An Economic Analysis of Occupational Safety at Agribusiness Retailers

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Erik Hanson

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Michael A. Boland, Advisor

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List of Abbreviations and Terms

BLS . . . . The Bureau of Labor Statistics, a U.S. Department of Labor agency that collects and publishes occupational injury data.

DAFW . . . . Days away from work, which are days when an employee is absent from work due to an occupational injury.

DART . . . . Days away from work, days of work restriction, or days of job transfer, which are days when an employee does not complete their normal work tasks due to work absence, work restriction, or job transfer caused by an occupational injury. DART injury totals are the sum of DAFW and DJTR injury totals.

DEA . . . . Data envelopment analysis, which is a nonparametric method for determining an efficient frontier for DMUs producing outputs using inputs.

DJTR . . . . Days of job transfer or work restriction, which are days when an employee does not complete their normal work tasks due to job transfer or work restriction caused by an occupational injury.

DMU . . . . Decision making unit, which is an entity using inputs to produce outputs. DMUs are the unit of analysis in DEA.

Incidence rate . . . . A measure of the number of injuries occurring in an employee population during a period of time. Incidence rates are most frequently calculated per 200,000 hours, representing the annual work exposure for 100 full time employees.

Injury severity . . . . Amount of normal work time missed due to a DART injury.

OSHA . . . . The Occupational Safety and Health Administration, a U.S. Department of Labor agency that determines standards for occupational safety conditions and recordkeeping.

Safety climate . . . . Expressed safety culture. In this dissertation, safety climate is defined as an employee’s expressed empowerment to take actions that promote occupational safety.

Safety culture . . . . . Employee values regarding the importance of occupational safety and the ability to work safely.

Safety outcomes . . . Occupational safety measures including injury frequency and severity.

Safety systems . . . . Policies, procedures, and programs designed to promote occupational safety. In this dissertation, safety systems describe discipline for safety violations, safety inspections, investigations into safety incidents, safety meetings, modified duty programs for employees returning to work after injury, off-the-job safety training, recognition for safety accomplishments, and safety training.

TRC . . . . Total recordable cases, which are all occupational injuries that must be recorded for OSHA purposes. TRC injuries include DAFW injuries and DJTR injuries. Other injuries resulting in death, loss of consciousness, medical treatment beyond first aid, or significant diagnosis must also be recorded (U.S. Department of Labor, OSHA 2004).

CHAPTER 1

Introduction

Agriculture's occupational safety challenges receive attention from many sources. The National Institute for Occupational Safety and Health supports ten Centers for Agricultural Disease and Injury Research, Education, and Prevention, including one at the University of Minnesota. The Occupational Safety and Health Administration (OSHA) also monitors the industry and recently attempted to increase enforcement of safety regulations at grain storage facilities. Moreover, the news media frequently publicizes agricultural safety issues. A 2015 series on farm safety published by the Minneapolis Star Tribune noted that over 200 workers died in Minnesota farm accidents from 2003 to 2013 (Meitrodt 2015). In that series, Jim Nichols, a former Minnesota Agriculture Commissioner, assailed the current level of agricultural safety as "a terrible thing to pass on to the next generation" that necessitates "thinking differently."

The widespread awareness of agricultural safety issues is in line with the industry's frequent injuries.[1] Figure 1.1 shows that total recordable case (TRC) incidence rates for crop production and support activities for agriculture and forestry are historically well above the TRC incidence rate for U.S. private industry as a whole (U.S. Department of Labor, Bureau of Labor Statistics [BLS] 2015).[2] The figure also indicates that TRC incidence rates for crop production and support activities for agriculture and forestry declined less markedly than the U.S. private industry rate from 2003 to 2014.

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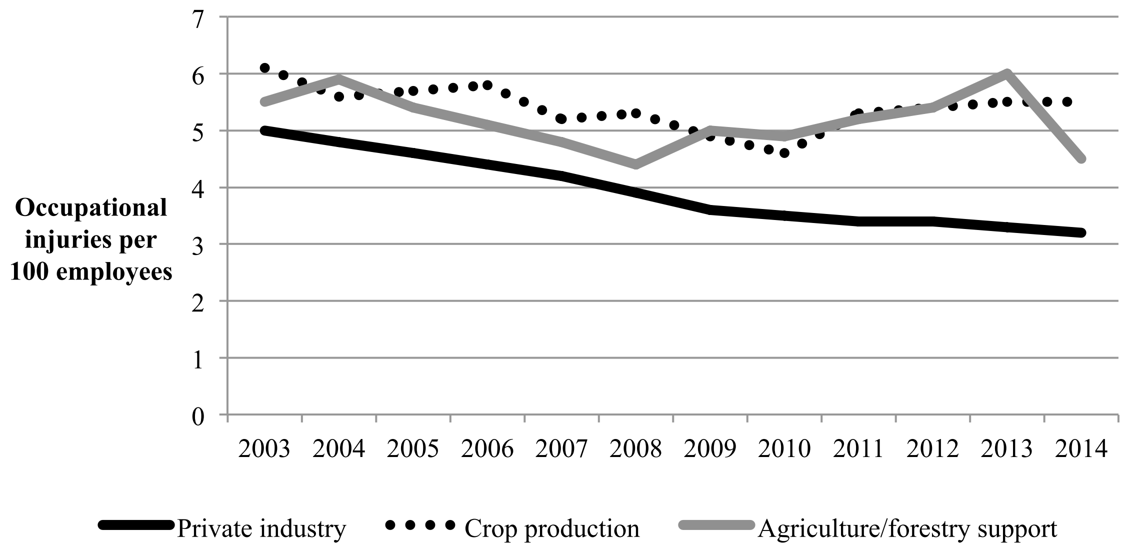
[1] For brevity, this dissertation uses "injury" to describe both injuries and illnesses.

[2] Incidence rates are calculated per 200,000 hours, which represents the annual hours worked by 100 full time employees working 40 hours per week for 50 weeks per year.

Figure 1.1. TRC incidence rates for U.S. private industry, crop production, and support activities for agriculture and forestry



Source: U.S. Department of Labor, BLS (2015)

Note: Incidence rates are calculated as (injury cases × 200,000)/total hours worked, representing injuries per 100 full time workers.

Agribusiness retailers are a major part of the U.S. agricultural economy. These firms provide farmers with crucial inputs including agronomic services, animal nutrition products, capital, chemicals, crop nutrients, energy, and seed. Agribusiness retailers also market farmers' outputs such as grains and oilseeds. Therefore, many of these firms do business in North American Industry Classification System (NAICS) industries 42491 (farm merchant suppliers) and 49313 (farm product warehousing and storage). In addition, many agribusiness retailers have nonagricultural retail operations and other nonagricultural business lines such as automobile repair shops and transportation divisions. Accordingly, agribusiness retailers are multipurpose enterprises that are unique relative to their more focused competitors. Agricultural cooperatives, which had more than 135,000 full time employees in 2014, are a common type of agribusiness retailer

(U.S. Department of Agriculture, Rural Development 2016). Agribusiness retailers face occupational safety hazards similar to those of the farmers they serve.

Occupational safety at agribusiness retailers generates less public concern than occupational safety in the wider agricultural industry. However, data collected for this dissertation indicate that occupational injuries may be more common at agribusiness retailers than in production agriculture.[3] Specifically, from 2012 to 2015, the fifteen agribusiness retailers surveyed for this dissertation had an aggregate TRC incidence rate of 6.3 injuries per 100 full time workers, a rate roughly double that of U.S. private industry in 2014 (U.S. Department of Labor, BLS 2015). Figure 1.2 shows that surveyed agribusiness retailers exceeded 2014 U.S. private industry incidence rates in all major injury categories: TRC injuries; days away from work, work restriction, or job transfer (DART) injuries; days away from work (DAFW) injuries; and days of job transfer or work restriction (DJTR) injuries.[4]

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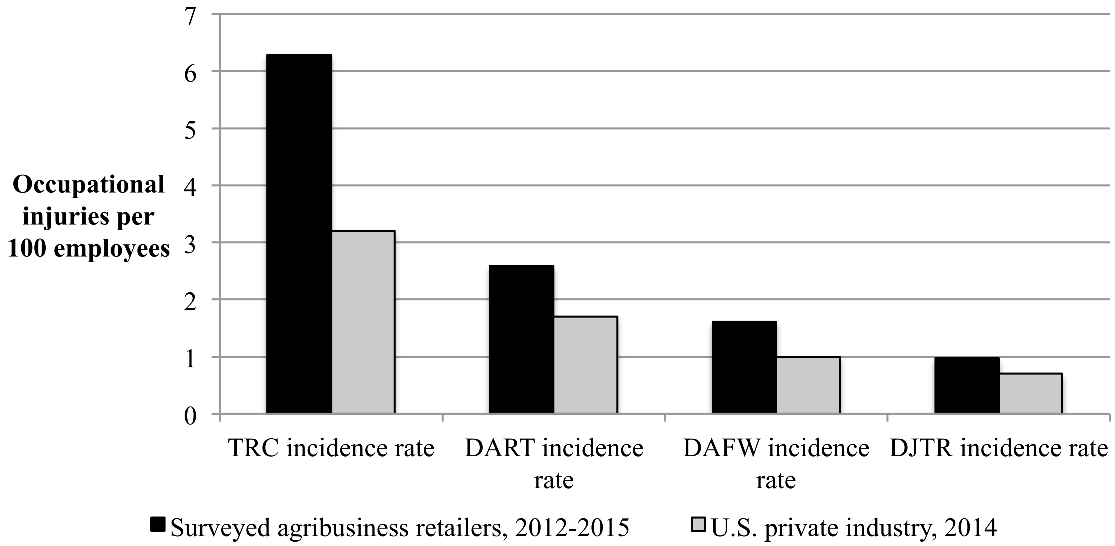
[3] Although the BLS does not publish occupational safety statistics specific to the entire agribusiness retail industry, it does report data for industries relevant to several agribusiness retailer business lines. Examples include nondurable good wholesalers (NAICS code 424) and warehousing and storage (NAICS code 493).

[4] DART injuries are the sum of DAFW injuries and DJTR injuries. If an injury leads to both DAFW and DJTR, it is classified as a DAFW injury.

Figure 1.2. Occupational injury incidence rates, surveyed agribusiness retailers versus U.S. private industry



Source: U.S. Department of Labor, BLS (2015)

Note: Incidence rates are calculated as (injury cases × 200,000)/total hours worked, representing injuries per 100 full time workers.

Agribusiness retailers are motivated to improve occupational safety outcomes such as injury frequency and injury severity.[5] Improved occupational safety is beneficial to the health and wellness of all employees. In addition to physical ailments and missed work time in the short-term, injured employees and their families may be harmed by long-lasting nonwork consequences of occupational injuries (Keogh et al. 2000). For firms, financial considerations are a major driver of occupational safety efforts. Specifically, occupational injuries create costs through experience-rated insurance premia, regulatory fines, legal settlements, reduced productivity, and work stoppages. A reduction in these costs may increase profitability.

[5] Improved safety outcomes are not the same as increased safety outcomes. Rather, increases in safety outcomes such as injury frequency and injury severity are worsened safety outcomes.

In pursuit of their occupational safety goals, many agribusiness retailers employ safety directors to guide occupational safety systems that include education, feedback, training and other elements.[6] Among other roles, safety directors are tasked with improving safety culture and safety climate. Turner et al. (1989) define safety culture as "the set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimising the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious." Flin et al. (2000) state that safety climate "is a snapshot of the state of safety providing an indicator of the underlying safety culture of a work group, plant or organisation." Accordingly, safety climate is viewed as a predictor and creator of safety outcomes. Safety directors attempt to improve safety climate and, by extension, reduce the frequency and severity of occupational injuries.

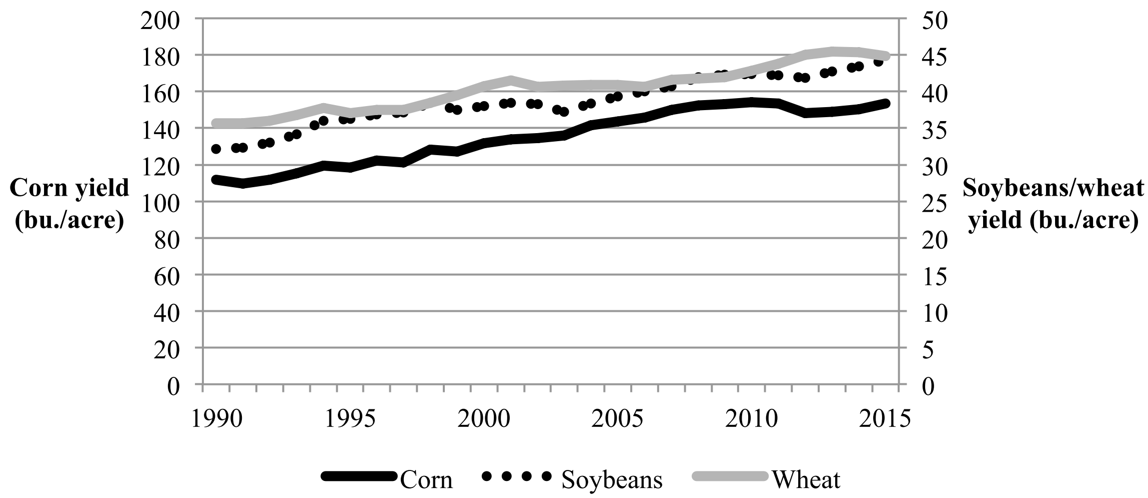
Although authors from many disciplines explore occupational safety climate and occupational safety outcomes across a variety of industries, Risch et al. (2014) are unique in examining agribusiness retailers.[7] Specifically, they collected survey and occupational injury data to estimate models of safety climate and safety outcomes at agribusiness retailers. Risch et al. find that managerial safety climate increases with policies, procedures, or programs for safety training, discipline, inspection, and modified duty. Nonmanagerial safety climate increases with policies, procedures, or programs for safety training, discipline, modified duty, and recognition. Furthermore, the authors find that

[6] Appendix 1 contains a description of the safety directors participating in this dissertation.
[7] Corey Risch was a doctoral student in applied economics at the University of Minnesota. One of the three essays from her doctoral dissertation (Risch 2013) forms the basis for Risch et al. (2014).

occupational injury frequency declines as managerial safety climate improves but occupational injury frequency is not significantly related to nonmanagerial safety climate. In total, Risch et al. take a major step toward understanding occupational safety at agribusiness retailers.

Occupational safety concerns at agribusiness retailers are amplified by increased activity in the industry. The business volume handled by agricultural cooperatives has more than doubled since 2005 (USDA, Rural Development 2016). The increased business volume of agribusiness retailers is due in part to agricultural advancements in genetics, yield, and planting density (Pardey and Wright 2003). Figure 1.3 shows strong growth in U.S. corn, soybean, and wheat yields from 1990 to 2015. Over that quarter century, five-year average yields for corn, soybean, and wheat increased by 37.4 percent, 37.9 percent, and 25.7 percent, respectively (USDA, National Agricultural Statistics Service 2016). In the upper Midwest, changed cropping patterns and shorter planting and harvesting windows have also intensified the demands placed on agribusiness retailers (Bechdol, Gray, and Gloy 2010; Beddow and Pardey 2015). Further increases in activity at agribusiness retailers may threaten occupational safety by exerting additional pressure on employees and the facilities in which they work.

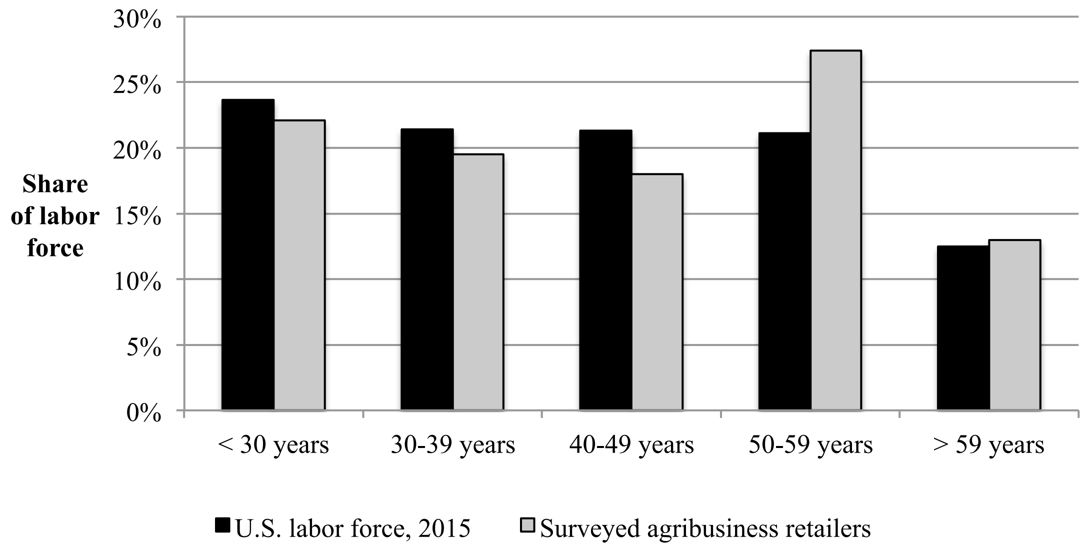
Figure 1.3. Five-year average yields for U.S. corn, soybeans, and wheat



Source: USDA, National Agricultural Statistics Service (2016)

The age distribution of agribusiness retailer employees adds another layer of complexity to occupational safety concerns. Specifically, as figure 1.4 illustrates, the workforce at surveyed agribusiness retailers is considerably older than the general U.S. labor force, with 40.4 percent of the industry's employees being age fifty or older. This suggests that a generational transition among agribusiness retailers will soon begin due to retirements. Although this transition may create alarm about introducing inexperienced, injury-prone workers to the workplace, a new generation of employees also represents an opportunity to change safety attitudes and practices at agribusiness retailers.

Figure 1.4. Age distribution of employees, U.S. labor force versus surveyed agribusiness retailers



Source: U.S. Department of Labor, BLS (2016)

Objective and hypotheses

The objective of this dissertation is to determine whether occupational safety efforts and investments improve safety outcomes at agribusiness retailers and to examine how those improvements happen within a firm. Survey data are used to estimate a model where safety climate is explained by safety system elements and employee background factors. As mentioned previously, Risch et al. (2014) find that several safety system elements are positively related to safety climate, a finding that agrees with theoretical expectations. Even though a new survey instrument is used and a different group of agribusiness retailers is analyzed, this relationship is not expected to change in this dissertation's safety climate model.

Hypothesis 1: The frequency or quantity of safety system elements experienced by an employee is positively associated with the employee's safety climate.

Risch et al. do not account for the influence of personal characteristics on safety climate. Participating safety directors suggested that factors such as agricultural background, community ties, and educational attainment may determine an employee's safety climate in the agribusiness retail setting.

Hypothesis 2: An employee's agricultural background is negatively associated with safety climate while an employee's workplace distance from their childhood home and educational attainment are positively associated with safety climate.

The effects of the aforementioned background factors are measured in this dissertation's safety climate model.

The importance of safety climate is highlighted by its inclusion in this dissertation's model of safety outcomes. Many researchers, including Risch et al., link safety climate to injury rates. However, this dissertation explores the connection between safety climate and safety outcomes in greater detail by estimating models explaining TRC injuries, DART injuries, DAFW injuries, total DART, and total DAFW at surveyed agribusiness retailers' business locations.

Hypothesis 3: A business location's safety outcomes improve with safety climate.

Besides safety climate, several other explanatory variables in the safety outcome model characterize workers and the work they do, thereby offering additional insight into occupational safety at agribusiness retailers.

Finally, an efficiency analysis of safety investments and outcomes is conducted to identify overall strengths and weaknesses of occupational safety investments on a firm-by-firm basis. Specifically, data envelopment analysis is used to assess the relationship between firm-level safety investments and safety outcomes. Although this sort of analysis is underutilized in the occupational safety literature, participating safety directors acknowledge that some agribusiness retailers are more effective than others in maximizing their returns on safety investments.

Hypothesis 4: The efficiency of a firm's occupational safety investments is determined by managerial experience.

This hypothesis and the others outlined above are studied using a rich data set describing occupational safety at agribusiness retailers.

Data were collected from fifteen agribusiness retailers with locations in seven states. A safety survey was created with the assistance of an advisory board composed of several safety directors at participating firms. Employees from the fifteen agribusiness retailers completed a combined 2,338 surveys on their personal characteristics, safety attitudes, and safety practices. In addition, annual injury and safety investment data were collected from each firm. These data are used to estimate empirical models of safety climate, safety outcomes, and safety efficiency.

The demographic and occupational injury data gathered for this dissertation yield a more complete description of agribusiness retailer employees and the injuries they suffer than exists elsewhere. Relatively little research, both safety-related and otherwise, focuses on agribusiness retailers and this dissertation expands the existing literature.

OSHA data collected from surveyed agribusiness retailers are used to summarize the frequency and severity of occupational injuries and to categorize the nature, affected body part, source, and event or exposure of those injuries. This thorough description of occupational safety at agribusiness retailers should help safety educators as they create outreach programs aimed at employees.

Organization of dissertation

The remainder of this dissertation is divided into six chapters. Chapter 2 provides context for subsequent chapters by detailing the frequency and characteristics of occupational injuries at surveyed agribusiness retailers. Chapter 3 summarizes the occupational safety literature that is at the foundation of this dissertation. Chapter 4 builds upon chapter 3 by outlining the theoretical underpinnings for this dissertation's models of safety climate, safety outcomes, and safety efficiency. Chapter 5 describes the resulting empirical models and the data used to estimate the models. The three distinct analyses presented in chapter 5 are assembled as a single dissertation rather than a series of essays because of shared themes and data. Chapter 6 offers a detailed description and discussion of the empirical results stemming from the empirical models of safety climate, safety outcomes, and safety efficiency. Finally, chapter 7 summarizes the dissertation and offers several implications, limitations, and future extensions of this research.

CHAPTER 2

Characteristics of Occupational Injuries at Agribusiness Retailers

Data on occupational injuries from 2012 to 2015 were collected from fifteen agribusiness retailers with business locations in seven states. Combined, these firms employed an annual average of 3,220 workers during the 2012 to 2015 period. Surveyed agribusiness retailers perform a wide variety of tasks including agronomic application, crop input sales, energy product delivery, farm product marketing, and farm product storage. Furthermore, several of these firms are diversified into nonagricultural businesses lines such as automobile repair and tire shops, convenience stores, country stores, gas stations, and transportation divisions. These varied business activities expose employees to a unique array of safety hazards.

