paid a salary, while crew workers usually get paid by the hour (AGC, 2017). The difference in method of payment, and the added pay security associated with salary pay, might be reasons why workers who are being paid by the hour have a lower probability of being extremely satisfied when compared to their salaried counterpart.

For the "time with current employer" variable, workers who have worked with the same employer for 3 or more years had a 0.17 higher probability of being extremely satisfied compared with other workers. Job tenure is a big factor in reward and job satisfaction. Workers might feel a sense of valuation by their employer (Allen and Rush, 1998), which in turn satisfies their self-esteem needs. Job tenure might also be seen as a commitment to the employer, which the workers in turn might be rewarded for (Allen and Rush, 1998). It is worth mentioning that job tenure, as a variable, has been linked to various aspects of construction worker behavior, such as quality of work-life (Shan et al., 2016) and safety performance (Siu et al., 2003), and is often used as a predictor of accident involvement (Frone, 1998, Siu et al., 2003).

With respect to the "supervisor job title" variable, workers who have a foreman or higher for a supervisor had a 0.14 lower probability of being extremely satisfied compared with other workers who have other types of supervisors. This finding might be best interpreted when seen with the social rewards of the total rewards approach, which includes work group affinity and quality of supervision in its construct (Shields et al., 2016). Furthermore, as mentioned previously, peer supervision might offer reviews, feedback, and insight that higher level personnel might not offer (Wilbur et al., 1994).

The job satisfaction variable was also found to be statistically significant, where workers who have low job satisfaction had 0.45 lower probability of being extremely satisfied. The lower probability is an expected finding, where workers who feel unsatisfied with their job have a lower chance of being extremely satisfied with their job rewards.

As for workers who have past experiences being involved in safety accidents, the workers had a 0.20 lower probability of being extremely satisfied when compared with their peers who have not been involved in accident. Past experiences have an effect on people's perception; an impact that Renn (1998) calls an anchoring effect. Furthermore, positive experiences of not being hurt leads to a worker's conclusion that the task at hand is safe (Carder and Ragan, 2016). Thus, it is suggested that the imposed safety risk might affect a worker's rewards perception. Leiter et al. (2009) indicated that workers who had experienced an accident in their work place perceived hazards to be of a higher risk when compared with their non-injured peers. The perception that was generated from past experiences might take some time to be adjusted (Liu et al., 1998).

Workers with skills in two or three trades were found to have a 0.20 higher probability of being extremely satisfied with their work compared to their peers who did not have the same number of skills. Multi-skilled workers provide extra flexibility to the employer and for the extra flexibility, they are often compensated with higher pay or longer than average employment (Burleson et al., 1998). This potential boost in rewards, as well as the unobserved effect of the worker's self-esteem, might be a reason for the positive increase in the probability of extreme reward satisfaction.

As for stress, workers with a higher level of stress have a 0.107 lower probability of being extremely satisfied when compared to their peers who have a lower level of stress. This finding conforms to the norms of any job, where if a worker is stressed, he/she is less likely to be happy in their job given that the stress is linked to job pressure (Fernández-Muñiz et al., 2012). Margolis et al. (1974) considered work stress as an unrecorded occupational hazard. De Jonge et al. (2000) considered stress to be, to an extent, a measure of well-being, and NIOSH is now pushing to advance worker health and well-being by reducing stress, among other factors, as part of the NIOSH Total

Worker Health® approach (NIOSH, 2016). The adverse health consequences caused by stress led researchers to measure effort-reward imbalance models by their ability to reduce occupational stress (Tsutsumi and Kawakami, 2004).

Finally, training impacted rewards perception positively, where workers who have had training that was more inclusive had a 0.05 higher probability of being extremely satisfied. This result is expected since training is already considered part of the total reward approach, as mentioned previously. Its impact on rewards has been documented (Sims et al., 1976). Furthermore, the impact of training has also been documented in construction workers' risk perception in more than one study (Rodríguez-Garzón et al., 2014, Demirkesen and Arditi, 2015).

Lastly, both region and skill level variables were found to be not statically significant at the 95% confidence interval, yet they were close enough that the researcher included them for practical significance.

3.9.3 Rewards Importance

For the last part of rewards analysis and understanding, workers' needs and what they deem to be important are examined. In this study, survey participants were asked to rank rewards (financial, developmental, social, and personal) from 1 to 4 with 1 being the most important reward and 4 being the least important reward. The participants were also allowed to rank more than one reward with the same rank to indicate that two or more rewards are equally important to them. As such, the responses indicate that most of the respondents feel that financial reward is the reward that they need the most, and social rewards is the least important to them. Figure 3.4 shows the importance given to each reward by the survey respondents.

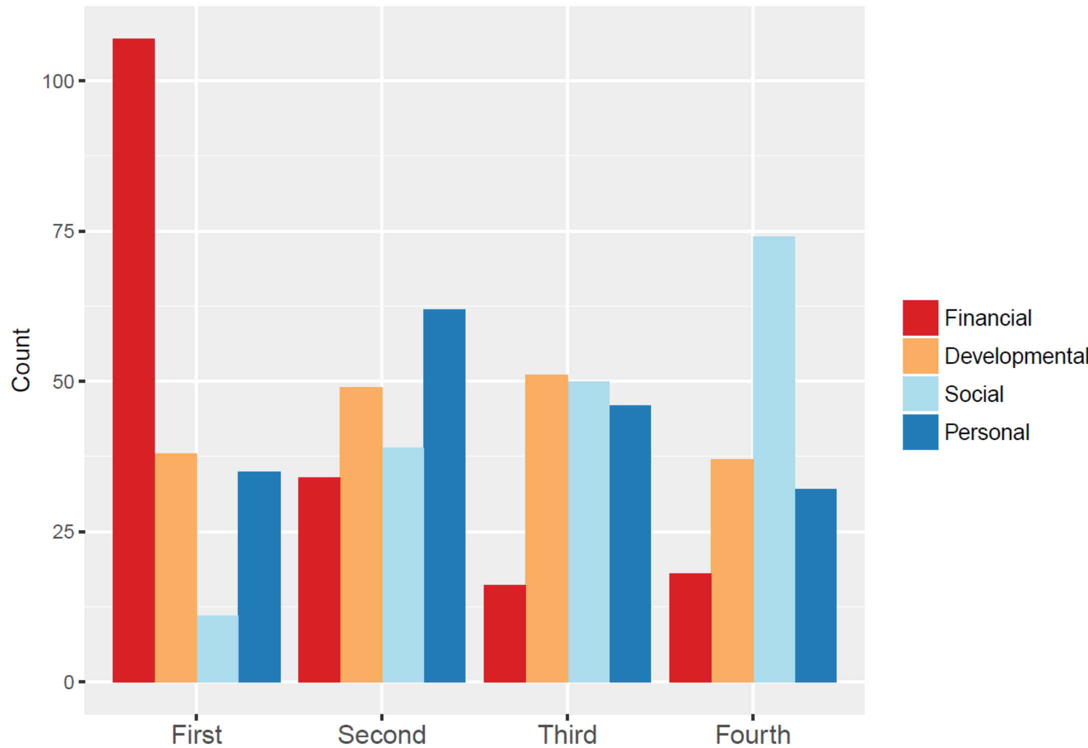

Figure 3.4: Reward importance as indicated by respondents

In Figure 3.4, it is clear at the two extreme ends that is the most important/needed reward is financial, and the least important reward is social. However, the close and marginal difference between personal and development rewards does not help in understanding a worker's needs.

It is not surprising that financial reward was cited as the most needed reward. A financial reward satisfies the first need in the hierarchy of needs (physical). Also, when the survey participants were asked to indicate whether they receive financial rewards or not, a good portion of them (25%) did not feel that they receive financial rewards.

As for personal rewards and why it was the least important, responsibility was the single highest ranked type of personal reward received by the responding workers. While task variety was selected by 34% of the workers, which is close to the average. Therefore, the reason for the low importance is the high reception rate by the workers.

For the second and third ranks of importance, workers needs were closer than with the extreme two ends. Where, Personal rewards had a small lead for the second most important reward, as seen in Figure 3.4. On the other hand, a smaller lead for the third most important reward rank was for developmental rewards.

Further analysis is needed to help understand how workers' choices can be utilized for developing a reward system that addresses workers' needs and complements what the deemed important.

Workers' needs and their drivers change over time, a prime example of which was provided by Wiley (1997) where the researcher provided the most important factors for workers (not just construction workers) as well as the least important factors for three different decades spanning over 40 years. That study found that for the year of 1946, workers indicated that appreciation was the most important reward, and discipline was the least important. In 1980, the most important reward changed to interesting work, while the least important factor remained as discipline. In 1986, the least important reward changed to personal rewards, while the most important reward remained as interesting work. The trend continued with the last measure in 1992, where the most important reward was good wages, while the least important reward remained as personal rewards.

Given the impracticality of studying reward needs for each participant, dimension reduction measures have been used when studying rewards. Mannheim (1975), for example, used dimension reduction to reduce thirteen types of rewards into four main categories. In the present study, there are four ranks for each of the four categories (financial, developmental, social, and personal). As such, there are 24 possible ranking choices. Given that the sample size is 176, which is about 7 times the number of possible choices, the researcher decided to conduct a cluster analysis. The clustering of these rankings helps decision-makers better understand workers' needs, and to facilitate designing a reward system that addresses them.

To do so, the researcher used two step cluster analysis to identify the optimal number of clusters. Two step cluster analysis is capable of handling categorical variables that have more than three categories (Trpkova and Tevdovski, 2009) as is the case with the present data. For guidance with the analysis and the interpretation of the results, the researcher adhered to recommendations from Hair et al. (2009), Mooi and Sarstedt (2011), and Ramsey and Schafer (2012). The main purpose of the analysis is to cluster ranking choices to a lower number of sets, allowing some form of generalization to be made. Using SPSS software, the researcher examined the Bayesian Criterion (Leiter and Robichaud) for each number of clusters. The results of the analysis are shown with a detailed description of each cluster size trial in Table 3.6.

Table 3.6: Bayesian criterion results per cluster size

Number of Clusters	Schwarz's Bayesian Criterion (Leiter and Robichaud)	BIC Change [a]	Ratio of BIC Changes [b]	Ratio of Distance Measures [c]
1.0	1822.774			
2.0	1592.590	-230.184	1.000	1.147
3.0	1399.826	-192.765	0.837	1.676
4.0	1309.832	-89.993	0.391	1.185
5.0	1243.591	-66.241	0.288	1.320
6.0	1208.424	-35.167	0.153	1.145
7.0	1185.526	-22.898	0.099	1.067
8.0	1167.931	-17.595	0.076	1.102
9.0	1157.676	-10.255	0.045	1.091
10.0	1153.434	-4.241	0.018	1.099
11.0	1155.134	1.699	-0.007	1.015
12.0	1157.723	2.589	-0.011	1.266
13.0	1172.793	15.071	-0.065	1.480
14.0	1203.075	30.282	-0.132	1.018
15.0	1233.923	30.848	-0.134	1.019

a. The changes are from the previous number of clusters in the table.
b. The ratios of changes are relative to the change for the two-cluster solution.
c. The ratios of distance measures are based on the current number of clusters against the previous number of clusters.

With the objective of minimizing BIC, while keeping the number of clusters at an acceptable level (Ramsey and Schafer, 2012) and the overall quality of the fit being good, six clusters were chosen. Visual confirmation of the adequacy of six clusters can be seen in Figure 3.5, where relatively little improvement in BIC value, which might warrant the need for increasing the number of clusters, can be seen in having more than six clusters.

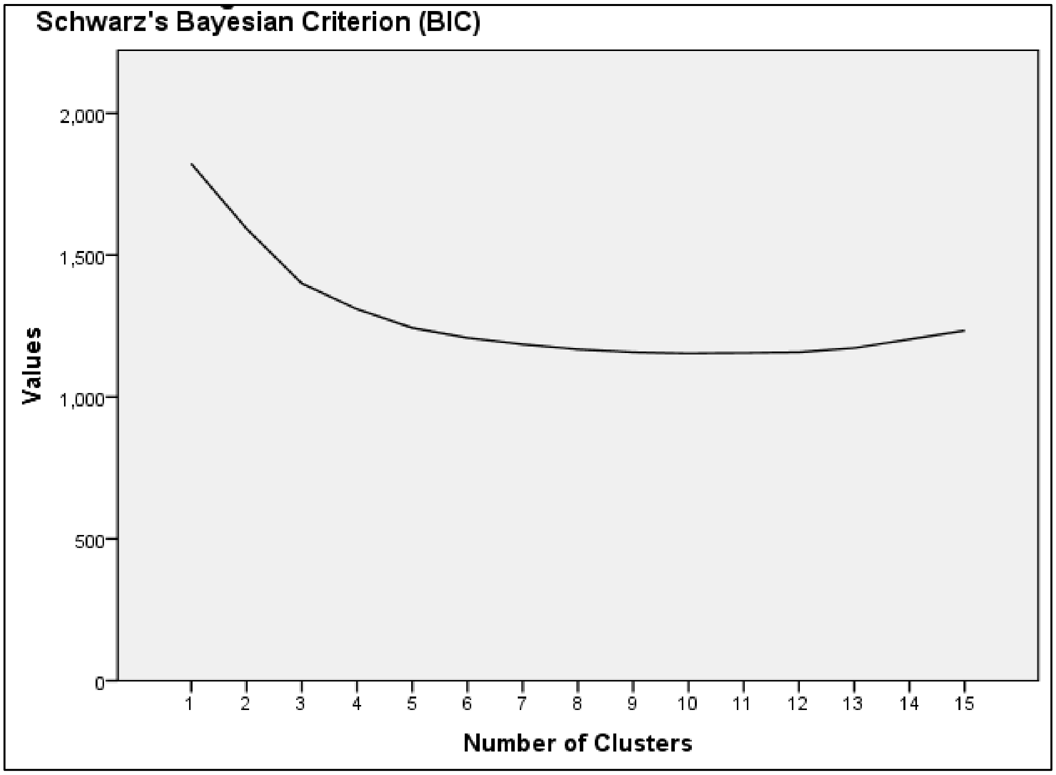

Figure 3.5: Bayesian Criterion (Leiter and Robichaud) Values at each number of clusters

With that, the silhouette measure was used. The silhouette is a measure of separation between clusters and cohesion within clusters that is calculated based on the average distances between the objects within the data set (Mooi and Sarstedt, 2011). For the chosen six clusters, the silhouette measure was 0.5, which is considered a satisfactory cluster quality (Mooi and Sarstedt, 2011). With six clusters, the number of workers in the smallest cluster was 18 (10.3% of the sample size), and the largest cluster contained 49 workers (28%). Thus, the ratio of largest to smallest cluster sizes is 2.72. As for the rewards importance distribution in each cluster and the clusters' size and percentage, Table 3.7 illustrates these values in an organized and simple manner.

Table 3.7: Rewards importance ranking within each cluster

Cluster	Financial	Developmental	Social	Personal	Cluster size (%)
1st Cluster	2	1	4	1	22 (12.6)
2nd Cluster	1	4	2	3	49 (28%)
3rd Cluster	1	2	3	4	37 (21.1%)
4th Cluster	1	3	2	4	27 (15.4%)
5th Cluster	1	4	3	2	18 (10.3%)
6th Cluster	1	2	4	3	22 (12.6%)

Clustering might not be an ideal solution to all workers' needs, meaning workers might be placed in a group that does not perfectly fit their indicated rewards importance. The goal of cluster analysis is to categorize collected worker responses into homogeneous groups (Ramsey and Schafer, 2012) while keeping in mind that there is no "right answer" or a null hypothesis to test (Garge et al., 2005). Thus, the researcher felt that clustering the responses is practical, since any rewards system that might be designed from this research will not develop a tailor-made reward system for each worker, and some form of generalization would be made in designing any rewards system. With that in mind, the following remarks should be noted with regards to the outcome of the clustering:

1- Financial rewards dominated most of the clusters, leaving only one cluster that does not have financial rewards ranked as the most important reward. Yet, the same cannot be said about the social rewards where only two clusters had social rewards ranked at number 4, i.e., the least important reward. This outcome means workers who have chosen social rewards as their least important reward, can be grouped into two clusters, each of which has a different opinion on the ranking of social and developmental rewards for the second and third place ranking.
2- Similar to the first remark above, workers who ranked financial rewards and developmental rewards as 1st and least respectively, had a different opinion on the ranking of social and personal rewards for the 2nd and 3rd needed reward.
3- Cluster 1 has two rewards as the most important: developmental, and personal. There is no reward ranked as 3rd most important because this group involved workers ranking developmental and personal rewards interchangeably between first and third.
4- Though there might be 24 possible ranking outcomes from the data, in realty not all ranking possibilities are often selected by workers. This result can be seen where there are two groups that have financial rewards as the 1st most important reward and development as second. Another two clusters also have financial rewards as 1st most important, but social reward as the second most important. Thus, it is safe to assume adequacy of the outcome of this analysis and it is helpfulness in grouping workers in terms of needs.

The last measure revealed by the cluster analysis is the clustering predictor importance. These values are the variables used to determine which cluster the worker belongs to. It was revealed that the workers' social reward ranking is the most important predictor with a value of 1. Developmental rewards were the second important clustering predictor at 0.767. Personal rewards were third at 0.633, and finally, financial rewards importance was 0.4167. The researcher feels that this revealed importance is of interest to the industry as it provides a little bit more clarity on how to approach workers' needs and how to combine workers in a certain reward program.

3.10 Discussion

In this study, construction workers showed that the industry offers a variety of rewards in return for their work, though their needs are not yet fulfilled. It is very important to remember that offering rewards is not a matter of quantity; it is however a very delicate balance of what is offered and what is needed. Therefore, it is only fitting that the received rewards should be discussed with the needed rewards.

With regard to what rewards are being offered, job responsibility is the reward that is received most often (received by 50% of respondents), while secession planning and autonomy are received by 16% and 15% of all workers respectively. As a reward category, developmental rewards are the received by workers the least (received by 50% of respondents), while personal rewards and social rewards are received by 57% and 58% of the workers, respectively. Consequently, while autonomy, a personal reward, might be important to workers, career progression, a developmental reward, should be addressed first given the category receiving rate, and its level within Maslow's hierarchy of needs. Learning and progression might be at the esteem and cognitive level of needs, while autonomy and interesting work might be at the aesthetic needs level. Kwon and Hein (2013) displayed that succession planning is among the most important factor in both retaining workers and engaging employees, while autonomy was listed among the most important factors in attracting new employees. Such a decision should be made according to a worker's needs, where a closer look at the outcome of the cluster analysis shown in Table 3.7 reveals that developmental rewards are at a higher need level compared to personal rewards.

Similar consideration will have to be made with regards to improving financial vs. non-financial rewards. Even if financial rewards are predominantly requested as the most important reward, striking a balance between the financial and non-financial rewards is crucial in framing a reward system (Shields et al., 2016). Financial rewards provide satisfaction as is a indicated by Herzberg et al. (1959), while other rewards offer motivation. It is clear from the workers' responses that they are satisfied with their rewards for now, albeit they still have needs that should be addressed. Improving workers' motivation should be the main goal of future research.

In the matter of how rewards should be offered, the researcher would like to express the importance of the implications of rewards and the way workers receive the rewards. Rewarding workers for a certain performance aspect might show unintentional encouragement for other, unintended behavior. This result implies that rewarding workers for better production and/or safety implications of rewards should not be forgotten, especially in light of the effect that flexibility, as reported by the respondents in the southern region, has on reward perception. LaBelle (2005) pointed to the implications of safety and productivity, where rewarding higher productivity might be seen as an encouragement for unsafe behavior. Safety is a source of concern in the industry, and an unintentional praise for neglecting safety represents a great barrier facing success in business and might have long term impact on the worker's behavior (LaBelle, 2005).

As such, reward design should not be conducted in a vacuum and absent of other factors that might be impacted by its adjustment, or by their administration. Among the impacted factors that should be considered are: productivity, safety, effort, and behavior.

Previous research has also shown that receiving rewards that are contingent on performance might have a negative impact on internally motivated workers (Deci, 1972). It was found that fear of punishment and negative feedback for poor performance decreased the motivation of internally motivated workers, while non-contingent financial rewards and positive feedback increased their motivation. Other research suggested “non-reward” as a reward to avoid punishing poor performance (LaBelle, 2005). More study is needed to better understand the multidimensional implications of rewards on worker behavior. The researcher recommends training and developmental rewards to be non-contingent for their benefits in improving worker’s satisfaction as well as increasing the worker’s ability to perform required tasks.

An important reason for why most workers choose financial rewards as the first most important reward has to do with their wages and how the wages have changed, if any, over the years. Looking at entry level construction positions, such as a laborer, the wages have not changed significantly from 1997 to 2016. Without adjusting for inflation, in 1997, the mean helper wage was $14.77 per hour; in 2006 the mean hourly wage was $14.39 (median is $12.66); and in 2016, the mean hourly wage was $18.22 (median is $15.49) (BLS, 1998, 2007, 2017). For the all employees in construction, the mean hourly wage increased from $23.43 in 2006 to $28.40 in 2016, adjusted seasonally (BLS, 2017). On a positive note, the no-change/slow growth in hourly wages might be one of the main reasons why construction workers stayed in the industry during the recession (Daly et al., 2012). The Federal Reserve Bank of San Francisco (FRBSF) did not mention the impact on the overall workers’ income during the recession, since their hourly wage may have stayed the same but the number of working hours may have changed (decreased). Furthermore, the FRBSF estimates that workers’ hourly wages will not change (Daly et al., 2012).

As for the underlining factors impacting workers reward perception, the factors can be divided into two groups based on the capability of the factors being improved by the employer: A) improvable, and B) non-improvable. Improvable factors are: time with current employer, type of supervision, job satisfaction, accident involvement, skill level, stress level, and training comprehensiveness. Though changes to each of these factors cannot be made overnight, the changes are possible. Employers can improve their workers benefits to increase workers’ rewards satisfaction and improve workers’ health beyond their on-site work hours. Coincidentally, those factors are a subset of the NIOSH Total Workers Health® approach (NIOSH, 2016) which is defined as “policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness–prevention efforts to advance worker well-being."

Strikingly, safety, and risk in general, has been linked in many ways to rewards more than one time throughout this study. This link is at both the surface level where workers' motivation and training contribute to accident prevention (Schafer et al., 2008), and at a deeper level where accident involvement, training, stress, and use of incentives impacts both safety and rewards perception. Thus, safety implications cannot be overlooked.

As for the second group of factors, non-improvable, these factors are: marital status, race, region, and method of payment. The first three factors are socio-demographic factors and, even if they are statistically significant in their impact on reward satisfaction, changing them is still out of the employer's hands. While method of payment as a factor that can be changed from by the hour to another method of payment (e.g., salary), the researcher considers this factor as a reflection of the nature of the job/position of the worker. Therefore, changing this factor just to improve reward satisfaction is likely not feasible. For example, not all workers should be paid in the same manner as supervisors. Moreover, the change in job nature needs a set of skills and experience that would not be achieved by lower level worker.

It should be kept in mind that what motivates people changes over time, and even the most motivated employee can be discouraged and unfulfilled at some point (Gee and Hanwell, 2014). Therefore, to ensure that a reward system adequately addresses their employees' needs, employers must conduct surveys of their employees' needs and desires regularly to address this issue (Wiley, 1997). Finally, measures should be taken to improve workers rewards since an employer's commitment to its employees has been confirmed as a boost of reputation to prospective employees and provides a viable advantage in attracting high quality employees (Turban and Greening, 1997). Other measures that can be used to attract new workers to the industry and that are highly connected with rewards are paid vocational training and apprenticeships. Presently, the United States falls behind Europe where this approach has proven its effectiveness in attracting and developing a higher skilled workforce (Harhoff and Kane, 1993, Dionisius et al., 2009).

3.11 Conclusions

Occupational rewards play an important part in motivating, retaining, and attracting workers to an industry. In this study of rewards, three aspects of rewards were examined. Those are: reward representation as seen by workers, factors impacting workers' reward perception, and workers' reward needs. Those three aspects should provide enough information to establish construction workers' reward perception that is based on the perceived value to the employee.