Data from OSHA Forms 300 and 300A were used to characterize occupational safety outcomes at surveyed agribusiness retailers.[8] OSHA Form 300 records the date, location, outcome, and type of each occupational injury in addition to providing a brief description of the injury. OSHA Form 300A summarizes this information by business location or firm. In total, surveyed agribusiness retailers submitted data on 807 injuries that occurred from 2012 to 2015.[9]

[8] Appendix 2 contains copies of OSHA Form 300 and 300A like those submitted by surveyed firms.
[9] According to OSHA regulations, an injury must be recorded if it is diagnosed as a significant injury by a medical professional, or if it results in death, loss of consciousness, work absence, work restriction, job transfer, or medical treatment beyond first aid (U.S. Department of Labor, OSHA 2004).

Frequency of occupational injuries

Altogether, the fifteen surveyed agribusiness retailers experienced 6.3 recordable injuries per 100 workers from 2012 to 2015. As table 2.1 indicates, aggregate yearly TRC incidence rates varied between 5.5 and 6.9 from 2012 to 2015. The aggregate TRC incidence rate from 2012 to 2015 (6.3) was nearly twice the 2014 TRC incidence rate for U.S. private industry (3.2), underscoring the hazards present in the agribusiness retail industry (U.S. Department of Labor, BLS 2015).[10] TRC incidence rates at surveyed agribusiness retailers were more similar to rates from industries related to agribusiness retailing. For example, the 2014 TRC incidence rates for crop production (5.5) and warehousing and storage (5.2) were relatively near to the TRC incidence rates at surveyed agribusiness retailers (U.S. Department of Labor, BLS 2015). These TRC incidence rates and others from industries related to agribusiness retailing are outlined in table 2.2.

Table 2.1. Occupational injury incidence rates at surveyed agribusiness retailers

Year	TRC incidence rate	DART incidence rate	DAFW incidence rate	DJTR incidence rate
2012	6.8	2.8	1.8	0.9
2013	6.9	2.4	1.5	0.9
2014	6.0	3.0	1.9	1.1
2015	5.5	2.2	1.3	0.9
Total	6.3	2.6	1.6	1.0

Note: Incidence rates are calculated as (injury cases × 200,000)/total hours worked, representing injuries per 100 full time workers. Cases are classified according to most serious result, where days away take precedence over job transfer or work restriction.

[10] Statistics from 2014 are the most recent data available from the BLS. BLS data from 2015 will be released in fall 2016.

Table 2.2. Occupational injury incidence rates for industries related to agribusiness retailing, 2014

Industry (NAICS code)	TRC incidence rate	DART incidence rate	DAFW incidence rate	DJTR incidence rate
Private industry	3.2	1.7	1.0	0.7
Crop production (111)	5.5	3.3	1.6	1.7
Agriculture/forestry support (115)	4.5	2.7	1.4	1.3
Nondurable good wholesalers (424)	3.9	2.8	1.5	1.3
Gasoline stations (447)	2.3	1.1	0.6	0.5
Warehousing/storage (493)	5.2	3.7	1.7	1.9

Source: U.S. Department of Labor, BLS (2015)

Note: Incidence rates are calculated as (injury cases × 200,000)/total hours worked, representing injuries per 100 full time workers. Cases are classified according to most serious result, where days away take precedence over job transfer or work restriction.

The TRC incidence rates outlined in table 2.1 are aggregate measures, which could be influenced by extreme incidence rates at firms with many employees. Table 2.3 summarizes firm-level TRC incidence rates at all surveyed agribusiness retailers.[11] As table 2.3 shows, median firm-level TRC incidence rates at surveyed agribusiness retailers generally exceeded mean firm-level TRC incidence rates during the four years analyzed, indicating that the high TRC incidence rates discussed previously were not driven by a few high-injury firms and seem to be fairly representative of all surveyed agribusiness retailers.

[11] Appendix 3 lists annual firm-level TRC and DART incidence rates for each surveyed agribusiness retailer.

Table 2.3. Summary of firm-level TRC incidence rates at surveyed agribusiness retailers

Year	Mean	Median	Min.	Max.
2012	6.6	6.9	2.7	10.7
2013	6.8	7.0	1.6	13.4
2014	6.3	6.1	2.1	11.2
2015	5.7	6.2	1.5	9.6

Note: Incidence rates are calculated as (injury cases × 200,000)/total hours worked, representing injuries per 100 full time workers. Cases are classified according to most serious result, where days away take precedence over job transfer or work restriction.

Surveyed agribusiness retailers also had high rates of DART injuries. From 2012 to 2015, these firms experienced 2.6 DART injuries per 100 workers. Table 2.1 shows that yearly aggregate DART incidence rates at surveyed agribusiness retailers ranged from 2.2 to 3.0 during the 2012 to 2015 period, thereby exceeding the 2014 private industry DART incidence rate of 1.7 (U.S. Department of Labor, BLS 2015). However, DART injuries were less frequent at surveyed agribusiness retailers than in several of the related industries described in table 2.2. All told, while DART incidence rates suggest that the agribusiness retail industry is dangerous relative to U.S. private industry, DART incidence rates at surveyed agribusiness retailers were not as unusual as TRC incidence rates at surveyed agribusiness retailers.

Table 2.4 summarizes firm-level DART incidence rates for all surveyed agribusiness retailers. The general agreement between the yearly mean and median DART incidence rates in table 2.4 indicates that the DART incidence rates contained in table 2.1 are representative of the fifteen surveyed agribusiness retailers. It seems likely that these rates are also generalizable to large agribusiness retailers such as those summarized in the list of the 100 largest agricultural cooperatives (USDA, Rural Development 2015).

Table 2.4. Summary of firm-level DART incidence rates at surveyed agribusiness retailers

Year	Mean	Median	Min.	Max.
2012	2.9	2.7	0.0	7.5
2013	2.3	2.3	0.0	3.9
2014	2.7	2.8	0.6	5.5
2015	2.4	2.5	0.4	5.3

Note: Incidence rates are calculated as (injury cases × 200,000)/total hours worked, representing injuries per 100 full time workers. Cases are classified according to most serious result, where days away take precedence over job transfer or work restriction.

Types of occupational injuries

Because empirical studies of occupational safety at agribusiness retailers are rare, little is known about the characteristics of occupational injuries in the industry. Understanding the dangers of agribusiness retailing is further complicated by the heterogeneous settings in which injuries occur, such as firm property, public roadways, and customers' farms, businesses, and homes. Characterizing the injuries at surveyed agribusiness retailers allows for greater awareness of the occupational safety challenges faced by these firms and their peers. The BLS has developed a system for classifying occupational injuries according to nature, affected body part, source, and event or exposure (U.S. Department of Labor, BLS 2012). Information from OSHA Form 300 was used to classify each injury in this study's data set according to the BLS system.[12]

[12] The BLS classification system provides two-digit, three-digit, and four-digit codes to describe each element of an injury. The first digit of each code is the division to which the code belongs. These divisions offer a convenient method for grouping classifications and summarizing classification data.

As table 2.5 shows, 84.6 percent of classifiable[13] injuries at surveyed agribusiness retailers from 2012 to 2015 belonged to one of five natures: nonspecified injuries and disorders[14]; sprains, strains, or tears; cuts or lacerations; bruises or contusions; and fractures. Table 2.5 indicates that these five injury natures were present in an even larger share of classifiable DART injuries. Sprains, strains, or tears were a large share of classifiable DART injuries at surveyed agribusiness retailers because 58.5 percent of sprains, strains, or tears resulted in days away, work restriction, or job transfer while injuries of other natures resulted in days away, work restriction, or job transfer just 33.5 percent of the time.

Table 2.5. Distribution of classifiable occupational injuries at surveyed agribusiness retailers by nature of injury, 2012-2015

Nature (BLS code)	Share of TRC injuries	Share of DART injuries
Sprains, strains, tears (123)	31.1%	44.1%
Nonspecified injuries and disorders (197)	28.2%	18.5%
Cuts, lacerations (132)	13.8%	6.7%
Bruises, contusions (143)	6.7%	6.7%
Fractures (111)	4.9%	9.8%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012). Natures are listed according to share of TRC injuries at surveyed agribusiness retailers from 2012 to 2015. The classifications are not comprehensive of all injuries so columns may not sum to 100%.

Table 2.6 shows that 17.3 percent of classifiable injuries from 2012 to 2015 affected hands, 13.4 percent of classifiable injuries affected legs, and 13.0 percent of

[13] 10.8 percent of injuries in the data set cannot be classified by nature because of vague or incomplete incident descriptions from OSHA Form 300.

[14] At the fifteen surveyed agribusiness retailers, nonspecified injuries and disorders were most frequently instances of general pain and soreness.

classifiable injuries affected backs.[15] However, hand injuries were just 12.6 percent of classifiable DART injuries because only 24.2 percent of hand injuries resulted in days away, work restriction, or job transfer. In contrast, leg, back, and shoulder injuries each resulted in days away, work restriction, or job transfer over forty percent of the time. These injuries may be particularly common at agribusiness retailers because of the industry's relatively old workforce.

Table 2.6. Distribution of classifiable occupational injuries at surveyed agribusiness retailers by affected body part of injury, 2012-2015

Affected body part (BLS code)	Share of TRC injuries	Share of DART injuries
Hand(s) (44)	17.3%	12.6%
Leg(s) (51)	13.4%	16.4%
Back (32)	13.0%	16.4%
Shoulder(s) (41)	10.8%	13.2%
Face (13)	10.6%	2.2%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012). Body parts are listed according to share of TRC injuries at surveyed agribusiness retailers from 2012 to 2015. The classifications are not comprehensive of all injuries so columns may not sum to 100%.

Injuries at surveyed agribusiness retailers were attributable to many sources. Table 2.7 indicates that containers, which may contain feed, seed, fuel, or other substances, were responsible for 13.3 percent of classifiable injuries from 2012 to 2015.[16] Furthermore, containers were responsible for 15.6 percent of classifiable DART injuries during the same period. Floors, walkways, and ground surfaces contributed to 11.7 percent of classifiable injuries and 14.6 percent of classifiable DART injuries at surveyed

[15] 4.1 percent of injuries in the data set cannot be classified by affected body part because of vague or incomplete incident descriptions from OSHA Form 300.
[16] 32.2 percent of injuries in the data set cannot be classified by source because of vague or incomplete incident descriptions from OSHA Form 300.

agribusiness retailers. Although scrap, waste, and debris were the source of 8.0 percent of classifiable injuries, these materials were the source of just 2.0 percent of classifiable DART injuries because only 9.1 percent of injuries caused by scrap, waste, and debris resulted in days away, work restriction, or job transfer. In contrast, motorized highway vehicles, which were also the source of 8.0 percent of classifiable injuries, caused 10.7 percent of classifiable DART injuries because 50.0 percent of motorized highway vehicle injuries resulted in days away, work restriction, or job transfer.

Table 2.7. Distribution of classifiable occupational injuries at surveyed agribusiness retailers by source of injury, 2012-2015

Source (BLS code)	Share of TRC injuries	Share of DART injuries
Containers (21)	13.3%	15.6%
Floors, walkways, ground surfaces (66)	11.7%	14.6%
Scrap, waste, debris (94)	8.0%	2.0%
Highway vehicles, motorized (84)	8.0%	10.7%
Person – injured or ill worker (56)	8.0%	9.3%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012). Sources are listed according to share of TRC injuries at surveyed agribusiness retailers from 2012 to 2015. The classifications are not comprehensive of all injuries so columns may not sum to 100%.

Injuries at surveyed agribusiness retailers were overwhelmingly caused by contact with objects and equipment, overexertion and bodily reaction, and falls, slips, or trips. As table 2.8 shows, a combined 84.5 percent of classifiable injuries from 2012 to 2015 were caused by these three events or exposures.[17] These three events or exposures accounted for a combined 84.2 of classifiable DART injuries over the same period. Table 2.8 reveals that injuries caused by contact with objects and equipment, while common,

[17] 32.2 of injuries in the data set cannot be classified by event or exposure because of vague or incomplete incident descriptions from OSHA Form 300.

caused days away, work restriction, or job transfer just 19.9 percent of the time. On the other hand, 55.7 percent of falls, slips, or trips resulted in days away, work restriction, or job transfer. Overexertion and bodily reaction caused 33.5 percent of classifiable DART injuries. Nearly three-quarters of these overexertion injuries involved "lifting, pulling, pushing, turning, wielding, holding, carrying, or throwing" an outside source (U.S. Department of Labor, BLS 2012).

Table 2.8. Distribution of classifiable occupational injuries at surveyed agribusiness retailers by event or exposure of injury, 2012-2015

Event or exposure (BLS code)	Share of TRC injuries	Share of DART injuries
Contact with objects and equipment (6)	35.6%	19.2%
Overexertion and bodily reaction (7)	28.0%	33.5%
Falls, slips, trips (4)	20.9%	31.5%
Exposure to harmful substances or environ. (5)	6.9%	7.4%
Transportation incidents (2)	5.1%	7.4%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012). Events or exposures are listed according to share of TRC injuries at surveyed agribusiness retailers from 2012 to 2015. The classifications are not comprehensive of all injuries so columns may not sum to 100%.

Appendix 4 contains TRC incidence rates based on joint classifications of injury type. The incidence rates in Appendix 4 offer a multidimensional perspective on injuries at surveyed agribusiness retailers from 2012 to 2015. The incidence rates in appendix 4 indicate that 93.3 percent of all (both classifiable and nonclassifiable) sprains, strains, or tears at surveyed agribusiness retailers affected trunk locations, upper extremities, or lower extremities. Moreover, 42.6 percent of all injuries to lower extremities were sprains, strains, or tears while 51.0 percent of all trunk injuries were sprains, strains, or tears. In contrast, just 23.2 percent of all injuries to upper extremities were sprains, strains, or tears. A similar share of all injuries to upper extremities (24.2 percent) were cuts or lacerations, representing 70.6 percent of all cuts or lacerations observed at surveyed agribusiness retailers. Finally, 72.7 percent of all overexertion injuries affected trunk locations or upper extremities and 58.5 percent of all overexertion injuries were sprains, strains, or tears.

Severity of DART injuries

The severity of DAFW injuries is a key marker of the damage inflicted by occupational injuries. From 2012 to 2015, DAFW injuries had a median severity of six days at surveyed agribusiness retailers. As table 2.9 shows, 24.2 percent of absences lasted just one or two days and 59.9 percent of absences were concluded within ten days.

Table 2.9. Distribution of DAFW injury severity at surveyed agribusiness retailers

Year	1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
2012	9.4%	11.3%	28.3%	13.2%	15.1%	3.8%	18.9%
2013	19.1%	10.6%	19.1%	17.0%	17.0%	4.3%	12.8%
2014	8.1%	12.9%	21.0%	12.9%	19.4%	6.5%	19.4%
2015	22.2%	4.4%	20.0%	11.1%	11.1%	2.2%	28.9%
Total	14.0%	10.1%	22.2%	13.5%	15.9%	4.3%	19.8%

Note: Severity is the length of time that an employee was away from work.

Appendix 5 offers detailed analysis of DAFW severity by injury type, thereby highlighting the most serious injury types at surveyed agribusiness retailers from 2012 to 2015. At surveyed agribusiness retailers, fractures had an extremely long median DAFW severity. Other injury types that frequently lead to extended work absence are injuries to upper extremities, injuries caused by vehicles, and injuries caused by tools, instruments, and equipment.

DAFW injury severities at surveyed agribusiness retailers were relatively mild compared to private industry as a whole, which had a median severity of six days away in 2014 (U.S. Department of Labor, BLS 2015). Absences of more than twenty days occurred for 24.2 percent of DAFW injuries at surveyed agribusiness retailers from 2012 to 2015. Similar absences occurred for 35.3 percent of DAFW injuries in 2014 private industry. Absences of more than twenty days were also less common at surveyed agribusiness retailers than were similar absences in related industries such as crop production; support activities for agriculture and forestry; nondurable good wholesaling; gasoline service; and warehousing and storage.

DAFW injury severities at surveyed agribusiness retailers from 2012 to 2015 resembled DAFW injury severities in the crop production industry in 2014 (U.S. Department of Labor, BLS 2015). Both industries had many DAFW injuries that were resolved in just a few days. The similarity between DAFW injury severity at surveyed agribusiness retailers and the crop production industry may reflect tasks, environments, and employee characteristics shared by the two industries.

Job transfers and work restrictions lasted longer than absences from work at surveyed agribusiness retailers. Specifically, from 2012 to 2015, the median job transfer and work restriction was 14.5 days. Table 2.10 reveals that just 16.0 percent of DJTR injuries at surveyed agribusiness retailers were resolved in five days or less, far less than the 46.4 percent of DAFW injuries that were resolved in that time. Injury types with lengthy median job transfers and work restrictions include fractures, injuries to multiple body parts, injuries caused by persons, plants, animals, and minerals, and injuries inflicted by transportation incidents. Appendix 5 contains more details on the severity of all DJTR injury types experienced at surveyed agribusiness retailers.

Table 2.10. Distribution of DJTR injury severity at surveyed agribusiness retailers

Year	1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
2012	2.3%	4.5%	11.4%	31.8%	18.2%	13.6%	18.2%
2013	5.0%	0.0%	20.0%	12.5%	20.0%	10.0%	32.5%
2014	1.6%	1.6%	6.6%	21.3%	26.2%	9.8%	32.8%
2015	2.0%	2.0%	10.2%	26.5%	20.4%	8.2%	28.6%
Total	2.6%	2.1%	11.3%	23.2%	21.6%	10.3%	28.4%

Note: Severity is the length of time that an employee was subject to job transfer or work restriction.

Days away from work and days of job transfer or work restriction combine to form DART, which measures how long an employee is unable to perform their normal work tasks due to work absence, work restriction, or job transfer. DART severity is particularly useful for analyzing the severity of injuries that involved both days away from work and days of job transfer or work restriction, which were 8.6 percent of injuries at surveyed agribusiness retailers. Table 2.11 shows that employees returned to their normal work tasks within five days in 28.3 percent of DART injuries at surveyed agribusiness retailers. Employees took more than thirty days to return to their normal work tasks in 26.2 percent of DART injuries at surveyed agribusiness retailers. Appendix 5 summarizes DART severity by injury type. Relative to surveyed agribusiness retailers' median DART severity of 14.5 days, median DART severities were particularly severe for fractures, injuries to multiple body parts, and injuries caused by persons, plants, animals, or minerals.

Table 2.11. Distribution of DART injury severity at surveyed agribusiness retailers

Year	1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
2012	5.0%	6.3%	17.5%	22.5%	18.8%	10.0%	20.0%
2013	14.7%	4.0%	17.3%	14.7%	17.3%	5.3%	26.7%
2014	4.0%	7.0%	12.0%	14.0%	25.0%	11.0%	27.0%
2015	10.4%	2.6%	14.3%	19.5%	11.7%	9.1%	31.2%
Total	8.1%	5.1%	15.1%	17.5%	18.7%	9.0%	26.2%

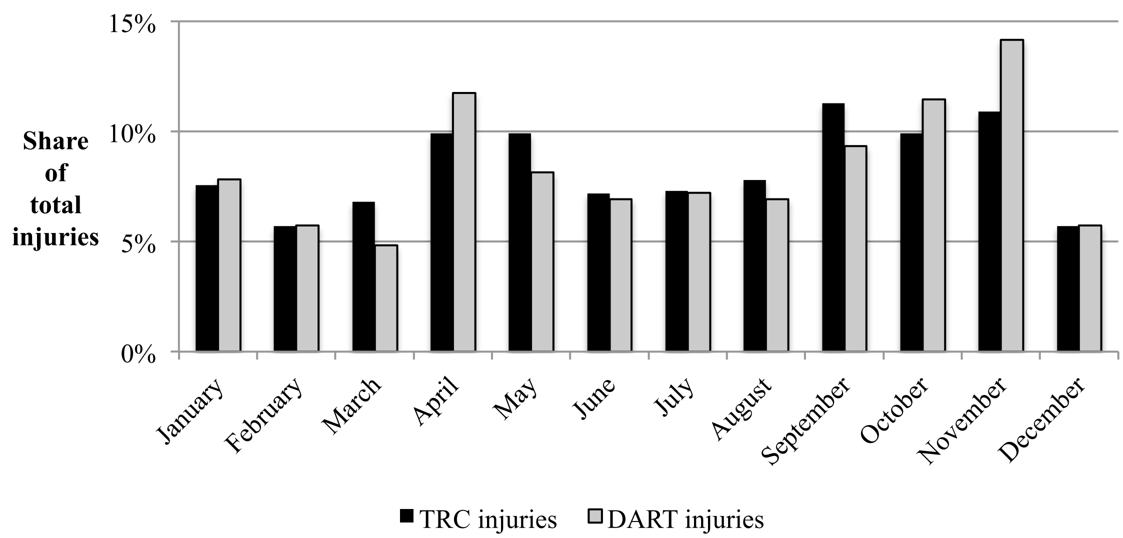
Note: Severity is the length of time that an employee was away from work or subject to job transfer or work restriction.

Seasonality of occupational injuries

From 2012 to 2015, occupational injuries at surveyed agribusiness retailers varied by season. Figure 2.1 indicates that injuries were most common during the months associated with the fall harvest. From 2012 to 2015, 32.1 percent of TRC injuries at surveyed agribusiness retailers occurred during the quarter of the year from September to November. Moreover, 34.9 percent of DART injuries occurred during those months, including 33.8 percent of DAFW injuries and 36.1 percent of DJTR injuries. Figure 2.1 shows that occupational injuries at surveyed agribusiness retailers were also relatively common in April and May, months associated with the spring planting season.

At agribusiness retailers, occupational injuries may surge during the planting and harvest seasons due to the increased hours worked by regular and temporary employees to meet the needs of agricultural clients. In addition, these seasons may expose employees to a unique array of dangerous tasks. Intense time pressure may also contribute to frequent injuries during planting and harvest. The seasonal injury patterns visible at surveyed agribusiness retailers are similar to those observed across a spectrum of production agriculture settings (e.g., Shireley and Gilmore 1995; Young 1995; Gerberich et al. 1998; Pickett et al. 1999).

Figure 2.1. Shares of occupational injuries at surveyed agribusiness retailers by month, 2012-2015



Summary of occupational injuries at agribusiness retailers

The preceding description of occupational injuries at agribusiness retailers identifies several salient points. First, although occupational injury incidence rates varied across firms, the aggregate TRC incidence rate for surveyed agribusiness retailers from 2012 to 2015 was very high relative to U.S. private industry. Second, DART incidence rates at surveyed agribusiness retailers exceeded the 2014 U.S. private industry rate, but a smaller share of injuries resulted in days away, work restriction, or job transfer. Finally, seasonal patterns in occupational injuries suggest that increased pressure on agricultural business lines increases occupational injury risk at surveyed agribusiness retailers. The aforementioned characteristics of occupational injuries at agribusiness retailers provide motivation and context for the remainder of this dissertation.