The study contributes to the body of knowledge by providing a clear statistical representation of the occupational rewards as perceived by workers. Results indicate that as a group of rewards, financial is the group most-received by workers in the construction industry, while as an individual reward, responsibility is the most-received category. Conversely, carrier planning and work autonomy are the two least-received rewards in construction.

Next, the study provided a deeper understanding of how occupational factors, as well as socio-demographic factors, impact reward perception for both increasing and decreasing the probability of workers being extremely satisfied. While interpretations of impact were discussed, variables were also grouped by the possibility of improvement in order to provide a more useful way of intervention by employers. Where, through statistical analysis, it was revealed that workers' needs can be short-listed into six different groups. Five of these six groups have financial rewards as the most important reward. As for the separating factor, the rank of the social reward on the importance list determined the clustering of workers within a group.

Lastly, reward importance, or the workers' needs for the financial, developmental, social, and personal rewards, were also provided. Where it was found that workers prioritize financial rewards higher than any other category, and deemed personal reward as the least important category. The researcher also conducted cluster analysis of workers' needs which revealed that workers generally fall under one of six main groups in terms on needs, where financial rewards usually are the most important reward.

These findings should help future researchers as well as employers in understanding how each category of the total reward approach is represented and provided in the industry, how each factor impacts rewards perception, and how to address workers' needs.

3.12 Limitations

While this research contributes greatly to the body of knowledge, it is not without limitations. These limitations limit the generalizability of the results to other populations and indicate areas of future work. First, during the sample size calculation, the margin of error chosen was 0.1 which gives a level of confidence of 90%. Though the researcher believes that this margin of error is adequate, not to mention that it has been used successfully in similar studies, it should be noted as a limitation. Second, the impact of the variance of the dependent variables (unobserved heterogeneity) on reward perception was not accounted for during the development of the ordered probit model. Future work should account for the variance by using a random parameter ordered probit model. Third, in the portion of the survey analysis that addressed reward satisfaction, a single measure of satisfaction was used for all the rewards received by workers. This limitation, though likely minor, does not allow for estimating workers' perceived satisfaction with each reward a worker receives, and should be addressed in future research. Fourth, given that a worker's needs and perceptions change over time, prediction of future behavior cannot be made for the long term. Nevertheless, over the short term, the finding of the study should hold true. Finally, to be able to reach workers across all of the states, and to maintain participant anonymity, an online survey questionnaire was utilized. Thus, validation of what workers receive in their occupation cannot be made. Answers and measures were based on worker's judgements with respect to their job.

For future work, the researcher recommends constructing a dynamic reward system that not only considers the nature of each type of reward, but also the impact of time on satisfaction. Therefore, the researcher suggests the Kano model for this task. Although the Kano model is mainly intended for customer satisfaction, to the best of the researcher's judgment it can also be applied to address and improve worker satisfaction. Also, when designing a worker reward system and given that this study was limited to one measure of satisfaction for all rewards, the researcher suggests clustering reward importance for each category (financial, social, developmental, and personal) as well as the corresponding reward satisfaction measure for a better representation of worker's assessment.

4 CONSTRUCTION SAFETY RISK AND OCCUPATIONAL REWARD PERCEPTION: FROM UNKNOWN TO UNDERSTOOD

The contents of this chapter are an extended version of work currently under review for publication in the American Society of Civil Engineers (ASCE), *Journal of Construction Engineering and Management*[3].

4.1 Summary

With the dynamic nature of construction and the ever-changing site conditions, the construction industry needs a method to assess the level of safety risk in construction that takes into account these industry characteristics. Risk perception has been used as a measure of safety risk in construction and has been applied in various forms and in different risk assessment methods. Meanwhile, rewards have been shown to have a significant impact on a person's decisions and behavior. Nevertheless, there is a general lack of attention to the potential impact of the risk/reward perception and relationship and their implication in construction safety research. This study aims to address this knowledge gap by: (1) conducting a thorough literature review of the topic to illustrate the missing information in the field of construction safety, and (2) conducting a data-driven study that focuses on risk and reward perceptions in terms of correlation, and the potential implications on a worker's decisions with respect to safety. Using statistical analysis, the study examines how workers think about risk and reward, as well as the interaction between a worker's perceptions of risk and reward. The research findings provide strong evidence that construction safety risk and occupational rewards perception are correlated in their assessments by workers. Furthermore, using an ordered probit modeling technique, safety risk was statistically found to share four different underlying variables with reward perception. The study results also indicate that construction workers do not have a clear understanding of the risk-reward relationship where, collectively, they were not able to identify the type of relationship risk and reward have. On the other hand, through statistical correlation, reward

[3] Azeez, M., Gambatese, J., and Hernandez, S. (2019). "Construction Safety Risk and Occupational Reward Perception: From Unknown to Understood". *Journal of Construction Engineering and Management,* ASCE. [Submitted on Dec. 2019]

perception was found to be correlated with multiple facets of risk perception. The findings of this study draw attention to the way that risk perception should be examined in construction safety, and how research addresses risk perception. The findings also provide evidence of why workers might proceed with an activity after accurately assessing the risk it involves.

4.2 Introduction

While safety improvements have been made in the construction industry, construction still experiences one of the highest number of fatalities annually compared to other industries in the United States with over 970 fatalities in 2016 alone (BLS, 2017). With the aim of improving safety on construction sites, safety professionals try to understand how accidents occur in order to prevent them from happening (Hinze, 1997). Though models of accident causation have migrated from blaming workers for accidents (such as in the Accident-Proneness Model and Distraction Theory) to more of a system failure causation (such as the Swiss Cheese Theory and Domino Theory), all of the models fall into one of two classes: those that focus on human failure and those that focus on system failure. However, researchers have argued that system failures can also be attributed to human failures (Gambatese et al., 2016). In construction, causes of accidents have been identified to be either: 1) worker inability to identify hazards, 2) identifying hazards and disregard for their impact, or 3) worker disregard for the safety conditions of their worksite (Abdelhamid and Everett, 2000).

The first cause listed above relates to risk perception, which has been properly and extensively addressed in previous studies (Vahed, 2015, Habibnezhad et al., 2016, Jeelani et al., 2016). Researchers have recommended better ways of introducing hazards to workers (Jeelani et al., 2016, Namian et al., 2016), and better ways of helping workers visualize those hazards and improve their situational awareness (Namian et al., 2016, Alomari et al., 2017). With respect to acting in an unsafe manner regardless of the safety conditions on their worksite, this cause of accidents can be attributed to a poor safety culture. Studies have shown that a positive safety culture motivates workers intrinsically to work safely (Wen Lim et al., 2018). More discussion regarding unsafe behavior and safety culture in construction can be found in the work of Dester and Blockley (1995).

The cause of accidents in which workers successfully identify the hazard, yet disregard its potential impact, is intriguing. Workers are trained to identify hazards in their job, and trained to mitigate the hazards in a proper manner that ensures their safety. Given their training, a question then arises as to why a worker would ignore a risk that they have identified and bear the possibility of an injury.

This question might be answered with a better understanding of how decisions are made. One of the prominent models used to understand decision-making is the situational awareness model presented by Endsley (2015). Though the model has evolved over time, the situational awareness model divides the decision-making process into three main components (as shown Figure 1.1): perception, comprehension, and projection. These three steps lead to a decision that a person, i.e., a worker in the present case, would make in a certain situation. The situational awareness model also indicates that there are many factors that impact the decision-making steps. These factors are either environmental such as system capacity and stress, or individual such as goals, preconceptions, and experience.

By examining the situational awareness model, it can be seen that the perception of an element in a current situation is only one part of the decision-making process. A decision is made after perceiving, comprehending, and projecting the impact of that decision, all the while being impacted by external factors. As such, it is not surprising that perceiving a certain risk does not necessarily equate to avoiding the risk. It should be kept in mind that not every risk is avoidable, nor do individuals completely avoid this decision-making process and accept risk regardless of the circumstances.

Safety professionals and academics have studied and used the situational awareness model to improve safety (Tixier et al., 2014). However, a problem with past studies remains that the main focus of the decision-making is risk perception and ways to improve it. A key factor might be missing from those studies, which is "*people are willing to suffer harm if they feel it is justified or if it serves other goals*" (Renn, 1989). This willingness to suffer in order to attain a benefit will be discussed further below.

While it is not believed that construction workers act in an unsafe manner intentionally (Tixier et al., 2014), it has been shown that preconceptions in risk perception cause risk misjudgments which in turn might cause unsafe conduct (Arezes and Miguel, 2008). The problem lies in a common misconception that the higher an individual's level of competency in risk perception, the more likely they will work in a safe manner. However, Mullen (2004) indicated that being aware of the risk associated with one's work does not necessarily mean that he/she will adopt safe practices in their work. Mullen (2004) noted that employees often weigh the negative aspects of their jobs against the positive aspects. This comparison made by workers provides the impetus for the present study and contribution to construction safety research. The topics of rewards and the perception of reward have not been studied extensively in construction (Azeez et al., 2019), nor have the topics been directly linked to construction safety. The present study cross-examines reward perception along with risk perception to determine how construction workers understand the risk-reward relationship and how that relationship is represented in their perceptions of risk and reward.

To further clarify the study focus, it is perhaps helpful to illustrate the issue by describing some general everyday situations. For example, when crossing a road, people may not always remember to look left and right to assess the risk; what is on their mind is, generally, getting to the other side. This example represents, in simple words, the relationship between risk (e.g., getting hit be a car) and reward (e.g., crossing the road promptly). Other examples are driving a car over the speed limit or simply driving a car fast. While driving a car at a high rate of speed carries a lot of risk, some people may drive fast for the rewards that it can bring, such as satisfaction, freedom, and/or self-enhancement. Young drivers may even consider it as a testament of their driving skills (Cestac et al., 2011). Again, both risk and reward are being considered together. Lastly, consider x-rays, for example. People are willing to have x-rays taken of themselves even though they are aware of the risks of radiation; that risk is easily overlooked given the benefits that can be gained from the x-rays (Slovic, 1996). In construction, one common example of the trade-off between risk and reward that is often cited, and specifically mentioned to the researcher during in-person interviews with workers in the present study, is related to using a ladder. Many workers mention that they are willing to step on the last (highest) step of a ladder, which they know to carry an additional risk, is not recommended by the ladder manufacturer, and may be contrary to their safety training. This willingness is often based on the benefit of saving time and effort compared to finding another, taller ladder to use.

Therefore, it is of paramount importance to diagnose reward perception and its effect on risk perception in order to address and improve worker risk taking behavior, and ultimately improve worker safety. The current study is intended to address this issue. The study begins with an extensive literature review on the topics of risk perception, reward perception, and their interaction. The results of the literature review are then used to inform the design of a survey of construction workers located across the United States. This manuscript presents the literature review and survey design, along with the survey results, analysis, and discussion of the results. Finally, conclusions and recommendations are presented alongside the limitations of the study.

4.3 Literature Review

Before diving into the details of the risk-reward relationship, and how it is manifested in various fields of research, it is of a high importance to describe and define each of the terms. Provided below are detailed explanations and definitions of the main concepts related to risk and reward, and to their relationship.

4.3.1 Risk

While the concept of risk is believed to be an invention of humankind to deal with and interpret the uncertainties and the dangers of life (Slovic, 1999), the concept has been in use ever since by decision-makers (Slovic, 1987). Risk, therefore, is not an exact value. “There is no such thing as ‘real risk’ or ‘objective risk’” (Slovic, 1992). Even the risk assessed by engineers through probabilistic models to provide quantitative estimates, for example, is based on theoretical models (Slovic, 1992). Subjectivity and assumptions are inherent in people’s assessments of risk regardless of whether they are engineers, scientists, risk managers, or involved in risk assessments in any way.

Risk has been explained differently in different fields of study. Defining risk is often described as an “exercise of power” (Slovic, 2001) and “whoever controls the definition of risk controls the rational solution to the problem at hand” (Slovic, 1999). An example related to defining risk is the number of deaths per million tons of coal produced. Using this value to quantify risk might give an impression that the coal industry is safe, while deaths per thousand coal mine employees is rising and the industry is suffering from poor safety performance (Slovic, 1999).

In the context of project management, risk has been defined as: "the quality of a system that relates to the possibility of different outcomes" (Schuyler, 2001). Risk is also used informally to refer to a large, unfavorable potential consequence, i.e., risk of failure (Schuyler, 2001). In finance, where quantitative data are used, risk is often recognized as being related to the variance or standard deviation of the expected outcome (Damodaran, 2003).

In the field of psychology, risk is often described as having a different meaning for different people (Slovic et al., 1982). Slovic (1999) argued that risk is a social construction of real danger. Renn (1998) defined risk as a mental depiction of a danger that is capable of causing actual loss.

In the construction industry, risk carries the same meaning as in other industries, plus more specific interpretations such as variation in productivity, uncertainty in material availability and site conditions, and fluctuation in material prices. Besides safety risk, contractors bear the burden of different risks when executing a project, such as unexpected soil conditions, soil contamination, material unavailability, labor shortage, and inadequate design (Seidell III, 2002). In general, it can be said that risk in construction is the potential impact of unforeseen or unplanned events on the planned goals of the project (Zou et al., 2007).

With respect to construction safety, there is general consensus on the quantitative assessment of safety risk (Hallowell and Gambatese, 2009), where unit risk is calculated by multiplying the frequency of an injury incident occurring due to a hazard by the severity of the injury incident. The aforementioned definition of safety risk is one of many others mentioned (Popov et al., 2016). Jannadi and Almishari (2003) calculated safety risk in activities as the product of probability, severity, and exposure. In a safety system, risk cannot have a value of zero; however, risk can be systematically reduced to a point that is considered "safe" (Tolbert, 2005). Safety, as a result, can be defined as the absence of unacceptable risk.

With that said, it can be clearly seen that risk has different meanings in different fields, and each definition has its own limitation within that field. Risk also has different meanings to different people in the same field. Experts in a field might view risk differently than those who are new to the field or who work in a different profession within the field. The realization that risk is person-specific, leads to the topic of risk perception.

4.3.2 Risk Perception

Risk perception has been a subject of study for decades. For example, researchers and policy makers have studied people's perception of various risks as a way to design policies and communication programs for educating the public about new technologies (Fischhoff et al., 1978, Slovic, 1987). As for what "risk perception" means, in simple terms, risk perception can be defined as the individual assessment of the hazards a person faces day-to-day (Sjöberg, 2000). It is important to understand that risk perception is not the same as perceived risk. Risk perception reflects a person's ability to perceive risk, whereas perceived risk is the assigned value for a certain risk/hazard perceived by a person. In simple terms, risk perception is the process of assigning value for risk, and the perceived risk is the value assigned to a certain risk. The main premise for using worker risk perception as a measure of occupational safety risk is that worker risk perception is influenced by the same factors that affect their perception of risk in their day-to-day lives (Weyman and Clarke, 2003). Additionally, studies have found that construction workers are highly capable of assessing their work safety risk (Hallowell, 2008). Finally, a worker's risk perception is often assessed through self-reported questionnaires (Visschers and Meertens, 2010, Chen and Jin, 2015).

4.3.3 Reward and Reward Perception

A reward is often used to describe a bonus for excellent performance. In scientific research, however, this depiction of the term is both impractical and incomplete (Schultz, 2015). From a neurological point of view, the human mind contains a system referred to as the "reward system" that is responsible for signaling information related to rewards, among other things (Pessoa and Engelmann, 2010, Schultz, 2015). Schultz (2015) stated that "rewards are the most crucial objects for life. Their function is to make us eat, drink, and mate." Schultz continued by stating that a reward can be a stimuli, object, event, activity, and situation.

In finance, reward is the expected outcome of an investment, where the better investment is considered to be the one that generates a higher return than expected with a lower standard deviation (Damodaran, 2003). In the field of psychology, the term "benefit" has often been used instead of reward. Studies in psychology have focused on the societal and personal benefits of various technologies, such as nuclear power, x-rays, and nanotechnology, and how these benefits impact reward perception (Alhakami and Slovic, 1994, Finucane et al., 2000, Siegrist et al., 2000). Early studies calculated benefits based only on the monetary cost savings to the public or the price that the public is willing to spend to save money (Starr, 1991).

In other fields, reward and benefit are defined as: "positive outcomes associated with a service" (Dibert and Goldenberg, 1995). Some of the types of occupational rewards that have been identified include: the ability to self-improve and improve others (feelings of effectiveness); increases in knowledge and skills; remaining motivated; carrier progression possibilities; professional/financial recognition and success; and flexible, diverse work (Kramen-Kahn and Hansen, 1998, Hyrkäs and Shoemaker, 2007).

From an organizational point of view, reward has a more general definition, though it is sometimes inconsistently presented. Occupational reward is considered as anything of value (tangible or intangible) that an employer or an organization delivers to its employees whether intentionally or unintentionally in contemplation of the employee's work contributions (Henderson, 2003; Shields et al., 2016) and "to which employees as individuals attach a positive value as a satisfier of certain self-defined needs" (Shields et al., 2016). A thorough examination of literature describing occupational reward revealed that reward is viewed in many different ways, including: intrinsic, financial, employee valuation, fringe benefit, and promotion studies (Azeez et al., 2019).

With respect to occupational safety and construction safety research, reward is often used when talking about safety incentives and how to recognize safety performance milestones (LaBelle, 2005, Karakhan and Gambatese, 2018). Under that definition, reward is commonly limited in scope to what is referred to as “performance-related pay.” However, based on the concept of reward presented in literature, and specifically occupational reward, reward is broader in nature and types of rewards should include more than just performance-related pay to reflect all of the different types of benefits received by a worker. Therefore, in recognition of present literature, the concept of “total reward” is used in this study to define reward as it brings a contemporary and inclusive understanding of reward. The total reward approach provides, in an organized and distinct manner, a clear understanding of reward where there is no overlap between each category of rewards and a clear definition of each of its components. The total reward approach overlaps with the neurological view of rewards in which it includes various aspects of reward that cover stimuli, object, and event.

The researcher believes that the definition of reward should include more than performance-related pay, and that benefit might not be an appropriate term to describe occupational reward in general. “Benefits” is often used to refer to what an employer provides to employees, often limited to such items as medical insurance, retirement contributions, and personal leave, and excludes the total of what the workers/employees actually receive from their employment. Additional benefits may be realized and gained by employees. For example, camaraderie may be a highly-valued reward for workers, but it cannot be provided by an employer. Therefore, the term reward as used herein refers to occupational reward (tangible and intangible) that workers perceive whether offered by the employer or not.

As for reward perception, the researcher was not able to find an exact definition of reward perception in the literature. However, similar to risk perception, reward perception can be viewed as an individual’s assessment of the rewards that they receive. Therefore, for the purposes of this study, reward perception was defined as a worker’s valuation of the total returns received from working in their job whether the returns are provided by the employer or not. As with risk perception, reward perception is different than perceived reward. Reward perception is associated with competency in recognizing rewards, and perceived reward reflects the amount and type of reward perceived.

4.3.4 Risk and Reward

Risk perception, as a topic, has been studied extensively with respect to construction safety. Due to the dynamic and complex nature of construction, however, it is very difficult to determine task-specific quantifiable safety metrics (Seo et al., 2015). Therefore, safety professionals in construction often rely on worker perception of risk as a measure of safety (Chen and Jin, 2015). As mentioned above, risk perception is a personal assessment of encountered hazards; therefore, it is very subjective. Slovic (1997) stated that risk perception by the general public is not just subjective, it is "often hypothetical, emotional, foolish, and irrational." Workers, however, are not supposed to have just a layman's view of risk, especially in their personal line of work. Workers are trained and educated about the risk that their work includes and are expected to take measures to mitigate that risk. Consequently, and as mentioned previously, the risk perception of construction workers has a strong presence and usage in both the construction industry and academia.

Early studies have viewed risk perception within the context of safety culture (Dedobbeleer and Béland, 1991). It is expected that risk perception would be related to safety culture given that risk perception is generally influenced by psychological, social, cultural, and political factors (Slovic, 1997). Initial research dedicated to workers' perceptions of safety risk was conducted in the early 1990s found that construction workers underestimate their work hazards (Helander, 1991). Later research by Hallowell (2008) indicated that workers are able to adequately assess the risk in their own work. Similarly, Schafer et al. (2008) argued that management personnel usually overestimate safety on their worksites, while Hallowell (2010) revealed that management personnel complain about workers' violations of safety standards and that construction workers tolerate five times the acceptable level of safety risk. Risk perception has been assessed and measured in research using one of three ways: 1) multiplying frequency times severity to calculate risk, where the researcher asks workers to assess the frequency of an injury incident associated with a hazard as well as the expected severity of that incident (Hallowell, 2008); 2) asking workers to identify hazards in a work scenario (Vahed, 2015); and 3) asking workers to self-assess safety risk using a Likert scale (Rodríguez-Garzón et al., 2014). While each method has been used multiple times in different studies, the commonality between the methods is that risk perception is often measured by using self-assessed questionnaires (Visschers and Meertens, 2010).

Examples of risk perception studies include studying the relationship between risk perception and training. For example, Rodríguez-Garzón et al. (2014) found that training impacts the level of risk perception. Workers with more training scored higher on the measures of risk perception employed in that study. Moreover, Namian et al. (2016) indicated that the training format also impacts a worker's risk perception where interactive and worker-oriented training yields a higher level of safety risk perception. Chen and Jin (2015) conducted a comparison between the risk perception of general contractors' workers and subcontractors' workers. The results of the study indicated a higher level of safety risk perception among general contractor workers when compared to subcontractor workers. In another study, Zou and Zhang (2009) conducted a comparison between construction workers' risk perception in China and Australia. Finally, Choe and Leite (2016) focused on construction workers' risk perception across different trades where it was found that each occupation has its own unique characteristics with respect to risk perception.

As for occupational reward, there are a small number of studies that discuss in detail the impact of reward perception on workers. For example, Lawler and Porter (1967) studied the impact of reward perception on worker performance and attitude. The researcher found that reward perception positively impacts worker effort which in turn impacts their performance. Reward has been studied as a source of creating a motivated workforce (Shields et al., 2016). Similarly, rewards, and the way they are perceived, have been studied in construction with regards to motivation, compensation systems, and the desire to balance the effort-reward relationship (Boutilier et al., 1995, Druker and White, 1997, Lehr et al., 2010). In construction, the researcher found a few studies that address construction worker rewards and their reward perception. However, in all of the studies found, construction workers appear to be satisfied with their benefits (Rowings et al., 1996). Rewards, however, have been rarely examined for their impact on safety. Most of the studies, as mentioned above, limit their definition of reward to performance-related pay programs, also known as safety incentive programs. Similar to risk perception, reward and reward perception are often assessed using self-assessment questionnaires.

4.3.5 Risk-Reward Relationship

Risk and reward are at the heart of many studies in psychology, neurobiology, and business/economics. It is important to study risk and reward together, where most of the decision making under uncertainty lies in the balance of these two concepts. While risk and reward might have different meanings in different fields, throughout a particular field, risk and reward are linked. As mentioned previously, in finance, reward is the expected outcome of an investment and risk is the variance of that outcome. The link between risk and reward is important when people are making a decision, including in the workplace. People tend to avoid risk for losses, and seek risk for gains (Hayden and Platt, 2009). Some researchers have even argued that the consequences or costs of an event are weighed in the human brain against the benefits expected before a motor response is committed (Pessoa and Engelmann, 2010).

Neurology studies, through the use of advance Magnetic Resonance Imaging (MRI), have shown that "the primary task of the brain reward system is to convey signals of upcoming stochastic rewards, such as expected reward and risk, beyond its role in learning, motivation, and salience" (Preuschoff et al., 2006). Furthermore, studies have shown that reward has a higher neuron dopamine response when compared to risk, meaning that rewards are a higher stimulus in the human brain when compared to risk (Schultz, 2010). Studies have also shown that offering monetary rewards for cognitive tasks caused an improvement in observed behavioral performance, as well as an increase in brain activity in the regions that are responsible for perceptional and cognitive function (Pessoa and Engelmann, 2010).