CHAPTER 3

Literature Review

A large occupational safety literature exists across disciplines including economics, management, medicine, psychology, public health, safety science, and sociology. Each discipline offers a unique perspective on safety attitudes, practices, and outcomes. The following literature review draws from a wide range of sources to summarize occupational safety research pertinent to this dissertation.

Safety culture and safety climate

Safety culture and safety climate are central to the occupational safety literature.[18] As mentioned in chapter 1, Turner et al. (1989) describe safety culture as beliefs, attitudes, and practices that promote occupational safety. Geller (1994) simplifies the concept in describing a total safety culture as one where "everyone feels responsible for safety and pursues it on a daily basis." While nuanced differences exist between the definitions of safety culture proposed by different researchers, a few key similarities are present in many definitions. Specifically, safety culture encompasses shared, enduring, and reinforced values regarding workplace safety behavior and responses to safety incidents (Wiegmann et al. 2004).

Although the terms are often used interchangeably, safety culture is gradually supplanting safety climate in the occupational safety lexicon (Hale 2000). Several authors

[18] As described in this chapter, safety culture and safety climate are related but not necessarily identical. Although safety culture and safety climate are not defined uniformly by all authors, the literature reviewed in chapter 3 is cited according to the term used in each work.

contend that safety climate is actually the expressed manifestation of safety culture. For example, Flin et al. (2000) state that safety climate is a “snapshot” of safety culture. Zohar (1980) adds that safety climate “reflects employees' perceptions about the relative importance of safe conduct in their occupational behavior.” From this perspective, because the questionnaires typically used to measure safety culture and safety climate are often similar in focusing on stated beliefs and attitudes, some safety culture research may be described more accurately as safety climate research (Cox and Flin 1998; Silbey 2009). Therefore, safety climate is the term of choice in the analysis undertaken in subsequent chapters.

The elements of safety culture and safety climate are widely debated in theoretical and applied research. However, managerial commitment and involvement emerge in many reviews of the safety culture and safety climate literature (Flin et al. 2000; Guldenmund 2000; Wiegmann et al. 2004; Frazier et al. 2013). Managerial commitment to safety includes providing necessary resources and maintaining supportive attitudes (Civil Aviation Safety Authority 2002). Managerial involvement in safety activities such as meetings and training sessions also demonstrates concern for employee safety (Wiegmann et al. 2004). According to Hofmann, Morgeson, and Gerras (2003), the relationship between strong safety climate and leadership may be reinforced by reciprocal behavior from employees who have good relationships with safety-conscious managers. Furthermore, Janssens, Brett, and Smith (1995) show that a large managerial emphasis on production negatively influences perceived safety. This sort of work pressure, which should be balanced with concern for safety, is another common aspect of the safety culture and safety climate studies reviewed by Flin et al. (2000), Guldenmund (2000), and Frazier et al. (2013).

Safety systems are another element of safety culture and safety climate that appears in much research (Flin et al. 2000; Guldenmund 2000; Wiegmann et al. 2004; Frazier et al. 2013). Fernández-Muñiz, Montes-Peón, and Vázquez-Ordás (2007) state that “an adequate safety management system must contain six key dimensions: safety policy, incentives for employee participation, training, communication, planning, and control.” Frazier et al. (2013) note that common safety system elements include training programs; safety policies, procedures, and rules; safety meetings and committees; discipline programs for safety violations; recognition programs for safety accomplishments; safety audits and inspections; reporting and analysis of injuries and near-injuries; and reporting of safety suggestions and concerns. The development and implementation of safety systems is another avenue by which management influences safety culture and safety climate (Fernández-Muñiz, Montes-Peón, and Vázquez-Ordás 2007).

Together, employee involvement and responsibility for personal safety form an additional shared element of many safety culture and safety climate studies (Flin et al. 2000; Guldenmund 2000; Wiegmann et al. 2004; Frazier et al. 2013). Fernández-Muñiz, Montes-Peón, and Vázquez-Ordás (2007) posit that employee involvement entails safety system participation and compliance and Harvey et al. (2002) emphasize employees’ “perceived responsibility for involvement in safety issues.” Dedobbeleer and Béland (1998) suggest that perceptions of risk are related to safety climate. Employees also contribute to safety culture and safety climate through supportive interactions with their peers (Frazier et al. 2013). Specifically, Geller (2001) assigns importance to employees providing one another with positive feedback for safe behaviors and corrective feedback for unsafe behaviors. Combined with personal responsibility for safety, supportive interactions are an important part of employee empowerment, which Wiegmann et al. (2004) describes as a situation where "employees have a substantial voice in safety decisions, have the leverage to initiate and achieve safety improvements, hold themselves and others accountable for their actions, and take pride in the safety record of their organization."

Safety culture and safety climate may differ across employee groups within a firm. Harvey et al. (2002) suggest that a conceptual difference may exist between managerial safety culture and nonmanagerial safety culture due to the different factors associated with safety culture for each group. Similarly, Arboleda et al. (2003) find that managerial safety culture and nonmanagerial safety culture are constructed differently. Moreover, Prussia, Brown, and Willis (2003) discover that attributions of safety responsibility, which are disparate for managerial employees and nonmanagerial employees when safety climate is poor, become more similar as safety climate improves.

Risch et al. (2014) explore the components of safety culture at agribusiness retailers. Particular attention is paid to the influence of safety system elements. For both managerial and nonmanagerial employees, the authors discover that ratings of safety culture increase with ratings of safety training, discipline, and modified duty programs for injured workers. In addition, managerial ratings of safety culture increase with ratings of safety inspections and nonmanagerial ratings of safety culture increase with ratings of recognition for safety accomplishments.

Relating safety culture and safety climate to safety performance

The connection between safety climate and safety outcomes is of great interest to researchers. Several theoretical models tie safety climate to safety performance or safety outcomes (e.g., Brown, Willis, and Prussia 2000; Griffin and Neal 2000; Christian et al. 2009).[19] For example, Neal and Griffin (2004) propose a model where workplace characteristics such as safety climate combine with personality factors to influence safety motivation and safety knowledge, which then influence safety performance, which finally determines safety outcomes. The relationships between the elements in the model are theorized to weaken as the elements become more distant from one another in the model's causal chain. Christian et al. (2009) explore this model through a meta-analysis of ninety studies on safety performance and safety outcomes, finding that safety climate has a moderate relationship with safety performance while safety climate has a weaker relationship with safety outcomes.

The safety outcomes model proposed by Neal and Griffin (2004) corresponds most closely with prospective empirical models where lagged safety climate influences safety outcomes. However, a literature review by Payne et al. (2009) indicates that empirical studies most frequently employ a retrospective design where current safety

[19] Following the example of Christian et al. (2009), this dissertation treats safety performance and safety outcomes as distinct concepts. That is, safety performance describes behaviors while safety outcomes are tangible measures such as injuries.

climate is compared to past safety outcomes. Payne et al. state that the frequency of retrospective analyses may stem from the ease with which retrospective safety outcome data can be acquired. Furthermore, past safety outcomes may influence current perceptions of safety system adequacy, workplace risk, or managerial trustworthiness (Rundmo 1995; Cree and Kelloway 1997; Barling, Kelloway, and Iverson 2003). Nevertheless, interpreting safety climate as a cause of safety outcomes rather than a consequence of safety outcomes is of great practical interest to safety professionals because safety climate is a proactive tool under the former interpretation (Payne et al. 2009). Clarke (2006) offers support for this perspective via a meta-analysis that reveals stronger relationships between safety climate and safety outcomes in prospective model designs than in retrospective model designs that offer less consistent results.

A host of empirical studies link safety climate to safety outcomes. Increased safety climate is associated with improved safety outcomes in many industries including chemical processing (Hofmann and Stetzer 1996), grain storage (Seo et al. 2004), and manufacturing (Zohar 2000). In fact, meta-analyses conducted by Christian et al. (2009) and Clarke (2010) indicate that a relationship between safety climate and safety outcomes is apparent across much empirical research.

Safety climate is one of many factors related to safety outcomes in empirical research. According to Laflamme and Menckel (1995), most researchers find that injury rates decrease as employee age increases while injury severity increases with employee age. Specifically, while employees under age twenty-five are the most susceptible to occupational injuries, employees over age sixty-four are the most susceptible to permanent disabilities and death (Mitchell 1988). The complex relationship between age and occupational safety may be due to the opposing effects of increasing experience and decreasing physical or mental capacity (Laflamme and Menckel 1995). Indeed, Breslin and Smith (2006) find that inexperience increases injury rates for workers of all ages.

Firms with many temporary employees may experience heightened injury rates, possibly as a result of the low knowledge or status those employees possess (Aronsson 1999). In addition, U.S. Department of Labor, BLS (2015) data show that occupational injury incidence rates vary greatly by industry, reflecting a spectrum of injury exposure. Furthermore, several studies find that occupational injury rates decrease as firm size increases (e.g., Moses and Savage 1994; McVittie, Banikin, and Brocklebank 1997; Fenn and Ashby 2004). Although U.S. Department of Labor, BLS (2015) data indicate that small firms have the lowest occupational injury incidence rates, those figures may be a product of underreporting by small firms (Oleinick, Gluck, and Guire 1995). Heightened occupational injury risk in small firms is attributed to insufficient safety funding or expertise (Dorman 2000).

Risch et al. (2014) examine the relationship between safety culture and TRC injury frequency at agribusiness retailers. They find that increased managerial safety culture ratings are associated with reduced TRC injury frequency, reinforcing the theoretical relationship between safety culture and safety outcomes. The authors contend that the relationship between managerial safety culture and safety outcomes reflects management's key leadership role. In contrast, nonmanagerial safety culture ratings are not associated with TRC injury frequency in a statistically significant manner. Factors other than managerial safety culture also influence TRC injury frequency at agribusiness retail business locations. Risch et al. find that TRC injury frequency varies based on business lines. Business locations with many seasonal workers are also associated with high TRC injury frequency, confirming previous research.

Business motivations for occupational safety

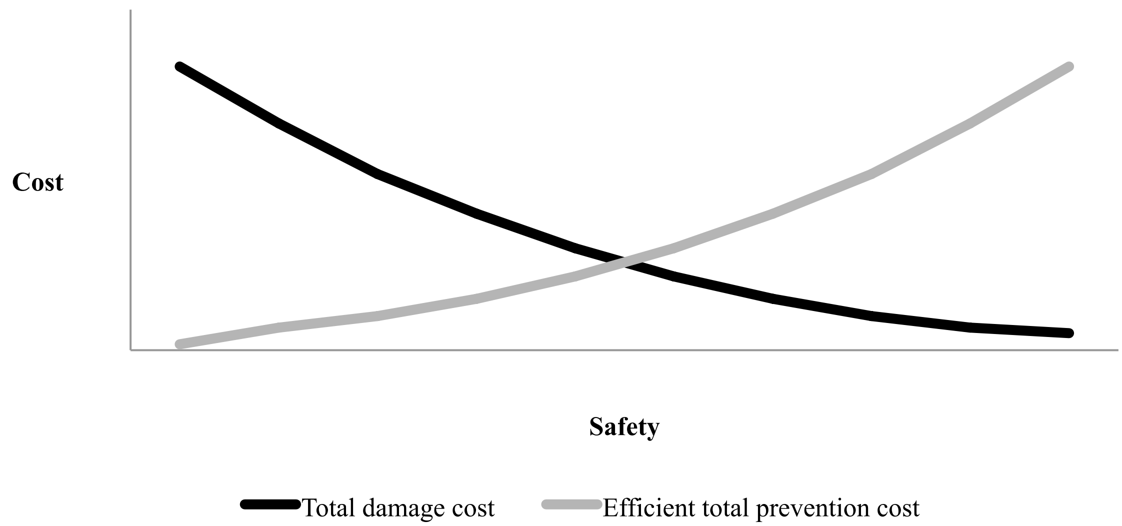
The previous section outlined a connection between safety climate and occupational injuries. In addition to satisfying altruistic or moral motivations, reducing occupational injuries may alter a firm's bottom line in several ways. OSHA fines may reduce profits, although Ruser and Butler (2010) show that these fines do not influence injury rates. Firms subject to experience-rated workers' compensation insurance are motivated to improve safety performance in order to avoid high premia (Thomason and Pozzebon 2002). Compensating wage differentials have been shown to create higher costs for unsafe firms in several settings (e.g., Viscusi 1978; Cousineau, Lacroix, and Girard 1992). Legal settlements, work stoppages, diminished productivity, diminished firm reputation, diminished employee morale, and replacement worker search and training impose additional injury-related costs on firms (Brody, Létourneau, and Poirier 1990; Dorman 2000; Shearn 2003). Reducing occupational injuries decreases the aforementioned damage costs, providing an incentive for firms to create strong safety climates that decrease occupational injuries.

Safety professionals contend that framing occupational safety topics in financial terms appeals to managers that assess recommendations on that basis (Adams 2002).

According to Veltri and Ramsay (2009), managers should view safety performance and business performance as complimentary rather than as unrelated. Indeed, Fernández-Muñiz, Montes-Peón, and Vázquez-Ordás (2009) find that safety management positively impacts financial performance. Furthermore, Smallman and John (2001) report that senior managers increasingly view occupational safety as a valuable business input rather than a compliance issue.

Henderson (1983) outlines a model of efficient occupational safety provision, which is depicted in figures 3.1 and 3.2. Similar models are described by other authors (e.g., Oi 1974; Brody, Létourneau, and Poirier 1990). According to Henderson (1983), firms choose a level of occupational safety by weighing increasing prevention cost against decreasing damage cost. Prevention cost includes the expense of safety system elements designed to reduce occupational injuries while damage cost includes the many injury-related costs described earlier in this section. As figure 3.1 shows, prevention cost increases at an increasing rate. This occurs because additional safety improvements become more difficult to implement, and are therefore more costly, as safety increases. The reverse is true for damage cost, which decreases at a decreasing rate because the most severe, common, and costly injuries will be eliminated with each increase in safety.

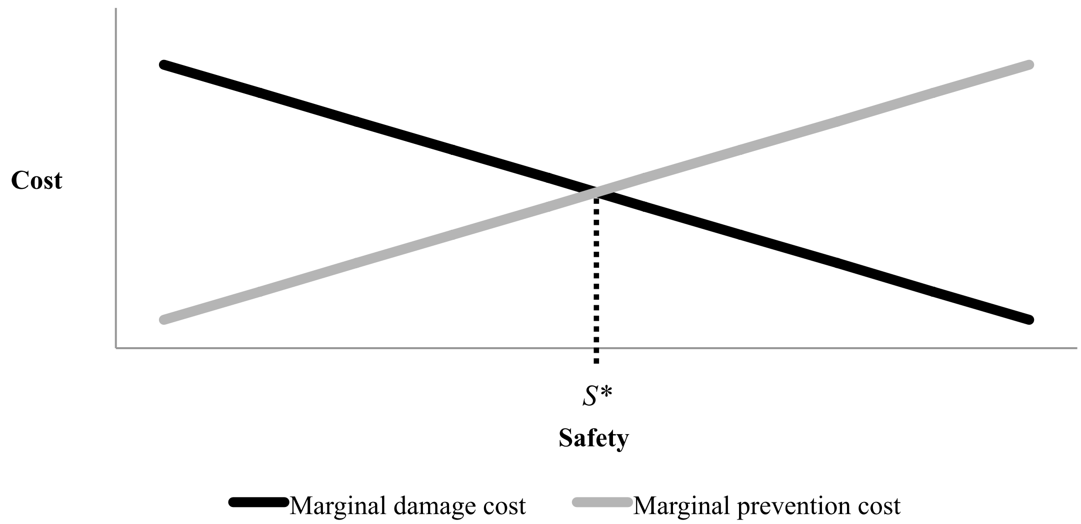
Figure 3.1. Total damage cost and total prevention cost



Source: Henderson (1983)

Figure 3.2 displays marginal damage and prevention curves based on figure 3.1. In figure 3.2, the efficient level of occupational safety provision occurs where marginal prevention cost equals marginal damage cost. At this level of occupational safety (*S**), the sum of total prevention cost and total damage cost is minimized. Henderson's model reinforces the conceptualization of occupational safety provision as an investment.

Figure 3.2. Efficient occupational safety based on marginal damage cost and marginal prevention cost



Source: Henderson (1983)

Quantifying the returns on occupational safety investments is critical to occupational safety decision making. Several researchers offer practical tools for economic evaluations of occupational safety interventions (e.g., Linhard 2005; Oxenburgh and Marlow 2005). However, academic evaluations of occupational safety interventions are relatively rare and methodologically inconsistent (Tompa, Dolinschi, and de Oliveira 2006). Economic evaluations of occupational safety are often complicated by insufficient data and difficulties defining all costs and benefits in question (Miller, Whynes, and Reid 2000). Alternatively, just as safety climate studies benchmark firms against one another (e.g., Mearns, Whitaker, and Flin 2001), the efficiency of occupational safety investments could be evaluated relative to investments by peer firms. All told, there is room for growth in the economic evaluations conducted by both safety professionals and researchers.

Contribution of this dissertation

This dissertation adds value to previous research on occupational safety and agribusiness retailers in several ways. First, this dissertation reassesses and augments the pioneering work of Risch et al. (2014) through more comprehensive data collection and modeling. A redesigned survey is used to gather data on employee safety attitudes and practices as well as data on employee background factors that may be related to safety attitudes and behaviors. These employee background factors are added to the safety climate model.

Furthermore, instead of simply focusing on TRC injuries, the safety outcome model is also estimated for DART injuries, DAFW injuries, total DART, and total DAFW. The inclusion of these dependent variables provides a more comprehensive picture of the frequency and severity of occupational injuries at agribusiness retailers. The number of safety outcomes modeled in this dissertation is somewhat unusual relative to the existing literature. Multiple robustness checks are estimated for both the safety climate model and the safety outcome model in order to gain a firmer grasp on results generated by the models.

Finally, this dissertation extends the existing literature by using data envelopment analysis (DEA) to estimate an efficient frontier for occupational safety investments by agribusiness retailers. The DEA analysis pairs data on safety investments, which are often difficult to obtain, with safety outcome data. The DEA approach to occupational safety is very new to the occupational safety literature and is unprecedented in its application to agribusiness retailers. Because this dissertation's DEA puts occupational safety inputs in financial terms, it describes occupational safety in a manner that is appealing to managers and decision makers at participating agribusiness retailers. More generally, this analysis provides an economic perspective on occupational safety that is largely absent in the existing literature.

CHAPTER 4

Theoretical Background

The preceding chapter explained that the rationale for occupational safety is multifaceted. This chapter focuses on the financial motivations for occupational safety. Specifically, firms seek to minimize total injury-related cost. Henderson (1983) decomposes total injury-related cost into total damage cost and total prevention cost. Figure 3.1 in chapter 3 indicates that total damage cost decreases at a decreasing rate as occupational safety increases. In contrast, total prevention cost increases at an increasing rate as occupational safety increases. All told, firm h should choose the level of occupational safety, S_h, that solves the total cost minimization problem:

$$min_{S_h}\ TDC_h + TPC_h \tag{4.1}$$

where TDC_h is total damage cost for firm h and TPC_h is total prevention cost for firm h. As discussed above, TDC_h is decreasing in S_h while TPC_h is increasing in S_h. Both TDC_h and TPC_h are assumed to be convex in S_h.

Figure 3.2 in chapter 3 shows that the solution to equation (4.1) occurs where marginal damage cost and marginal prevention cost are equal. However, in figures 4.1 and 4.2 it is apparent that, no matter which level of occupational safety it chooses, a firm's injury-related cost will not be as low as possible if prevention investment is inefficient. That is, if a firm is not achieving the greatest prevention possible given their investment level, or, alternatively, achieving their prevention through the smallest investment possible, it cannot effectively minimize total injury-related cost. Figure 4.2

represents this concept. Inefficient prevention investment may result from suboptimal selection or implementation of safety systems.

Figure 4.1. Total damage cost and inefficient total prevention cost

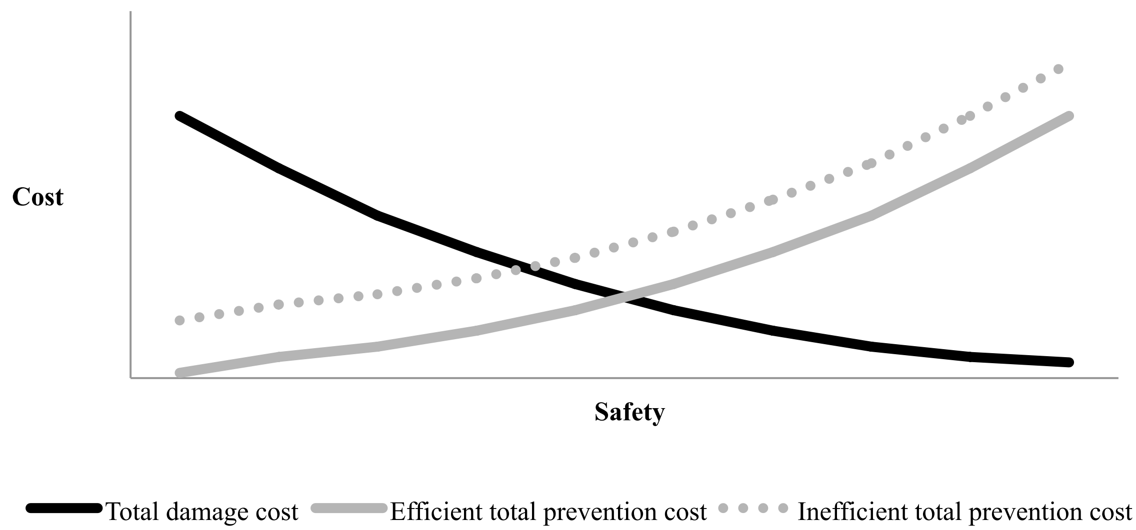


Figure 4.2. Total injury-related cost, efficient prevention versus inefficient prevention

Prevention costs are investments in occupational safety. These investments are typically spent on occupational safety personnel and the safety systems implemented by those safety personnel. Safety systems are made up of many policies, procedures, and programs that reinforce and enhance occupational safety. According to Neal and Griffin (2004), safety climate, which is an antecedent of safety outcomes, is based on safety system elements. As described in chapter 3, Neal and Griffin trace a causal path from safety climate to safety outcomes via safety knowledge, motivation, compliance, and participation.

Although the model proposed by Neal and Griffin presents safety outcomes as a function of safety climate, it does not account for the heterogeneous inherent risks present across firms' business locations. That is, even if a pair of business locations are identical in safety climate, one may experience more injuries than another because it undertakes more dangerous tasks or employs workers who lack the physical or mental skills to avoid injuries. Accounting for exposure to occupational injuries, safety outcomes at business location j, SO_j, can be modeled as:

(4.2) $$SO_j=f(SC_j, WE_j)$$

where SC_j is the safety climate at business location j, WE_j is the workplace exposure to injuries at business location j, and f is a function that is decreasing in SC_j and increasing in WE_j.

Equation (4.2) describes safety climate at the business location level. Although some disagreement exists as to whether safety climate's lowest level of measurement should be an individual or a business location, much literature utilizes individual-level measures of safety climate (Das et al. 2008). Location-level safety climate can be viewed as the mean of individual safety climate for a business location's employees. That is:

$$SC_j = \frac{\sum_{i=1}^{n} SC_{ij}}{n} \tag{4.3}$$

where SC_{ij} is the safety climate of individual i at business location j and n is the number of employees at business location j.

As explained previously, safety climate is thought to be determined by safety system elements. In the model proposed by Neal and Griffin (2004), individual differences determine safety knowledge and motivation just as safety climate does. According to Neal and Griffin, individual differences reflect many different personality traits. One individual difference that may be related to occupational safety is internal locus of control, which refers to whether an employee feels able to control their own safety outcomes and does not ascribe those outcomes to external forces. In this dissertation, safety climate describes an employee's empowerment to take actions that support safety. Defined in this manner, safety climate may be influenced by individual differences. Accordingly, the safety climate of individual i at location j, SC_{ij}, can be expressed as:

$$SC_{ij} = g(SS_{ij}, EB_{ij}) \tag{4.4}$$

where SS_{ij} represents the safety system elements experienced by the employee and EB_{ij} represents the employee's background. Although employee backgrounds include many factors, EB_{ij} is concerned with those that determine whether an employee believes they can control their safety outcomes. In equation (4.4), g is assumed to be increasing in the frequency or quantity of SS_{ij}.

In summary, firms make investments in safety system elements with the expectation that such preventative expenditures will reduce the frequency of occupational injuries or lessen the severity of occupational injuries. Improved safety outcomes will reduce damage costs incurred due to occupational injuries. Manipulating total prevention cost and total damage cost allows a firm to minimize total injury-related cost, a problem represented in equation (4.1). Safety climate is a link between safety system elements and safety outcomes. Equation (4.4) indicates that individual safety climate is determined by safety system elements and employee background factors. In turn, as summarized by equation (4.2), safety climate and workplace exposure to injuries determine a business location's safety outcomes.

CHAPTER 5

Empirical Models and Data

This chapter specifies empirical models based on the theory outlined in chapter 4. The data used to estimate these models are also detailed. This chapter's empirical models of safety climate and safety outcomes make extensive use of data from the University of Minnesota Occupational Health and Safety Survey. Therefore, the survey is examined prior to the description of the empirical models.

Description of survey data

In 2011, Corey Risch administered a preexisting occupational safety survey to twelve agribusiness retailers in eleven states. In subsequent years, several Minnesota agribusiness retailers expressed interest in participating in a similar survey. In 2014, safety directors from these firms formed an advisory committee to provide ideas and feedback regarding a new occupational safety survey. Special attention was paid to addressing occupational safety issues specific to agribusiness retailers and using terminology familiar to the industry's employees. After several rounds of drafts and revisions, the survey was finalized by the advisory committee. Shortly thereafter, the survey received approval from the University of Minnesota's Institutional Review Board.

The University of Minnesota Occupational Health and Safety Survey collects data on respondent demographics and other factors through fifteen multiple choice questions. In addition, safety attitudes, behaviors, and practices are measured by forty-four Likert-style questions that measure a respondent's agreement with a safety-related statement on a scale of “never” to “all of the time.” To assess the reliability of survey responses, the survey addresses important concepts several times through closely-related questions. By combining responses to related questions into a scale, Cronbach’s α can be calculated to measure the internal consistency of surveyed agribusiness retailer employees’ responses (Cronbach 1951). Based on responses from employees at the fifteen surveyed agribusiness retailers, related questions regarding safety system elements such as disciplinary policy, safety observations, and safety investigations yield high α that suggest internal consistency. Reliability tests will continue as the survey is administered more widely. The results of these tests will influence revisions to any future versions of the survey.

The fifteen surveyed agribusiness retailers primarily provide farm inputs, marketing, and warehousing for grain and oilseed farmers in the upper Midwestern United States. The survey was administered between October 2014 and March 2016. Seven agribusiness retailers completed hard copies of the survey at company meetings or via mail while five agribusiness retailers completed their surveys online. Three agribusiness retailers used a combination of these methods. All surveys were completed anonymously and voluntarily. In total, 2,338 surveys were submitted, representing 78.7 percent of employees at the fifteen surveyed firms. Many of the employees that failed to complete the survey are part time employees at convenience stores and other nonagricultural retail locations. Of the 2,338 submitted surveys, 2,118 are considered complete because they contain valid answers to all questions used in this dissertation’s empirical models.

Characteristics of the 2,118 agribusiness retailer employees that submitted complete surveys are summarized in tables 5.1 through 5.5. The age distribution of employees at surveyed agribusiness retailers is displayed in table 5.1, which shows that 27.4 percent of surveyed agribusiness retailer employees are fifty to fifty-nine years old. Figure 1.4 in chapter 1 indicates that this share is considerably higher than the share of fifty to fifty-nine year-old employees in the general U.S. workforce. As described in table 5.2, 14.9 percent of the surveyed agribusiness retail workforce has less than one year of experience with their employer while 53.4 percent of employees have five or more years of experience at their firm. Table 5.3 shows that all surveyed agribusiness retailers have an agronomy and crop production department and those departments employ 35.2 percent of surveyed agribusiness retailer employees. Finally, tables 5.4 and 5.5 indicate that surveyed agribusiness retailer employees are overwhelmingly employed in nonmanagerial, full time roles. Appendices 6 and 7 break down these characteristics by age and tenure, respectively, creating a detailed picture of agribusiness retailer employees that is not available elsewhere in the existing literature or public domain.

Table 5.1. Summary of surveyed agribusiness retailer employees by age

Age	Overall share	Mean share	Min. share	Max. share
< 30 years	22.1%	21.9%	12.8%	37.8%
30-39 years	19.5%	19.5%	14.5%	24.0%
40-49 years	18.0%	17.9%	11.2%	21.8%
50-59 years	27.4%	27.5%	17.6%	34.5%
> 59 years	13.0%	13.3%	5.8%	28.4%

Note: Overall share assigns equal weight to each surveyed employee while the other statistics in the table assign equal weight to each surveyed firm.

Table 5.2. Summary of surveyed agribusiness retailer employees by tenure

Tenure	Overall share	Mean share	Min. share	Max. share
< 1 year	14.9%	14.5%	3.6%	26.1%
1-4 years	31.7%	32.0%	20.8%	45.2%
5-9 years	18.5%	18.1%	13.7%	30.1%
10-19 years	19.5%	19.2%	9.0%	27.8%
> 19 years	15.4%	16.2%	4.8%	25.3%

Note: Overall share assigns equal weight to each surveyed employee while the other statistics in the table assign equal weight to each surveyed firm.

Table 5.3. Summary of surveyed agribusiness retailer employees by department

Department of primary employment	Overall share	Mean share	Min. share	Max. share
Agronomy/crop production	35.2%	36.7%	6.4%	61.9%
Auto/tire shop	1.3%	1.5%	0.0%	7.1%
Corporate/financial	10.8%	10.7%	6.0%	17.4%
Energy	9.7%	10.6%	0.0%	35.1%
Feed	9.4%	8.8%	0.0%	20.8%
Grain/beans	12.2%	11.0%	0.0%	38.3%
Nonagricultural retail	9.7%	9.6%	0.0%	63.8%
Transportation/trucking	5.5%	5.7%	0.0%	17.4%
Other	6.2%	5.4%	0.0%	14.9%

Note: Overall share assigns equal weight to each surveyed employee while the other statistics in the table assign equal weight to each surveyed firm.

Table 5.4. Summary of surveyed agribusiness retailer employees by managerial status

Managerial status	Overall share	Mean share	Min. share	Max. share
Managerial	25.0%	25.0%	17.5%	35.8%
Nonmanagerial	75.0%	75.0%	64.2%	82.5%

Note: Overall share assigns equal weight to each surveyed employee while the other statistics in the table assign equal weight to each surveyed firm.

Table 5.5. Summary of surveyed agribusiness retailer employees by employment status

Employment status	Overall share	Mean share	Min. share	Max. share
Full time	86.7%	84.7%	69.8%	99.2%
Part time	8.1%	8.6%	0.0%	28.2%
Seasonal	5.3%	6.7%	0.0%	25.4%

Note: Overall share assigns equal weight to each surveyed employee while the other statistics in the table assign equal weight to each surveyed firm.

Data on employee background characteristics such as agricultural background, hometown proximity, and educational attainment were also collected via the survey. The data show that most surveyed agribusiness retailer employees have a familiarity with production agriculture beginning in childhood. Table 5.6 reveals that 53.1 percent of surveyed agribusiness retailer employees grew up on a farm and an additional 27.6 percent of employees grew up in rural communities and had knowledge of production agriculture. Furthermore, table 5.7 indicates that employees tend to work close to home. Specifically, 54.4 percent of surveyed agribusiness retailer employees work within 20 miles of where they grew up. Lastly, table 5.8 shows that, although only 20.0 percent of surveyed employees hold a bachelor’s or advanced degree, 64.7 percent have attempted post-secondary education of some sort.

Table 5.6. Summary of surveyed agribusiness retailer employees by agricultural background

Agricultural background	Overall share	Mean share	Min. share	Max. share
Little or no ag. knowledge	12.1%	12.2%	5.6%	31.4%
Ag. knowledge in nonrural community	7.2%	6.9%	2.4%	17.0%
Ag. knowledge in rural community	27.6%	26.9%	19.0%	39.9%
Grew up on a farm	53.1%	54.0%	24.5%	66.4%

Note: Overall share assigns equal weight to each surveyed employee while the other statistics in the table assign equal weight to each surveyed firm.

Table 5.7. Summary of surveyed agribusiness retailer employees by workplace distance to childhood home

Distance from workplace to childhood home	Overall share	Mean share	Min. share	Max. share
< 20 miles	54.4%	55.1%	40.9%	77.4%
20-50 miles	20.9%	20.8%	11.9%	30.4%
> 50 miles	24.6%	24.0%	10.7%	39.6%

Note: Overall share assigns equal weight to each surveyed employee while the other statistics in the table assign equal weight to each surveyed firm.

Table 5.8. Summary of surveyed agribusiness retailer employees by educational attainment

Educational attainment	Overall share	Mean share	Min. share	Max. share
Did not complete high school	3.0%	3.2%	0.0%	10.7%
High school diploma	32.3%	32.5%	22.7%	41.7%
Some college	28.9%	28.7%	20.6%	41.0%
Associate's degree	15.7%	15.3%	9.7%	20.0%
Bachelor's degree	17.4%	17.7%	11.2%	28.6%
Professional or graduate degree	2.6%	2.6%	0.0%	4.5%

Note: Overall share assigns equal weight to each surveyed employee while the other statistics in the table assign equal weight to each surveyed firm.

Appendix 8 describes how agricultural background, hometown proximity, and educational attainment vary by age, tenure, department, managerial status, and employment status. The tables in appendix 8 offer considerable insight regarding the makeup of the surveyed agribusiness retail workforce. For example, table A8.1 reveals that young employees tend to have weaker agricultural backgrounds, work closer to their childhood home, and have higher educational attainments than their older coworkers.

Empirical model of safety climate

In the preceding chapter, equation (4.4) states that safety system elements and personal factors determine an individual's perceived safety climate. The literature review in chapter 3 explains that the precise definition of safety climate is a topic of much debate. Like Risch et al. (2014), this dissertation uses safety empowerment as its definition of safety climate. Safety empowerment is a dimension of safety climate that emerges in much of the literature reviewed in chapter 3. Data on safety climate were collected through a survey question that asked employees to rate their empowerment to take actions that prevent injuries to themselves and their coworkers. Responses were recorded on a four-point scale. Safety climate is defined in table 5.9, which contains definitions of all variables in the safety climate model. Tables 5.10 and 5.11 provide summary statistics for safety climate model variables for managerial workers and nonmanagerial workers, respectively. For the purposes of this dissertation, managerial employees are supervisors and others who report directly to firm leadership while nonmanagerial employees are hourly and professional employees without supervisory roles.

Table 5.9. Definitions and data sources for safety climate model variables

Variable (symbol)	Definition	Source
Safety climate (*SC*)	Employee's rating of empowerment to act in ways that promote safety of self and others.	Survey
Discipline (SS_1)	Employee's rating of frequency with which safety violations are disciplined.	Survey
Inspections (SS_2)	Employee's rating of frequency of inspection-based feedback.	Survey
Investigations (SS_3)	Employee's rating of frequency with which safety incidents are investigated.	Survey
Meetings (SS_4)	Employee's rating of frequency of safety meetings.†	Survey
Modified duty (SS_5)	Employee's rating of frequency with which injured employees have duties modified.	Survey
Off-the-job (SS_6)	Employee's rating of frequency with which off-the-job safety training is addressed.	Survey
Recognition (SS_7)	Employee's rating of frequency of safety accomplishment recognition.	Survey
Training (SS_8)	Employee's rating of amount of safety training received in previous 12 months.†	Survey
Agricultural background (EB_1)	Employee's rating of childhood familiarity with agriculture.	Survey
Childhood home distance (EB_2)	Distance from employee's childhood home to current workplace.*	Survey
Education (EB_3)	Employee's maximal educational attainment.‡	Survey

Note: Survey items summarized in this table are measured on a 4-point scale unless otherwise indicated. Items measured on a 3-point scale are noted by *, items measured on a 5-point scale are noted by †, and items measured on a 6-point scale are noted by ‡.

Table 5.10. Summary statistics for managerial safety climate model variables

Variable (symbol)	Mean	St. dev.	Min.	Max.
Safety climate (*SC*)	3.57	0.66	1	4
Discipline (SS_1)	3.00	0.90	1	4
Inspections (SS_2)	3.00	0.78	1	4
Investigations (SS_3)	3.54	0.70	1	4
Meetings (SS_4)	3.23	1.07	1	5
Modified duty (SS_5)	3.17	0.87	1	4
Off-the-job (SS_6)	2.72	0.98	1	4
Recognition (SS_7)	2.69	0.99	1	4
Training (SS_8)	3.37	0.89	1	5
Agricultural background (EB_1)	3.34	0.95	1	4
Childhood home distance (EB_2)	1.91	0.88	1	3
Education (EB_3)	3.56	1.24	1	6

Table 5.11. Summary statistics for nonmanagerial safety climate model variables

Variable (symbol)	Mean	St. dev.	Min.	Max.
Safety climate (*SC*)	3.39	0.77	1	4
Discipline (SS_1)	2.99	0.93	1	4
Inspections (SS_2)	3.02	0.84	1	4
Investigations (SS_3)	3.46	0.79	1	4
Meetings (SS_4)	2.98	1.11	1	5
Modified duty (SS_5)	3.13	0.89	1	4
Off-the-job (SS_6)	2.79	1.00	1	4
Recognition (SS_7)	2.79	1.02	1	4
Training (SS_8)	3.40	0.92	1	5
Agricultural background (EB_1)	3.18	1.04	1	4
Childhood home distance (EB_2)	1.63	0.81	1	3
Education (EB_3)	3.08	1.19	1	6

Although safety systems vary across firms and business locations, Risch et al. (2014) outline a list of elements common to many occupational safety systems. Included on that list are discipline programs for safety violations, workplace safety inspections, investigations of safety incidents, safety meetings, modified duty programs that accommodate injured employees as they return to work, training on off-the-job safety topics, recognition programs for safety accomplishments, and safety training sessions. These safety system elements are used as explanatory variables in the empirical model of individual safety climate. Hypothesis 1 states that safety climate is expected to increase as safety system elements improve. Data on safety system elements were collected through survey responses. Responses were coded so that higher responses indicate the safety system element is of higher frequency or quantity. Tables 5.9 through 5.11 define and summarize the safety system variables used in the empirical model of safety climate.

Employee background factors are the other key component of the theoretical model of safety climate outlined in equation (4.4). Conversations with safety directors at surveyed firms highlighted several employee background factors that may influence safety climate. For example, production agriculture, which shares many similarities with the agribusiness retail industry, has notoriously poor safety climate and safety outcomes. Indeed, research indicates that knowledge of production agriculture's risks does not necessarily translate into safe behaviors (Elkind 1993). Furthermore, some agricultural workers believe that occupational injuries are often unavoidable or outside of their control (Harrell 1995; Seiz and Downey 2001). Safety directors suggested that poor safety climate may be retained by employees with agricultural backgrounds and reduce their empowerment to act safety in the agribusiness retail setting.

Safety directors identified two other employee background factors that may influence safety climate. First, safety directors claimed that employees with lifelong local ties may be less risk averse, and therefore less empowered to control their own safety, compared to other employees because they are working with familiar people and environments. Second, safety directors stated that educational attainment may be positively related to employees' beliefs in the efficacy of safety training and education efforts.

Based on the preceding discussion, data measuring the agricultural background, childhood home proximity, and educational attainment of employees were gathered through the survey and included as explanatory variables in the empirical model of safety climate. These explanatory variables offer a test of hypothesis 2, which predicts a negative relationship between safety climate and agricultural background and a positive relationship between safety climate and both childhood home distance and educational attainment. Agricultural background, childhood home distance, and educational attainment are measured on scales of four, three, and six points, respectively. Higher responses signify increased childhood familiarity with production agriculture, increased distance from an employee's workplace to their childhood home, and increased educational attainment. Further descriptions and summaries of these variables are available in tables 5.9 through 5.11.

For several of the variables listed in tables 5.10 and 5.11, noticeable differences exist between the mean for managerial employees and the mean for nonmanagerial employees. Distributional differences in responses for these variables were tested for via Mann-Whitney-Wilcoxon tests (Wilcoxon 1945; Mann and Whitney 1947). At the one percent level, equality between the distributions of managerial and nonmanagerial ratings is rejected for five variables: safety climate, meetings, agricultural background, childhood home distance, and educational attainment. In addition, at the ten percent level, distributional equality is rejected for the recognition and investigation variables.

Because the dependent variable in the empirical model of safety climate is an ordinal rating of safety climate, an ordered probit model is an appropriate empirical framework. Cameron and Trivedi (2005) outline the specification of a general ordered probit model. Applied to this section's empirical model, the precise, but unobserved, safety climate, SC^*_{ij}, of employee i at business location j is:

$$SC^*_{ij} = \sum_{a=1}^{8} \beta_a SS_{a,\,ij} + \sum_{b=1}^{3} \gamma_b EB_{b,\,ij} + \varepsilon_{ij} \qquad (5.1)$$

where $SS_{a,\,ij}$ is the rating of safety system element a by employee i at business location j and $EB_{b,\,ij}$ is background variable b for employee i at business location j. The error term, ε_{ij}, is assumed normal.

As unobserved safety climate, SC^*_{ij}, changes, observed ordinal safety climate ratings, SC_{ij} , change according to:

$$SC_{ij} = \begin{cases} 1 \text{ if } SC^*_{ij} \leq \mu_1 \\ 2 \text{ if } \mu_1 < SC^*_{ij} \leq \mu_2 \\ 3 \text{ if } \mu_2 < SC^*_{ij} \leq \mu_3 \\ 4 \text{ if } SC^*_{ij} > \mu_3 \end{cases} \qquad (5.2)$$

where μ_c are threshold parameters estimated from the data. Maximum likelihood is used to estimate μ_c and the unknown parameters in equation (5.1): β_a and γ_b. The signs of β_a and γ_b indicate whether unobserved safety climate, SC^*_{ij}, increases or decreases with increases in the associated explanatory variables. Estimated probabilities for observed ordinal safety climate ratings, SC_{ij}, can be estimated based on μ_c, β_a, and γ_b and selected values of $SS_{a,\,ij}$ and $EB_{b,\,ij}$. Specifically, for the four possible values of SC_{ij}:

$$Pr(SC_{ij} = c) = \begin{cases} \Phi\left(\mu_1 - \widehat{SC}_{ij}\right) \text{ for } c = 1 \\ \Phi\left(\mu_2 - \widehat{SC}_{ij}\right) - \Phi\left(\mu_1 - \widehat{SC}_{ij}\right) \text{ for } c = 2 \\ \Phi\left(\mu_3 - \widehat{SC}_{ij}\right) - \Phi\left(\mu_2 - \widehat{SC}_{ij}\right) \text{ for } c = 3 \\ 1 - \Phi\left(\mu_3 - \widehat{SC}_{ij}\right) \text{ for } c = 4 \end{cases} \tag{5.3}$$

where Φ is the cumulative normal distribution and $\widehat{SC}_{ij}$ is an estimate of unobserved safety climate, SC^*_{ij}, defined as:

$$\widehat{SC}_{ij} = \sum_{a=1}^{8} \beta_a SS_{a,\,ij} + \sum_{b=1}^{3} \gamma_b EB_{b,\,ij} \tag{5.4}$$

for selected values of $SS_{a,\,ij}$ and $EB_{b,\,ij}$.

The ordered probit model of safety climate outlined above is estimated separately for managerial employees and nonmanagerial employees at surveyed agribusiness retailers. Several researchers suggest that fundamental differences in safety climate may exist between these two groups of employees (e.g., Harvey et al. 2002; Arboleda et al. 2003; Prussia, Brown, and Willis 2003). Indeed, as discussed previously, managerial employees rate safety climate higher than nonmanagerial employees at surveyed agribusiness retailers. Risch et al. (2014) also analyze managerial safety climate and nonmanagerial safety climate separately. At surveyed agribusiness retailers, complete surveys were submitted by 529 managerial employees and 1,589 nonmanagerial employees.

Empirical model of safety outcomes

In chapter 4, equation (4.2) describes safety outcomes as a function of safety climate and exposure to injuries. This section outlines an empirical model of business location-level safety outcomes. Safety climate data and other survey data gathered in late 2014 and early 2015 are used to explain annual safety outcomes from 2015. This prospective design reflects safety climate's role as a tool for occupational safety promotion. Clarke (2006) indicates that the relationship between safety climate and safety outcomes is stronger prospectively than retrospectively. Eighty-three business locations at nine surveyed agribusiness retailers are included in this analysis.[20]

Risch et al. (2014) use TRC injuries as the dependent variable in their safety outcome model. However, TRC injuries are just one of several important occupational safety outcomes at a business location. Indeed, TRC injury rates do not reveal how frequently injuries are serious enough to require days away from work, work restriction, or job transfer or how quickly those DART cases are resolved. This study attempts to provide a more comprehensive view of the determinants of safety outcomes at agribusiness retailers by estimating separate safety outcome models for several dependent variables: TRC injuries, DART injuries, DAFW injuries, total DART, and total DAFW. These variables are defined in table 5.12 and summarized in table 5.13. TRC injuries, DART injuries, and DAFW injuries represent increasingly severe safety outcomes. Specifically, DART injuries are a subset of the most severe TRC injuries, and DAFW

[20] Five of the fifteen surveyed agribusiness retailers are excluded from the empirical model's sample because the late timing of their surveys does not allow a prospective relationship between safety climate and safety outcomes to be established. That is, safety outcome data for the year following the survey are not yet available for these firms. An additional surveyed agribusiness retailer was excluded from the empirical model's sample because they did not provide all necessary data.

injuries are a subset of the most severe DART injuries. Table 5.14 shows that the safety outcome variables are all positively correlated. Nevertheless, several of the correlations are mild enough that different safety outcomes may exhibit different relationships with explanatory variables.