One of the fields that has studied this relationship extensively since the 1960s is the field of psychology and decision-making. A study by Starr (Starr, 1969) aimed to investigate risk indicated by fatality rate with benefit calculated in monetary value. A person, for example might choose to travel in a motor vehicle compared to a train or an airplane. While traveling via motor vehicle may be riskier, it may be less expensive and therefore have greater monetary value. The Starr study was instrumental in creating a new field of study in risk analysis (Starr, 1991). While the study had its shortcomings, one of them being reliance solely on financial value to calculate benefits (Fischhoff et al., 1978), the study helped to create quantifiable means to measure risk and reward. Starr (1969) ultimately developed a numerical relationship illustrating the risk-benefit balance, which is that the risk which people are willing to accept related to technology equals the perceived benefit of technology raised to the third power. Other researchers have approached this topic differently and relied more on an individual's assessment of risk and reward rather than calculating the risk and reward in terms of monetary value (Fischhoff et al., 1978). Findings from several studies reveal that activities and technologies that have a higher risk are assessed to have lower rewards, and vice versa (Alhakami and Slovic, 1994; Siegrist and Cvetkovich, 2000). The researchers concluded that risk and reward (benefit) have a robust inverse relationship across various activities and technologies. That is, an increase of one will decrease the other. Additionally, researchers have indicated that in real life, risk and reward tend to be positively correlated (Slovic et al., 2005). Many studies investigated the risk-reward relationship with respect to different technologies, activities, and domains. For example, Currall et al. (2006) conducted a comparative study about nanotechnology and 43 other industries. In the study, construction, specifically related to large construction endeavors, was found to be of high benefit and average risk in the minds of the general public. Weller and Tikir (2011) examined risk and reward perception among other factors for their impact on risk-taking in various domains, all of which had risk and reward negatively correlated. Of interest to the present study, risk and reward perception were found to be negatively correlated (correlation coefficient = -0.28) in the health and safety domain. Risk and reward were also found to be of moderate strength in predicting risk-taking. Similarly, Siegrist (2000) found reward to have a negative impact on risk perception (correlation coefficient = -0.203). Later research concluded that people's opinions of risk and reward depend on the first impression of their impact. If risk or reward is perceived to be positive, the other one would be perceived to be negative, and vice versa (Finucane et al., 2000). The risk-reward relationship has also been exploited by conducting a Balloon Analogue Risk Task (BART) (Daly et al.) test for risk-taking. In the test, participants might risk popping the balloon, but they are rewarded for pumping more air into the balloon and making it bigger (Bornovalova et al., 2009).

Researchers caution against assessing risk disjointedly from reward since they are often linked in people's minds (Gregory and Mendelsohn, 1993). With all of the available information about the risk-reward relationship, the researcher found only a few studies that mentioned or alluded to the risk-reward relationship in occupational safety. Furthermore, the researcher was not able to find a study dedicated to the relationship in the context of construction safety.

For occupational safety in general, LaBelle (2005) examined the impact of reward on risk, where the researcher warned against using incentives to improve safety without having a clear understanding of how rewarding impacts workers. Labelle (2005) warned that rewards might have a negative impact on safety when improperly managed, and provided examples of when rewarding should be used, and when discouraging can be used, to improve safety. Mullen (2004) studied the personal factors impacting job safety behavior and identified the importance of studying reward in conjunction with risk. The study findings indicated that individuals who knew the health risks that their work involves and the possibility of being injured, were weighing the negative aspects of their work against the positive aspects of their work (income) in order to make a judgement as to whether to proceed with an unsafe practice. Mullen also stressed that this process of comparing the risk of being injured to the good wages and benefits yields a higher chance of accepting unsafe behavior.

Related to construction safety, Karakhan and Gambatese (2018) presented a hypothetical case to assess perceived risk of a certain hazard. The researchers explained how the perceived reward associated with an action related to a hazard reduces the total level of perceived risk in that hazard.

Other examples of studies exist that illustrate a connection between risk and reward, though that connection is never directly stated. For example, Dao et al. (2018) utilized the BART test in a study related to construction safety. As stated previously, this test explores personal risk-taking for reward. The study by Dao et al., however, examined civil engineering students' risk-taking behavior and how the behavior relates to risk perception. Furthermore, Schafer et al. (2008) considered training, which is part of rewards, and motivation, which is one of the goals of rewards, as the key factors in preventing accidents. Again, the risk and reward relationship is not directly stated, but the manifestation of that relationship was present. Popov et al. (2016) considered inadequate reward or recognition as a psycho-social hazard and among the common hazards impacting worker safety. Lastly, NIOSH's (2016) new campaign titled Total Worker Health® (TWH) is also worth mentioning here. The aim of TWH is to address workers' health beyond that required by the OSHA regulations. Some of the issues listed in the TWH concept have an extensive overlap with the total reward concept, such as: worker recognition, career and skill development, financial and job security, and work-life balance.

4.4 Problem Statement / Research Gap

As stated previously, the use of risk perception is very common in construction, whether it is in job hazard analysis reports prepared by workers before new tasks, or by relying on experts' opinions in estimating risk. The common consideration of risk perception does not necessarily mean that risk perception is devoid from bias or unaffected by exterior influences. On the contrary, with all of the studies that have been conducted to identify factors impacting people's risk perception, researchers have failed to identify a single factor that is more significant when compared to another in terms of their impact on perception (Nathan, 2010). Similarly, the concept of reward and its application have been a topic of studies for decades, as described in literature, with various applications and utilizations. Reward has been shown to be impacted by a variety of factors such as age, stress, organization culture, and other individual and organizational characteristics. Furthermore, the abundance of literature supporting the risk-reward relationship in peoples' minds cannot be transferred to construction directly since findings in other industries cannot be used to draw conclusions with regards to safety in construction (Weber et al., 2002, Rodríguez-Garzón et al., 2014, Choe and Leite, 2016). Therefore, a dedicated study in construction is needed. To start understanding the impact of the risk-reward relationship on construction safety, it is important to understand how that relationship effects people. The researcher generally noticed four important knowledge gaps:

1- Workers' understanding and perception of risk and reward;

2- The extension of the risk-reward relationship to the decision-making process regarding safety risk-taking;

3- The magnitude of risk-taking/risk normalization on construction sites caused by the risk-reward relationship; and

4- Methods to limit, and/or eliminate, risk-taking caused by a risk-reward imbalance.

While all of these four gaps in knowledge are important to develop a full understanding of the risk-reward relationship in construction, only the first one will be addressed in this study.

4.5 Research Method and Survey Design

After reviewing the available literature on the study topic, it is apparent that risk and reward are linked, and people associate risk and reward in their minds. Given that perception and its assessment are often examined through self-assessment surveys and the goal of this study is to examine the perceived relationship, to stay consistent with literature, the researcher selected self-assessment surveys as the method of data collection for the study. Furthermore, the researcher aims is to examine the risk-reward relationship as it is stated by workers, and as it is presented through statistical analysis for comparison.

Starting with the stated risk-reward relationship, it is important to determine how workers think about risk and reward, including whether they are linked or not in decision-making, and in what direction that link is (i.e., positive or negative correlation). The need for determining the direction of the link is because the industry does not have an established baseline for the relationship, and to the best of the researcher's knowledge, this is the first study solely aimed at addressing this issue.

The second step is to examine the attributes of risk perception for construction workers against the workers' perception of reward satisfaction. The measures of risk perception that are utilized in this study have been developed and examined in previous studies of construction safety. The importance of selecting measures that have been previously developed lies in the utilization of work validated in construction rather than establishing new measures that have not been verified. In the present study, the work of Rodríguez-Garzón et al. (2014) was selected because it offers nine different attributes of risk perception that are based on of earlier work in decision-making and psychology (Fischhoff et al., 1978; and Rohrmann, 1999). The nine attributes are: 1) worker's knowledge of safety, 2) company's knowledge of safety, 3) fear of accident, 4) personal vulnerability, 5) potential consequences, 6) preventability of risk causing the accident, 7) possibility of worker intervention, 8) potential to impact a large number of workers, and 9) long-term potential of risk. The researcher also added another measure of safety risk perception in which participants were asked to personally assess how safe their current work is. This additional measure will also be used when comparing risk to reward perception, and will be assessed using a question that asks how satisfied workers are with their rewards based on a Likert scale of 1 to 7. For more details, please refer to the survey design section below.

4.5.1 Empirical Setting

Similar to the work conducted in the second manuscript, the research described in this manuscript will also utilize the capabilities of the ordered probit model to understand the underlying factors of both risk perception and reward perception. Therefore, to examine the equations and the underlying mathematics, please refer to the empirical setting section in the second manuscript.

4.5.2 Variable Selection

The variables selected to understand the underlying factors impacting risk and reward are the same variables selected in the second manuscript. Please refer to the variable selection section in the second manuscript.

4.5.3 Survey Results

This manuscript utilizes the same survey responses used in the second manuscript. Please refer to the survey results section in the second manuscript.

4.6 Risk Reward - Stated Relationship

To examine the impact of risk and reward, it is best to start with how workers think risk and reward are connected, whether positively, negatively, or not connected at all. Workers were asked to answer the following question: For safety risk and occupational reward, if one increases, the other would: A) Remain the same, B) Decrease, or C) Increase. As for the results, Figure 4.1 shows that most workers (by a very small margin) felt that risk and reward have a negative relationship. While perceiving risk and reward to be negatively correlated is very worrisome, it is, at the same time, similar to what the general public think about the risk and reward relationship (Alhakami and Slovic, 1994). The second-most frequently given answer was increasing risk or reward will not affect the other. This relationship might be true in very few cases. For instance, workers who are working in a very safe environment and have a high reward perception might feel that a risk increase will not affect his/her assessment of reward. The opposite may be correct too, where if a worker is working in a high safety risk situation (e.g., an ironworker working at a high elevation), the worker might not feel safer if their reward is greater, or even less. Nevertheless, the literature shows no evidence to back up the assessment of disassociation between risk and reward. A small portion of workers in the survey, less than 25%, felt that risk and reward have a positive correlation where if risk or reward increases, the other will follow suit.

The general observation that can be made about the workers' responses is that a convergence or consensus was not reached. There is no clear answer that is significantly agreed upon by the respondents compared to the other two answers. Also,

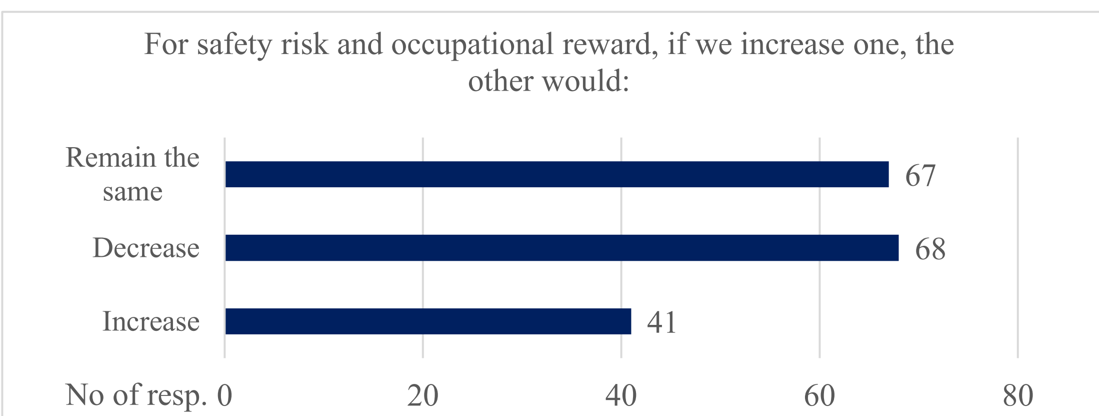

Figure 4.1: Perceived relationship between risk and reward (n = 176)

the close margin between the first (remain the same) and second (decrease) answers is too low to ignore. The researcher conducted a Chi-Square goodness of fit test to determine if the observed answers are random.

The Chi-Square test revealed, with moderate statistical evidence (P-value = 0.0462), that the answers related to the risk-reward relationship are not random. Table 4.1 provides the details of the test.

Table 4.1: Chi-Square Goodness of Fit Test for the Stated Risk and Reward Relationship

	Increase	Decrease	Remain the same	Total
Actual Observed Responses	41	68	67	176
Expected Random Response Chance	0.33	0.33	0.33	1
Expected number if random	58.67	58.67	58.67	176
Null Hypothesis	Observed responses = random responses			
Degrees of freedom = number of groups -1 = 2				
Chi square statistic = sum ((observed - expected) ^ 2 / Expected)				
Statistic	7.9886			
P-value	0.0462			
Result: Moderate evidence that this answer distribution is different from a random guess.				

As a result, it is clear that workers do not have a clear understanding of how risk and reward are linked in the construction industry. Therefore, a more detailed examination is needed to understand how construction workers assess risk and reward.

4.7 Risk-Reward - Revealed Relationship

While asking workers for their assessment of a subject is important, it is of high importance to verify and cross-reference those assessments. In this study, workers were asked to assess various measures of risk and reward. Given that job satisfaction includes reward satisfaction and the social and cultural aspects of employment that constitute work values (Kalleberg, 1977), the researcher elected to include job satisfaction as an added measure for investigating the risk and reward relationship. This measure was assessed based on a 7-point Likert scale where 1 equaled “very satisfied with my job,” and 7 equaled “very dissatisfied with my job.”

For risk, the researcher utilized the nine measures of risk perception developed by Portell and Sole (2001) based on the work of Fischhoff et al. (1978). These measures have also been used multiple times to assess construction workers' risk perception (Rodríguez-Garzón et al., 2014, Rodríguez-Garzón et al., 2015, Forcael et al., 2018). The nine measures are self-assessed measures of safety risk perception (based on a 7-point Likert scale) that ask workers to assess:

- A1) their knowledge of safety and health;
- A2) their company's knowledge of safety and health related to the worker's risk;
- A3) the fear of potential harm from their work;
- A4) accident likelihood (personal vulnerability);
- A5) the consequence severity if an accident happens;
- A6) the potential to control the risk that can cause an accident;
- A7) the intervention potential of an existing situation;
- A8) the catastrophe potential in terms of the number of workers who can be impacted by the accident; and
- A9) the immanency of the impact of occupational risks.

Finally, the researcher also asked the workers to assess the overall risk in their job using a 5-point scale which will act as the overarching assessment of risk. Table 4.2 presents the descriptive statistics of the aforementioned measures of risk and reward.

For scale reliability and internal response consistency examination, the Cronbach Alpha coefficient was calculated (Cronbach, 1951, DeVellis, 2016). The results of the analysis revealed an alpha of 0.702, which is considered reliable in most fields (Taber, 2018) as well as in construction (Goldenhar et al., 1998, Gillen et al., 2002, Qiang Chen et al., 2010).

While this study is not about examining workers' risk perception or reward perception individually, it is important to shed some light on how workers view their jobs. A general observation that can be made based on the responses is that most workers felt that their jobs are relatively safe as shown by the general safety assessment. Similarly, workers, in general, felt very satisfied in their jobs as well as their occupational rewards. There are two answers that might cause some worry, even though most workers felt relatively safe in their jobs: the low assessment of fear of an accident, and the assessment of risk being mostly immediate. Workers assessed their level of fear of an accident to be below average (3/7), which might be associated with the worker's feelings of being in control (Dikmen et al., 2018). The assessment of the safety risk immanency to be very immediate is a bit worrisome also. The assessment of risk is relevant to the respondent's job, and the most physically demanding job might cause some latent impact. Moreover, without knowing the actual job conditions of each worker, one cannot definitely conclude that the result is an accurate assessment or if this measure of risk is underestimated by the workers. Therefore, a future study in that regard is highly recommended.

Table 4.2: Descriptive Statistics of Risk and Reward Perception Variables

Risk and Reward Perception Variable	Mean	Median	Stand. Dev.	Scale
A1: Worker's knowledge of safety	2.06	1	1.39	1 = very high level of knowledge, 7 = very low level of knowledge
A2: Company's knowledge of safety	2.00	2	1.27	1 = very high level of knowledge, 7 = very low level of knowledge
A3: Fear of accident	2.93	3	1.72	1 = very little fear, 7 = extreme fear
A4: Personal vulnerability	3.32	4	1.68	1 = extremely unlikely, 7 = extremely likely.
A5: Potential consequences	4.45	4	1.57	1 = low impact potential, 7 = very high impact
A6: Preventability of risk causing the accident	2.71	2	1.53	1 = extremely preventable, 7 = extremely unpreventable
A7: Possibility of worker intervention	2.93	3	1.55	1 = very high possibility, 7 = very low possibility
A8: Potential to impact a large number of workers	2.98	3	1.80	1 = very low level of impact, 7 = very high level of impact
A9: Long-term potential of risk	1.84	1	1.25	1, immediate impact, 7 after a very long time
GSA: General safety assessment	4.02	4	0.97	1 = very unsafe, 5 = very safe
Reward perception	1.85	2	1.13	1 = very satisfied with reward, 7 = very dissatisfied with rewards
Job satisfaction	1.95	2	1.09	1 = very satisfied with my job, 7 = very dissatisfied with my job

To examine the risk-reward relationship from a more detailed perspective, and given that the variables in question are categorical variables, the tetrachoric correlation was utilized to assess the correlation between the variables in question (Greene, 2002). Table 4.3 provides the details of the correlation test.

Table 4.3: Correlation of Risk and Reward Perception Variables

	Reward Perception			
Risk Variable	Correlation Coefficient	P-value	Stand. Error	Confidence Intervals
A1	**0.279**	**0.0068**	0.103	0.077, 0.482
A2	**0.261**	**0.0053**	0.093	0.077, 0.444
A3	-0.0013	0.989	0.097	-0.191, 0.188
A4	0.0887	0.322	0.089	-0.087, 0.265
A5	0.1006	0.207	0.079	-0.055, 0.257
A6	**0.286**	**0.0004**	0.081	0.127, 0.445
A7	**0.345**	**<0.0001**	0.077	0.194, 0.497
A8	0.063	0.502	0.093	-0.120, 0.245
A9	0.012	0.901	0.096	-0.177, 0.201
GSA	**-0.452**	**< 0.0001**	0.084	-0.617,-0.286
	Job Satisfaction			
GSA	**-0.393**	**<0.0001**	0.090	-0.57, -0.21

As seen in Table 4.3, reward perception is correlated with various aspects of risk assessment. First and most importantly, there is a negative correlation value (-0.45) between the general safety assessment and reward perception. This result is a relatively high correlation value given that most workers considered risk and reward to be unconnected. Similar results were obtained from a domain-specific study of risk and reward that revealed risk and reward to be negatively correlated in the domain of safety and health at a value of (-0.28). The importance of this correlation lies in its unknown nature, where it might create added risk for workers who are highly satisfied with their job.

While no causation inference can be made from a correlation analysis, it is important to examine reward as a factor for decision-making and risk assessment. Studies have shown that the second main cause of accidents in construction, as previously mentioned, is workers proceeding with a hazardous activity after diagnosing its riskiness (Abdelhamid and Everett, 2000). This cause, combined with the fact that workers have been found to compare the negative aspects of their jobs against the positive aspects before making a decision, places more pressure on company management to understand what factors impact their workers' decision-making. Decision-making and risk-taking have been known to be influenced by external factors. Studies in construction safety as well as other fields have found that task voluntarily (Starr, 1969), worker's emotional status (Bhandari et al., 2016), social trust (Siegrist et al., 2000), and other factors to be of impact when making a decision (Weller and Tikir, 2011).

Pertaining to the first attribute of risk perception and its relationship with reward, it was found to be positively correlated with reward perception (correlation coefficient = 0.28). This result indicates that workers who are highly satisfied with their rewards, also have a high level of knowledge about the safety and health concerns in their jobs. Similarly, rewards and company knowledge of a worker's risk concerns were found to be positively correlated, with a correlation coefficient = 0.26. Workers with employers that are aware of the risky conditions in the worker's job, were highly satisfied with their rewards.

A worker's perception of their fear of accidents, personal vulnerability, seriousness of the consequences, potential catastrophe, and the delayed consequence of the incident were found to not be correlated to the worker's reward perception at a statistically significant level.

Finally, risk preventability and controllability were both found to be positively correlated with reward perception at a statistically significant level, 0.29 and 0.35, respectively. This result means that higher perceived control was associated with higher reward perception, while lower perceived control was associated with lower reward perception. The same result pertains to preventability of risk, where the more preventable the risk was, the higher the perception of reward.

In short, risk and reward were found to be correlated, and linked by the respondents. Knowledge of risk, and having control over it, are linked to having a higher reward perception. Also, over all, workers with less safe jobs were found to be less satisfied with their rewards.

4.8 Risk-Reward – Underlying Factors Relationship

After evaluating the risk and reward relationship as stated, and as independent variables, it is also important to examine the factors impacting risk and reward to understand their potential impacts. A variable can impact risk positively, and impact reward negatively, or vise-versa. Understanding this relationship between variables and both risk and reward is very important when designing a system to optimize the risk and reward balance. As a hypothetical example, assume that promoting workers' control over task execution is a factor in improving workers' reward perception. The same factor might cause the magnitude of perceived risk to increase just by having workers perceive the risk of their task being lower than what it actually is due to the illusion of control.

To investigate this issue, the results of the reward perception ordered probit model analysis presented in the second manuscript are used (Table 3.4, and Table 3.5). Please refer to the Model Results section in the second manuscript.

Detailed results of the ordered probit model for risk perception are shown in Table 4.4. As can be seen in the table, seven statistically significant variables impact worker risk perception, six of which negatively impact worker risk perception, and one variable that positively impacts worker risk perception. Furthermore, none of the sociodemographic variables were found to be statistically significant in the results of the ordered probit model. To better understand the impact of each of the variables on the dependent variable, and similar to the measures conducted in the analysis of rewards, marginal effects were used. Table 4.5 shows the results of the examination of marginal effects.

Starting with job title, respondents who identify as journeyman or tradesman were found to have a 0.164 lower probability of being extremely knowledgeable about the safety and health issues in their work when compared to other workers. This level of knowledge might be associated with having lower control over risk when compared to foremen and crew leaders (Choe and Leite, 2016).

Table 4.4: Estimated results for best fit ordered probit model

Variable Description	Coefficient	T-stat	P-Value
Constant	2.517	9.21	<0.0001
Job title (1 if journeyman or a tradesman, otherwise = 0)	-0.415	-2.23	0.026
Method of payment (1 if per hour, otherwise = 0)	-0.434	-2.17	0.029
Job satisfaction (1 if low, otherwise = 0)	-0.559	-2.38	0.017
Number of elements in training (1 to 7)	0.519	2.80	0.005
Crew size (1 if crew has 4 to 5 workers, otherwise = 0)	-0.558	-2.66	0.008
Number of projects worked on in the last 3 years (1 if 5-10, otherwise = 0)	-0.407	-1.94	0.05
Level of trust in work procedure (1 if extreme, otherwise = 0)	0.792	4.25	<0.0001
Threshold Parameters			
Threshold 1 Mu (01)	0.957	8.19	<0.0001
Threshold 2 Mu (02)	1.408	12.81	<0.0001
Threshold 3 Mu (03)	2.066	16.52	<0.0001
Number of variables = 11 Number of observations = 176 Log likelihood at convergence = -205.373; Log likelihood at zero = -232.0714 Significance level: <0.00001; McFadden Pseudo R-squared: 0.115			

Workers who are at a supervisor or superintendent level are usually paid a salary, while crew workers usually get paid by the hour (AGC, 2017). Other workers who might assess themselves as having a high level of safety risk knowledge are maintenance workers who mostly work on something that they are extremely familiar with. This high level of familiarity with the work might be the reason behind the negative impact.

The job satisfaction variable was also found to be statistically significant, where workers who have low job satisfaction had 0.22 lower probability of being very knowledgeable about safety and health in their work. The lower probability is an expected finding; job satisfaction includes reward satisfaction (Kalleberg, 1977) and job satisfaction was found to be positively associated with risk perception where workers with higher job satisfaction found their jobs to be safer.

Table 4.5: Marginal effects of variables in the best fit ordered probit model

Independent variables	**Risk Perception Level**				
	Below average knowledge	Moderate knowledge	Above average knowledge	High level of knowledge	Very high level of knowledge
Job title (1 if journeyman or a tradesman, otherwise = 0)	0.0216	0.0716	0.0426	0.0283	-0.164
Method of payment (1 if per hour, otherwise = 0)	0.0175	0.0673	0.0458	0.0406	-0.171
Job satisfaction (1 if low, otherwise = 0)	0.0383	0.1053	0.0528	0.0210	-0.217
Number of elements in training (1 to 7)	0.0271	0.0891	0.0529	0.0355	-0.205
Crew size (1 if crew has 4 to 5 workers, otherwise = 0)	0.0363	0.1033	0.0536	0.0243	-0.217
Number of projects worked on in the last 3 years (1 if 5-10, otherwise = 0)	0.0239	0.0736	0.0406	0.0220	-0.160
Level of trust in work procedure (1 if extreme, otherwise = 0)	-0.0490	-0.0140	-0.0757	-0.0408	0.306

With regard to the number of elements in the training program, the results indicated a negative impact of 0.2 on the probability of having a very high knowledge of safety risk. This result does not match what was indicated in the literature, where previous studies have found that having more comprehensive training would translate to higher risk perception. One explanation, though it cannot be verified, is that workers who have more comprehensive training lean towards under-estimating their knowledge. Workers would know their knowledge limits and, therefore, those workers would not self-assess their knowledge to be very high.

As for the number of projects worked on in the last three years variable, this variable is used to measure a worker's mobility and resilience (Chen et al., 2017). Workers who worked on 5-10 projects in the past three years were found to have a 0.16 lower probability of having very high knowledge of safety risk in their work. Though mobility is a measure of rewards (Shields et al., 2016), here it was found to represent a negative impact on a worker's knowledge of their work hazards. This finding might be due to task familiarity, where it was found that being familiar with the work at hand increases the awareness of the risks and improves safety conditions.

Workers who are part of a 4-5 men crew were found to have a 0.22 lower probability of having a very high level of knowledge of the safety conditions of their job when compared to other workers. Having a larger crew requires a higher level of coordination and delegation, which might have an impact on the worker's ability to fully comprehend their job safety conditions.

The last variable is the assessment of trust in the work procedure. The analysis reveals that workers who trust their work procedure have a 0.36 higher probability of having a very high level of knowledge of their job safety conditions compared to other workers. Trust was mentioned to have an impact on risk perception in previous studies, where it was found that trust has a positive correlation with risk knowledge (Siegrist and Cvetkovich, 2000). Trust, along with control over risk, was found to be linked to, and have an impact on, the perception of risk (Das and Teng, 2001).

4.9 Discussion

The use of worker risk perception to evaluate and improve safety performance has been in response to the unique nature of construction. By relying on people's assessments of risk that they encounter in their jobs, researchers and practitioners have improved and are improving construction safety. Similarly, reward perception has been used for decades to motivate workers, and to improve productivity. While the workers' perceptions of both risk and reward are highly useful, they are not infallible. Workers are humans, and humans are inherently susceptible to biases and external influences. These biases, if unnoticed, can create an unknown risk. The lack of knowledge of the risk is the key factor here. By examining the potential relationship between risk and reward, an unknown hazard might become known, or even understood.

Academia has been methodically exploring and illustrating biases and influences in risk perception, whether it is conformance bias, overconfidence, illusion of control, emotional status, or other types of bias (Tixier et al., 2014, Bhandari et al., 2016, Carder and Ragan, 2016, Dikmen et al., 2018). The risk and reward relationship has been found to be of importance and impact in many fields. Popov et al. (2016) even caricaturized inadequate reward and recognition to be a psychosocial hazard impacting work conduction. Yet, the construction industry has yet to examine and characterize that relationship in the industry. What raises the concern even further, is that contractors are attracting new crew members and skilled labor by giving them signing bonuses (Paquette, 2018; Parsons, 2018). While encouraging workers in this way to join their workforce might sound good on paper, the results of studies have cautioned against rewarding workers without understanding the impact of that reward on behavior (LaBelle, 2005). Furthermore, by having workers who do not understand the relationship between risk and reward and its impact on their decision-making, how can they distinguish between signing bonuses aimed to increase productivity and encourage employment and those that are intended to be hazard money (danger money) that are often paid for high risk jobs, which in itself has been found to be significantly correlated with higher accident rates (Sawacha et al., 1999)?

The present research takes the first step in the path of examining risk and reward in construction. While the study did not answer all of the identified questions associated with this topic, it provides the necessary starting point for that discussion, starting with connecting risk and reward through literature followed by the findings of previous work conducted in various fields.

This study examined the workers' understanding of the risk-reward relationship. While it failed to provide an exact representation of the workers' thinking, it shows the lack of understanding of that relationship. Specifically, an almost equal number of workers (approximately 38% of participants) selected either the no-link or the negative relation assessments, while the positive correlation between risk and reward was selected by only 23.4% of the workers.

The next step was to examine the risk and reward relationship through statistical correlations. Nine attributes of risk perception that were previously validated were assessed for correlation with reward perception. Furthermore, job satisfaction and overall safety assessment were added to the examination for added measures. With respect to the overall assessment of safety, the perceptions of reward and job satisfaction were found to be negatively correlated at values of 0.45 and 0.39, respectively. These are relatively high values and do not need to be addressed by future studies. With regard to the individual attributes of risk, reward perception was found to be connected to four out of the nine attributes of risk. Those four attributes are: 1) personal knowledge of safety and health at work; 2) employer's knowledge of worker's safety and health at work; 3) preventive control; and 4) intervention control. On the other hand, fear of accident, personal vulnerability, potential consequences, catastrophic impact, and long term risk potential were all found to not be correlated to reward perception.

As for the reasons behind having only four attributes of risk being correlated to the workers' reward perception, the researcher expects that the other five attributes (immanency of risk, the likelihood of risk to occur, the potential harm from their work, catastrophe potential to others, and the outcome severity) might have been subliminally considered when assessing the worker's knowledge of safety risk in their job. That is, a worker's knowledge of the risks present in their job fed their knowledge of risk attributes when assessing risk and reward; therefore, the only factor that might influence their judgement is the 'external control' that they have over risk. An example of this relationship is when a worker who assesses their job to be of severe consequences, and imminent danger, sees them self to be highly knowledgeable when it comes to the safety risk in their job. Therefore, the assessment of immanency of risk or the severity of risk were not factors in decision-making (preconceived knowledge), while control (which might vary from task-to-task, and job-to-job) is a contributing factor in their decision-making.

Finally, through statistical regression, examination of the underlying factors revealed that risk and reward are linked by three variables that impact both risk and reward perception. Those three variables are: job satisfaction, training format, and type of payment. Type of payment and job satisfaction had a similar impact on both risk and reward perception, where they were found to negatively impact the worker's perception. Training format, on the other hand, was associated with a higher reward perception and a lower risk perception. This mixed outcome also needs to be addressed in future research.

While this study addressed the relationship of risk and reward, there are other issues and questions that need to be addressed in future studies. Research questions that remain unanswered include: Does the risk and reward relationship impact risk-taking? How does this relationship impact risk-taking? What can be done to address and utilize that relationship? A separate study that cross-examines each risk element and each type of reward, similar to what has been conducted by Alhakami and Slovic (1994), is highly recommended.

4.10 Conclusions

Though this study reveals that construction workers do not understand the risk-reward relationship, that relationship does exist, and their perception is influenced by it, as shown by the statistical correlation. The researcher believes that the risk-reward trade-off, although present in every worker's mind, is not the direct cause nor the sole consideration when making every single work decision. Workers do not think about what the construction industry gives them for their work in every situation, such as before climbing up a ladder. But, the researcher believes that workers do think about risk and reward in high risk situations, or when choosing a career path, i.e., carpentry vs. iron work, and construction vs. manufacturing. Therefore, minimizing unnecessary risk-taking, and helping workers realize the actual risk level without being affected by the impact of reward perception on their decision, is critical to ensuring long-term safety. Striking a balance between risk and reward is important, and its importance increases with the higher need for construction workers in the industry where potential crew members are now being given a signing bonus to work with new firms. That benefit adds pressure to their job. Though companies will not be asking workers to work in an unsafe condition, the increase in wages and pay for workers comes with an expected increase in production. Although there are, as described above, many studies that have focused on safety risk perception in construction, the researcher has found only a few studies that include potential factors affecting reward perception. The present study contributes to the body of knowledge by examining the relationship between these two variables as it was stated by the workers and as it was revealed through statistical analysis. The overall findings of this study are:

1- Workers generally lack a clear understanding of the risk and reward relationship. Workers, in almost equal proportions, assess the risk-reward relationship to be either non-existent or to be of a negative nature. A small portion of workers assess the relationship to be positive.

2- Through statistical correlation, it was revealed that the overall assessment of safety risk and the perception of reward are negatively correlated, at a value of 0.45.

3- The knowledge aspects, as well as the control aspects, of risk perception, were found to be correlated to reward perception. A worker's knowledge of risk and the employer's knowledge of risk were found to be positively correlated with reward. Similarly, control over the outcome (both in terms of preventability and intervention) were found to be positively correlated to reward, where the increase in control translates to an increase in reward perception, and vice-versa.

4- Through statistical regression, risk and reward were found to overlap with respect to the underlying factors impacting them. Namely, training format, method of payment, and job satisfaction were found to impact both risk and reward perception. Training format impacted risk and reward differently, decreasing the former and increasing the latter. Method of payment and job satisfaction, on the other hand, had a similar effect on both risk and reward, where they were found to be associated with higher levels of perception assessments.

4.11 Limitations and Future Work

While this study illustrates the relationship between the perceptions of risk and reward, it is important to frame those findings by the following limitations:

The assessments of risk and reward in the study are for all the risks that the worker's job includes. Separate studies dedicated to each of the individual risk assessments and each individual reward category are of high importance to gain a higher level of understanding of the risk-reward relationship. Examples of such studies can include: the impact of implementation of rewards on the assessments of the immanency of risk in construction, or the impact of social reward on the assessment of the consequence severity of accidents in construction. Finally, to give priority to worker anonymity and to gather assessments from across the entire US, an online survey questionnaire was utilized. Therefore, the worker assessments of risk and reward listed here cannot be cross-referenced with the employers of those workers. Collecting and comparing worker assessments and employer assessments are recommended for future studies. Replication of the present study is also recommended to achieve a higher level of certainty in the presented outcomes. While this study had two limitations that need future research, the researcher believes that these limitations does not impact the results of the study, but rather limit the scope of the understanding with regards to the risk-reward relationship that this study offers. Future studies will provide more details and shed light on other aspects of the risk reward relationship.

MANUSCRIPT 4

USING THE RISK TARGET CONCEPT TO INVESTIGATE CONSTRUCTION WORKERS' POTENTIAL BIASES IN ASSIGNING/ASSUMING SAFETY RISK

Mohammed Azeez, and John Gambatese

American Society of Civil Engineers (ASCE), Construction Research Congress (CRC), 2020, Tempe, AZ.

5 WORKERS' SAFETY RISK TAKING AND SAFETY RISK TAKING FOR REWARDS: A MIXED METHOD STUDY IN CONSTRUCTION

The contents of this chapter are an extended version of work that have been submitted and accepted for publication by the American Society of Civil Engineers (ASCE), *Construction Research Congress* (CRC, 2020) in Tempe, AZ[4].

This manuscript will also be submitted for publication in the peer-reviewed *Journal of Safety Research*, published by Elsevier.

5.1 Summary

Construction is one of the riskiest industries in the United States, as well as the rest of the world, with one of the highest fatality and injury rates. While workers may accept the fact that their job creates a higher chance of getting injured, or being involved in a fatal accident, that does not necessarily mean that workers in construction are unconcerned risk takers. To understand risk taking, and what factors into it, a better understanding of a worker's willingness to take risk is needed. This study examines worker willingness to take safety risk and their willingness to take safety risk for a better reward or more of the rewards that their job offers. A mixed-methods approach was utilized to understand workers' perspectives about risk and reward, both numerically and qualitatively.

The results indicate that risk taking is a product of risk perception, comprehension, and projection, while being influenced by accident involvement, age, and reward perception. Furthermore, the study results present five different themes under which construction workers view risk taking. Those themes are: safety is prioritized over reward; high risk for high reward; working for less compensation for better safety conditions is unacceptable; safety is preferred, but more risk is also acceptable; and willingness to work in any job as long as they receive payment for their work. In the qualitative study, cutting corners to get the job done was the most frequently cited reason for taking risk. In the quantitative study, production pressure was shown to have

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no impact on risk taking. The findings of this study contribute greatly to the construction safety field and to knowledge about risk-taking in construction specifically. The outcomes of this study are expected to be of importance to both in field safety managers in the way they address worker risk taking, and to academics in addressing potential impacts and other knowledge gaps related to construction safety.

5.2 Introduction

From a safety system point of view, risk cannot take a zero value, meaning, “Nothing is free of the ability to do harm” (Tolbert, 2005). Such thinking is mainly based on the notion that total safety is unattainable, but having a system with an acceptable level of risk is (Hallowell, 2010). This realization points to reducing safety risk to a level that will not cause an accident to occur. Progressive safety programs have been able to do just that, where programs such as Zero Injury and Zero Accidents control and diminish various risks within a project to such levels that are incapable of causing an injury incident. The manifestation of implementing the programs can be seen when some companies are able to achieve over one million hours worked without an Occupational Health and Safety Administration (OSHA) recordable injury, while other companies have even reached over four million hours of work without an OSHA recordable injury (Wang and Griffis, 2018). These outcomes show that risk in construction, for the most part, can be mitigated to levels that will not translate into injuries to the workers.

While acknowledging that high levels of safety can be achieved, it is also important to take a closer look at whom it was achieved by. Taking a closer look at the contractors that were able to achieve such safety success, it turns out that the companies on the list of over a million hours (or higher) of injury-free work are also on the Engineering News-Record (ENR) top 400 contractors list. This indicates that high levels of safety for prolonged periods of times may currently only be achievable by elite, large contractors. That correlation leaves construction workers who work for non-major contractors, mid-size contractors, and subcontractors, and who are self-employed, working on a temporary basis, small home-building contractors, and smaller companies to endure higher levels of risk in their daily jobs. These groups have been found to be the most vulnerable to injuries (CPWR, 2016), and some have also been found to have lower risk perception when compared to workers in general contracting firms (Chen and Jin, 2015).

In previous studies, construction workers have been found to tolerate higher levels of risk than the company management would prefer (Hallowell, 2010), which results in accidents by acting in an unsafe manner regardless of site safety conditions (Abdelhamid, 1999). While that impacting factor can be ignored, there are a few other factors that come into consideration when making a decision related to safety. Some of those factors have been studied in construction safety research, such as emotional attachments (Tixier et al., 2014), while other factors have not. For example, decision making competency was identified as being impacted by job demands, available resources, risk perception consistency, overconfidence/under-confidence, and exhaustion, among other factors (Ceschi et al., 2018, Parker et al., 2018). Construction was also found to have higher than average cognitive and physical demands compared to other industries (Azeez et al., 2019).

While workers may act to compromise their own safety when considering the positive outcome (rewards) of their job (Mullen, 2004), workers do take risk to get the job done (Lingard, 2002). Workers also take risk because that risky job pays more, what is commonly known as “danger money” (Sawacha et al., 1999). So, are workers taking risk for personal gain? Or, is their decision part of an overall risk-taking culture that is present in construction? These questions demand prompt answers, especially now with the introduction of contractors giving signing bonuses to attract new crew members due to labor shortages (AGC, 2017; Paquette, 2018; Parsons, 2018). If construction workers are receiving signing bonuses for accepting a job with a company, would the workers be able to distinguish between the signing bonus, which is part of occupational rewards, and danger money that is given to workers performing high risk jobs? Furthermore, with respect to the risk taking that would take place, would it be a risk taken due to negligence/ignorance by the worker, or a risk taken to “get the job done” that was influenced by the worker’s sense that taking the risk is expected with the high reward job? This study aims to address this knowledge gap through a better understanding of construction workers’ risk taking. To conduct the study, a mixed methods approach is used to examine, contrast, and compare workers’ responses to gain a deeper understanding of risk taking in construction. The areas of interest in the study are: the impact of the risk and reward relationship on worker willingness to take risk, worker willingness to take risk for occupational rewards, as well as other factors that have been found to impact risk taking. It is important to reiterate what Occupational rewards mean. As defined earlier, Occupational rewards are "anything of value (tangible or intangible) that an employer or an organization delivers to its employees whether intentionally or unintentionally in contemplation of the employee's work contributions" (Henderson, 2003, Shields et al., 2016), and "to which employees as individuals attach a positive value as a satisfier of certain self-defined needs" (Shields et al., 2016). As such, by examining worker risk taking for rewards, a better understanding of worker risk taking can be achieved.

Before conducting the study, it should be mentioned that while risk taking is a domain specific topic, the lack of inclusion of risk taking from other fields in construction risk taking (Tixier et al., 2014) calls for a thorough examination of existing literature regarding risk taking and the consequent decision making. As such, a detailed literature review within the construction industry, as well as other fields of study, was conducted.

5.3 Literature Review

5.3.1 Risk Taking

With the uncertainty associated with many life choices, taking risk is a term that casually comes up to describe the process of making such decisions (Platt and Huettel, 2008). Culturally, risk is associated with a decision, where the word "risk" is derived from an Italian word that means "to dare" (Bernstein, 1996). Taking risk often carries an upside as well; in Chinese, "risk" is denoted by two characters, one meaning "danger", and the other meaning "opportunity" (Damodaran, 2003).

Early studies that focused on risk taking examined gambling and payoff, where the decision would be made based on the subjective function of probability and payoff (Slovic and Lichtenstein, 1968). When a person takes a risk, there is an expectation of a greater outcome. Studies of human behavior have found that when there is a perceived higher chance of success, there is greater risk taking, and actions that have a lower chance of success (i.e., a long-shot) were not as highly sought after (Isen and Patrick, 1983).

Risk taking has been studied in a manager's role in the workplace since risk taking is not considered a gamble, but rather taking a calculated risk. In this instance, calculated is the keyword, where in business, models or trends are often presented and evaluated. In everyday tasks, or gambling, the same level of evaluation and scrutiny might not be achieved and issues are more subjective. A manager's risk taking has been shown to be driven by three mechanisms: 1) risk taking is an essential part of success in decision making; 2) risk taking is the manager's job, not their personal desire; and 3) the emotional aspects associated with risk taking whether thrill, fear, anxiety, stimulation, joy, pain, or pleasure (March and Shapira, 1987).

While people's risk taking has been studied from various angles, two of the main ways that risk taking is examined are: risk taking based on perceived risk and/or reward; and the human factors influencing risk taking, such as emotions, gender, age, personal tendency, etc.

With regard to the factors impacting risk taking, age has been studied and found to have a negative association with risk taking (Vroom and Pahl, 1971). Furthermore, age and the physiological factors that are associated with it have an impact on people's risk taking, regardless of the way risk is perceived or measured (Steinberg, 2004).

Gender has also been studied for its impact on risk taking. For various types of physical and intellectual risk taking, men are more likely to take risks when compared to women (Byrnes et al., 1999). Also, it has been found that the gap in risk taking between the two genders is smaller for older men and women when compared to younger groups (Byrnes et al., 1999). The impact of emotions on risk has also been studied and shown to be influential. For both real bets involving money as well as hypothetical cases, people with positive emotions are more likely to take risks when compared to the control group (Sönmez and Graefe, 1998). While for hypothetical cases, the control group wagered more when chances of success increased, and the positive emotion group wagered more even on the long-shot. This result suggests that emotions impact the cognitive process that governs decision making (Sönmez and Graefe, 1998).

Previous experiences have been studied, too, for their impact on risk taking. One study found that people avoided places that they had a negative experience (risky) at, when compared to places with more positive experience (Renn, 1992). Previous experiences were not the only influencing factor. The impact of the previous experiences on risk perception also had an impact on risk taking. Perceived risk, and reward, have been studied extensively for their impact on risk taking, especially in the field of psychology known as the economics of risk (Renn, 1992).

As for the decision-making process, situational awareness has been considered to be a prominent model for understanding human behavior for over 20 years (Endsley, 2015). Though it has been improved over the years, the situational awareness model divides the decision-making process into three main components: perception, comprehension, and projection, as shown in Figure 1.1. These three steps lead to a decision that a person makes, which if then followed by an action. The situational awareness model also notes that there are many factors that impact the decision-making steps. These factors are either environmental such as system capacity and stress, or individual such as goals, preconceptions, and experience.

Similar models of the decision-making process have also been produced to explain this process for various areas of interest. For example, to understand driver risk taking, Deery (2000) proposed a model that, similar to the situational awareness model, accounts for risk perception. In Deery's model, risk taking is based on the perception as well as the skills of the driver, as shown in Figure 5.1.

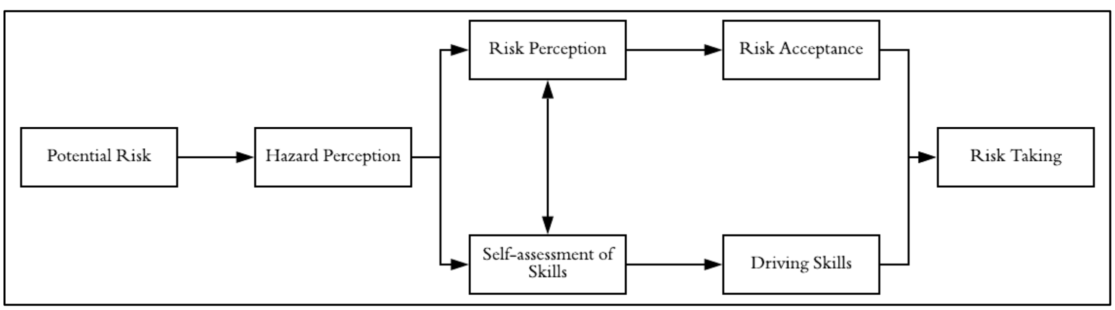

Figure 5.1: Driver Response Model to Potential Hazards (Deery, 2000)

Within the model, Deery included a factor in risk taking that has also been previously examined, that is, risk acceptance. Though the definitions of risk acceptance have not been consistent, a definition that includes most of the common language describes it as a determination of "how safe is safe enough" that is based on the trade-off between the risks and benefits of a certain activity (Slovic, 1987). That definition is consistent with the concept of the economics of risk mentioned above. However, given that the assessment of risk is very subjective (Slovic, 1992), the measure of acceptable risk is subjectively bias, and has even been described as an outright fallacy (May, 2001). That being said, researchers have argued that even objective risk measurement is in itself based on some subjective hypothesis and/or opinions (Rundmo, 1996). Starr (1969) formula for calculating the acceptable risk is that acceptable risk equals the expected benefit cubed, and for voluntary activities (such as skiing), acceptable risk can be a thousand times greater than the benefit.

It is worth mentioning that personal tendency toward risk taking has often been studied using a concept that, on the surface, resembles the risk-reward trade-off in a test that is known as Balloon Analogue Risk Task (Daly et al.). In this test, participants are encouraged to inflate a balloon because the bigger the balloon the more money it is worth. The risk here is popping the balloon, in which case, the participants lose all of the ‘money’ that they collected from the balloon (Lejuez et al., 2002). In such a test, the balance between risk (popping the balloon) and reward (amassing money) is considered risk taking. Again, this experiment also aligns with the economics of risk. This concept has not only been examined in psychology, neurology has also utilized it as well. Neuroeconomics is an emerging field studying human decision making that combines economic and psychological factors (Ahmad, 2010). Studying decision making in neurology is conducted using powerful Magnetic Resonance Imaging for examining the level of dopamine that is released in the brain in response to risk and reward stimulations (Preuschoff et al., 2006, Schultz, 2010).
Another example of a risk taking model was the one used to understand the risk taking associated with starting a new business. In this case, risk taking is influenced by risk perception, which in turn is biased by other factors such as: illusion of control, overconfidence, and the belief in the law of small numbers (Simon et al., 2000). More complex models have been later introduced to include cultural factors, individual factors, personal and societal rewards, controllability, and other factors (Rohrmann, 1999).