Table 5.12. Definitions and data sources for safety outcome variables

Outcome (symbol)	Definition	Source
TRC injuries (SO_1)	Location's annual total recordable injuries.	300A
DART injuries (SO_2)	Location's annual injuries requiring days away from work, work restriction, or job transfer.	300A
DAFW injuries (SO_3)	Location's annual injuries requiring days away from work.	300A
Total DART (SO_4)	Location's annual total days away from work, work restriction, or job transfer.	300A
Total DAFW (SO_5)	Location's annual total days away from work.	300A

Table 5.13. Summary statistics for safety outcome variables

Outcome (symbol)	Mean	St. dev.	Min.	Max.
TRC injuries (SO_1)	1.18	1.62	0	7
DART injuries (SO_2)	0.54	0.95	0	4
DAFW injuries (SO_3)	0.30	0.69	0	3
Total DART (SO_4)	20.12	55.49	0	297
Total DAFW (SO_5)	5.34	19.46	0	113

Table 5.14. Correlation matrix for safety outcome variables

	TRC injuries	DART injuries	DAFW injuries	Total DART	Total DAFW
TRC injuries	1.00				
DART injures	0.70	1.00			
DAFW injuries	0.63	0.88	1.00		
Total DART	0.43	0.56	0.41	1.00	
Total DAFW	0.23	0.36	0.44	0.62	1.00

Note: Correlation coefficients calculated using rates per 200,000 hours.

According to equation (4.2), safety outcomes should improve as safety climate improves. Indeed, hypothesis 3 predicts such a relationship. Business location-average safety climate ratings for managerial employees and nonmanagerial employees are included as explanatory variables in the empirical model of safety outcomes. Similar to Risch et al. (2014), managerial employee safety climate and nonmanagerial employee safety climate are included separately in the empirical model of safety outcomes. Definitions and summary statistics for managerial safety climate and nonmanagerial safety climate are contained in tables 5.15 and 5.16, respectively, as are definitions and summary statistics for all other explanatory variables in the safety outcome model.

Table 5.15. Definitions and data sources for safety outcome model explanatory variables

Explanatory variable (symbol)	Definition	Source
Managerial safety climate (SC_1)	Average rating (1-4 scale) of empowerment by location's managerial employees.	Survey
Nonmanagerial safety climate (SC_2)	Average rating (1-4 scale) of empowerment by location's nonmanagerial employees.	Survey
Safety capital (SK)	Average rating (1-4 scale) of safety of location's equipment and facilities.	Survey
Total employees (TE)	Total employees at location.	300A
Managerial employee share (MS)	Share of location's employees that have managerial roles.	Survey
< 1 year tenure share*	Share of location's employees with less than 1 year of experience.	Survey
1-4 year tenure share (TS_1)	Share of location's employees with 1 to 4 years of experience.	Survey
5-9 year tenure share (TS_2)	Share of location's employees with 5 to 9 years of experience.	Survey
10-19 year tenure share (TS_3)	Share of location's employees with 10 to 19 years of experience.	Survey
> 19 year tenure share (TS_4)	Share of location's employees with 20 or more years of experience.	Survey
Full time employee share*	Share of location's employees that are employed full time.	Survey
Part time employee share (ES_1)	Share of location's employees that are employed part time.	Survey
Seasonal employee share (ES_2)	Share of location's employees that are employed seasonally.	Survey
Agronomy share (DS_1)	Share of location's employees that work in the agronomy or crop production department.	Survey
Automobile/tire shop share (DS_2)	Share of location's employees that work in the automobile maintenance or tire shop.	Survey
Corporate/financial share (DS_3)	Share of location's employees that work in corporate or financial positions.	Survey
Energy share (DS_4)	Share of location's employees that work in the energy and petroleum department.	Survey
Feed share (DS_5)	Share of location's employees that work in the feed department.	Survey
Grain/beans share*	Share of location's employees that work in the grain or beans department.	Survey
Nonagricultural retail share (DS_6)	Share of location's employees that work in convenience, grocery, or other stores.	Survey
Transportation/trucking share (DS_7)	Share of location's employees that work in transportation or trucking.	Survey
Other share (DS_8)	Share of location's employees that work in department not listed above.	Survey

Note: Reference categories, which are excluded from estimation due to collinearity, are indicated by *.

Table 5.16. Summary statistics for safety outcome model explanatory variables

Explanatory variable (symbol)	Mean	St. dev.	Min.	Max.
Managerial safety climate (*SC_1*)	3.65	0.41	2.33	4.00
Nonmanagerial safety climate (*SC_2*)	3.38	0.31	2.57	4.00
Safety capital (*SK*)	3.26	0.26	2.40	4.00
Total employees (*TE*)	20.45	18.90	3.00	124.00
Managerial employee share (*MS*)	0.24	0.12	0.07	0.67
Under 1 year tenure share*	0.15	0.14	0.00	0.67
1-4 year tenure share (*TS_1*)	0.27	0.17	0.00	0.88
5-9 year tenure share (*TS_2*)	0.18	0.14	0.00	0.75
10-19 year tenure share (*TS_3*)	0.23	0.14	0.00	0.63
> 19 year tenure share (*TS_4*)	0.17	0.14	0.00	0.57
Full time employee share*	0.86	0.22	0.10	1.00
Part time employee share (*ES_1*)	0.09	0.20	0.00	0.90
Seasonal employee share (*ES_2*)	0.05	0.10	0.00	0.48
Agronomy share (*DS_1*)	0.35	0.34	0.00	1.00
Automobile/tire shop share (*DS_2*)	0.02	0.06	0.00	0.33
Corporate/financial share (*DS_3*)	0.09	0.17	0.00	0.90
Energy share (*DS_4*)	0.15	0.27	0.00	1.00
Feed share (*DS_5*)	0.12	0.25	0.00	1.00
Grain/beans share*	0.13	0.21	0.00	0.75
Nonagricultural retail share (*DS_6*)	0.07	0.22	0.00	1.00
Transportation/trucking share (*DS_7*)	0.02	0.09	0.00	0.63
Other share (*DS_8*)	0.05	0.14	0.00	1.00

Note: Reference categories, which are excluded from estimation due to collinearity, are indicated by *.

Equation (4.2) indicates that safe facilities and equipment should reduce occupational injuries by reducing a business location's exposure to injuries. Surveyed agribusiness retailer employees were asked to rate these assets, which are referred to as safety capital, for the business location at which they work. Ratings were averaged by business location and are included in the empirical model of safety outcomes. A business location's total number of employees is also included as an explanatory variable in the empirical model of safety outcomes to assess whether any returns to scale exist in occupational safety outcomes. The share of managerial employees at a business location is another explanatory variable in the empirical model of safety outcomes because managerial employees often perform different, typically less dangerous, work tasks than nonmanagerial employees. As such, business locations with a large share of managerial employees should experience fewer injuries than otherwise identical business locations. Managerial employee share was calculated based on survey responses. As in the safety climate model, managerial employees are employees that supervise others or report directly to upper management.

Research shows that inexperienced workers are at heightened risk of occupational injury (Breslin and Smith 2006). To account for the effect of employee experience on a business location's safety outcomes, tenure shares are included in the empirical model of safety outcomes. Using survey data, tenure shares were calculated to represent the number of employees in a given tenure category at a business location relative to the total number of employees at that business location. Survey respondents chose between five tenure categories, which are listed in table 5.15. The share of employees with less than one year of experience is dropped from the empirical model to prevent collinearity issues, thereby serving as the reference category against which the influences of other tenure shares are measured.

Non-full time employees may also have unique exposure to occupational injuries. Compared to full time employees, non-full time employees may be less knowledgeable about occupational hazards and less likely to speak out about their own safety (Aronsson 1999). To measure the extent of different safety outcomes for non-full time employees, employment status shares are included in the empirical model of safety outcomes. Using survey data, employment status shares were calculated to represent the number of employees working full time, part time, or seasonally at a business location relative to the total number of employees at that business location. Full time employee share is dropped from the empirical model. Therefore, full time employees form the reference category for comparing the effects of part time employee share and seasonal employee share.

Finally, a business location's exposure to occupational injuries is determined by the type of work performed by employees at the business location. For example, all else equal, a business location where employees exclusively perform administrative tasks in an office setting is less likely to experience injuries than a business location where employees engage in more hazardous activities such as handling grain or fixing machinery. To account for differences in injury exposure based on business lines, several department share variables are included in the empirical model of safety outcomes. Using survey data, department share variables were calculated to represent the number of employees working in a given department at a business location relative to the business location's total number of employees. Table 5.15 lists the nine departments into which surveyed agribusiness employees were grouped. Similar to Risch et al. (2014), grain and bean department share is excluded from the empirical model, so the grain and bean department is the reference category for comparing department share coefficients.

The explanatory variables summarized in table 5.16 are connected to the safety outcome variables in table 5.13 via Poisson models and negative binomial models, which are frequently used to analyze occupational safety outcomes such as injuries, lost workdays, and fatalities (e.g., Bailer, Reed, and Strayner 1997; Jin, Kite-Powell, and Talley 2001; Benavides et al. 2006; Blanch et al. 2009; Risch et al. 2014). A Poisson specification of the empirical model of safety outcomes expresses the log of safety outcome v at location j, $SO_{v,j}$, as a function of the explanatory variables at location j:

$$(5.5) \qquad ln(SO_{v,j}) = ln(Hours_j) + \delta + \sum_{w=1}^{2} \zeta_w SC_{w,j} + \eta SK_j + \theta TE_j + \kappa MS_j$$

$$+ \sum_{x=1}^{4} \lambda_x TS_{x,j} + \sum_{y=1}^{2} \pi_y ES_{y,j} + \sum_{z=1}^{8} \rho_z DS_{z,j} + \sigma_j$$

where $SC_{w,j}$ is the average safety climate rating for employees of managerial status w at business location j, SK_j is the average safety capital rating at business location j, TE_j is the total number of employees at business location j, MS_j is the share of managerial employees at location j, $TS_{x,j}$ is the share of employees in tenure category x at business location j, $ES_{y,j}$ is the share of employees of employment status y at business location j, $DS_{z,j}$ is the share of employees in department z at business location j, and σ_j is an error term.

The model represented by equation (5.5) is very similar to the one estimated by Risch et al. (2014). It is critical to note that the natural log of total hours worked at business location j, $Hours_j$, is included on the right hand side of equation 5.5 even though hours worked are not one of the explanatory variables described above. No coefficient is attached to $ln(Hours_j)$ because its coefficient is constrained to one when the model is estimated. The addition of $ln(Hours_j)$ with a coefficient constrained to one forces the Poisson model to account for safety outcomes as rates, not simply as counts. This can be seen through the simple manipulation of equation (5.5) into:

(5.6) $$ln(SO_{v,j}/Hours_j) = \delta + \sum_{w=1}^{2} \zeta_w SC_{w,j} + \eta SK_j + \theta TE_j + \kappa MS_j$$

$$+ \sum_{x=1}^{4} \lambda_x TS_{x,j} + \sum_{y=1}^{2} \pi_y ES_{y,j} + \sum_{z=1}^{8} \rho_z DS_{z,j} + \sigma_j$$

where the natural log of safety outcomes per hour is now clearly the dependent variable.

Poisson regressions rest on an assumption of equidispersion, which is equality between the dependent variable's conditional variance and conditional mean. If equidispersion does not hold, a relative of Poisson regression called negative binomial regression is preferred. First introduced by Greenwood and Yule (1920), negative binomial regressions are highly similar to Poisson regressions. The chief difference is the inclusion of an additional coefficient to model overdispersion. Regardless of whether a Poisson regression or a negative binomial regression is employed, maximum likelihood methods are used to estimate δ, ζ_w, η, θ, κ, λ_x, π_y, and ρ_z, the unknown parameters in equation (5.5).

Empirical model of safety efficiency

Equation (4.1) in chapter 4 indicates that efficient safety investments are key to minimizing total injury-related cost. That is, relative to other firms in their industry, firms should aim to achieve their occupational safety outcomes through minimal inputs. If a firm does not accomplish this goal, their safety investments are inefficient relative to other firms and the firm's total injury-related cost is greater than necessary.

To investigate safety efficiency at agribusiness retailers, data on safety investments and safety outcomes were collected from fourteen firms.[21] Annual, firm-level data were collected from each firm from 2012 to 2014, creating a pool of forty-two firm-year observations. Data on firm-level safety investments were grouped into two categories that are used in the empirical model of safety efficiency: safety personnel compensation and safety system investment. Safety personnel compensation includes salaries and benefits paid to safety directors as well as the value of the time firm executives and location managers devote to occupational safety efforts. That is, if a firm's chief executive had ten percent of their time committed to occupational safety, ten percent of their annual total compensation (salary and benefits) is included in the firm's safety personnel compensation. Safety system investment is the sum of funds spent on safety meetings, training materials, and other safety system elements. Data in both categories were adjusted to 2014 dollars via the consumer price index. The safety investments analyzed herein are defined in table 5.17 and summarized in table 5.18.

Table 5.17. Definitions and data sources for safety efficiency model variables

Variable (symbol)	Definition	Source
Compensation investment (I_1)	Firm's annual compensation (in 2014 dollars) for managerial time devoted to occupational safety.	Interview
Safety system investment (I_2)	Firm's annual expenditures (in 2014 dollars) on safety meetings, training, etc.	Interview
Uninjured employees (O_1)	Firm's annual employees (calculated as firm hours worked/2,000) less total injuries.	300A
Non-DART injuries (O_2)	Firm's annual injuries not requiring days away from work, work restriction, or job transfer.	300A
DART injuries (O_3)	Firm's annual injuries requiring days away from work, work restriction, or job transfer.	300A

[21] Due to a managerial transition that complicated recordkeeping, one surveyed agribusiness retailer did not provide accurate data for several categories in multiple years, leading to its exclusion from the analysis.

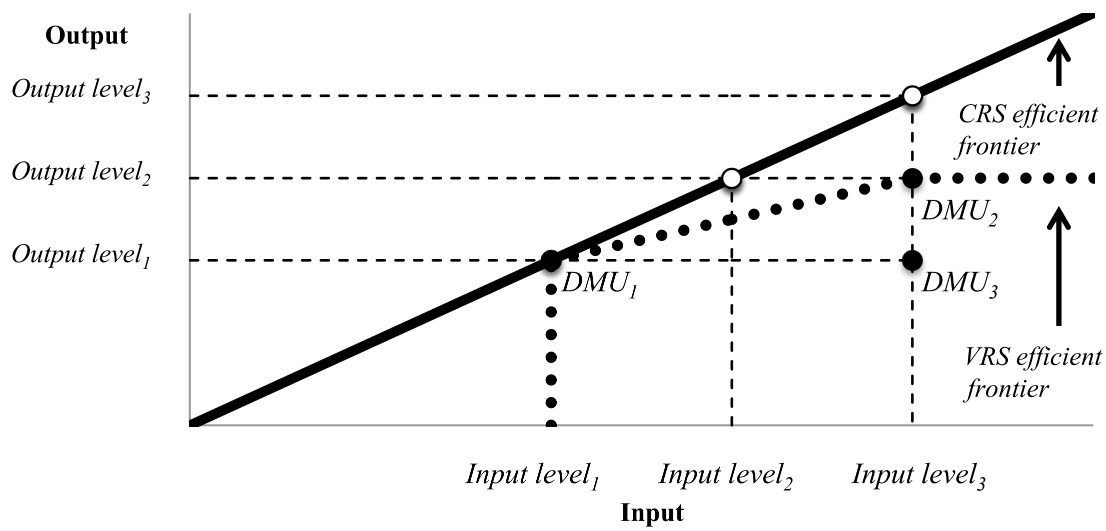
Table 5.18. Summary statistics for safety efficiency model variables

Explanatory variable (symbol)	Mean	St. dev.	Min.	Max.
Compensation investment (I_1)	109,378.65	32,709.90	69,660.00	248,803.36
Safety system investment (I_2)	5,097.11	2,763.40	2,000.00	12,640.78
Uninjured employees (O_1)	199.39	87.97	45.42	482.13
Non-DART injuries (O_2)	8.31	5.42	0.00	21.00
DART injuries (O_3)	5.81	4.84	0.00	23.00

The efficiency of compensation investments and safety system investments is evaluated relative to safety outcomes. Firm-level safety outcomes used in the empirical model of safety efficiency are uninjured employees, non-DART injuries, and DART injuries. Uninjured employees are the annual number of employees at a firm less the total number of annual injuries. For consistent measurement, annual employees are defined as the annual hours worked at a firm divided by 2,000, which represents a full time employees' annual workload of forty hours per week for fifty weeks per year. Total injuries are composed of non-DART injuries and DART injuries, which are separate outcomes in the empirical model of safety efficiency. Non-DART injuries and DART injuries are included separately to more accurately describe the returns on a firm's safety investments. Additional information on firm-level safety outcomes is contained in table 5.17 and table 5.18.

Data envelopment analysis (DEA) is a useful tool for measuring the productive efficiency of a decision making unit (DMU) such as a firm. DEA, which was first defined by Charnes, Cooper, and Rhodes (1978), is a nonparametric method that uses linear programming to create an efficient frontier based on inputs and outputs for a group of DMUs. The DEA model proposed by Charnes, Cooper, and Rhodes assumes constant returns to scale (CRS), meaning that efficient DMUs are expected to increase inputs and outputs at the same rate. Figure 5.1 offers a basic example of efficiency analysis under constant returns to scale for three DMUs producing a single input and a single output. *DMU_1* achieves the greatest output per input and the CRS efficiency frontier is therefore a ray beginning at the origin and passing through the input-output pairing achieved by *DMU_1*. *DMU_2* and *DMU_3* are in the inefficient region below the efficient frontier because they produce less output per input than *DMU_1*.

Figure 5.1. Efficiency measures under different returns to scale



Efficiency can be evaluated from input-oriented and output-oriented perspectives. From an input-oriented perspective, a DMU's efficiency is measured as the amount by which a DMU must contract inputs to reach the efficient frontier given their current output level. In figure 5.1, *DMU_2* must contract inputs from *Input $level_3$* to *Input $level_2$*, which is the efficient input level for *DMU_2*'s output level created by a CRS projection of

DMU_1. The efficiency of DMU_2 can be measured as $\frac{Input\ level_2}{Input\ level_3}$, which indicates how many inputs an input-efficient DMU uses relative to DMU_2's inefficient input usage. Likewise, the efficiency of DMU_3 can be measured as $\frac{Input\ level_1}{Input\ level_3}$. Obviously, this ratio equals one for efficient DMUs such as DMU_1. From an output-oriented perspective, a DMU's efficiency is measured as the amount by which a DMU must expand outputs to reach the efficient frontier given their current input level. In figure 5.1, DMU_2 must expand outputs from *Output level*$_2$ to *Output level*$_3$, which is the efficient output level for DMU_2's input level according to a CRS projection of DMU_1. The efficiency of DMU_2 can be measured as $\frac{Output\ level_2}{Output\ level_3}$, which indicates how many outputs DMU_2 produces relative to an output-efficient DMU. Similarly, the efficiency of DMU_3 can be measured as $\frac{Output\ level_1}{Output\ level_3}$. Once again, this ratio equals one for efficient DMUs such as DMU_1. DEA uses linear programming to undertake efficiency analysis similar to the graphical analysis exemplified in figure 5.1.

DEA is not restricted to CRS. Specifically, Banker, Charnes, and Cooper (1984) add flexibility to DEA by incorporating variable returns to scale (VRS). In contrast to CRS, VRS does not assume proportional expansion of inputs and outputs. Instead, the relationship between inputs and outputs varies based on convex combinations of observed DMUs that produce at different scales. In figure 5.1, a VRS efficient frontier is plotted with a dotted line. Just like in the CRS model, DMU_1 is technically efficient. However, DMU_2 is also technically efficient under VRS as no DMU produces more outputs using the same inputs or the same outputs using fewer inputs. DMU_3 remains technically inefficient under VRS. Its input-oriented efficiency is $\frac{Input\ level_1}{Input\ level_3}$ and its output-oriented efficiency is $\frac{Output\ level_1}{Output\ level_2}$.

DEA has several appealing features including its data-driven form and compatibility with multiple inputs and multiple outputs measured with different units (Coelli, Rao, and Battese 1998; Cooper, Seiford, and Tone 2000). Fare, Grosskopf, and Lovell (1994) provide a thorough description of DEA's uses in production economics. Moreover, the aforementioned characteristics make DEA an attractive option for benchmarking studies in many disciplines. Accordingly, DEA is used for this dissertation's empirical model of safety efficiency.

In this DEA, each firm-year is considered to be a separate DMU. The variables defined in table 5.17 are not compatible with the traditional DEA format. That is, two of the outputs, non-DART injuries and DART injuries, are undesirable and should be minimized instead of maximized. Seiford and Zhu (2002) outline several strategies for dealing with undesirable outputs in DEA. One such strategy involves transforming the outputs so that maximization is beneficial. In this case, for each DMU, q, non-DART injuries, $O_{2,q}$ are transformed into $O^*_{2,q}$ by:

$$O^*_{2,q} = O_{2,max} - O_{2,q} + 1 \tag{5.7}$$

where $O_{2,max}$ is the maximum value of untransformed non-DART injuries across all DMUs. Similarly, DART injuries, $O_{3,q}$, are transformed into $O^*_{3,q}$ by:

$$O^*_{3,q} = O_{3,max} - O_{3,q} + 1 \tag{5.8}$$

where $O_{3,max}$ is the maximum value of untransformed DART injuries across all DMUs.

The transformations in equations (5.7) and (5.8) make it desirable to increase the outputs and set the minimum output value to one for the DMU with the greatest quantity of the untransformed undesirable output. Uninjured employees, $O_{1,q}$, do not need to be transformed because increasing levels of $O_{1,q}$ are already increasingly desirable. Nevertheless, for uniformity, uninjured employees can be expressed as:

$$O^*_{1,q} = O_{1,q} \tag{5.9}$$

which means all outputs are included in $O^*_{m,q}$ as desirable outputs, allowing a conventional DEA framework to be employed.