While many factors associated with the risk taking topic have been described above, many other impacting factors have not been mentioned. Additional impacting factors include: peer influence on risk taking, satisfaction form risk taking, and people's risk taking decision competency (March and Shapira, 1987, Gardner and Steinberg, 2005, Parker et al., 2018). Recent research has also identified the potential biases that might impact risk taking through risk perception biases, such as risk target, illusion of control, etc. (Azeez and Gambatese, 2018).

Lastly, risk taking is considered to be highly domain specific, where a person's risk taking can vary greatly depending on the different issues at hand and different domains (Weber et al., 2002). Furthermore, in a separate study that examined five different domains (including health, social, and financial, among others) with 126 respondents revealed that all respondents, except four, were never constantly seeking risk, or constantly avoiding risk. Respondents were found to be a risk seeker and risk averse based on the domain in question (Platt and Huettel, 2008). Therefore, in order to confidently understand risk taking with respect to construction safety, a dedicated examination of risk taking is needed in the safety and construction safety domains.

5.3.2 Risk Taking in Health and Safety

Before focusing on risk taking in construction, it is important to first examine risk taking in safety and health in general, where most of the concepts and ideas are generated. Early studies of occupational risk taking evolved around employee behavior, where recklessness of younger workers was suggested as one of the causes of accidents in the workplace. It was suggested that a higher number of injuries occurs within a younger workforce, but more severe injuries occur to older workers (Root, 1981). Similarly, in behavior-based safety studies, impulsivity was considered as a measure of unsafe behavior, reflecting how people act impulsively, unaware of the risk involved nor the consequences (DePasquale and Geller, 1999). Taking risk to get the job done has also been considered as one of the factors that impact job stress, strain, perceived risk, and ultimately, risk behavior when examining oil platform workers (Rundmo, 1996).

Continuing with occupational safety, LaBelle (2005) warned against incentive programs that are not clearly examined. Rewards can unintentionally increase negative behavior leading to poorer safety conditions. Tolbert (2005) advocated taking acceptable risks based on a thoughtful process of calculating risk (frequency, likelihood, and severity) as well as the reduction of risk through added controls. Tolbert (2005) further elaborated that "These judgments—decisions on whether a thing is safe—are by nature, subjective. They are affected by context and situation to the degree that what might be judged as acceptable at one time, in one place or setting, or even for one individual or group, may be unacceptable when the circumstances are slightly different."

Regarding previous experiences, when examining the perception of 350 workers in the Italian printing industry for the influence of injury experience, Leiter et al. (2009) found that previous experiences with injuries have a positive impact on a worker's risk perception where those experiences increased the awareness of risk that the work involves. Providing an important distinction, Leiter et al. (2009) reported that risk behavior did not change, only risk perception changed.

Finally, in the domain of health and safety, Weller and Tikir (2011) study concluded that health and safety risk taking is influenced by both risk perception and reward perception. Emotional factors were also found to have an impact on risk perception. Furthermore, risk taking in all of the domains examined was found to be influenced by reward perception and risk perception.

5.3.3 Risk Taking in Construction Safety

One of the earliest studies that examines risk taking in construction was conducted in the United Kingdom in which Shimmin et al. (1980) suggested that risk taking is not an issue that can be examined without social context as well as structural design elements of the project being built. The researchers indicate that particular practices within an organization, such as productivity bonuses, might encourage 'proneness' to taking risk. Furthermore, Shimmin et al. (1980) illustrated that certain design elements that prohibit workers from using conventional tools might create safety risk and force workers to use other methods and improvise, eventually causing workers to take additional risk. This result emphasizes the need for safety considerations to start from the planning and design stages of construction.

Based on a reputation of construction workers being careless risk takers, Landeweerd et al. (1990) investigated Dutch construction worker preferences for physical activities that are considered 'risky' compared to a group of skiers and a group of general practitioners. The researchers used the Thrill and Adventure Seeking (TAS) Scale to assess risk taking. Contrary to the general beliefs, construction workers scored lower than the other two groups on that test, providing evidence against the notion of workers' recklessness.

The work of Sawacha et al. (1999) and Langford et al. (2000) related to UK construction workers echoed that by Shimmin et al. (1980) with regards to the impact of design elements on risk taking and the negative aspects of productivity bonuses on the safety behavior of UK construction workers. The researchers revealed that productivity bonuses impact worker risk taking and a supervisor turning a 'blind eye' when there is a productivity bonus offered. Furthermore, these studies continued to investigate economic factors by adding the influence of danger money where workers are offered higher pay for jobs that involve higher risk (Sawacha et al., 1999). Finally, human psychological factors was also found to be a factor impacting risk taking. Older workers were more likely to adopt safety behaviors on condition that they have training and experience that comes with such age (Langford et al., 2000).

In a qualitative study conducted in Australia, Lingard (2002) reported that risk taking behavior was present in most workers interviewed and a 'getting the job done' mentality was prevalent. Furthermore, four out of the 22 workers interviewed reported taking 'calculated risk' after weighing the benefits and costs of occupational health and safety risk. According to those workers, taking risk was considered to be 'worth it'.

For United States construction workers, risk taking was reported to be 'very much part of the job' for a higher percentage of nonunion workers than union workers, 34% and 20%, respectively (Gillen et al., 2002). Menzel and Gutierrez (2010) reported that workers with questionable immigration status have a higher prevalence of job risk taking when compared to other workers. CPWR (2016) indicated that the population of these workers in the US construction industry represents about 13% of the overall workforce.

Risk taking is also categorized under workers safety behavior and safety attitude concepts in construction safety studies. In the studies, reducing risk taking to ‘get the job done’ has been shown to improve safety behavior in the Chinese construction sector (Zhou et al., 2010).

Though risk taking was not mentioned directly, the work of Fernandez-Muniz et al. (2012) considered worker compliance with safety regulation and procedures in Spain. Specifically the researchers investigated compliance even if it makes the job harder or wearing their personal protective equipment despite discomfort. These impacting factors were two of the three factors under the safety compliance section of positive worker behavior. The study results indicated that such positive behavior positively affected employee satisfaction, safety performance, as well as the company’s ability to compete in Spain.

Martin and Lewis (2013) conducted a study that examined construction managers’ safety leadership performance based on self-reported questionnaires by their subordinate workers in Trinidad and Tobago. Using statistical regression, the researchers identified factors that can improve safety in the future, and reduce worker risk taking. Involving workers in hazard identification, and increasing communication of safety practices were indicated. Martin and Lewis (2013) also mentioned other factors that raised some questions in the study. Those factors are: put pressure on workers to get the job done safely, and reduce employee involvement in general decision making. Knowing that the study mentioned above used a predictive statistical model, predicting future behavior is not as simple as excluding workers from decision making, or putting pressure on them to get the job done.

More recent studies in construction have explored emotional and technological aspects of risk taking, Tixier et al. (2014) examined the impact of emotional attendance on the risk taking behavior of construction students. The study results reveal a strong impact of emotion on increasing willingness to take risk among participating subjects. Habibnezhad et al. (2016) utilized eye tracking techniques to improve construction worker risk perception in an aim to improve overall risk taking. And finally, Dao et al. (2018) examined the impact of students' safety risk perception on their willingness to take risk using the BART test. The study revealed that students who had a lower safety risk perception were more likely to take more risk in the BART test.

5.4 Research Objectives

Considering the aforementioned literature, it is clear that risk taking is a major issue in many fields and has complex and far-reaching implications. Risk taking is also a domain specific issue, where inference from one field cannot necessarily be applied to another. Therefore, a study that is dedicated to worker views of risk taking as well as the overall thought process that occurs when making a decision is direly needed in construction. This study aims to address this knowledge gap by starting where previous studies have ended and following through to complete the full picture of risk taking. As such, the following are the objectives of the study:

1- Examine the intricate relationship between risk perception, comprehension, and projection for their impact on risk taking.
2- Examine the impact of reward perception and the risk-reward relationship on risk taking.
3- Examine the relationship between risk taking and risk taking for personal gain, represented here by risk taking for better/more rewards
4- Explore the potential implications of accident involvement, production pressure, emotions, and age on the overall situational awareness model.
5- Explore, through non-numeric analysis, a worker's reasoning when deciding how and why to take or refrain from taking safety risk.

5.5 Methodology

While risk taking has been studied in construction before, each of the aforementioned studies have aimed at one specific goal. Also, for worker views, when considered, either a qualitative or quantitative method has been utilized. The present study aims to address that the shortcomings of prior studies, where a mixed-methods approach using a convergence model is utilized. Figure 5.2 shows the research design for the study.

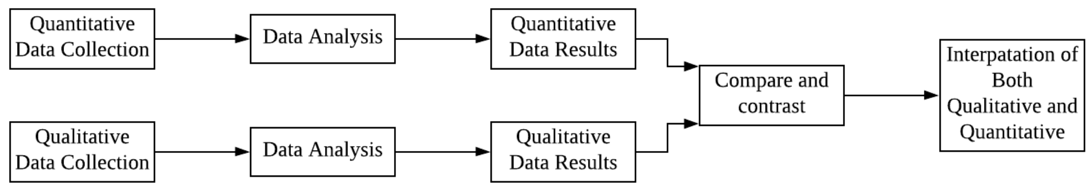

Figure 5.2: Mixed-Method Design, Convergence Model (Creswell and Creswell, 2017)

To satisfy the mixed-methods design, data collection and analysis for both qualitative data and quantitative data have to be performed separately in order to obtain both qualitative and quantitative results. Therefore, each set of data will have its own analysis methods. For the quantitative part, this study will rely on the concepts of situational awareness, risk taking for reward, risk perception impact on risk taking, emotional involvement in making a decision, the impact of work pressure, and the impact of age. The method that is most suited to examine such intricacies is Structural Equation Modeling (SEM) (Hair et al., 2009). For the qualitative part, and since the study aims to understand worker views on risk taking, safety risk, and occupational rewards, Thematic Analysis (Guest et al., 2011) is selected to understand worker risk taking behavior. Further details of each of the analytical methods used as well as a discussion of the results are provided below.

5.6 Quantitative Analysis: Design, Data Collection, and Results

The quantitative data was collected through a survey of workers in the construction field. It is important to begin by discussing the design and development of the survey. The survey questionnaire was initially developed by the researcher, verified by the advisor, then reviewed by five graduate students and two academic researchers for clarity and content. After obtaining Institute Review Board (IRB) approval, the survey was launched locally within the School of Civil and Construction Engineering at Oregon State University, involving over 90 undergraduate students at the junior and senior levels. Finally, after addressing minor details on word selection and question flow, the survey questionnaire was converted to the Qualtrics platform for dissemination and data collection.

The survey questions were organized in the following order: 1) respondent personal information, such as age, marital status, race, etc.; 2) occupational information, such as the type of contractor they work for, number of years of experience, accident involvement, how often they take a safety risk even if it is against their training, production pressure, emotional impact, and more; 3) risk perception measures, where nine risk attributes developed by Portell and Solé (2001) based on the work of Fischhoff et al. (1978), are used to examine a worker's overall risk perception. Afterwards, the survey participants were given example pictures of an activity that was marked with good safety practices, bad safety practices, and hazards present. Then the participants were asked to answer three questions for a certain scenario. The reward section in Part 4 of the survey questionnaire asked the participants to indicate the specific type of reward that they receive (directly or indirectly) from their work. In response to this question, the rewards stated by the participants included, as mentioned above, financial rewards, development rewards, social rewards, and personal rewards. Furthermore, the participants were asked to indicate their reward satisfaction level using a scale from very dissatisfied to very satisfied. Finally, the Part 5 risk taking section, participants were asked, "Will it still be safe if you take more risk?", and "Are you willing to take more risk for more/better rewards?" These two questions form the projection and the decision parts of the situational awareness model.

5.6.1 Survey Results

As mention above, this study utilized the Qualtrics platform to develop, disseminate, and collect the survey data. The targeted pool was construction workers located within the United States across different sectors of the industry (residential, industrial, commercial, etc.). For further details regarding the survey results, please refer to the Survey Results section, page 36. Furthermore, for the full list of questions asked on the survey, please refer to Appendix I – Survey Questionnaire section, page 166.

5.6.2 Model Development

As mentioned previously, Structural Equation Modeling (SEM) is utilized for this part of the study. SEM was selected for its capability of enabling understanding a construct with complex and multiple relationships between independent and dependent variables (Mohamed, 2002). The SEM method has gained in importance in recent years in construction and construction safety research (Mohamed, 2002, Eybpoosh et al., 2011, Wu et al., 2015). While there is no general consensus on the appropriate sample size for conducting an analysis in SEM, a literature review conducted by Wang and Wang (2012) revealed two rules that are considered to be the minimum requirements: 1) 10 observations per indicator variable, and 2) a minimum of 100-150 observations (respondents). Similar consideration has been suggested by Hair et al. (2009). As such, given the number of variables in the model, in the present study, the sample size collected and used is considered to be adequate. Bentler and Chou (1987) suggested a ratio of five observations per one indicator variable. In any case, the number of observations (number of respondents) collected in this study is well beyond the minimum needed for SEM. It is worth noting that during the development of the model, the following references were utilized as guidance: (Bentler and Chou, 1987, Hu and Bentler, 1998, Hu and Bentler, 1999, Hair et al., 2009, Wang and Wang, 2012, Hair Jr et al., 2016).

Under the structural equation model construct, a path is created from nodes that have arrows starting from exogenous variables to nodes that have arrows pointing at them (endogenous variables). Links were either based on hypotheses or results of prior studies (Bentler 2006). Given that the goal of this study is to understand risk taking and risk taking for occupational rewards, and relying on the aforementioned literature review, it can be clearly seen that there are perceptional factors, occupational factors, and personal factors influencing and impacting risk taking. Therefore, an initial diagram was constructed to be examined for potential implications on risk taking, and based on the connections established by the situational awareness model. Figure 5.3 shows the initial diagram illustrating risk taking and risk taking for rewards.

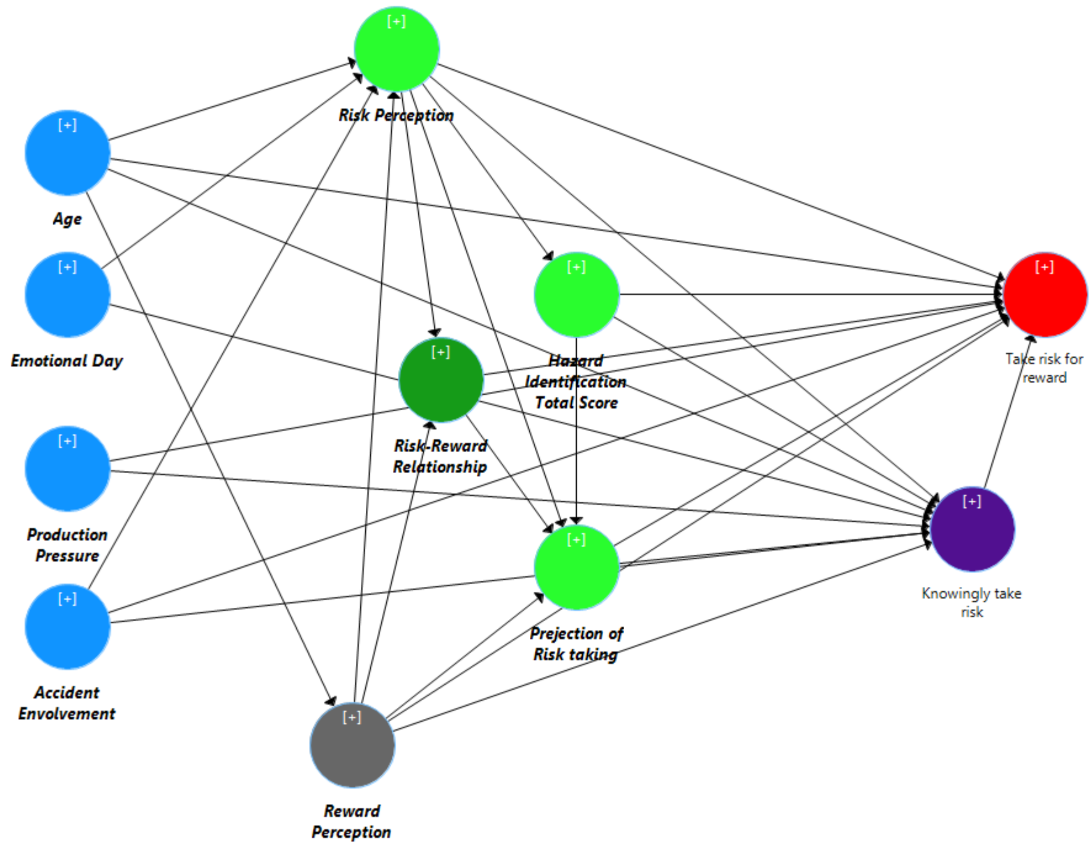

Figure 5.3: Initial path for construction safety risk taking and risk taking for rewards

The starting model, constructed using SmartPLS software, is inclusive of most of the factors that impact risk taking which were mentioned in the literature reviewed. Personal factors like age, and having an emotional day, occupational factors like production pressure and previous experiences with accidents, and perception factors represented by rewards perception, risk perception, comprehension, projection, and risk reward relationship are included in the figure above. Also, general risk taking has been considered for its impact on risk taking for rewards.

5.6.3 Quantitative Data Results

After the development of the model initiated in Figure 5.3, iterative analyses were conducted where various paths that have no statistical significance were eliminated to achieve a model that is best suited to describe the decision-making process of taking safety risk. As part of the process, the previous literature was kept in mind when choosing paths to eliminate to ensure consistency with established theories and concepts. The resulting model describes risk taking relying on seven independent variables: age, accident involvement, risk perception, reward perception, risk-reward relationship, risk comprehension, and risk projection. Figure 5.3shows more details of the connection between the variables.

The final path model shown in Figure 5.4 represents paths that have been shown to have statistical significance, except for the connection between risk perception and comprehension which was intentionally left in the model to satisfy the situational awareness model. The researcher believes that this connection would have been statistically significant if more cases of hazard identification were assessed by the respondent workers. Only one case was used in the survey. That case might not have been well-suited with all of the various work conditions that workers might be exposed to. Hence, the researcher would like to state this matter as a limitation of the study.

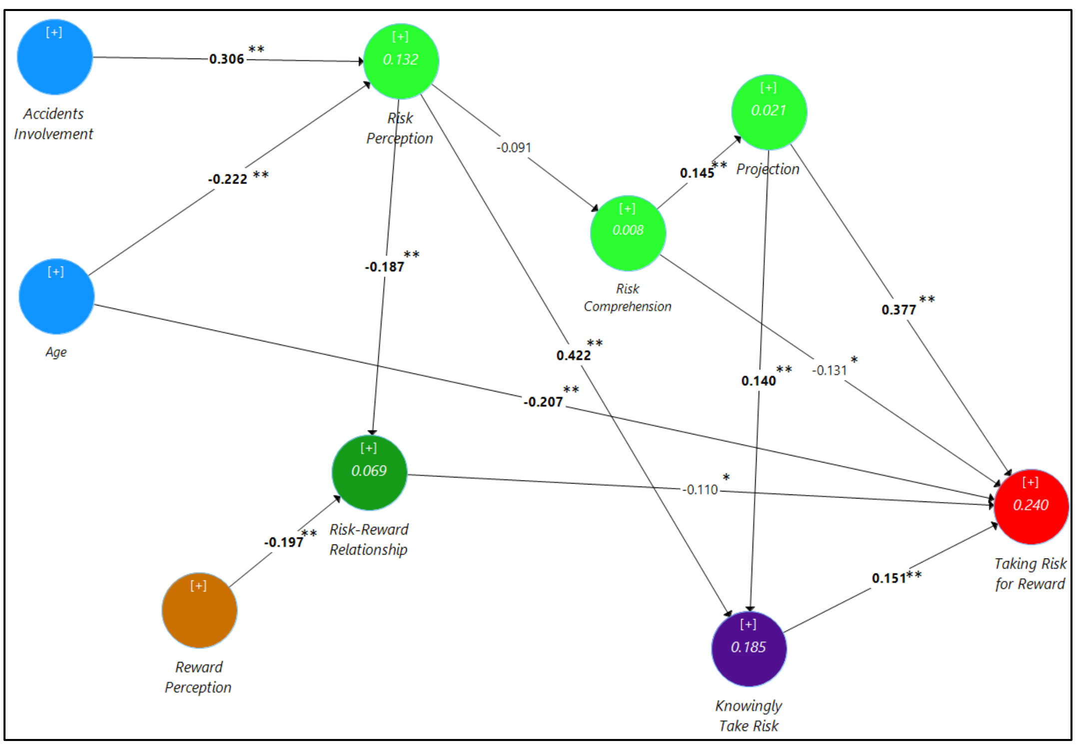

Figure 5.4: Structural Equation Model Final Fit

* represents p-values >0.05 and <0.1, indicating suggestive evidence; ** represents p-values <0.05, indicating strong statistical evidence

The path analysis revealed the following relationships:

1) Production pressure has no impact on risk perception or risk taking. Therefore, that production pressure variable has been removed from the final model.

2) Having an emotional day impacts worker perception of risk, reward, and risk taking. Having an emotional day has also been removed from the model.

3) Past experiences with accidents is shown to impact risk perception rather than risk taking. Workers with previous accidents involvement have higher assessments of their risk perception. This finding conforms with previous literature, where Leiter et al. (2009) indicated that past experiences do not impact behavior and only impact risk perception.

4) Age, on the other hand, was found to have an impact on both risk perception and risk taking for reward. Older workers were less likely to take risk for reward compared to their younger peers, and older workers have a lower assessment of risk perception (B= 0.207). Reward perception was found to have no direct impact on risk taking, but rather an indirect impact through the risk-reward relationship which reward perception affected negatively.

5) Risk taking was found to be influenced by a worker's tendency to take risk, age, projection of risk taking, and hazard identification.

Regarding the variance explained by the variables in the model, 24% of the variance in risk taking for reward is explained by the variables connected to it. Also, 18.5% of the variance in knowingly taking risk is explained by risk perception and risk projection. Table 5.1 provides detailed statistical values for the paths indicated in Figure 5.4.

Regarding the adequacy of the model fitted above, and following the process used by Eybpoosh et al. (2011) and Parry (2017), three additional statistical measures were examined to assess the model fit. The fit indexes assessed are: Bentler-Bonett Index or Normed Fit Index (NFI), Chi-Square, and Root Mean Square Error of Approximation (RMSEA). Table 5.2 provides more details about the statistical measures examined.

As can be seen from the model fit results shown in Table 5.2, the model has fitting values are well within the required limits for the Structural Equation Model. One note that should be mentioned regarding the NFI is that it rewards complex models (Kenny, 2015), and since the final model is less complex than the estimated model, NFI dropped below the cut-off value.

Table 5.1: Results of Regression Analysis for Specific Groups by SEM

Connection	Regression Weights	Standard Deviation	T-Statistics	P-Values
Risk-Reward Relationship - Taking Risk for Reward	-0.11	0.061	1.807	0.071
Risk Perception - Risk-Reward Relationship	-0.187	0.085	2.194	0.028
Risk Perception - Risk Comprehension	-0.091	0.082	1.114	0.265
Risk Perception - Knowingly Take Risk	0.422	0.066	6.385	<0.001
Risk Comprehension - Taking Risk for Reward	-0.131	0.067	1.951	0.051
Risk Comprehension - Projection	0.145	0.066	2.206	0.027
Reward Perception - Risk-Reward Relationship	-0.197	0.076	2.577	0.01
Projection - Taking Risk for Reward	0.377	0.069	5.457	0.001
Projection - Knowingly Take Risk	0.14	0.07	1.987	0.047
Knowingly Take Risk - Taking Risk for Reward	0.151	0.065	2.346	0.019
Age - Taking Risk for Reward	-0.207	0.071	2.925	0.003
Age - Risk Perception	-0.222	0.07	3.161	0.002
Accidents Involvement - Risk Perception	0.306	0.07	4.387	0.001

Table 5.2: Model Fit Indexes

Fit index	Description	Saturated Model	Model Estimated	Cut-off Criteria	References
Bentler-Bonett Index or Normed Fit Index (NFI)	Checks the proportion in the improvement of the overall fit of the model to independent model	0.941	0.823	0.09 is accepted	(Bentler and Bonett, 1980)
Chi-Square	Assess overall fit and the discrepancy between the sample and fitted covariance matrices. Sensitive to sample size.	14.47	43.59	>1.96	(Parry, 2017)
Root Mean Square Error of Approximation (RMSEA)	The square-root of the difference between the residuals of the sample covariance matrix and the hypothesized model.	0.029	0.058	<0.08	(Hu and Bentler, 1999)

5.7 Qualitative Analysis: Design, Data Collection, and Results

Starting with the interview questions, the devised questions were developed by the researcher, revised by the research advisor, and externally peer reviewed by one academic researcher and two graduate students for clarity and goal conformance. Input received from the reviewers was incorporated into the interview questions. After obtaining IRB approval, a non-probability sample of construction companies was obtained by contacting various contractors scattered across the general Oregon area. The companies were asked to allow the researcher to interview their workers. While the contractors were not selected randomly (a convenience sample), the workers who participated in the study were not preselected. Willing participants were interviewed one-on-one in which semi-standardized interviews were conducted (Berg, 2009). That is, workers could be asked the same question using different wording (when needed), and follow-up questions were allowed, as well as question rephrasing. Each interview took between 6 and 10 minutes depending on the length of the worker's answer. Transcription of the answers were made on paper directly.

As for the structure of the interview questions, the structure consisted of three parts: Part 1 consisted of risk-reward questions and their impact on decision making; Part 2 focused on the risk taking of construction workers, i.e., why they take/refrain to take risk, and what they expect to receive by taking extra risk; and Part 3 contained questions about the workers themselves, such as age, experience, job title, education, etc. For more details regarding the questions asked during the interview, please refer to Appendix II – Interview Questions section, page 175.

A total of 37 interviews were conducted in six different locations, with different contractors and different trades involved. The interviewed sample had an average age of 38 years, and 15.6 years of work experience on average. Table 5.3 provides descriptive statistics and information about the interviewed workers.

Table 5.3: Descriptive Statics of Interviewed workers, per Job Title.

Job Title	No. of workers	Average Age (years)	Average Amount of Work Experience (years)	Trade	Education	Union Status
Superintendent / Supervisor	5	43.2	20.5	Carpenters, Iron worker, Plumber	HS+	3 Union, 2 undisclosed
Foreman	11	39.9	21.5	Electricians, architectural Sheet metal workers, Glazers, Carpenters, Concrete workers, interior finishing worker.	11th grade +	4 Union, 1 non-union, and 6 undisclosed
Journeyman	11	33.5	12.8	Iron workers, HVAC workers, Carpenters, plumbers, Electrician, Glazer, Roofer, suspended ceiling worker	10th grad and GED +	4 Union, 7 undisclosed
Apprentice	7	27.5	3.4	HVAC, workers, Sheet metal workers, Steel framing, Carpenters, Electricians	HS+	1 Union, 6 undisclosed
Other	3	46.5	22	Traffic control labor, lowboy operator, paver operator	HS+	3 undisclosed

5.7.1 Data Analysis

Through the literature review described above, US construction workers' perspectives on risk, rewards, and risk taking has been shown to be lacking. This study aims to address that deficiency by taking a broader look at workers' views in an aim to extract some commonality in their views. The importance of the study is amplified by the clear complexity of the human decision-making process and the lack of non-qualitative examination of the process with respect to construction safety.

Given that this study is a convergence mixed-methods study, a separate investigation of risk taking was used for each method of analysis, as stated previously in the methodology section. For the qualitative analysis, thematic analysis was selected to understand worker behavior and the risk-taking process. Thematic analysis is often used in qualitative analysis studies, and has been defined as "a method for identifying, analyzing and reporting patterns (themes) within data" (Braun and Clarke, 2006). Thematic analysis can include identifying code frequencies, and/or representing relationships graphically (Guest et al., 2011).

Thematic analysis has gained some interest and been used more frequently in the recent years in construction research in general (Alaka et al., 2016, Weidman et al., 2017, Yoon and Dai, 2017, Sepasgozar et al., 2018) as well as construction safety research specifically (Ghosh et al., 2010). With regards to sample size and number of participants needed in the study, recommendations vary from one research study to another, and range from approximately 15 respondents (Ghosh et al., 2010, Alaka et al., 2016) to 100 respondents (Sepasgozar et al., 2018). As mentioned above, the total number of respondents in the present study is 37 construction workers. Hence, the number of respondents is within the recommended range. Given the number of respondents, the researcher did not need computer software to examine the data and analyze the respondents' answers. It is usually considered useful to employ software but it is typically only required for data from 100 respondents or more (Guest et al., 2011).

Thematic analysis has a minimal set rules for an analysis method of such wide use (Braun and Clarke, 2006). However, the process followed in the analysis for this study is one of the most widely used, if not the most widely used process, which is the process devised by Braun and Clarke (2006). In concert with the process, the study analysis will be conducted by following six steps proposed by Braun and Clarke (2006). These steps are: familiarity to the data, initial codes generation, themes searching, themes reviewing, themes naming, and report production. Braun and Clarke (2006) also emphasized that the analysis process is recursive, where going back and forth between the codes and the themes is not only encouraged, but it is, in a way, part of the process itself. During the analysis of the study, a recursive effort happened 3 or 4 times, where the researcher went back and forth between the themes and the codes before settling on what is presented here. Finally, during the development of the themes, suggestions from Guest et al. (2011) with regards to connecting themes to theoretical models, supporting themes with quotes, structural coding (the identification of the structure imposed on qualitative data by the researcher's questions and design), and external peer review of the codes and the themes extraction. Table 5.4 presents the themes extracted from the qualitative analysis combined with corresponding quotes and extracts from the data. Detailed description of the themes as well as outcome reporting can be found in the next section, which is the qualitative data analysis results.

Table 5.4: Themes, Codes, and Data Extracts

Issue	Themes	Data Extracts (Bold text represents codes extracted)
Reasons for Risk Taking in Construction	Cutting corners to get the job done	"Doing things **faster**, you get complacent. I'll be fine anyways."; "Do what you need to get done, but it is all safe"; "If have everything to complete the task and the risk is not too high, it **saves time**. Five minutes instead of half an hour"; "Moderate safety **risk is oka**y to finish the task"; "Working in a hurry or the end of the day end of work"
	Every job has some risk, even if I don't take risk myself	"I have a family to provide for and bills don't pay themselves. **Every job has some risk**"; "If there is no other way like **there is no way** to tie properly. Tools are dangerous but there is no other way. But **it has to be minimal** [risk] for all"; "**nothing will happen**… if it is not enforced, I'll do it"; "I'm providing for my family, **I have to take risk**".
	I don't risk safety.	I **don't take** safety risk", I **don't take** any risk"; "I **try not to take** any safety risk"; "I need a safe site **or I will not work**"
	Other reasons to take risk.	"If you go strictly by the book, the guidelines are quite restrictive. You can do it safely without all the restrictions"; "sometimes, the task I'm doing and the way I'm told to do it more dangerous with OSHA regulations"
Reasons for Not Taking Safety Risk	Severe and immediate consequences	"limb or **life**"; "I don't take risk when it is **more than what I'm used to**, and could cause harm… like a broken **leg, or arm**"; "I can **see myself getting injured**"; "it is quite easily to **die or cripple** yourself"

	Valuation of life and family	“**Going home** in once piece”; “**getting back home** the way you came from it”; “**go home** uninjured. I **have people** with me to go home to safely” “Go home safely”
	Social obligation, policy control, and available alternatives	“For **other worker’s** safety…also, I will get **fired**”; “looking for **alternative ways** of doing the job instead, … I ask for help.”; “**Everybody** goes home safe”; “**someone** gets hurt”; “because of **rules and regulations**”
Risk and Reward Preferences	Working on a safe site with low benefits is not acceptable	“I won’t work for **less compensation**…. I like to work on the hazardous site but I want to do it safely.”; “probably not [on working on a safe site that offers less compensation] … I like to have the best of both worlds, safe site that offers good comp”.
	Safer is better, but a bit more reward for risk is okay too	“How much less are we talking about? **A little** bit less is okay… if safety is addressed, I will work on [a risky site that offers more] … higher pay range for a **little more** risk. I left jobs for new ones for higher pay and advancements options”
	Safety is prioritized over reward	“**Yes, in a** heartbeat [on working on a safe site that offers less]”; “you do the job **as safe as possible** you get what you worth”
	Yes, to all jobs, as long as I'm paid	“No **not really** [on having any preference for the levels of risk and reward], as long as they compensate well”; “I don’t [on having any preference for the levels of risk and reward], I just like to work”; “**Not really** [on having any preference for the levels of risk and reward]”.
	High risk, high reward	“**High risk** high benefit… after training risk is controlled”; “I have done the hazardous work. It **does not bother me**”

5.7.2 Qualitative Data Results

By examining the workers’ responses, and through the use of thematic analysis, it was clear that workers, in general, do not immediately think about their personal gain (rewards) before taking risk. The worker’s thought process was usually larger than just themselves, as represented by such statements as: “We [construction workers] are building the world,” “I don’t take it [risk] if it jeopardizes my crew,” “I have a family to provide for,” and “I have a family to go back to.” Those, and similar, statements were often said by the interviewed workers. It is undeniable that workers would like to receive a higher amount of pay (Azeez et al., 2019), yet workers’ answers for taking risk were never directly based on reward.

Regarding the thematic analysis conducted, after the codes were extracted (see Table 5.44), the researcher examined the codes for general themes. Figure 5.5 is a graphical, not-to-scale, representation of the five risk taking themes found during the analysis. Furthermore, Table 5.5presents the workers' reasoning for taking and not taking risk for each of the themes shown in Figure 5.5.

Given that risk and reward impact decision making, each of the risk-taking themes extracted was based on how workers viewed that dynamic balance. Starting with Theme A, "Safety is Prioritized over Reward", workers view safety as their priority. Those workers viewed compromising safety for rewards as unacceptable, and adamantly avoided risk as described in statements like, "right at the beginning if you do something unsafe you are out of the job." For the workers who fit within this theme, their views of safety distinguished them from other groups. This group justified taking risk mainly to get their task done (50% of members in this group), took safety risk that was part of their job nature (33%), or never take safety risk to begin with (17%). The Safety is Prioritized over Reward group avoids risk mainly in recognition of their co-worker's safety, company policy, and ability to do the job safety (50%); to place value on life and family (33%); and due to the high consequences of risk taking (17%).

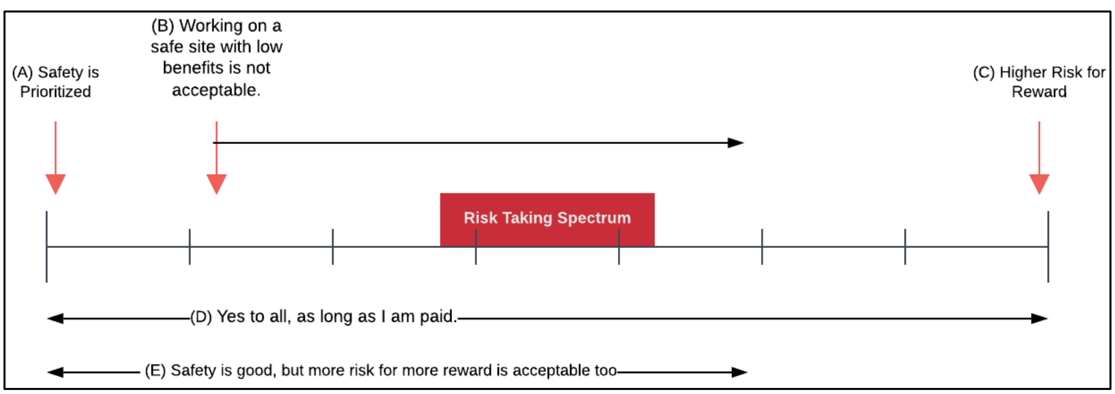

Figure 5.5: Risk-taking themes based on workers' responses

The second theme, Theme B, revolves around workers appreciating safety, but refusing to take a lower reward to work on a safer job. These workers appreciate safety and their behavior is to avoid higher risk taking. However, they are not willing to work for lower reward. The workers in this group had similar views of risk taking and reasons for not taking risk. When a difference existed, is the view of having to take risk, where the worker judged that following the OSHA rules while performing the task at hand imposes greater risk when compared to performing the task differently. Descriptive statistics related to reasons for taking risk and reasons not to take risk for this group can be found in Table 5.5.

The third group, which is represented by Theme C, prefers jobs that have higher risk and higher reward. These workers accept risk and have an exuberantly high desire for higher pay, and high threshold for risk. For example, one worker mentioned, "I do what I'm comfortable with. If so, I do it before the guy next to me." When a follow-up question about how would you assess the outcome of that risk taking was asked, that worker's answer was "you can tell." Other workers drew from past experiences to assess their level of risk taking. For example, "you get complacent [with risk] … I'll be fine anyways. I was shocked 2 or 3 times." Others stated that risk is controlled after training ("yes, high risk high benefit after training risk is controlled"). Overall, those workers within this group had similar views of risk-taking reasoning, but their reasons for not taking risk were mainly about valuing their life, going back to their families, or the ability to do it differently (44% of members in this group). High consequences, possible injury, and comfort zone were the next most cited reasons (34%), and other workers and company policy were cited the least number of times (22%).

The next theme that emerged (Theme D) is that of the workers who are willing to accept any job that pays. These workers did not express any preference towards safety or pay. Their reasons for taking risk were to get the job done (75% of members in this group), and viewing OSHA regulations as not being the safest way of executing their task (25%). Their reasons for not taking risk were primarily family and self-valuation (75%), and having other workers get injured, or company policy (25%). High consequences and comfort zone reasons were not expressed by this group. For example, when asked about risk-reward preference, one worker stated: "Depends on the risk and depends on the benefits. If all on me, okay. If all on someone else, no".

The last theme that was exposed (Theme E) is represented by a worker's willingness to work for less reward for safer work conditions, but also take a little more risk for more reward. This group has the preference of the first two themes (Themes A and B) combined, where safety is a priority for them, but higher reward preference is not neglected either. This theme represents workers who mainly take risk to get the job done (40% of members in this group), while all the other reasons have equal representation of 20% of workers. As for the reasons they avoid risk, family valuation, and self-valuation (80%), and high consequences and comfort zone (20%), were most prevalent. As an example, one worker stated: “I don’t take risk when it is more than what I’m used to, and can cause harm… like a broken leg, or arm. Medical bills are an important factor.”

Apart from the main themes that emerged from the analysis, there were some general observations that the researcher detected while conducting the analysis. The first observation is that older workers tend more to stay away from risk and work either on the safer side of the spectrum or near the average risk range. On the other hand, younger workers tend to explore the risk spectrum a bit more. Previous studies have concluded similar results (Chen and Jin, 2015).

Secondly, workers in general responded with statements that indicate a sense of urgency to get the job done. Statements like, “I have everything to complete the task and the risk is not too high. That saves time. Five minutes instead of half hour,” or “If I think I can do it safely and a better product to the customer I’m willing to take the risk.” One worker probably described that thinking in clearer terms, where he stated, “We call them shortcuts, when I'm doing a small thing, no need for full safety procedure.”

Another observation is that during both the interviews as well as the analysis, it was clear that most workers were not pushed by their superior to take risk. Only one worker said that they feel pressure from their boss. That worker stated, “Typically, I take risk for production… my boss is an [expletive] that wants the job done.” This reasoning is perhaps why ‘getting the job done’, ‘get things done’, and ‘get the chore done’ are all phrases that were mentioned repeatedly by different workers.

Union workers, especially those who have been in the union from the start, were also observed to rarely think about rewards when thinking of new jobs. Unionized workers have pre-negotiated contracts that apply to most jobs that they get to work on. For those workers, selecting the job is mainly selecting longer-term employment, more professional people to work with, or selecting jobs that are closer to their homes.

The researcher also observed that some workers said that they would prefer prevailing wage jobs, but those do not come often. It was noticed that workers do appreciate other factors when thinking about their job risk. Getting other crew members injured is often a reason for not taking risk for construction workers.

Lastly, it was observed that, regarding risk threshold and what is considered to be acceptable, workers often draw a line of not taking risk when that risk leads to "[loss of] limb or life," "a broken hand or leg," or becoming "severely injured." While it is encouraging to see workers realizing the dangers in their jobs, the threshold that they are setting might be more than a figure of speech. It appears that a worker's threshold is imminent danger or a high consequences outcome. One worker stated that, "It depends on the risk climbing up for the last step of the ladder is more acceptable than holding the [nail] gun in an awkward position." Another comment was, "Yes, I have [worked on hazardous site that offered more] …. it depends on the hazards, chemicals, or nuclear waste, no, if heights, yes."

Table 5.5: Thematic Analysis Outcome

Theme/Group (% of all participants)	Theme Description	Job Titles	Age Avg. (y)	Reasons for Taking Risk	Freq. (%)	Reasons for not Taking Risk	Freq. (%)
A (16.2%)	Safety is prioritized over reward	Foreman, Superintendent	46	Cut corners to get the job done	3/6 (50%)	high consequences: possible injury/outside of my comfort zone	1/6 (17%)
				Every job has some risk, even if I don’t take risk myself	2/6 (33%)	I value my life/getting back to my family/no reason to take risk	2/6 (33%)
				I don’t risk safety	1/6 (17%)	Other workers safety, I can get fired, company policy, I find ways to do it safely	3/6 (50%)
B (35.1%)	Working on a safe site with low benefits is not acceptable	Apprentice, Journeyman, Foreman	39	Cut corners to get the job done	6/13 (46%)	high consequences: possible injury/outside of my comfort zone	5/13 (38%)
				Every job has some risk, even if I don’t take risk myself	5/13 (38%)	I value my life/getting back to my family/no reason to take risk	4/13 (31%)
				I don’t risk safety	1/13 (38%)	Other workers safety, I can get fired, company policy, I find ways to do it safely	4/13 (31%)
				Other reasons	1/13 (8%)		
C (24.3%)	High risk for high reward	Apprentice, Journeyman, Foreman	35.5	Cut corners to get the job done	5/9 (56%)	high consequences: possible injury/outside of my comfort zone	3/9 (34%)
				Every job has some risk, even if I don’t take risk myself	2/9 (22%)	I value my life/getting back to my family/no reason to take risk	4/9 (44%)
				I don’t risk safety	2/9 (22%)	Other workers safety, I can get fired, company policy, I find ways to do it safely	2/9 (22%)
D (10.8%)	Yes to all, as long as I am paid	Apprentice, Journeyman	28.25	Cut corners to get the job done	3/4 (75%)	I value my life/getting back to my family/no reason to take risk	3/4 (75%)
				Other reasons	1/4 (25%)	Other workers safety, I can get fired, company policy, I find ways to do it safely	1/4 (25%)
E (13.5%)	Safety is good, but a bit more risk is acceptable too	Apprentice, Journeyman, Foreman	34.4	Cut corners to get the job done	2/5 (40%)	high consequences: possible injury/outside of my comfort zone	1/5 (20%)
				Every job has some risk, even if I don’t take risk myself	1/5 (20%)	I value my life/getting back to my family/no reason to take risk	4/5 (80%)
				I don’t risk safety	1/5 (20%)		
				Other reasons	1/5 (20%)		

5.8 Discussion

Accidents in construction have a huge impact on the whole industry, from being one of the most dangerous occupations, to the loss of life and the financial consequences of accidents that add up to about 6% of the total cost of a project (Helander, 1991). While previous research studies have revealed worker risk taking tendencies, a deeper understanding of the reasons for these tendencies has never been explored. This study addressed this knowledge gap, where construction workers views and perspectives have not only been quantitatively analyzed, but also qualitatively examined.

5.8.1 Relationship between risk comprehension, projection, and risk taking

The situational awareness model shown in Figure 1.1 illustrates the three main steps that are associated with taking risk. The three steps are: perception, comprehension, and projection. These steps have been examined here in this study for their impact on risk taking. The structural equation model revealed that there is a statistically significant path between these three steps and risk taking as well as risk taking for rewards. This relationship means that workers do follow such a process in making a decision. One item that is worth re-mentioning is the connection between risk perception and risk comprehension which has been found to be not significant from a statistical point of view. The researcher argues here that this is a research limitation rather than a proof of lack of connection between risk perception and risk comprehension. Workers were asked to assess the good safety practices, bad safety practices, and identify hazards present in one work scenario. As such, that scenario might not have been a setting or operation that all workers were familiar with. For that reason, the researcher suggested that the lack of statistical significance might be more associated with the survey design rather than the situational awareness model.

5.8.2 Impact of risk and reward perception on risk taking

Risk and reward perception with respect to risk taking was examined in both of the study methods employed. Through the quantitative analysis, it was revealed that reward perception does not have an impact on either risk taking or on risk taking for personal gain (rewards). This result is different than for risk perception, where risk perception was found to have an impact on risk taking. The risk and reward relationship, however, was found to be impacting risk taking for rewards. In other words, unlike risk perception, reward perception indirectly impacts risk taking for reward.

Similarly, during the qualitative analysis portion of the study, rewards were never expressed as a reason for taking risk. Workers did have preferences and biases towards a certain level of risk and reward, but when asked about reasoning for taking risk, reward was never the answer. Therefore, the researcher concludes that rewards are an impact on risk taking, but that impact is hard to examine and might not be easily identified. That impact in itself might be an issue in construction safety, where safety professionals might not address the influence of rewards simply because it has not been detected to begin with. Further research is needed to find ways to practically detect the influence of reward perception on risk taking.

5.8.3 Relationship between risk taking and risk taking for rewards

Workers were asked if they would take risk even if it is against their training. Almost 65% of the responding workers indicated that they do take such risk. That percentage in itself is quite worrisome. However, to the point of this objective, workers were also found to be willing to take more risk for better reward. This result is evident in the SEM model which revealed that there is a positive correlation between taking risk in general, and taking risk for rewards. A worker who would generally take risk, would feel less bothered for taking risk for a better reward. That being said, there is no clear distinction of whether or not these two risk taking decisions would be concurrent or not. Workers might take safety risk to save time on the job, but they might also take risk to work in a more rewarding job. If these two decisions coincided, it would likely pose a real danger in the workplace.

5.8.4 Impact of accident involvement, production pressure, emotions, and age on the situational awareness model

Previous studies, as it was alluded to above, have strongly emphasized the importance of age, emotions, production pressure, and accident involvement on the decision-making process that is encapsulated by the situational awareness model. Through the SEM analysis conducted, it was revealed that having an emotional day and production pressure are not of impact on the whole decision-making process. While that might be contradicting previous studies, the researcher does believe that these two issues might not be directly linked to risk perception, comprehension, or projection. The researcher feels that the issues might have greater impact on decision making competency, or difficulty of balancing job demands and job decisions, rather than the decision of whether or not to take risk. Studies of factors impacting decision making competence can be found (Parker et al., 2018, Weller et al., 2018), and studies on the implication of job demand and job decisions have also been conducted (Karasek, 1979).

Accident involvement and age were found to have a statistically significant impact on both risk perception and risk taking. Older workers were less likely to take risk, and workers who were involved in an accident did have a higher risk perception. Similar results have been reported in previous research (Hallowell, 2010, Chen and Jin, 2015).

5.8.5 Worker Risk Taking Reasoning

The qualitative analysis of this study revealed five different risk-taking themes that workers generally fall under. These themes are: 1) safety is prioritized over rewards; 2) working on a safe site with low benefits is not acceptable; 3) high risk for high rewards; 4) yes to all jobs, as long as I am paid; and 5) safety is good, but a bit more risk is acceptable too.

Workers generally had four main reasons for taking risk: 1) cutting corners to get the job done; 2) accepting risk because every job have some risk even if the worker does not take it; 3) other reasons such as feeling that OSHA requirements are too restrictive; and finally, 4) a few number of workers adamantly refused to take risk regardless of the case that might force them to. As for the reasons that were identified for not taking safety risk, these were: 1) high consequences, possible injury, or the amount of risk being outside of the worker's comfort zone; 2) workers valuation of their life and/or family, and not finding enough reasons to take risk; and lastly, 3) other workers' safety, getting fired, executing the work in a different way, and not taking risk due to company policy. Again, reward was never a reason for taking or avoiding risk. While workers did have a risk/reward preference and acceptance, only risk influenced the final decision directly. Further research is needed to determine how workers would react in real life scenarios.