Safety efficiency at surveyed agribusiness retailers is analyzed through an input-oriented Banker, Charnes, and Cooper (1984) DEA model that utilizes VRS. An input-orientation is preferred because safety investments are controlled by each DMU. Furthermore, given that transformed outputs are used, input contraction is more easily interpretable than output expansion. VRS are employed in order to avoid restrictions on the shape of the efficient frontier. The linear program solved for each of the forty-two DMUs is:

$$\begin{aligned} &(5.10) \qquad Min\ \tau \\ &\text{Subject to:} \quad \sum_{q=1}^{42} \varphi_q O^*_{m,q} \geq O^*_{m,0}, \ m = 1, 2, 3; \\ &\sum_{q=1}^{42} \varphi_q I_{r,q} \leq \tau I_{r,0}, \ r = 1, 2; \\ &\sum_{q=1}^{42} \varphi_q = 1; \\ &\varphi_q \geq 0, \ q = 1, \ldots, 42 \end{aligned}$$

where $I_{r,0}$ and $O^*_{m,0}$ are the inputs and transformed outputs for DMU_0, which is the DMU under consideration in the linear program, and φ_q is the DEA weight placed on DMU_q in the optimized linear program.

The linear program specified in equation (5.10) calculates an efficient frontier based on observed DMUs. Each inefficient DMU aims to reach a particular point on the efficient frontier. The efficient DMUs that create that point, either individually or through convex combination, are reference DMUs for the inefficient DMU. An inefficient DMU should emulate the strategies and techniques employed by the efficient reference DMU or DMUs in order to join them on the efficient frontier.

Equation (5.10) also yields a technical efficiency score for each DMU. These scores, which range from zero to one, represent the amount by which all inputs should be scaled to place the DMU on the efficient frontier. For example, a technical efficiency score of 0.90 indicates that a DMU should use ten percent fewer inputs in order to reach technical efficiency. In contrast, a technical efficiency score of 1.00 represents full technical efficiency relative to other analyzed DMUs. The determinants of efficiency scores can be examined through regressions on explanatory variables hypothesized to influence efficiency. According to hypothesis 4, one possible determinant of the scores generated by the safety efficiency DEA is the experience of a firm's leadership. In the following chapter, the relationship between firm leadership and safety efficiency is explored.

Summary of empirical models

The empirical models described in the previous sections examine three aspects of occupational safety at agribusiness retailers. First, an ordered probit model of individual safety climate is specified. This model, which is estimated separately for managerial employees and nonmanagerial employees, explains safety climate through safety system variables and employee background variables. Managerial safety climate and nonmanagerial safety climate serve as explanatory variables in the second empirical model discussed above, a model of safety outcomes at business locations. Five different safety outcomes are dependent variables in Poisson and negative binomial regressions on safety climate variables and workplace injury exposure variables. Finally, a DEA approach compares firms' annual investments in safety personnel and safety systems to their annual uninjured employees, non-DART injuries, and DART injuries. Together, the three empirical models offer a multi-layered analysis of occupational safety at agribusiness retailers.

CHAPTER 6

Empirical Results and Discussion

This chapter contains results stemming from the three empirical models outlined in chapter 5. Specifically, the following sections present and discuss results from the individual-level safety climate model, the business location-level safety outcome model, and the firm-level safety efficiency model. Together, these empirical results create a comprehensive representation of occupational safety at surveyed agribusiness retailers.

Results from the empirical model of safety climate

The empirical model of individual safety climate was estimated separately for a group of 529 managerial employees and a group of 1,589 nonmanagerial employees via ordered probit. Table 6.1 presents empirical results from these models. At the one percent significance level, a Wald test rejects equality between the estimated regression coefficients for the two groups. [22] This finding supports the separate estimation of the safety climate model for managerial employees and nonmanagerial employees.

[22] The Wald test yields a test statistic of 33.27, which has a p-value of 0.00 based on a Chi-squared distribution with eleven degrees of freedom.

Table 6.1. Ordered probit estimates for safety climate model

Explanatory variable	Managerial employees			Nonmanagerial employees		
	Coeff.	S.E.	P-val.	Coeff.	S.E.	P-val.
Discipline	0.205***	0.072	0.005	0.118***	0.041	0.004
Inspections	0.283***	0.084	0.001	0.236***	0.045	0.000
Investigations	0.073	0.086	0.400	0.191***	0.045	0.000
Meetings	-0.077	0.053	0.152	0.027	0.029	0.360
Modified duty	0.179***	0.065	0.006	0.107***	0.035	0.002
Off-the-job	0.115*	0.066	0.084	0.130***	0.034	0.000
Recognition	0.151**	0.068	0.027	0.233***	0.037	0.000
Training	0.032	0.070	0.652	0.021	0.038	0.576
Agricultural background	-0.073	0.061	0.231	-0.044	0.030	0.146
Childhood home distance	0.053	0.066	0.422	0.074*	0.039	0.056
Education	0.020	0.048	0.670	-0.010	0.026	0.700
μ_1	0.279	0.501		0.845***	0.265	
μ_2	1.075**	0.487		1.819***	0.264	
μ_3	2.387***	0.493		3.061***	0.269	
Pseudo R^2	0.117			0.126		
Observations	529			1,589		

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6.1 shows that managerial safety climate is positively related to five safety system elements at the ten percent level or better. These safety system elements are discipline, inspections, modified duty program, off-the-job safety training, and recognition. For nonmanagerial employees, individual safety climate is also positively associated with several safety system elements. Discipline, investigations, inspections, modified duty program, off-the-job safety training, and recognition are all positively related to nonmanagerial safety climate at the one percent level. The results in table 6.1 agree with hypothesis 1, which predicts positive relationships between safety system elements and safety climate. For both managerial employees and nonmanagerial employees, training sessions and safety meetings are not associated with nonmanagerial safety climate at the ten percent significance level.

For managerial employees, agricultural background, childhood home distance, and educational attainment are unrelated to individual safety climate at the ten percent significance level. Thus, the predictions of hypothesis 2, which connects employee background factors to safety climate, are not realized for managerial employees at surveyed agribusiness retailers. In contrast, distance to an employee's childhood home is positively related to nonmanagerial safety climate at the ten percent significance level. This result signals that employees working near their childhood home report relatively poor safety climate. Neither of the other employee background factors are related to nonmanagerial safety climate at the ten percent significance level. However, the relationship between agricultural background and safety climate is negative, as hypothesized, and its p-values are not far from the ten percent level of significance. Moreover, if the surveyed agribusiness retailer with the fewest employees engaged in agricultural business lines and the fewest employees with farm backgrounds is excluded from the sample, the negative coefficient for agricultural background is significant at the ten percent level for nonmanagerial employees. All other statistically significant results remain unchanged when the safety climate model is estimated for this modified sample of fourteen firms.

The ordered probit estimates in table 6.1 can be somewhat difficult to interpret. Therefore, an alternative interpretation of the empirical results from the safety climate model is offered in appendix 9, which displays predicted probabilities of a maximal safety climate rating calculated using equation (5.3) and the empirical estimates contained in table 6.1. By tracing the changes in the predicted probability of a maximal safety climate rating, the meaning of the safety climate model's estimated coefficients may become more clear. Appendix 9 shows that increased ratings of inspection programs and recognition programs are linked to particularly large increases in the predicted probability of a maximal safety climate rating.

Although the empirical model of safety outcomes outlined in chapter 5 is a prospective model where safety climate has a predictive or causal relationship with subsequent safety outcomes, several researchers posit that past safety outcomes may influence perceptions of safety climate (e.g., Rundmo 1995; Cree and Kelloway 1997; Barling, Kelloway, and Iverson 2003). If this were the case at surveyed agribusiness retailers, the estimation of equation (5.1) would be complicated by the omission of a key variable. To measure the presence and extent of this effect, an explanatory variable representing the TRC incidence rate at an employee's business location for the year preceding the survey was added to the empirical safety climate model. Results from this model are displayed in table 6.2, which indicates that prior year TRC incidence rates are not associated with managerial or nonmanagerial safety climate. Furthermore, the signs and significance levels attached to safety system variables and employee background variables are unchanged from those reported in table 6.1. These results suggest that the empirical model of safety climate is properly specified without accounting for the frequency of injuries in the preceding year.

Table 6.2. Ordered probit estimates for safety climate model with prior year location TRC rate effect

Explanatory variable	Managerial employees			Nonmanagerial employees		
	Coeff.	S.E.	P-val.	Coeff.	S.E.	P-val.
Discipline	0.205***	0.072	0.005	0.118***	0.041	0.004
Inspections	0.283***	0.084	0.001	0.236***	0.045	0.000
Investigations	0.071	0.086	0.410	0.191***	0.045	0.000
Meetings	-0.078	0.054	0.144	0.027	0.029	0.355
Modified duty	0.179***	0.065	0.006	0.107***	0.035	0.002
Off-the-job	0.115*	0.067	0.083	0.130***	0.034	0.000
Recognition	0.152**	0.069	0.026	0.232***	0.037	0.000
Training	0.030	0.070	0.665	0.021	0.038	0.574
Agricultural background	-0.071	0.062	0.247	-0.044	0.030	0.145
Childhood home distance	0.053	0.066	0.426	0.074*	0.039	0.056
Education	0.023	0.048	0.633	-0.010	0.026	0.710
Prior year loc. TRC rate	0.007	0.009	0.447	0.001	0.005	0.813
μ_1	0.319	0.506		0.856***	0.269	
μ_2	1.117**	0.492		1.829***	0.268	
μ_3	2.429***	0.497		3.072***	0.273	
Pseudo R^2	0.117			0.126		
Observations	528			1,589		

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% levels, respectively.

Safety climate models were also estimated after adding explanatory variables representing prior year injury severity at an employee's business location. Specifically, a location's total DART per 200,000 hours worked and total DAFW per 200,000 hours worked were used as measures of recent injury severity in different models. Like the regressions summarized in table 6.2, empirical results from these augmented models are essentially identical to those in table 6.1 Neither of the prior year injury severity variables are related to safety climate at the ten percent significance level for managerial employees and nonmanagerial employees, offering additional evidence that past safety outcomes did not determine safety climate ratings by surveyed agribusiness retailer employees. The same holds for safety climate models estimated with explanatory variables representing TRC incidence rates, total DART rates, and total DAFW rates at an employee's firm over periods two and three years prior to the survey.[23]

Discussion of results from the empirical model of safety climate

The positive coefficients attached to safety system elements in the managerial and nonmanagerial safety climate models indicate that safety climate improves as safety system elements improve. This finding meets expectations created by the results of Risch et al. (2014) and hypothesis 1, providing further evidence that investing time and financial resources into safety system elements generates improved safety climate. Safety climate is an increasingly well-known topic among safety directors and management teams. The connections between safety system elements and safety climate displayed in table 6.1 offer some validation to the current approach to safety climate development.

As noted previously, five of the eight safety system elements in table 6.1 are positively associated with both managerial and nonmanagerial safety climate at the ten percent significance level or better: discipline, inspections, modified duty program, off-the-job safety training, and recognition. Additionally, investigations are positively associated with nonmanagerial safety climate at the one percent significance level. These results indicate that high safety climate exists where safety systems provide tools and feedback that allow employees to improve their safety habits. Participating safety directors insist that occupational safety improvement is a continual process where

[23] Due to business location closures, openings, and reorganizations at several surveyed agribusiness retailers, location-level TRC rates cannot be accurately assigned to employees beyond one year prior to the survey.

employees benefit greatly from reflecting on safety successes and failures. Because this safety feedback is specific to employees, work teams, business locations, or firms, it is valuable relative to more standardized methods of instruction.

At surveyed agribusiness retailers, occupational safety feedback reaches employees through several avenues. Although receiving feedback may be uncomfortable for employees or business locations that need occupational safety improvement, lessons learned from actual safety experiences are eye-opening for many employees. For example, one surveyed agribusiness retailer applies information gleaned from injury investigations by issuing reports that list the factors causing the injury, knowledge gained from the injury, and actions that will prevent the injury from occurring in the future. On top of providing practical occupational safety advice to employees, these reports heighten employees' awareness of occupational safety hazards that are often overlooked.

The recognition of safety accomplishments supports positive safety behaviors. At surveyed agribusiness retailers, safety accomplishments are recognized through methods ranging from signs celebrating injury-free milestones to celebratory meals at business locations with excellent safety outcomes. On the other hand, if poor safety behaviors are addressed with consistent disciplinary practices, employees gain a clear understanding of their firm's occupational safety standards. Likewise, frequent safety inspections help eliminate unsafe work environments before injuries occur, reinforcing the idea that work can and will be completed safely.

Empirical results also indicate that safety climate is high where modified duty programs and off-the-job safety training are accessible and commonplace. Modified duty programs for employees returning to work after an injury signal that firms prioritize the health and safety of their employees above short-term firm productivity. Similarly, off-the-job safety training, which is often relevant to an employee's entire family, emphasizes a firm's concern for employees' overall wellness.

Interestingly, safety meetings and training sessions, which are some of the most visible and regular elements of occupational safety systems at surveyed agribusiness retailers, are the only two safety system elements that are not related to safety climate at the ten percent significance level in either the managerial model or the nonmanagerial model. The statistically insignificant coefficients attached to meetings and training may be a reminder that, if safety climate enhancement is the goal, safety directors should provide well-targeted safety programming instead of merely maximizing the amount of information they convey to employees. For example, many firms use computerized safety education programs that require an employee to read an online module and complete a short quiz afterwards. While such programs measure exposure to safety concepts, it is unclear whether employees actually fully understand the information they were supposed to learn.

None of the employee background factors in the empirical model of safety climate are significant at the ten percent level in the managerial safety climate model and just one, workplace distance to childhood home, is significant at that level in the nonmanagerial safety climate model. These largely insignificant results somewhat undermine hypothesis 2, which predicts that safety climate is positively related to the distance between an employee's workplace and childhood home and an employee's educational attainment but negatively related to an employee's agricultural background.

The finding that nonmanagerial safety climate increases with the distance between an employee's workplace and childhood home meets expectations created in discussions with safety directors at surveyed agribusiness retailers. Employees working in their home area may have their judgment compromised when working with farms, firms, or individuals with which they have long-standing relationships. Observations by participating safety directors suggest that these employees may be too willing to perform work tasks for their family, friends, and neighbors regardless of the risk, causing them to feel less empowered to control their own safety. Relative to managerial employees, nonmanagerial employees would be more influenced by this effect because they spend more time interacting directly with customers.

Although the estimated coefficients attached to agricultural background in table 6.1 are of the predicted negative sign, agricultural background is associated with neither managerial safety climate nor nonmanagerial safety climate at the ten percent significance level. The statistically insignificant relationships between agricultural background and safety climate contradict anecdotal evidence presented by safety directors at surveyed agribusiness retailers. Compared to managerial employees, nonmanagerial employees are more likely to be working in hands-on situations similar to those in production agriculture and are therefore more likely to have their safety climate influenced by their agricultural background. In table 6.1, the p-value attached to agricultural background in the nonmanagerial employee model is not far from significance at the ten percent level. In addition, the relationship between agricultural background and nonmanagerial safety climate is significant at the ten percent level if the sample of surveyed agribusiness retailers is modified slightly to create a more homogenous group of agriculture-focused firms. Given these results and the hypothesized relationship between the two variables, the relationship between agricultural background and safety climate is worth monitoring in future studies of safety climate at agribusiness retailers.

Results from the empirical model of safety outcomes

Poisson and negative binomial models were estimated for specifications of the location-level safety outcome model explaining TRC injury frequency, DART injury frequency, DAFW injury frequency, total DART, and total DAFW. In the latter two specifications, the dispersion coefficient in the negative binomial regression is significantly different from zero at the one percent level. Non-zero dispersion parameters indicate that equidispersion is not present and Poisson regression is inappropriate. Accordingly, negative binomial regression results are reported for the safety outcome models explaining total DART and total DAFW. Poisson regression results are reported for the other safety outcome models.

Table 6.3 contains Poisson regression estimates from the safety outcome model's application to TRC injury frequency, DART injury frequency, and DAFW injury frequency. Managerial safety climate is negatively related to TRC injury frequency at the ten percent significance level, indicating that increases in managerial safety climate are tied to improvements (i.e., decreases) in TRC injury frequency. However, similarly significant relationships do not exist between managerial safety climate and DART or DAFW injury frequency. Furthermore, nonmanagerial safety climate is not related to any of the injury frequencies at the ten percent significance level. Although managerial safety climate and nonmanagerial safety climate are positively correlated, nonmanagerial safety climate is not associated with TRC, DART, or DAFW injury frequencies even if managerial safety climate is dropped from equation (5.5). All told, hypothesis 3, which posits that safety outcomes improve with safety climate, is supported by the relationship between managerial safety climate and TRC injury frequency but is not supported by models explaining DART and DAFW injury frequency.

Table 6.3. Poisson regression estimates for occupational injury frequency models

Explanatory variable	TRC injuries			DART injuries			DAFW injuries		
	Coeff.	S.E.	P-val.	Coeff.	S.E.	P-val.	Coeff.	S.E.	P-val.
Managerial safety climate	-0.547*	0.328	0.096	-0.289	0.530	0.585	0.220	0.844	0.795
Nonmanagerial safety climate	-0.134	0.559	0.810	-0.361	0.859	0.674	-1.135	1.277	0.374
Safety capital	-0.378	0.658	0.565	-0.651	1.057	0.538	-1.216	1.522	0.424
Total employees	0.000	0.004	0.839	0.008	0.006	0.160	0.004	0.011	0.701
Managerial employee share	-1.086	1.581	0.492	-2.739	2.668	0.305	-7.301*	4.092	0.074
1-4 year tenure share	-0.833	1.112	0.454	-3.084	1.954	0.115	-4.310*	2.543	0.090
5-9 year tenure share	-0.808	1.366	0.554	-2.070	2.165	0.339	-1.634	2.889	0.572
10-19 year tenure share	-1.703	1.347	0.206	-0.986	2.013	0.624	0.549	2.691	0.838
> 19 year tenure share	-1.151	1.293	0.374	-2.027	1.898	0.285	-1.511	2.428	0.534
Part time employee share	-5.336*	3.069	0.082	-8.095	5.273	0.125	-12.018	7.310	0.100
Seasonal employee share	1.918	1.323	0.147	2.924	2.034	0.151	6.845***	2.537	0.007
Agronomy share	-1.941***	0.721	0.007	-2.136*	1.293	0.098	-4.180**	1.841	0.023
Automobile/tire shop share	6.297**	2.892	0.029	12.019**	4.937	0.015	12.031*	6.603	0.068
Corporate/financial share	-1.777*	0.979	0.070	-1.046	1.351	0.439	-0.269	1.610	0.867
Energy share	-1.024	0.716	0.153	-1.463	1.184	0.216	-3.748**	1.824	0.040
Feed share	-1.665**	0.806	0.039	-1.412	1.337	0.291	-2.897	1.877	0.123
Nonagricultural retail share	2.859	2.745	0.298	4.863	4.573	0.288	8.021	5.985	0.180
Transportation share	-1.418	1.322	0.283	-1.206	2.374	0.611	-1.048	3.034	0.730
Other share	-4.987*	2.614	0.056	-14.812**	6.156	0.016	-9.951	8.040	0.216
Constant	-4.215*	2.544	0.098	-3.246	3.976	0.414	0.330	6.019	0.956
Pseudo R^2	0.123			0.168			0.244		
Observations	83			83			83		

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% levels, respectively.

Several employee characteristics are linked to occupational injuries at surveyed agribusiness retail locations. Managerial employee share and DAFW injury frequency are negatively related at the ten percent significance level, demonstrating that nonmanagerial employees are more prone to DAFW injuries than managerial employees. This finding stands to reason since managerial employees are unlikely to be doing as many hands-on tasks that frequently produce injuries. However, at the ten percent significance level, the same relationship does not exist for TRC injury frequency or DART injury frequency.

The employee tenure shares listed in table 6.3 measure whether the share of a location's employees in a tenure category influence injury frequency relative to a comparison group of inexperienced employees with less than one year of tenure. In general, tenure shares are not linked to TRC, DART, or DAFW injury frequency. The only exception is that an increasing one-to-four year tenure share is associated with decreasing DAFW injury frequency at the ten percent significance level. This effect does not go away if employee age shares are added as explanatory variables to equation (5.5) as a robustness check. Part time employee share is negatively related to TRC injury frequency at the ten percent significance level and seasonal employee share is positively related to DAFW injury frequency at the one percent significance level.

A variety of department shares are tied to TRC, DART, and DAFW injuries. The effects of department shares on injury rates are measured relative to a baseline composed of grain and bean department employees. Most notably, agronomy department share is negatively associated with all three injury frequencies in table 6.3 at the ten percent significance level. Automobile repair and tire shop department share is positively associated with all three injury frequencies at the ten percent significance level. Furthermore, at the ten percent significance level, corporate and financial department share is negatively related to TRC injury frequency, energy department share is negatively related to DAFW injury frequency, feed department share is negatively related to TRC injury frequency, and other department share is negatively related to both TRC and DART injury frequency.

Table 6.4 contains negative binomial regression estimates from the empirical safety outcome model's application to total DART and total DAFW. At the ten percent significance level, increased managerial safety climate is associated with both decreased total DART and decreased total DAFW. In addition, increased nonmanagerial safety climate is linked to decreased total DART at the five percent significance level. Once again, hypothesis 3 is confirmed by these findings. Moreover, estimating equation (5.5) after dropping managerial safety climate does not change the significance of the nonmanagerial safety climate variable in the total DAFW and total DART models. That is, without managerial safety climate in the model, nonmanagerial safety climate is still negatively related with total DART at the five percent level significance level but unrelated with total DAFW at the ten significance percent level.

While one-to-four year tenure share and twenty-plus year tenure share are negatively associated with total DART at the ten percent significance level, no tenure shares are associated with total DAFW at that significance level. The significant employee tenure results do not disappear if employee age shares are added. Part time employee share is not significantly related to either total DART or total DAFW. In contrast, at the ten percent significance level, total DART and total DAFW both increase with seasonal employee share. Finally, although several department shares are associated with total DART or total DAFW at the ten percent level or better, agronomy share, which is positively related to safety outcomes, is the only department share associated with both total DAFW and total DART.