Throughout the analysis, and from the results of this study, there are a few human behavior and decision-making concepts that the researcher believes are linked to the results and outcome of this study, and that they should be discussed when exploring risk-taking. The likely interacting concepts are:

1. Normalization of Deviance. This term is often used to refer to the habit of accepting flawed situations or mishaps to the point that they become normal (Prielipp et al., 2010). This issue poses a great threat to worker safety where, over time, even great deviation from the standard practice becomes normalized (Banja, 2010, Prielipp et al., 2010). Normalization of deviance was apparent in the study when workers indicated that they see cutting corners to get the job done as standard practice and as one of the main reasons for taking safety risk. Examples of workers normalizing risk were found in worker responses such as: “Doing things faster, you get complacent [with risk] … I'll be fine anyways. I was shocked 2 or 3 times.” Previous studies have indicated that normalization of deviance does not fall solely on the workers’ shoulders. Management and safety personnel are also responsible for taking actions that would counter and prevent such behavior (Langford et al., 2000).

2. Risk Hemostasis. Risk hemostasis is a concept presented by Wilde (1982) based on a study of traffic accident data. People were found to drive more safely in new driving conditions, and drive in an unsafe manner when they have added safety features. According to the risk homeostasis concept, people would compensate for risk when conditions are perceived to be too safe (Williams and Noyes, 2007), and when there is an apparent benefit to that added risk. The goal, under this concept, is to reach the target level of risk.

Wilde (1982, 1998) presented his hypothesis on risk taking as a balance between the cost and benefits of risk taking. An example of the cost and benefits of risk is: driving fast to gain time is a benefit, and the cost is the potential speed ticket or car repair. Another example is the cost and benefit of safe behavior where benefit is represented by an insurance discount or an accident-free period, and the risk is using an uncomfortable seatbelt or being called a coward by a peer. Based on these reasons, Wilde (1982) presented four strategies to counter such risk taking: 1) decreasing the benefit of risky behavior, 2) deceasing the cost of safe behavior, 3) increasing the cost of risky behavior, and 4) increasing the benefit of safe behavior. Going back to the topic of this study, risk taking might be a symptom of increased benefit of risky behavior. Few workers, as mentioned in the qualitative study results, complained about safety getting in the way of their ability to perform the job. That perspective might be a good example of cost of a good behavior that safety managers need to address. Previous studies have mentioned that the discrepancy between the perceived risk of experts and non-experts might be a sign of an inappropriate mechanism of measuring and dealing with that risk (Kunreuther, 1990).

Another example is getting the job done where getting the job done might be seen by the employer as a desirable employee quality. Workers who do get the job done might be more appealing for future hiring. Therefore, employers might inadvertently reward unsafe actions, represented by getting the job done on time, by not increasing the cost of unsafe behavior, or by not decreasing the benefit of unsafe behavior. From an employee stand point, it is worth investigating if workers in a relatively safe environment (most workers in the qualitative study reported that they are working in average, or higher than average safe conditions), are more willing to take more risk than those who work in riskier conditions. The researcher expects that the riskier the work environment, the less likely that a higher percentage of workers would act in an unsafe manner.

It is worth mentioning that there are similar concepts to the one that was proposed about the risk-reward relationship (Alhakami and Slovic, 1994, Finucane et al., 2000). Similarly, Weber et al. (202) provided a regression model equation that states risk taking preference is the result of adding the expected benefit, perceived risk, and an error term. The common denominator in risk taking presented here is the expected benefit that the worker might see.

While the results of this study, as pointed out previously, show that rewards are not a direct contributor to risk taking, the chance that the expected benefit might not be directed to the workers themselves has not been included in this study. Workers might see finishing the job on time as a benefit to the organization or their job, and that viewpoint might lead them to see the risk as being acceptable.

3. Psychological Contract: Psychological contract is a term that is used to describe the reciprocal promises and obligations that are perceived by both the employer and the employee (Guest and Conway, 2002). The keywords here are perceived promises and obligations. While the present study is not aimed at assessing or detecting the existence or the impact of a psychological contract on worker risk taking, the researcher felt the need to mention the potential consequences of such an issue. Worker commitment to getting the job done might be a direct result of a psychological contract where workers perceive an unstated obligation towards their organization or their customer to get the job done on time. That sense of obligation generated by the psychological contract might influence the worker's sense of commitment and the worker's trustworthiness, therefore leading to stimulated risk taking to exceed the formal job description (Guest and Conway, 2002, Choi, 2007). Though the psychological contract implication on risk taking has not been studied in construction, the topic is gaining some attention in occupational safety as well as construction safety (Walker, 2010, Chih et al., 2016, Newaz et al., 2016).

Other evidence that points toward this issue is the finding of Azeez et al. (2019) where responsibility was the highest perceived reward of all the construction workers surveyed (47% of workers perceived responsibility as a reward they get from their work).

4. Risk taking vs. decision making under uncertainty. Risk taking implies that the decision is made when the outcome is unknown but the probability of each of the outcomes is known. Uncertainty, on the other hand, implies that both the outcome and the probability of the outcome are unknown (De Groot and Thurik, 2018). An argument can be made that in most decisions workers make, the outcome probability is unknown; therefore, workers are making decisions under uncertainty, rather than taking risk. In non-construction safety study, Dror et al. (1998) suggested that judgement and skill can produce a high-quality decision when faced with uncertainty, and calculated risk-taking curbs the outcome to the decision maker's benefit. Generally, risk taking has long been

rejected in construction safety, but researchers from other fields have indicated the importance of taking risk. Tolbert (2005) states that, "To be human is to be a risk taker," and supports 'calculated' risk taking. Based on the present study, the researcher is not attesting to that statement; but it is important to understand that risk taking is part of the safety equation. Amalberti et al. (2006) stated: "Human beings never fully comply with rules, and deviation from procedures occurs in all industrial systems."

Based on that understanding, safety managers and professionals should direct their attention to assessing good decisions made vs. assessing good outcomes, similar to how a good manager would be evaluated for their decision making (March and Shapira, 1987). Workers mostly make sound decisions. If every decision that workers make are bad decisions, the accident count would be enormously high. Guidance can be drawn from the concepts of Safety I and Safety II (Hollnagel, 2018), where Safety I is identified as the absence of the undesired outcome, and Safety II views everyday performance variability as a chance to adapt and respond to varying conditions. Safety II aims to understand what goes right to explain how occasionally things go wrong (Hollnagel et al., 2015). As such, near-miss investigations might be of paramount importance not only to assess good decisions vs. good outcomes, but also to help safety managers understand what goes right to prevent what goes wrong. No wonder that near-miss investigation was found to be in all of the companies' safety plans when aiming to reach the zero-accidents goal (Hallowell et al., 2013).

5. Finally, rewards play an important role in making a decision. Examination of decisions made should not exclude a worker's reward perception due to the mounting neurological-, psychological-, and industry-related evidence. A worker's ability to separate between being paid to work on a high-risk job (i.e., danger money) and getting a signing bonus might not be possible. Also, with a worker's commitment to getting the job done and the risk taking associated with it, getting paid to work in a new place might cause an unintended increase in risk-taking that might eventually raise injury and fatality rates in construction. Langford et al. (2000) stated that the "pay and reward system are seen to be a major factor in risk taking," where the emphasis is on monitoring the impact of a productivity bonus safety. That emphasis should hold true

for signing bonuses and other methods of attracting new workers. Alternative methods have been mentioned in literature to attract new workers, such as a company's social performance as a valid and attractive metric (Turban and Greening, 1997). It is also worth mentioning that a worker's rewards should not be the only interest, but also the perceived benefits of taking risk. The benefits associated with risk taking might have more value than personal gains to the organization, or the public good. For example, getting the job done and saving time for a delayed project might provide sufficient benefit to encourage taking the risk.

5.9 Conclusions

Risk taking is a vastly complicated topic in which construction safety research is barely scratching its surface. The study and its scope aim to address some of the main issues that professionals and academics agree on regarding their importance. The following are conclusions that can be drawn from this study:

1- Through the SEM analysis, it was revealed that there is a statistical correlation with regard to the influence of risk perception, comprehension, and projection on risk taking in construction safety. Therefore, the study finds that the situational awareness model is well suited for construction safety risk taking assessment. No statistical significance was found between risk perception and risk comprehension; the researcher attributed this finding to the use of only one scenario to assess worker risk comprehension. As such, this is a limitation of this current study.

2- The results of this mixed methods study (specifically the results of both the qualitative and the quantitative models) indicate that reward perception does have an impact on risk taking; however, this impact is not direct. In the qualitative study, workers did exhibit preference associated with risk and reward, and that preference did impact their responses related to risk taking/avoidance. Nevertheless, rewards were never the reason to take, or not to take, risk for any of the workers. In the quantitative study, the SEM analysis revealed that reward perception did not have a direct impact on risk taking, but rather through the risk-reward relationship. This relationship showed suggestive statistical evidence of its impact on risk taking. Risk perception, on the other hand, did have a direct impact on risk taking in both methods of the analysis.

3- The quantitative analysis revealed that risk taking tendencies impact a worker's willingness to take risk for better rewards. A positive correlation between risk taking tendency and risk taking for reward was found in the SEM analysis (Correlation Coefficient = 0.15). A worker who would generally take risk, would feel less bothered for taking risk for a better reward.

4- Regarding the factors impacting risk taking, four factors that were repeatedly mentioned in the literature review were examined for their impact. The study results indicate that work pressure and having an emotional day, in the grand scheme of risk taking, were not impactful from a statistical point of view. A worker's age and accident involvement, on the other hand, were found to be statistically significant in terms of their impact on a worker's risk-taking decision.

5- Through the qualitative analysis, it was revealed that workers generally fall into five groups and have four different risk-reward preferences. Workers either prefer safety over reward, prefer high reward for high risk, accept working at a higher level of safety for low reward but at the same time are willing to accept more risk for better rewards, or prefer to work in a safe environment but refuse to take less compensation for it. Additionally, there is one group that does not have any preference; these workers show that they are willing to work at any job at any compensation level.

As for a worker's reasoning associated with risk taking, one group refuses to take any risk, while three others take risk to: 1) cut corners to get the job done, 2) accepted risk since their job has residual risk even if they themselves do not take it, and/or 3) accept risk for other reasons such as feeling restricted under the OSHA requirements. The reasons workers fit in the not taking risk group are: 1) the high consequences and potential injury that fall outside the comfort zone of the worker; 2) the worker's valuation of their life and their family, and not finding a reason to take safety risk; and 3) other external factors (such as company policy, or fear for their co-workers) and internal factors (such as finding different ways to execute the work safely).

6- Finally, the researcher exposed the importance of focusing on other factors that have been revealed as potential influencing factors through the analyses and results of this study. Those additional factors are: normalization of deviance, risk compensation, the psychological contract, and decision making under uncertainty.

5.10 Recommendations and Future Work

While this study provided answers for some of the industry and academic questions, the outcomes of this study also shine a light on some of the issues that need to be addressed in future research. The following are recommendations for further work on this research topic:

1- A detailed study is needed to see if workers are taking risk or making decisions under uncertainty. That distinction needs to be cross-examined with the worker's safety record and performance. The prevalence of workers taking risk or making decisions under uncertainty might prove its importance when combined with issues associated with worker self-management. A worker's self-assessment of risk can have severe consequences when it goes unchecked.

2- Considering rewards in risk taking cannot be stressed enough. Therefore, the researcher suggests a detailed study that examines every type of reward against various types of risk. Such a study would provide results in detail that balance between risk and reward perception.

3- The researcher highly recommend replicating work pressure by introducing a time limit in order to answer risk taking questions. Such a method would reveal the associative and cognitive processes of risk perception. Devising BART-like scenarios for construction should be part of the study since BART measures the tendency to take risk for personal gain. Time-bounded hazard identification can be found to have the ability to show the dysfunction of the risk-reward relationship (Finucane, et. al, 2000). Finally, the researcher also recommend developing a test for construction that is similar to the Extrinsic Affective Simon Task (EAST).

4- The findings of this study expose the need for addressing the impact of delaying discounting on both risk and reward perception simultaneously. Delayed discounting has shown that people prefer a smaller reward that would be offered immediately compared to a larger reward that would be offered after a longer period of time. Similarly, people tend to fear hazards that pose an immediate risk, such as fall hazards, to hazards that might impact their health at a later stage, such as exposures to toxic fumes or silica.

5.11 Limitations

Though this study provides unique and considerable contributions to the risk-taking field in construction safety studies, as in any work, there are limitations to the conclusions and the scope of the study. Those limitations that are recognized as restricting generalization of the results to the field as a whole include:

- The models and the analyses that were used in this study are aimed to understand risk taking, and not to project or predict risk taking. Risk taking is a very complex process where no study can fully predict future risk taking of human beings.

- Using self-reported data often incorporates bias into the results (Landeweerd et al., 1990). The researcher aimed to remove/avoid all possible biases that are under their control. Examples of sources of biases that the researcher addressed include: ambiguous question, double-barreled questions, technical words, unknown words, sensitive options, and others. More details regarding biases in questionnaires can be found in literature (Choi and Pak, 2005). As for the interviews, the researcher also aimed to eliminate conformance bias by interviewing workers one at a time.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The goal of this chapter is divided into two main aspects: (1) provide a reflection on the research goals and objectives that were set out in Chapter 1 of this dissertation; and provide insights for future work that can be carried out to expand this study. Some of those areas of future research are inspired by the industry needs that this research can help make a reality, while others are inspired by the limitations that this study included and how future work can help in addressing them.

Since this dissertation contains multiple studies that aimed to address various research objectives and goals, the summary of conclusions will be based on each of the objectives that were stated in Chapter 1. As stated in Chapter 1, the overarching goal of this research is to create new knowledge that will lead to the reduction of unnecessary risk taken by construction workers, and to remove personal biases and external influences from the process of safety related decision-making to improve safety outcomes. The collective outcome of the research efforts presented in this study facilitated achieving this principal goal.

6.2 Conclusions

All of the main objectives of this dissertation were fulfilled. A study of the biases of risk perception of construction workers was conducted, an understanding of workers' rewards was achieved, the relationship between risk and reward perception was illustrated, the underlying factors impacting the perception of risk and rewards were introduced and explained, and the overall interaction of the influencing factors in decision making was offered. Furthermore, there were other objectives that were not the stated direct objectives of this study; these additional objectives are listed in each of the research manuscripts presented in this dissertation. While the other objectives are not mentioned in the introduction to this dissertation, they were listed and achieved as described in each of the manuscripts. To recall, the following are the objectives of this dissertation:

1. Explore workers' perception of risk for potential biases that impact their assessment of safety risk, and assess the impact of the biases when present.

2. Establish a clear understanding of reward perception and workers' needs in the construction industry.
3. Illustrate the relationship between safety risk and occupational rewards as perceived by construction workers.
4. Investigate the influencing factors that impact risk and reward perception.
5. Present, in an in-depth manner, the influence of biases and compromises of risk perception on workers' willingness to take safety risk.

The following sections provide a summary of the conclusions found regarding each of the aforementioned objectives.

6.2.1 Explore workers' perception of risk for potential biases that impact their assessment of safety risk, and assess the impact of the biases when present

As mentioned previously, the goal of this part of the study is to examine workers' perception of risk for biases. Given the reliance on personal judgments in assessing daily risks in construction, it is important to make sure that the people whom contractors rely on for input have an accurate assessment of risk. To examine that condition, the first manuscript of this dissertation explored this topic, where the focus was to estimate the variabilities in assessing risk by construction workers for self and others. To do so, workers were asked to give a value of risk for the work that they execute in their daily jobs. Then, workers were asked to make two assessments of the risk in their work, once for workers with more training and experience, and again for workers with less training and experience.

The study results indicate that workers' risk perception is biased. For the same risk exposure, the risk in the workers' daily jobs was assessed differently for self, for workers with less experience, and for workers with more experience. On average, workers with more experience were assessed to have the lowest safety risk level and workers with less experience were assessed to have the highest safety risk level, while maintaining personal safety risk fell in-between these two assessments. As for the potential cause for this bias, further details are mentioned in the minor objectives section of this chapter. The impact of this bias can be the difference between a successful outcome of a daily task and a negative outcome of that same task.

6.2.2 Establish a clear understanding of reward perception and workers' needs in the construction industry

The second manuscript started out by establishing a clear and inclusive definition of rewards and what they mean in construction. Prior literature was found to be inconsistent with the reward term and what it represented. Consequently, the goal established in the second manuscript was to understand what workers perceive as their reward(s), what workers need from their rewards, and what are the factors that impact their reward perception.

Starting with what is perceived as a reward for construction workers, this study took a new approach into this topic by asking workers what they value and what they consider as a reward for their job in construction, rather than asking companies and their human resources specialists for what the company offers their construction workers. This clear distinction between previous approaches and the approach taken shows the industry what workers value and consider as compensation for their daily effort. This important piece of insight will be most influential in understanding why workers might take risks in their jobs. The study revealed that developmental rewards are the least present in construction where only 50% of the workers felt that they receive any of the categories that developmental rewards consisted of. Financial rewards on the other hand were present in the minds of 75% of the construction workers that were surveyed. Personal rewards and social rewards are almost tied for the second most types of rewards present in the construction industry.

As for what the workers wanted for their rewards, unsparingly, financial rewards were the most desired rewards by the surveyed workers. Personal and developmental rewards were the second most important desires for the construction workers. Lastly, social rewards were the least important need as indicated by the construction workers. While workers' needs were not consistent across all respondents, the researcher conducted a cluster analysis that grouped the construction workers' needs into six major clusters according to their responses.

The outcome presented in Manuscript 2 can be very useful for the industry to develop and customize a reward system that not only addresses workers' needs, but can also help in attracting new workers to the industry, as well as retaining and motivating the existing workforce. While this outcome is important by itself, the decades long industry's labor shortage creates added importance to this study's outcome.

6.2.3 Illustrate the relationship between safety risk and occupational rewards as perceived by construction workers

While the impact of reward perception on risk perception has been well documented in other fields, the construction safety community had yet to understand this relationship and its implication. This study, to the best of the researcher's knowledge, is the first one that addresses this topic. Three levels of examination for this relationship were studied for a more complete understanding of the relationship. The first level is the stated relationship, where workers were asked to answer whether risk and reward have a negative, positive, or no relationship between them. While the results were similar for each level, most workers assessed risk and reward to have a negative relationship. That is, if risk increases, reward decreases, and vice versa. The second most viewed connection between risk and reward was that there is no connection between them. This perspective means that neither increasing risk nor decreasing risk will affect rewards, and vice versa. The least held perspective was the positive relationship between risk and rewards (i.e., as risk increases, reward also increases). It was clear from this examination, that construction workers do not have a clear consensus or understanding of this relationship.

The second level of the examination was the evaluation of the correlations between the attributes of risk assessment and rewards assessment. The researcher conducted nine correlation analyses for each of the attributes of risk measured. The results indicated that there is a positive correlation between risk perception and rewards perception in four of the nine attributes. Those attributes that exhibited positive correlation were: worker's knowledge of safety, company's knowledge of safety, preventability of risk causing the accident, and the possibility of worker intervention. The more risk perceived in any of these attributes, the less the workers perceived their job being rewarding. Similarly, the more rewarding the worker's job was perceived, the less risky it was assessed in these attributes. From the correlation analysis, you can see that while most workers assessed risk and reward to be negatively correlated, a positive correlation between risk control and satisfaction was observed (i.e., the more risk control that the worker had over the outcome, the more satisfying they perceived their jobs to be).

Lastly, through the examination of the underlying factors influencing risk and reward perception, the researcher found three shared underlying factors that impacting risk and rewards perception. Those factors are: job satisfaction, training and its format, and the method of payment that the workers were compensated by. Further details regarding the underlying factors can be found in the next section.

6.2.4 Investigate the influencing factors that impact risk and reward perception

While there are multiple studies that have in more than one way explored the factors impacting risk perception, none of the studies examined it from a holistic point of view. This research examined over 20 different variables collected from multiple studies that examined the topics of reward perception and risk perception. For the reward perception analysis, 11 factors were found that impact workers' reward perception. Those factors are: marital status, race, region, *method of payment*, time with the current employer, supervision type*, job satisfaction*, accident involvement, workers skillfulness, stress levels, and *training format*. As for the risk perception influencing factors, they are: *method of payment*, job title*, job satisfaction, training format,* crew size, number of projects in the last 3 years, and the level of trust in work procedure. The researcher grouped the factors into two different groups, sociodemographic factors and occupational factors. As can be seen from the lists, none of the sociodemographic factors that were examined were shown to have an impact on both risk and rewards perception. As for the factors that were shown to link these two perceptions, they are: job satisfaction, training format, and method of payment. Type of payment and job satisfaction had a similar impact on both risk and reward perception, where they were both found to negatively impact the worker's perception. Training format, on the other hand, was associated with a higher reward perception and a lower risk perception. This mixed outcome needs to be addressed in future research.

6.2.5 Present, in an in-depth manner, the influence of biases and compromises of risk perception on workers' willingness to take safety risk

The topic of risk perception and risk taking, as mentioned previously, has been extensively studied. While previous studies documented the connection between the two, the inclusion of influencing factors and biases has not had the same level of attention. Thus, a detailed study was needed. In the fourth manuscript of this dissertation, a mixed-method study was conducted that employed both the qualitative analysis of workers' responses as well as a quantitative analysis of workers' interviews. The researcher set a goal to conduct two separate analyses such that their results can be contrasted and compared for a comprehensive understanding of risk taking for rewards in construction. The results of this mixed methods study (specifically the results of both the qualitative and the quantitative models) indicate that reward perception does have an impact on risk taking; however, this impact is not direct.

In the qualitative study, the results reveal that workers do exhibit preference associated with risk and reward, and that preference does impact their responses related to risk taking/avoidance. Nevertheless, rewards were never the reason to take, or not to take, risk for any of the workers. In the quantitative study, the SEM analysis revealed that reward perception does not have a direct impact on risk taking, but rather through the risk-reward relationship. This relationship showed suggestive statistical evidence of its impact on risk taking. Risk perception, on the other hand, does have a direct impact on risk taking as found in both methods of the analysis.

Through the qualitative analysis, it was revealed that workers generally fall into five groups and have four different risk-reward preferences. Workers either (1) prefer safety over reward, (2) prefer high reward for high risk, (3) accept working at a higher level of safety for low reward but at the same time are willing to accept more risk for better rewards, or (4) prefer to work in a safe environment but refuse to take less compensation for it. Additionally, there is one group that does not have any preference; these workers show that they are willing to work in any job at any compensation level. As for a worker's reasoning associated with risk taking, one group refuses to take any risk, while three other groups take risk to: 1) cut corners to get the job done, 2) accepted risk since their job has residual risk even if they themselves do not take it, and/or 3) accept risk for other reasons such as feeling restricted under the OSHA requirements. The reasons workers fit in the "not taking risk group" are: 1) the high consequences and potential injury that fall outside the comfort zone of the worker; 2) the worker's valuation of their life and their family, and not finding a reason to take safety risk; and

3) other external factors (such as company policy, or fear for their co-workers) and internal factors (such as finding different ways to execute the work safely).

6.2.6 Minor Objectives

Besides the five main objectives of this dissertation that were identified in the introduction chapter, there were a few objectives set forth in each of the research manuscripts of this dissertation. These objectives were clearly established before the start of each of the manuscripts, and they were addressed and their implications on the topic of study were discussed. The following points provide brief descriptions of the outcomes related to each minor objective:

A. *The examination of the cause of risk perception bias (risk target).* While the original theory of the cause of risk target bias suggested that control is the causing factor for this bias, the researcher examined three types of controls present in the construction industry for validation. Surprisingly, comparative risk that is associated with the perceived control was found to not be present in construction. Examples of types of control that could be present, and which were investigated, include: control over the construction safety of an activity, control over how to execute the work at hand, and job title control where supervisors and crew leaders have supervision control over other workers. None of these types of controls were found to impact the bias that existed in the perception of risk in construction workers' minds.