Table 6.4. Negative binomial regression estimates for occupational injury severity models

Explanatory variable	Total DART			Total DAFW		
	Coeff.	S.E.	P-val.	Coeff.	S.E.	P-val.
Managerial safety climate	-2.368*	1.251	0.058	-4.993**	2.127	0.019
Nonmanagerial safety climate	-6.158**	2.842	0.030	-6.037	4.114	0.142
Safety capital	3.436	2.949	0.244	5.585	5.384	0.300
Total employees	0.041	0.028	0.145	0.018	0.024	0.452
Managerial employee share	-2.040	5.755	0.723	-15.057	9.701	0.121
1-4 year tenure share	-9.223*	5.156	0.074	-11.852	7.575	0.118
5-9 year tenure share	-1.998	6.477	0.758	-8.302	9.511	0.383
10-19 year tenure share	-3.889	4.756	0.414	3.144	8.400	0.708
> 19 year tenure share	-8.513**	3.949	0.031	-8.687	6.521	0.183
Part time employee share	-24.638	15.039	0.101	-32.657	24.953	0.191
Seasonal employee share	9.060**	4.104	0.027	9.289*	4.906	0.058
Agronomy share	-7.651**	3.631	0.035	-8.443*	5.050	0.095
Automobile/tire shop share	14.828	15.193	0.329	26.606	19.887	0.181
Corporate/financial share	-8.960*	5.286	0.090	1.947	7.933	0.806
Energy share	-2.703	2.596	0.298	-8.910**	4.528	0.049
Feed share	-4.043	4.059	0.319	-6.052	6.524	0.354
Nonagricultural retail share	10.878	12.528	0.385	19.560	20.978	0.351
Transportation/trucking share	4.957	8.124	0.542	7.580	9.297	0.415
Other share	-22.918*	13.466	0.089	-18.459	16.261	0.256
Constant	18.986	12.095	0.116	22.554	17.937	0.209
Pseudo R^2	0.095			0.142		
Observations	83			83		

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% levels, respectively.

In the section discussing results from the safety climate model, potential reverse causality between safety outcomes and safety climate was mentioned. To examine this potential endogeneity, a Hausman test was conducted based on the recommendation of Cameron and Trivedi (2005). Predicted business location-level managerial safety climate and nonmanagerial safety climate variables were created by estimating equation (5.1). These predicted safety climate variables were added to model (5.5) to create an augmented model, which was then estimated. The predicted safety climate variables are not significant at the ten percent level in the augmented safety outcome models estimated for any of the safety outcomes defined in table 5.12, indicating that the null hypothesis of exogeneity is not rejected. Therefore, a causal relationship connecting safety climate to safety outcomes seems appropriate.

As a robustness test of the results listed in table 6.3 and table 6.4, firm effects were added to the safety outcome model. Firm effects may account for a variety of unmodeled effects that influence safety outcomes.[24] Poisson regression results of the occupational injury models with firm effects are detailed in table 6.5. Many of the results summarized in table 6.5 are similar to their counterparts estimated without firm effects. Chiefly, increased managerial safety climate is still associated with decreased TRC injury frequency at the ten percent significance level. Also, at the ten percent significance level, managerial safety climate is not related to DART or DAFW frequency and nonmanagerial safety is not related to any of the three injury frequencies explained by the

[24] Injury underreporting is a possible firm effect. Injury underreporting varies across firms based on factors such as injury communication systems, record keeper expertise, and incentive policies tied to low injury rates (Wuellner and Bonauto 2014). However, this effect may be minimal among surveyed firms because many receive similar training on injury recording.

models in table 6.5. These results are unchanged from the results in table 6.3. One agribusiness retailer has a negative firm effect that is significant at the ten percent level in all three models, indicating that the firm's locations consistently have superior safety outcomes.[25] Although this firm did not have the lowest firm-level TRC incidence rate in the 2015 data analyzed by the safety outcome model, it had the lowest firm-level TRC incidence rate in two of the four years from 2012 to 2015.

[25] This firm is referred to as firm 15 in appendix 3.

Table 6.5. Poisson regression estimates for occupational injury frequency models with firm effects

Explanatory variable	TRC injuries			DART injuries			DAFW injuries		
	Coeff.	S.E.	P-val.	Coeff.	S.E.	P-val.	Coeff.	S.E.	P-val.
Managerial safety climate	-0.620*	0.340	0.068	-0.415	0.544	0.445	-0.100	0.955	0.916
Nonmanagerial safety climate	-0.061	0.605	0.920	-0.892	0.979	0.362	-1.356	1.397	0.332
Safety capital	0.400	0.803	0.618	0.324	1.351	0.810	0.088	1.998	0.965
Total employees	0.000	0.006	0.950	0.003	0.008	0.711	0.015	0.016	0.346
Managerial employee share	-1.841	1.781	0.301	-3.941	3.041	0.195	-7.689	4.847	0.113
1-4 year tenure share	-1.090	1.321	0.409	-4.648*	2.643	0.079	-7.163*	4.342	0.099
5-9 year tenure share	-0.879	1.530	0.566	-1.364	2.540	0.591	-2.230	3.568	0.532
10-19 year tenure share	-0.644	1.526	0.673	-0.118	2.393	0.961	0.534	3.286	0.871
> 19 year tenure share	-0.289	1.388	0.835	-1.381	1.997	0.489	-1.891	3.083	0.540
Part time employee share	-2.433	3.244	0.453	-6.724	6.018	0.264	-8.642	8.209	0.292
Seasonal employee share	4.165**	1.749	0.017	4.061	2.568	0.114	9.143***	3.405	0.007
Agronomy share	-2.208***	0.846	0.009	-1.496	1.660	0.368	-3.051	2.542	0.230
Automobile/tire shop share	5.169*	3.098	0.095	10.985**	5.265	0.037	13.019**	6.619	0.049
Corporate/financial share	-2.147*	1.195	0.073	-0.500	1.813	0.783	1.224	2.390	0.608
Energy share	-0.784	0.882	0.374	-0.088	1.628	0.957	-0.682	2.570	0.791
Feed share	-1.737*	0.890	0.051	-1.003	1.716	0.559	-0.880	2.526	0.728
Nonagricultural retail share	0.604	3.057	0.843	5.319	5.414	0.326	8.808	7.293	0.227
Transportation/trucking share	-1.277	1.528	0.404	1.562	2.957	0.597	1.760	4.415	0.690
Other share	-1.924	2.457	0.434	-4.515	6.236	0.469	-2.284	8.702	0.793
Constant	-7.109**	3.145	0.024	-4.958	5.054	0.327	-2.336	7.032	0.740
Pseudo R^2	0.169			0.254			0.318		
Observations	83			83			83		

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6.6 summarizes results for the injury severity models estimated with firm effects. Once again, at the five percent significance level, managerial safety climate is negatively related to both total DART and total DAFW. However, nonmanagerial safety climate is negatively related to total DAFW at the five percent significance level, which was not the case without firm effects. The reverse is true for total DART, which is unrelated to nonmanagerial safety climate at the ten percent significance level in the model estimated with firm effects. The firm with a significant negative firm effect in the injury frequency models also has a significant negative firm effect in the injury severity models.

Table 6.6. Negative binomial regression estimates for occupational injury severity models with firm effects

Explanatory variable	Total DART			Total DAFW		
	Coeff.	S.E.	P-val.	Coeff.	S.E.	P-val.
Managerial safety climate	-3.361***	1.246	0.007	-6.023**	3.046	0.048
Nonmanagerial safety climate	-4.871	3.195	0.127	-10.182**	5.076	0.045
Safety capital	7.131**	3.406	0.036	7.215	7.851	0.358
Total employees	0.025	0.037	0.499	0.117**	0.053	0.026
Managerial employee share	-12.549	8.296	0.130	-25.515*	14.162	0.072
1-4 year tenure share	-11.701**	5.198	0.024	-24.950**	12.200	0.041
5-9 year tenure share	-4.071	5.875	0.488	-8.427	9.263	0.363
10-19 year tenure share	6.233	5.872	0.288	-1.406	8.525	0.869
> 19 year tenure share	-6.517	4.946	0.188	-22.314*	11.654	0.056
Part time employee share	-15.060	12.942	0.245	-22.091	17.562	0.208
Seasonal employee share	8.945	5.626	0.112	22.703**	10.947	0.038
Agronomy share	-5.407	3.911	0.167	-17.613*	9.645	0.068
Automobile/tire shop share	20.409	12.764	0.110	31.875	19.394	0.100
Corporate/financial share	-5.456	4.457	0.221	-1.917	5.489	0.727
Energy share	-0.903	3.424	0.792	-11.774	9.405	0.211
Feed share	-3.083	4.408	0.484	-8.350	7.304	0.253
Nonagricultural retail share	8.377	10.998	0.446	9.239	14.367	0.520
Transportation/trucking share	14.367*	7.665	0.061	8.185	16.613	0.622
Other share	-1.841	11.383	0.872	-13.388	27.652	0.628
Constant	2.777	14.337	0.846	47.988	32.566	0.141
Pseudo R^2	0.127			0.201		
Observations	83			83		

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% levels, respectively.

Discussion of results from the empirical model of safety outcomes

Based on safety climate's prominence in both this dissertation's theoretical model of occupational safety and in the occupational safety literature, the safety climate implications of the empirical models of safety outcomes are particularly important. Table 6.7, which summarizes the significant coefficients from all of the safety outcome regressions, indicates that managerial safety climate is associated with TRC injury frequency, total DAFW, and total DART regardless of whether firm effects are estimated. The connection between nonmanagerial safety climate and safety outcomes is not as apparent. That is, nonmanagerial safety climate is related to total DART when firm effects are not estimated and to total DAFW when firm effects are estimated but is otherwise not significantly related to safety outcomes.

Whenever either safety climate variable is significantly related to a safety outcome, the relationship is negative, indicating that safety outcomes improve with safety climate. This finding agrees with hypothesis 3. Because the safety outcome model has a prospective design where safety outcomes are explained by past safety climate ratings, the results support the notion that safety climate is a leading indicator of safety outcomes and that efforts to improve safety climate are rewarded with fewer and less severe occupational injuries. In addition, the significant safety climate effects described herein underscore the need for safety climate analyses like the one presented earlier in this chapter.

Table 6.7. Signs of significant coefficients from safety outcome regressions

Explanatory variable	TRC injuries	DART injuries	DAFW injuries	Total DART	Total DAFW	Interpretation of significant coefficient
Managerial safety climate	– (–)			– (–)	– (–)	Outcomes improve as managerial safety climate increases.
Nonmanagerial safety climate				–	(–)	Outcomes improve as nonmanagerial safety climate increases.
Safety capital				(+)		Outcomes worsen as safety capital increases.
Total employees					(+)	Outcomes worsen as total employee count increases.
Managerial employee share			–		(–)	Outcomes improve as share of managerial employees increases.
1-4 year tenure share		(–)	– (–)	– (–)	(–)	Outcomes improve as share of emp. w/ 1-4 yr. tenure increases.
5-9 year tenure share						Outcomes improve as share of emp. w/ 5-9 yr. tenure increases.
10-19 year tenure share						Outcomes improve as share of emp. w/ 10-19 yr. tenure increases.
> 19 year tenure share				–	(–)	Outcomes improve as share of emp. w/ 20+ yr. tenure increases.
Part time employee share	–					Outcomes improve as share of seasonal employees increases.
Seasonal employee share	(+)		+ (+)	+	+ (+)	Outcomes worsen as share of seasonal employees increases.
Agronomy share	– (–)	–	–	–	– (–)	Outcomes improve as share of agronomy employees increases.
Automobile/tire shop share	+ (+)	+ (+)	+ (+)			Outcomes worsen as share of auto/tire employees increases.
Corporate/financial share	– (–)			–		Outcomes improve as share of corp./fin. employees increases.
Energy share			–		–	Outcomes improve as share of energy employees increases.
Feed share	– (–)					Outcomes improve as share of feed employees increases.
Nonagricultural retail share						Outcomes improve as share of nonag. retail employees increases.
Transportation share				(+)		Outcomes worsen as share of transport. employees increases.
Other share	–	–		–		Outcomes improve as share of other employees increases.

Note: This table summarizes the signs of all coefficients significant at the 10% level in the safety outcome models estimated in chapter 6. The TRC injuries, DAFW injuries, and DART injuries models were estimated using Poisson regressions while the total DAFW and total DART models were estimated using negative binomial regressions. Coefficients estimated for models without firm effecttts are listed first in each column. Coefficients estimated for models with firm effects are listed second in each column and are enclosed in parentheses.

The significance of managerial safety climate may reflect the importance of leadership in improving occupational safety at agribusiness retailers. In fact, safety directors at surveyed firms consistently state the importance of integrating managers into occupational safety planning and implementation. Having managers, instead of just the safety director, plan and lead occupational safety efforts is an example of this integration. Although the relative importance of managerial safety climate is somewhat vexing given that nonmanagers are 75.0 percent of the surveyed agribusiness retail workforce, Risch et al. (2014) also conclude that TRC injury frequency is negatively related to managerial safety climate but unrelated to nonmanagerial safety climate in a statistically significant manner. Therefore, the results summarized in table 6.7 reinforce their findings about the importance of managerial safety climate in avoiding occupational injuries and show that the same is true for total DART and total DAFW.

Table 6.7 shows that, although explanatory variables are not always consistently significant across models, the signs of statistically significant coefficients are consistent between models. Table 6.7 indicates that safety capital is not linked to safety outcomes in most models. Risch et al. (2014) reached a similar conclusion in their study of TRC injury frequency. In both cases, the relationship is unexpected because high quality facilities and equipment should allow employees to work more safety. Risch (2013) suggests that the lack of a connection between safety capital ratings and TRC injury frequency may be a product of relatively inaccurate or uninformed ratings by employees, and that is a plausible explanation here, too. At the ten percent significance level, total employee count is associated with safety outcomes in just one of the ten models summarized in table 6.7. The single significant employee count variable has a positive coefficient, representing disagreement with the oft-cited negative relationship between firm size and safety outcomes.

Managerial employee share is significantly related to safety outcomes in two of the models summarized in table 6.7. The negative relationships between the significant managerial employee share variables and safety outcomes imply that safety outcomes improve as more of a location's employees are managerial. Because managerial employees tend to have less dangerous jobs than nonmanagerial employees, this result meets expectations.

There is little connection between most of the employee tenure share variables and safety outcomes. At the ten percent significance level, five-to-nine year tenure share and ten-to-nineteen year tenure share are not related to any safety outcomes and twenty-plus year tenure share is related to safety outcomes in just two of the models summarized in table 6.7. The most consistent influence is that of one-to-four year tenure share, which is associated with improved safety outcomes at the ten percent significance level in six of the ten models summarized in table 6.7. None of the employee tenure shares have a positive coefficient that is significant at the ten percent level, implying that safety outcomes become no worse as employees gain experience and move out of the under-one year tenure category. Even if employee age shares are added, none of the aforementioned significant tenure shares change sign or significance level.

In six of the ten models summarized in table 6.7, seasonal employee share is associated with significantly poorer safety outcomes. Risch et al. (2014) reach the same conclusion in their study of TRC injury frequency at agribusiness retailers. Seasonal employees may suffer more frequent or severe injuries because they lack safety education or are ineffective advocates for their personal safety (Aronsson 1999). Furthermore, inexperienced or undertrained seasonal employees may expose their coworkers to elevated risk. The poor safety outcomes linked to seasonal workers should motivate safety directors to thoroughly train seasonal workers and pay special attention to the challenges they face in a relatively unfamiliar workplace.

Both with and without firm effects, several department shares are significantly related to safety outcomes. The majority of statistically significant department share coefficients are negative, indicating that safety outcomes for many departments are better than those of the grain department, which serves as the baseline against which department share coefficients are tested. This finding reflects the relative danger of the grain departments at agribusiness retailers. Grain bin entrapment is a large concern and many agribusiness retailers have a policy where an employee loses their job if they enter a grain bin to dislodge grain without taking proper precautions. Many rural fire departments have equipment to deal with grain bin entry since this accident is so widespread for farms and agribusiness retailers. In short, the hazards of handling and storing grain are among the most publicized occupational safety challenges at agribusiness retailers (e.g., USDA, Rural Development 2013). The empirical results summarized in table 6.7 suggest that attention is warranted.

Agronomy and crop production department share is positively related to safety outcomes in many of the models represented in table 6.7. The strong safety outcomes of agronomy and crop production department employees relative to grain department employees are interesting because the two departments, which employ a combined 47.4 percent of surveyed employees, perform many tasks similar to those found in production agriculture. It is possible that safety climate and safety outcomes relate differently for agronomy and crop production employees than they do for other employees, giving rise to the significant department effect for agronomy and crop production. The only department with consistently worse safety outcomes than the grain department is the automobile repair and tire department, which has positive relationships with TRC, DART, and DAFW frequencies that are significant at the ten percent level or better. This might be the result of repetitive tasks associated with automobile and truck repair. However, only 1.3 percent of surveyed agribusiness retailer employees work in automobile repair and tire departments, so the poor safety outcomes for these employees have a small effect on overall safety outcomes.

Results from the empirical model of safety efficiency

Scores describing the technical efficiency of surveyed agribusiness retailers are presented in table 6.8. Technical efficiency scores reflect the ability of each firm-year (DMU) to convert safety personnel investments and safety system investments (i.e., safety inputs) into uninjured employees, transformed non-DART injuries, and transformed DART injuries (i.e., safety outputs). Table 6.8 shows that eight of the forty-two DMUs were considered efficient by the DEA, meaning that no DMU produced the same safety outcomes with fewer safety investments in any of the three years analyzed. The efficient

DMUs represent seven of the fourteen agribusiness retailers included in the analysis. Of the thirty-four DMUs that were not technically efficient, five were over ninety percent efficient, indicating that they needed to scale down inputs by less than ten percent to achieve technical efficiency. Another five DMUs were between eighty and ninety percent efficient and an additional five DMUs were between seventy and eighty percent efficient.

Table 6.8. Technical efficiency scores from safety efficiency model

DMU	Rank	Technical eff. score	DMU	Rank	Technical eff. score
Firm 1, 2012	1	1.000	Firm 10, 2012	22	0.750
Firm 13, 2013	1	1.000	Firm 12, 2014	23	0.747
Firm 14, 2014	1	1.000	Firm 2, 2013	24	0.699
Firm 15, 2013	1	1.000	Firm 2, 2014	25	0.698
Firm 15, 2014	1	1.000	Firm 12, 2012	26	0.667
Firm 6, 2014	1	1.000	Firm 6, 2013	27	0.664
Firm 7, 2014	1	1.000	Firm 12, 2013	28	0.662
Firm 8, 2012	1	1.000	Firm 9, 2014	29	0.660
Firm 15, 2012	9	0.999	Firm 6, 2012	30	0.655
Firm 7, 2013	10	0.967	Firm 9, 2012	31	0.627
Firm 1, 2014	11	0.928	Firm 9, 2013	32	0.576
Firm 13, 2012	12	0.923	Firm 5, 2012	33	0.567
Firm 8, 2013	13	0.921	Firm 3, 2014	34	0.529
Firm 14, 2013	14	0.899	Firm 5, 2014	35	0.528
Firm 8, 2014	15	0.889	Firm 3, 2013	36	0.525
Firm 14, 2012	16	0.886	Firm 3, 2012	37	0.524
Firm 1, 2013	17	0.871	Firm 4, 2013	38	0.518
Firm 13, 2014	18	0.848	Firm 5, 2013	39	0.511
Firm 7, 2012	19	0.776	Firm 4, 2014	40	0.504
Firm 10, 2014	20	0.762	Firm 4, 2012	41	0.500
Firm 10, 2013	21	0.754	Firm 2, 2012	42	0.368

Note: Firm numbers are the same as those used in appendix 3 to describe annual safety outcomes.

Although most of the DMUs deemed efficient in table 6.8 are excellent safety performers relative to all firms, this is not universally true. For example, despite underwhelming safety outcomes outlined in appendix 3, firm 1 has a technical efficiency score of 1.000 in 2012 because firm 1's uniquely small size means it is being compared against itself in other years rather than against several other firms. Other technically efficient DMUs stand out in absolute terms. The DMUs with the lowest TRC and DART incidence rates in the 2012 to 2014 period (firm 13 in 2013 and firm 8 in 2012, respectively) have efficiency scores of 1.000. Moreover, table 6.8 indicates that firm 15's occupational safety efficiency is consistently strong across all three analyzed years. When firm effects were applied to the safety outcome models discussed earlier in this chapter, firm 15 was the only surveyed agribusiness retailer with significantly better outcomes in all five safety outcome models. All told, the strong occupational safety profile possessed by firm 15 makes it a good candidate for a case study on occupational safety excellence.

Safety personnel compensation is one of two inputs incorporated in the DEA. As explained in chapter 5, safety personnel compensation encompasses compensation for safety directors as well as the value of the time other firm managers devote to safety. While it can be reasonably assumed that safety director time is being spent on safety issues, managerial time devoted to occupational safety may be a rough approximation of their actual efforts. That is, a chief executive who is contracted to spend ten percent of their time on occupational safety issues may actually devote considerably more or less time to those issues based on the burdens of their other responsibilities. To examine whether potentially inaccurate measures of safety personnel investments are driving the DEA scores in table 6.8, another DEA was formulated where safety personnel compensation was redefined as solely safety director compensation while the value of managerial time was excluded from analysis. Technical efficiency scores calculated from that DEA and the technical efficiency scores reported in table 6.8 have a nearly perfect correlation coefficient of 0.964 and all efficient firms are the same between the two models. Accordingly, the technical efficiency scores in table 6.8 can be analyzed without great concern about the influence of inaccurate safety personnel compensation data.

Chapter 5 stated that managerial ability may determine safety efficiency. Managerial experience, which is easily measured, can be used as a proxy for managerial ability. In fact, hypothesis 4 predicts that safety efficiency is driven by managerial experience. Data on the experience of safety directors and chief executives at surveyed agribusiness retailers were collected for each of the three analyzed years. Several surveyed firms hired new chief executives or safety managers during this period. Safety director experience and chief executive experience are used as explanatory variables in regressions describing the safety efficiency scores listed in table 6.8. These variables are defined in table 6.9 and summarized in table 6.10.

Table 6.9. Definitions for safety efficiency score explanatory variables

Explanatory variable	Definition
Chief executive tenure	Years of experience for a firm's top manager (chief executive officer, general manager, etc.).
Safety director tenure	Years of experience for a firm's primary occupational safety employee.

Note: Tenure is measured by the year of service an employee is in on the final day of a calendar year. Both experience variables are limited to a maximum of 20 years.

Table 6.10. Summary statistics for safety efficiency score explanatory variables

Explanatory variable	Mean	St. dev.	Min.	Max.
Chief executive tenure	10.79	5.99	1	20
Safety director tenure	5.02	3.54	1	13

Based on the recommendation of McDonald (2009), ordinary least squares (OLS) is used to assess the determinants of safety efficiency scores. Regression results presented in table 6.11 indicate that safety director experience and chief executive experience are unrelated to safety efficiency scores at surveyed agribusiness retailers at the ten percent significance level and explain almost none of the variation in safety efficiency scores. In light of hypothesis 4, this finding is somewhat surprising and warrants further examination.