B. *Defining rewards as a term in the construction industry.* Occupational rewards play an important part in motivating, retaining, and attracting workers to an industry. That being said, there was no clear definition to be found for this term. Multiple definitions were found in literature that were not exactly consistent. The following definition and the four major categories of rewards were introduced by the researcher based on the available research and the consistency of the context: Occupational rewards can be anything of value (tangible or intangible) that an employer or an organization delivers to its employees whether intentionally or unintentionally in contemplation of the employee's work contributions (Henderson, 2003, Shields et al., 2016), "and to which employees as individuals attach a positive value as a satisfier of certain self-defined needs.” (Shields et al., 2016).

As for the main categories of rewards, the total rewards approach by Shields et al. (2016) provides the clearest distinction between the categories of rewards, and they are: financial, social, developmental, and personal.

C. The study provides a clear understanding of how occupational factors, as well as socio-demographic factors, impact reward perception for both increasing and decreasing the probability of workers being extremely satisfied. While interpretations of impact were discussed, variables were also grouped by the possibility of improvement in order to provide a more useful way of intervention by employers. Through statistical analysis, it was revealed that workers’ needs can be short-listed into six different groups. Five of these six groups have financial rewards as the most important reward. As for the separating factor, the rank of the social reward on the importance list determined the clustering of workers within a group.

D. In the second manuscript, reward importance, which reflects the workers’ needs for the financial, developmental, social, and personal rewards, was also provided. It was found that workers prioritize financial rewards higher than any other category of rewards, and deem personal reward as the least important category. The researcher also conducted cluster analysis of workers’ needs which revealed that workers generally fall under one of six main groups in terms on needs, where financial rewards usually is the most important reward. These findings should help future researcher as well as employers in understanding how each category of the total reward approach is represented and provided in the industry, how each factor impacts rewards perception, and how to address workers’ needs in terms of rewards.

E. Through the SEM analysis described in the fourth manuscript, it was revealed that there is a statistical correlation with regard to the influence of risk perception, comprehension, and projection on risk taking in construction safety. Therefore, the study finds that the situational awareness model is a model that is very well-suited for construction safety risk taking assessment. While no statistical significance was found between risk perception and risk comprehension; the researcher attributed this finding to the use of only one scenario to assess worker risk comprehension. As such, this is a limitation of the current study.

F. Finally, the researcher revealed the importance of focusing on other factors that have been made known as potential influencing factors through the analyses and results of the risk-taking study described in the fourth manuscript. Those additional factors are: normalization of deviance, risk compensation, the psychological contract, and decision making under uncertainty.

6.3 General Conclusions and Applications

As mentioned previously, all of the major objectives of this research were addressed and fulfilled. Risk perception, one of the main components of assessing safety risk in construction, was found to be biased in construction workers. This bias is not due to a lack of training, but due to the inherit characteristics of personal assessments. As described in the first manuscript, workers' risk perception was found to be biased, where they over-assessed the safety outcome of their work's risk for someone with less experience, and under-assessed the safety outcome of their work's risk for a worker with more experience and training. Subsequently, this research revealed the lack of understanding that construction workers exhibit when it comes to the relationship between risk and reward. This research showed that workers' risk and reward perception are linked and that the more valuable the rewards are perceived, the lower the safety risk is perceived. Lastly, the researcher went back to the situational awareness model, and examined the impact of the risk reward relationship throughout the whole process of assessing and deciding whether to take risk. As a result, it was shown that, among other factors, rewards perception and the risk-reward relationship have a major impact on the outcome of the decision of whether to take risk. Approximately 24% of the variance in the risk-taking decision was explained by the factors examined. While this percentage might be small, the factors that influence decision making have not been fully studied, and it is an area where science is still evolving. Twenty-four percent of the variance in the decision making process might be the key to reducing unwanted risk taking on a construction site, and could be the difference between a successful and safe day and an accident or even a fatality at work. The link between risk and rewards has been examined and cross-referenced with a qualitative analysis of many construction workers in multiple sites across the State of Oregon. The results of this examination showed that, like the quantitative study, rewards perception has an indirect impact on the workers' decisions of whether to take risk. In other words, risk perception can be swayed by rewards perception, and the inclusion of this relationship is justified. The researcher is confident that the results shown here in this body of work can be applied to both future academic research as well as in the industry to further study the impact of rewards perception in decision making, and to guide safety training to address unwanted biases and influencing factors in safety risk decisions.

The research, albeit successfully executed, contains a few limitations that the reader should know. While the researcher believes that the results of the models presented in this body of work are accurate, in practice, the direct use of the models' output values should be restricted. A detailed discussion of the limitations of the data and the methods used in this study are provided in the following section.

6.4 Limitations

While the research presented here in this dissertation contributes greatly to the body of knowledge in the area of construction safety, it is not without limitations. These limitations draw the boundaries of generalizability of the results to other populations and indicate areas of future work that can be made from the results of the studies presented here in this dissertation.

First, during the sample size calculation for the online survey, the margin of error chosen was 0.10 which gives a level of confidence of 90%. Though the researcher believes that this margin of error is adequate, not to mention that it has been used successfully in similar studies, it should be noted as a limitation. Second, the impact of the variance of the dependent variables (unobserved heterogeneity) on reward perception as well as risk perception was not accounted for during the development of the ordered probit models. Future work should account for the variance by using a random parameter ordered probit model.

Third, given that a worker's perceptions change over time, prediction of future behavior cannot be made for the long term. Nevertheless, over the short term, the finding of the study should hold true. Fourth, to be able to reach workers across all of the states in the US, and to maintain participant anonymity, an online survey questionnaire was utilized. Thus, validation of what workers receive in their occupation cannot be made. Answers and measures were based on worker's judgements with respect to their job. Fifth, the data collection instrument used was a self-assessment questionnaire. While using such a data collection process is the main source of collecting perception information, it is important to understand that surveys do not have a time limit or setting, where workers are not asked to answer each question within a predetermined time. Real-life situations requiring split-second decisions might lead to different answers than the time unbounded questions. Sixth, the models and the analyses that were used in this study are aimed to understand risk taking, and not to project or predict risk taking. Risk taking is a very complex process where no study can fully predict future risk taking of human beings.

Finally, to give priority to worker anonymity and to gather assessments from across the entire US, an online survey questionnaire was utilized for a portion of this study. Therefore, the worker assessments of risk and reward listed in the online survey cannot be cross-referenced with the employers of those workers. To address this issue, the researcher conducted in-person interviews with over 35 construction workers scattered across the State of Oregon and cross-examined the results of that outcome with the online study.

6.5 Future Work

While this study provided answers for some of the industry and academic questions, the outcomes of this study also shine a light on some of the issues that need to be addressed in future research. The following are recommendations for further work on this research topic:

1- For future work, the researcher recommends constructing a dynamic reward system that not only considers the nature of each type of reward, but also the impact of time on satisfaction. Therefore, the researcher suggests the Kano model for this task (Matzler et al. 2004). Although the Kano model is mainly intended for customer satisfaction, to the best of the researcher's judgment it can also be applied to address and improve worker satisfaction. Also, when designing a worker reward system, and given that this study was limited to one measure of satisfaction for all rewards, the researcher suggests clustering reward importance for each reward category (financial, social, developmental, and personal) as well as the corresponding reward satisfaction measure. Doing so will provide a better representation of worker's assessment.

2- The researcher highly recommends replicating work pressure by introducing a time limit in order to answer risk-taking questions. Such a method would reveal the associative and cognitive processes of risk perception. Devising BART-like scenarios for construction should be part of the study since BART measures the tendency to take risk for personal gain. Time-bounded hazard identification can be found to have the ability to show the dysfunction of the risk-reward relationship (Finucane, et. al, 2000). Finally, the researcher also recommends developing a test for construction that is similar to the Extrinsic Affective Simon Task (EAST) that provides a measure of implicit evaluation.

3- A detailed study is needed to determine if workers are taking risk or making decisions under uncertainty. That distinction needs to be cross-examined with the worker's safety record and performance. The prevalence of workers taking risk or making decisions under uncertainty might prove its importance when combined with issues associated with worker self-management. A worker's self-assessment of risk can have severe consequences when it goes unchecked.

4- Considering rewards in risk taking cannot be stressed enough. Therefore, the researcher suggests a comprehensive and detailed study that examines every type of reward against various types of risk. Such a study would provide results in detail that balance between risk and reward perception.

5- The researcher highly recommends studying the impact of variance in workers' decision making on the overall safety plan of a certain project. Such a study can create a measure for safety plan reliability, and create a resilient safety system that has fewer vulnerabilities.

6- The assessments of risk and reward in the study are for all the risks that the worker’s job includes. Separate studies dedicated to each individual risk source and each individual reward category are of high importance to gain a higher level of understanding of the risk-reward relationship.

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8 Appendix I – Survey Questionnaire

Section 1: Personal Information

Question One: Name

Question Two: Age (16-80)

Question Three: Gender

- Male
- Female
- Prefer not to answer

Question Four: Marital Status

- Married
- Widowed
- Divorced
- Separated
- Never married
- Prefer not to answer

Question Five: Number of children

- Scale 1 – 10
- Prefer not to answer

Question Six: Race and Ethnicity

- White
- Black or African American
- Asian
- Native Hawaiian or Pacific Islander
- Other
- Prefer not to answer

Question Seven: Languages Spoken (select all that apply

- English
- Spanish
- Other, Please specify -------

Question Eight: Level of education

- Less than high school
- High school graduate
- Some college study
- 2 years degree
- 4 years degree
- Professional degree

Question Nine: In which state do you currently reside?

Question Ten: Do you work in the same state that you reside in?

- Yes
- No

Question Eleven: In which state do you currently work?

Section 2: Occupational Information:

Question Twelve: Your job title

- Helper
- Tradesman
- Journeyman
- Crew leader
- Foreman
- Other, please specify --------

Question Thirteen: Your Supervisor job title:

- Helper
- Tradesman
- Journeyman
- Crew leader
- Foreman
- Superintendent
- Other, please specify -------

Question Fourteen: You work for (select all that apply)

- General contractor
- Subcontractor
- Self-employed

Question Fifteen: Method of payment (select all that apply)

- Per hour
- Per unit
- Salary

Question Sixteen: What is your annual income range?

- Below $20,000
- $20,000 - $29,999
- $30,000 – $39,999
- $40,000 – $49,999
- $50,000 – $59,999
- $60,000 – $69,000
- $70,000 – $79,999
- $80,000 – $89,000
- $90,000 or more
- Prefer not to answer

Question Seventeen: Your trade (please select all that apply)

- Carpenter
- Electrician
- Roofer
- Equipment operator
- Iron worker
- Welder
- Mason
- Laborer
- Painter
- Pipefitter
- Other, please specify ------

Question Eighteen: Number of years of experience -----------

Question Nineteen: Number of hours of safety training that you have in total ----------------

Question Twenty: Time since your last safety training ---------------

Question Twenty-one: Format of safety training received (select all that apply)

- Training in English only
- Training is given in workers' own language
- Visual aid used in training
- Feedback is provided for workers
- Middle management participate in training
- Content of training is designed to satisfy workers needs/interest
- No safety training received

Question Twenty-two: Number of crew members working with you ---------------

Question Twenty-three: Time with current employer (in months) -------------

Question Twenty-four: Time with current crew (in months) --------------------

Question Twenty-five: Number of projects you worked on in the last 3 years ---------------

Question Twenty-six: Size of your company in terms of number of workers

- Less than 300 employees
- More than 300 employees

Question Twenty-seven: Are you a union member

- Yes
- No

Question Twenty-eight: How satisfied are you with your current job?

- Extremely satisfied
- Moderately satisfied
- Slightly satisfied
- Neither satisfied nor dissatisfied
- Slightly dissatisfied
- Moderately dissatisfied

- Extremely dissatisfied

Question Twenty-nine: How familiar are you with the work at hand?

- Extremely familiar
- Very familiar
- Moderately familiar
- Slightly familiar
- Not familiar at all

Question Thirty: How complex is the current work at hand?

- Extremely complex
- Somewhat complex
- Neither complex or simple
- Somewhat simple
- Extremely simple

Question Thirty-one: What is the current level of stress in your work?

- Very high
- Moderately high
- Average
- Moderately low
- Very low

Question Thirty-two: What is the current level of construction safety risk in your work?

- Very high
- Moderately high
- Average
- Moderately low
- Very low

Question Thirty-three: Do you have any personal or emotional stress today?

- Yes
- No

Question Thirty-four: Are you overload at work today?

- Yes
- No

Question Thirty-five: Are you allowed to stop the work (without being rebuked at) if the current work situation is hazardous?

- Yes
- No
- Prefer not to answer

Question Thirty-six: Do you feel pressure if your production rate is less than what it normally is due to safety concerns?

- Yes
- No
- Prefer not to answer

Question Thirty-seven: In your work, do you follow a preset procedure to execute your work or do you execute it in the way you see fit?

- Follow a procedure
- Execute as I see fit

Question Thirty-eight: For the question above, how confident are you that the procedure used is the safest way to get the work done?

- Extremely confident
- Somewhat confident
- Neither confident nor doubtful
- Somewhat doubtful
- Extremely doubtful

Question Thirty-nine: Have you personally experienced an accident at work?

- Yes
- No

Question Forty: (if your answer for the question above is yes) How long ago was the last accident that you were involved in?

- Less than a month
- 1 month to a year
- More than a year

Question Forty-one: What were the injury severities in that accident? (select all that apply)

- Fatal
- Severe injury
- Disabling injury
- Non-incapacitating injury

Question Forty-two: Have you witnessed an accident at work?

- Yes
- No

Question Forty-three: (if your answer for the question above is yes) How long ago was the last accident that you have witnessed?

- Less than a month
- 1 month to a year
- More than a year

Question Forty-four: What were the injury severities in that accident? (select all that apply)

- Fatal
- Severe injury
- Disabling injury
- Non-incapacitating injury

Question Forty-five: Do you knowingly take a calculated risk even though it is against your training / work safety plan?

- Yes
- No

Question Forty-six: Do you think you can recognize all of the safety risks in your work area?

- Yes
- No

Question Forty-seven: For your work, what do you think the safety risks will be for workers with different levels of experience of training?

a. Worker with more training or experience
   i. Much safer
   ii. Safer
   iii. Same level of safety risk
   iv. Riskier
   v. Much riskier
b. Workers with less training or experience
   i. Much safer
   ii. Safer
   iii. Same level of safety risk
   i. Riskier
   ii. Much riskier

Section 2: Risk Perception:

Question Forty-eight: How would you rate your level of knowledge of the safety risks and hazards that your work involves?

- Very low level of knowledge
- ....
- Moderate level of knowledge
- …….
- Very high level of knowledge

Question Forty-nine: How would you rate the company safety personnel's knowledge of the safety risks and hazards that your work involves?

- Very low level of knowledge
- ....
- Moderate level of knowledge
- …….
- Very high level of knowledge

Question Fifty: To what extent do you fear the hazards that can be derived from your work safety risks?

- Extremely unlikely
- ………..
- Extremely likely

Question Fifty-one: What is the possibility that you might personally experience an injury (small or large, either now or later) as a result of your work safety risks?

- Extremely unlikely
- ………..
- Extremely likely

Question Fifty-two: If a risky situation happens, what would be the severity of injury related to that situation?

- No injury can happen

- ……….
- Fatality

Question Fifty-three: To what extent, do you think that the safety risks causing accidents in your work can be prevented?

- Extremely controllable
- ………….
- Extremely uncontrollable

Question Fifty-four: To what extent, do you think that you can intervene to control (prevent or mitigate) the damage / injury that your work safety risk might be cause?

- Extremely controllable
- ………….
- Extremely uncontrollable

Question Fifty-five: Do you think that your work safety risks can cause damage / injury to a large number of people at once?

- Extremely unlikely
- ………..
- Extremely likely

Question Fifty-six: If an accident happens, when would the most harmful consequences of this safety risk be experienced?

- Immediately
- ………..
- After a long period of time

Section 3: Reward Perception:

Question Fifty-seven: How satisfied are you with your work benefits/rewards?

- Extremely dissatisfied
- Moderately dissatisfied
- Slightly dissatisfied
- Neither satisfied nor dissatisfied
- Slightly satisfied
- Moderately satisfied
- Extremely satisfied

Question Fifty-eight: Do you consider being safe in your work environment a reward (benefit)?

- Yes
- No

Question Fifty-nine: What type of reward / benefit are you getting from your job? (select all that apply)

- Fixed or base pay
- Cash benefits
- Performance-based pay
- Learning, training, and development
- Succession planning
- Career progression
- Safety climate / safety culture
- Performance support
- Work group affinity

- Work-life balance
- Job challenge
- Responsibility
- Autonomy
- Task variety
- Other, Please specify

Question Sixty: How satisfied are you with the benefits / rewards listed above?

- o Extremely dissatisfied
- o Moderately dissatisfied
- o Slightly dissatisfied
- o Neither satisfied nor dissatisfied
- o Slightly satisfied
- o Moderately satisfied
- o Extremely satisfied

Question Sixty-one: Please rank the rewards / benefits that you receive in your work from most satisfied to least satisfied with

- « Fixed or base pay
- « Cash benefits
- « Performance-based pay
- « Learning, training, and development
- « Succession planning
- « Career progression
- « Safety climate / safety culture
- « Performance support
- « Work group affinity
- « Work-life balance
- « Job challenge
- « Responsibility
- « Autonomy
- « Task variety
- « Other

Question Sixty-two: Which reward / benefit you feel needs to be adjusted in your work?

- o Fixed or base pay
- o Cash benefits
- o Performance-based pay
- o Learning, training, and development
- o Succession planning
- o Career progression
- o Safety climate / safety culture
- o Performance support
- o Work group affinity
- o Work-life balance
- o Job challenge
- o Responsibility
- o Autonomy
- o Task variety
- o Other

Section 5: Risk Taking:

Question Sixty-three: For your current work, how safe is it?

- o Very safe
- o ……..
- o Moderately safe

- ……..
- Very risky

Question Sixty-four: Will it still be safe to work if you take a little more risk?

- Yes
- No

Question Sixty-five: Are you willing to take on higher risk for better benefit(s)

- Yes
- No

If the answer to the question above is yes, please answer questions sixty-six to seventy. If the answer for the question above is no, please answer question seventy-one.

Question Sixty-six: What is the reward that you might consider the most in taking that higher reward?

- Fixed or base pay
- Cash benefits
- Performance-based pay
- Learning, training, and development
- Succession planning
- Career progression
- Safety climate / safety culture
- Performance support
- Work group affinity
- Work-life balance
- Job challenge
- Responsibility
- Autonomy
- Task variety
- Other

Question Sixty-seven: How much of a higher safety risk percentage (based on your current level of safety risk) are your willing to take? (scale from 0 to 100 percent)

Question Sixty-eight: Do you think that this increase in safety risk will not affect your personal safety or the safety of those working with you or around you?

- Yes
- No

Question Sixty-nine: Do you think that you have the necessary training, experience, pieces of equipment, or tools to execute that higher risk work safely?

- Yes
- No

Question Seventy: How much control do you have over the safety risk in your own work area?

- Very high control
- Moderately high
- Average control
- Moderately low
- No control

Question Seventy-one: What is (are) the reason(s) for not taking that higher risk? (select all that apply)

- Your current construction safety risk level is already high
- You lack qualification, training, or experience for that increase in safety risk level.
- Your personal safety, or the safety of those around you will be compromised with lower safety conditions
- You are satisfied with your current level of risk/reward
- Other, please specify ----------

9 Appendix II – Interview Questions

Regarding rewards/benefits:

1- Which type of reward/benefit is the most important to you?
   a. Social (organizational climate, management culture, performance support, work group affinity, work-life balance)
   b. Financial (fixed or base pay, cash benefits, performance-related pay)
   c. Development (learning, training, and development; succession planning; career progression)
   d. Personal (job challenge, responsibility, autonomy)
2- What reward/benefit does the construction industry lack (or offer the least) in your opinion?
3- Do you think about your benefits/rewards when you work in a new job, or on a new site?
   - How do rewards/benefits effect your decision?

Regarding risk and the risk-reward relationship:

1- Do you weigh risk vs. rewards in making a work or task decision? If no, what do you weigh risk against?
   - Please describe your decision-making process?
2- Will you work on a safe site if your benefits are low (not that high)?
3- Will you work on a hazardous site if your benefits are high (higher than what you normally work with)?
4- Do you have a preference in site conditions, and job benefits?
   - If yes, what are your preferences?
5- In general, where do you draw the line with regard to choosing not to perform the work? (When the job becomes unworthy)?

Regarding safety risk taking:

1- In general, what is your reasoning for taking safety risk?
2- In general, what is your reasoning for **not** taking safety risk?
3- How much extra risk are you willing to take? What and how much do you want in return?
4- How do you assess these results?

Sociodemographic Questions:

1- Age
2- Years of experience in construction
3- Safety training info
4- Trade(s)
5- Job title
6- Education
7- Type of construction work (commercial, industrial, residential, maintenance, …. Etc.)

Q1: Working in the construction industry involves hazards that may have long term health effects like working in lead contaminated areas, exposure to fumes, and exposure to toxic materials. Construction companies try to eliminate those hazards. To what extent are there long-term hazards present in the construction industry?

☐ None at all	☐ A little	☐ A moderate amount	☐ A lot	☐ A great deal

Q2: Compared to the impact on your health, is the health impact different for management personnel or for other workers with less experience/training than you?

	Much worse	Somewhat worse	About the same	Somewhat better	Much better
Management	☐	☐	☐	☐	☐
Other workers	☐	☐	☐	☐	☐

Q3: The construction industry is typically the lead industry in the number of fatalities in the US, and among the highest in the number of severe injuries. Companies all over the US strive to minimize safety risk.
In general, how much potential danger does the construction industry involve?

☐ None at all	☐ A little	☐ A moderate amount	☐ A lot	☐ A great deal

4: Compared with the potential danger to you in your work, is the potential danger different for management personnel or for workers with less experience/training than you?

	Much worse	Somewhat worse	About the same	Somewhat better	Much better
Management	☐	☐	☐	☐	☐
Other workers	☐	☐	☐	☐	☐

Q5: Given the safety risk involved in the construction industry, it is still one of the largest sources of income for people in the United States. Construction workers are paid well, help build people's homes, hospitals, and roads, and are insured against work-related injuries.
Is there a presence of a trade-off between the safety risks and the benefits for being a worker in the construction industry?

☐ None at all	☐ A little	☐ A moderate amount	☐ A lot	☐ A great deal

Q6: Compared to the trade-off for yourself, does the presence of a trade-off differ for management personnel or for workers with less experience/training than you?

	Much worse	Somewhat worse	About the same	Somewhat better	Much better
Management	☐	☐	☐	☐	☐
Other workers	☐	☐	☐	☐	☐

Q7: Working in the construction industry involves work that is engaging, diverse, controlled, voluntary, and aggressive, and requires training for each new task.

How much of the factors mentioned above do you think the construction industry involves?

☐ None at all	☐ A little	☐ A moderate amount	☐ A lot	☐ A great deal

Q8: Compared to how the factors affect you, are the factors different for management personnel or for workers with less experience/training than you?

	Much worse	Somewhat worse	About the same	Somewhat better	Much better
Management	☐	☐	☐	☐	☐
Other workers	☐	☐	☐	☐	☐

Q9: With respect to the questions above regarding the risk for management personnel and other workers, what was your reasoning for your assessments?

Q10: Which of the following statements, by and large, represents you the most:

- ☐ Life is a lottery. Risks are out of our control; safety is a matter of luck.
- ☐ Safety risks are acceptable as long companies have the policies and practices to control them.
- ☐ Safety risks are acceptable as long as they do not involve coercion of others.
- ☐ Safety risks offers opportunities and should be accepted in exchange for benefits.
- ☐ Safety risks should be avoided unless they are necessary to protect the public good.
- ☐ None of the above