Table 6.11. OLS estimates for determinants of safety efficiency scores

Explanatory variable	Coeff.	S.E.	P-value
Chief executive tenure	-0.004	0.009	0.648
Safety director tenure	-0.005	0.008	0.493
Constant	0.818***	0.078	0.000
Observations	42		
R^2	0.012		

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% levels, respectively.

Chief executives at agribusiness retailers vary in their involvement with occupational safety issues. Specifically, while some chief executives delegate all occupational safety responsibilities to safety directors or other employees, other chief executives take a more hands-on approach. Indeed, eight of the fourteen agribusiness retailers analyzed in the DEA indicated that their chief executive is contracted to spend time on occupational safety issues. A dummy variable was created that represents whether a firm's chief executive has contracted safety responsibilities. By multiplying this dummy by chief executive experience and including the interaction variable as an additional explanatory variable, it is possible to ascertain whether contracted safety responsibilities alter the relationship between chief executive experience and safety efficiency scores. Table 6.12 contains OLS results from this regression.

Table 6.12. OLS estimates for determinants of safety efficiency scores with chief executive tenure interaction effect

Explanatory variable	Coeff.	S.E.	P-values
Chief executive tenure	-0.003	0.009	0.575
Chief executive tenure interaction	0.009*	0.005	0.085
Safety director tenure	-0.009	0.008	0.271
Constant	0.793***	0.057	0.000
Observations	42		
R^2	0.083		

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% levels, respectively.

The results in table 6.12 show the chief executive experience interaction variable is positively related to safety efficiency scores at the ten percent significance level. This finding suggests that chief executives who are contractually obligated to participate in occupational safety efforts leverage their experience to improve safety efficiency relative to other firms. As in table 6.11, neither safety director experience nor non-interacted chief executive experience are associated with safety efficiency scores at the ten percent significance level. Alternative safety efficiency scores were calculated using a simpler DEA where TRC injuries were used in place of both non-DART injuries and DART injuries. Results very similar to those presented in tables 6.11 and 6.12 emerge from regressions explaining those safety efficiency scores.

Discussion of results from the empirical model of safety efficiency

The safety efficiency scores in table 6.8 offer context for agribusiness retailers as they assess their occupational safety efforts. Chapter 5 explained that reference DMUs can be assigned to inefficient DMUs based on the results of the DEA. Reference DMUs are efficient DMUs that create the efficient frontier point that an inefficient DMU is aiming to reach through input contraction. Appendix 10 displays reference DMUs relevant to each inefficient DMU.

Although the summary of reference DMUs provided in appendix 10 may not provide much insight to the reader, these comparisons should provide a fruitful starting point for conversations between safety directors at surveyed firms. Like their peers in other industries, safety directors at surveyed agribusiness retailers regularly meet to share ideas and learn new material. Indeed, according to appendix 1, over eighty percent of safety directors at surveyed agribusiness retailers network with other safety directors at least once every two months. However, safety directors currently have limited ability to identify other firms facing similar safety efficiency challenges or other firms succeeding where they are not. Scores such as those presented in table 6.8 may encourage safety directors to engage in discussions that uncover patterns in safety efficiency that were undetectable in this research and are unknown in the existing literature.

The regression results summarized in tables 6.11 and 6.12 offer a mixed assessment of the relationship between managerial experience and safety efficiency. Although safety director experience and chief executive experience explain little of the variation in safety efficiency scores, table 6.12 shows that contractual safety responsibilities may alter the relationship between chief executive experience and safety efficiency. Specifically, at the ten percent significance level, chief executive experience has a greater impact on safety efficiency for firms where chief executives have occupational safety responsibilities compared to firms where they do not.

Chief executives with contractual commitments to occupational safety may have increased time to consider occupational safety issues and increased external motivation from boards of directors to achieve safety goals. Therefore, experienced chief executives with occupational safety responsibilities may be more likely to implement successful strategies or techniques they have learned through their time on the job. Chief executives at agribusiness retailers are increasingly tasked with formal occupational safety obligations. The results in table 6.12 suggests that such arrangements may improve occupational safety efficiency.

The relationship between firm leadership and occupational safety efficiency is far from clear despite the muted support for hypothesis 4 contained in table 6.12. Nevertheless, this application of DEA charts a useful course for future research. That is, moving to a more efficiency-based perspective on occupational safety offers potential benefits not only in mitigated injuries but also in saved dollars. This viewpoint should appeal to firm decision makers who operate with a bottom-line mindset.

CHAPTER 7

Conclusions

The agribusiness retail industry faces unique occupational safety challenges that reflect the varied products and services provided by the industry's firms. Although many of the hazards at agribusiness retailers are similar to those in production agriculture, nonagricultural business lines also contribute to high injury rates. Indeed, from 2012 to 2015, occupational injuries at fifteen surveyed agribusiness retailers were nearly twice as frequent as occupational injuries in U.S. private industry. However, relatively little research explores the intricacies of occupational safety in the agribusiness retail industry.

The costs imposed by poor occupational safety negatively effect firm financial performance. In addition, occupational safety influences employee welfare in both the short-term and long-term. The preceding chapters investigate three models of occupational safety at agribusiness retailers. As summarized below, empirical results from this dissertation offer multiple insights regarding safety climate, safety outcomes, and safety efficiency at agribusiness retailers. Nevertheless, several promising extensions of this dissertation exist. These opportunities for future research are discussed at the end of this chapter.

Summary of findings

This dissertation's empirical analysis begins by modeling safety climate as a function of safety system elements and employee background factors. Results from this empirical model of safety climate reveal that safety system elements such as discipline programs, inspection programs, modified duty programs, off-the-job safety training programs, and recognition programs are positively related to individual safety climate for both managerial employees and nonmanagerial employees at surveyed agribusiness retailers. The positive relationships between safety system elements and safety climate meet theoretical expectations and reinforce the approach of safety directors that attempt to enhance safety climate through safety systems.

In contrast, the effects of employee background factors are somewhat less important than was hypothesized. For nonmanagerial employees, safety climate increases as an employee works farther from their childhood home. This relationship does not hold for managerial employees. The negative relationship between agricultural background and safety climate is not as strong, but its ramifications for nonmanagerial safety climate are worthy of further exploration. Educational attainment and safety climate are not meaningfully linked for surveyed agribusiness retailer employees.

Much of the interest in safety climate is driven by the hypothesized relationship between safety climate and safety outcomes. Results from the empirical model of safety outcomes indicate that increases in managerial safety climate decrease a business location's TRC injury frequency, total DAFW, and total DART. These findings agree with theory suggesting that improved safety climate should decrease the frequency of occupational injuries and lessen the severity of injuries that do occur. While nonmanagerial safety climate is also negatively related to a few of the safety outcomes explained by the safety outcome model, its relationship to safety outcomes is generally less significant. As represented by explanatory variables for employees' tenure, employment status, and department, a workplace's exposure to occupational injuries also determines safety outcomes.

Finally, a DEA approach offers a different perspective of occupational safety at agribusiness retailers. The DEA compares expenditures on safety personnel and safety systems to uninjured employees, non-DART injuries and DART injuries. The DEA indicates that eight of the forty-two analyzed firm-years were technically efficient relative to occupational safety investments for other firm-years. A basic analysis of the determinants of safety efficiency suggests that the effect of chief executive experience on safety efficiency is determined by whether the chief executive had contracted safety responsibilities. However, the determinants of safety efficiency at surveyed agribusiness retailers remain relatively unclear.

Overall, results from this dissertation's three empirical models trace a path from safety system elements to safety outcomes at agribusiness retailers. Multiple safety elements are positively related to individual safety climate. In turn, improved safety climate is linked with improvements in several safety outcomes. The relationship between occupational safety inputs and outputs is represented in a more basic fashion by DEA, which reveals that disparities exist in the occupational safety efficiency of surveyed agribusiness retailers.

Implications of findings

Many of the key implications from this dissertation agree with best practices identified in the occupational safety literature or applied knowledge possessed by safety directors at surveyed agribusiness retailers. First, empirical results and survey responses each show that employee backgrounds should be considered when planning occupational safety systems. Empirical results from the safety climate model's application to nonmanagerial employees indicate that the distance to an employee's childhood home is positively related to the employee's safety climate. While the relationship between agricultural background and individual safety climate is less definitive, multiple surveyed safety directors contend that production agriculture experience diminishes safety climate and these safety directors construct their safety systems accordingly.

More generally, as discussed in chapter 1, a generational transition is approaching where many agribusiness retailer employees will retire and be replaced by younger employees. If the trends outlined in appendix 8 hold for these young employees, they will have different backgrounds than the employees they replace. Considering employee backgrounds is also paramount when firms add employees through expansions or acquisitions. All told, safety directors should be cognizant that employee backgrounds differ in ways that may influence occupational safety at agribusiness retailers. Thus, tailored safety education is likely preferable to a one-size-fits-all type of training.

Findings from the empirical model of safety climate show that strong safety climate exists where there is an ongoing occupational safety conversation supported by strong safety system elements. Specifically, feedback from discipline, investigation, inspection, and recognition programs steers employees toward better safety. The importance of feedback contrasts with the insignificant effects of safety meetings and training sessions. As several participating safety directors acknowledged, the ability to apply occupational safety knowledge is more important than simply possessing it.

Results from the empirical model of safety outcomes identify managerial safety climate as a determinant of several safety outcomes. Chapter 3 explains that much research assigns importance to leadership's role in promoting occupational safety. Participating safety directors agreed that engaging managers is crucial to successful occupational safety efforts. This dissertation finds that, although managerial employees are small in number, their safety climate has an important effect on safety outcomes. Occupational safety leadership takes many forms. For example, visible participation in occupational safety systems shows managerial commitment to occupational safety. Moreover, consistent enforcement of safety rules, even during busy times, reminds employees that productivity does not take precedence over safety. All told, managerial employees are key allies for safety directors as they attempt to improve safety outcomes at agribusiness retailers.

Limitations of research

This dissertation's results are limited by several factors. First, the business locations analyzed in the safety outcome model do not represent all fifteen surveyed agribusiness retailers because multiple firms did not take the survey early enough to have their survey data matched with safety outcome data from the following year. As a result, the sample of business locations used to estimate the safety outcome model is not as large as possible. In total, roughly half of all surveyed business locations are excluded due to this timing issue. A year from now, these models could be re-estimated using all of the data.

Although useful for comparisons across individuals, business locations, and firms, the cross sectional survey data do not allow for comparisons across time. Temporal changes in safety climate and other variables may be as important as their absolute levels. The survey data do not capture those changes. The one-dimensional nature of the survey data reduces the information available for analysis and, thereby, the power of the findings. Maintaining this data over time and getting additional firms to participate in the future can overcome this limitation.

Finally, the data used for this dissertation's DEA approach to safety efficiency are not ideal. Most surveyed agribusiness retailers struggled to break down safety investments by business location, thereby necessitating a firm-level approach with fewer DMUs. Surveyed agribusiness retailers also keep safety investment records with varying levels of detail, forcing general investment categories to be used in the DEA. It is important to correct these shortcomings in future iterations of this research. However, like all of the limitations discussed in this section, limitations to this dissertation's DEA could be addressed by repetition of this analysis occurring as soon as 2017.

Opportunities for future research

Continued, improved data collection is central to moving this research forward. At a fundamental level, gathering occupational injury data from more firms and extending data collection into the future would allow for a more detailed and conclusive version of the occupational injury summary contained in chapter 2. Although the BLS collects and publishes data on many different industries, including several related to agribusiness retailers, statistics focused on the agribusiness retail industry are not published. Increased data on occupational injuries at agribusiness retailers should create a better representation of where the industry's safety outcomes are situated relative to other industries' safety outcomes. In addition, greater understanding of the types and timing of occupational injuries may motivate safety solutions at agribusiness retailers.

Increased survey participation will allow for further testing of the survey's reliability and validity. Furthermore, if the number of surveyed employees is increased, stronger conclusions and recommendations can be drawn from the survey's results. This would allow the survey to be used as a proactive tool for occupational safety management rather than simply as a descriptive measure. That said, the survey's results are currently useful for service providers attempting to understand the nature of an agribusiness retailer's safety climate before undertaking safety education efforts.

Additional survey participation will facilitate improved analysis of safety climate and safety outcomes. Follow-up surveys at the firms studied in this dissertation create opportunities to observe temporal changes in safety climate or safety outcomes and to study the factors driving those changes. Offering the survey to other agribusiness retailers also provides opportunities to test this dissertation's results in new settings.

This dissertation utilizes DEA, a method that is very new to the occupational safety literature. As explained in chapter 6, the DEA model featured in this dissertation is more of a first step than a final destination. Relatively general input categories are used in the empirical model of safety efficiency described in chapter 5. Future DEA assessments based on more detailed safety investment data could offer a more sophisticated viewpoint of occupational safety efficiency at agribusiness retailers. However, because safety investment details are not recorded accurately or uniformly by all firms, managers may need outside guidance on their recordkeeping in order for this data to be collected. Data on insurance premia, fines, and other damage costs could also be implemented in DEA and other efficiency analyses.

Despite changes within the industry and in agriculture generally, agribusiness retailers remain a critical part of U.S. agriculture. Accordingly, occupational safety at agribusiness retailers will continue to be a relevant topic for researchers and industry decision makers. Further research on occupational safety will benefit both the physical and financial health of the agribusiness retail industry in years to come.

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Appendix 1

Duties and Characteristics of Safety Directors at Surveyed Agribusiness Retailers

This appendix contains a description of safety directors at surveyed agribusiness retailers. All fifteen surveyed agribusiness retailers employ a person who devotes substantial time to occupational health and safety issues. These employees, who are referred to as safety directors in this dissertation, are crucial to occupational health and safety improvement efforts at their firms. In order to better understand the role of safety directors in the agribusiness retail industry, a brief survey was distributed to each surveyed firm's primary occupational health and safety employee in early 2016. This voluntary, anonymous survey was competed by eleven safety directors.

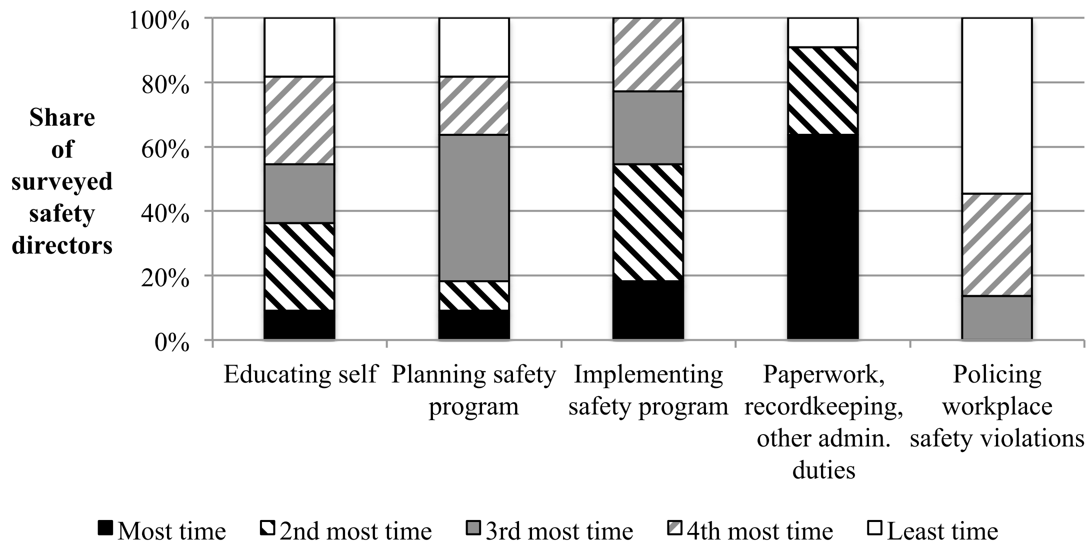
The age and tenure characteristics of the eleven surveyed safety directors are similar to the entire agribusiness retail workforce summarized in tables 5.1 and 5.2. In contrast, the survey indicates that safety directors have attained higher levels of education than the general workforce at surveyed agribusiness retailers. All of the surveyed safety directors completed at least some college and 72.7 percent completed a post-secondary (associate's, bachelor's, professional, or graduate) degree. Only 64.7 percent of the general workforce at surveyed agribusiness retailers attended college and 35.7 percent completed a post-secondary degree.

Of the eleven surveyed safety directors, 45.5 percent have 100 percent of their position committed to occupational health and safety matters. Safety duties are approximately seventy-five percent of the work responsibilities for 27.3 percent of surveyed safety directors and safety duties are approximately fifty percent of the work responsibilities for the remaining 27.3 percent of surveyed safety directors. Just 36.4 percent of surveyed safety directors indicated that they are the primary authority for policing safety violations at their workplace.

Monthly safety meetings are the norm at surveyed agribusiness retailers as 81.8 percent of surveyed safety directors indicated that they hold safety meetings once per month. Safety directors were also asked to describe the sources of information and safety programming that they pass on to employees. Several safety directors stated that they receive safety information from insurance and compliance organizations to which their firms belong. Government, trade, and university publications were also cited as sources of safety information. Networking with other safety directors is another major source of practical information and advice, as 36.4 percent of surveyed safety directors consult with safety directors at other agribusiness retailers at least once per month and an additional 45.5 percent do so every two months.

Surveyed safety directors ranked the work time consumed by several of their position's common job activities. As figure A1.1 shows, considerable variation exists in the amount of time safety directors spend on educating themselves, planning safety programming, and implementing safety programming. Greater consensus exists regarding the large amount of time devoted to paperwork, recordkeeping, and related administrative duties. Indeed, 90.9 percent of the respondents ranked this as the greatest or second-greatest use of time among the five activities listed. Policing workplace safety violations consumes relatively little work time for surveyed safety directors. This duty was not the greatest or second-greatest use of time for any of the surveyed safety directors. In fact, 54.5 percent of surveyed safety directors indicated that policing workplace safety violations consumes the least time of the five activities listed.

Figure A1.1. Rankings of time consumed by common job activities of safety directors



Note: 12 votes were received for "3rd most time" and only 10 votes were received for "4th most time" because one respondent voted twice for "3rd most time" and did not select a "4th most time." To correct this, the figure assigns half votes to the effected categories.

Finally, because 54.5 percent of surveyed safety directors have job duties beyond occupational safety, safety directors were asked to describe the other tasks that fill their workdays. The survey reveals that other tasks performed by surveyed safety directors include advertising, computer technology assistance, daily operations assistance, fleet management, marketing, and truck driving,

Appendix 2

OSHA Injury Reporting Forms

This appendix contains OSHA Form 300 and OSHA Form 300A. Surveyed agribusiness retailers submitted occupational injury data via these forms. Both forms are annual recordkeeping documents required by OSHA rules. OSHA Form 300, which is contained in figure A.2.1, lists and describes annual occupational injuries at a firm or business location. OSHA Form 300A, which is contained in figure A.2.2, summarizes annual occupational injury totals, employees, and hours worked at a firm or business location. Together, OSHA Form 300 and OSHA Form 300A were used to create this dissertation's unique occupational injury data set.

Figure A2.1. OSHA Form 300

OSHA's Form 300 (Rev. 01/2004)

Log of Work-Related Injuries and Illnesses

Attention: This form contains information relating to employee health and must be used in a manner that protects the confidentiality of employees to the extent possible while the information is being used for occupational safety and health purposes.

Year 20__ __

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

You must record information about every work-related death and about every work-related injury or illness that involves loss of consciousness, restricted work activity or job transfer, days away from work, or medical treatment beyond first aid. You must also record significant work-related injuries and illnesses that are diagnosed by a physician or licensed health care professional. You must also record work-related injuries and illnesses that meet any of the specific recording criteria listed in 29 CFR Part 1904.8 through 1904.12. Feel free to use two lines for a single case if you need to. You must complete an Injury and Illness Incident Report (OSHA Form 301) or equivalent form for each injury or illness recorded on this form. If you're not sure whether a case is recordable, call your local OSHA office for help.

Establishment name ________________

City __________ *State* ________

Identify the person			Describe the case			Classify the case — CHECK ONLY ONE box for each case based on the most serious outcome for that case:				Enter the number of days the injured or ill worker was:		Check the "Injury" column or choose one type of illness: (M)					
								Remained at Work									
(A) Case no.	(B) Employee's name	(C) Job title (*e.g., Welder*)	(D) Date of injury or onset of illness	(E) Where the event occurred (*e.g., Loading dock north end*)	(F) Describe injury or illness, parts of body affected, and object/substance that directly injured or made person ill (*e.g., Second degree burns on right forearm from acetylene torch*)	Death (G)	Days away from work (H)	Job transfer or restriction (I)	Other record-able cases (J)	Away from work (K)	On job transfer or restriction (L)	Injury (1)	Skin disorder (2)	Respiratory condition (3)	Poisoning (4)	Hearing loss (5)	All other illnesses (6)
___	___	___	__/__ month/day	___	___	☐	☐	☐	☐	__ days	__ days	☐	☐	☐	☐	☐	☐
___	___	___	__/__ month/day	___	___	☐	☐	☐	☐	__ days	__ days	☐	☐	☐	☐	☐	☐
___	___	___	__/__ month/day	___	___	☐	☐	☐	☐	__ days	__ days	☐	☐	☐	☐	☐	☐
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___	___	___	__/__ month/day	___	___	☐	☐	☐	☐	__ days	__ days	☐	☐	☐	☐	☐	☐
___	___	___	__/__ month/day	___	___	☐	☐	☐	☐	__ days	__ days	☐	☐	☐	☐	☐	☐
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___	___	___	__/__ month/day	___	___	☐	☐	☐	☐	__ days	__ days	☐	☐	☐	☐	☐	☐
___	___	___	__/__ month/day	___	___	☐	☐	☐	☐	__ days	__ days	☐	☐	☐	☐	☐	☐
					Page totals ➤	___	___	___	___	___	___	___	___	___	___	___	___
												Injury (1)	Skin disorder (2)	Respiratory condition (3)	Poisoning (4)	Hearing loss (5)	All other illnesses (6)

Be sure to transfer these totals to the Summary page (Form 300A) before you post it.

Page ___ **of** ___

Public reporting burden for this collection of information is estimated to average 14 minutes per response, including time to review the instructions, search and gather the data needed, and complete and review the collection of information. Persons are not required to respond to the collection of information unless it displays a currently valid OMB control number. If you have any comments about these estimates or any other aspects of this data collection, contact: US Department of Labor, OSHA Office of Statistical Analysis, Room N-3644, 200 Constitution Avenue, NW, Washington, DC 20210. Do not send the completed forms to this office.

Source: U.S. Department of Labor, OSHA (2004)

Figure A2.2. OSHA Form 300A

OSHA's Form 300A (Rev. 01/2004)

Summary of Work-Related Injuries and Illnesses

Year 20__ __

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

All establishments covered by Part 1904 must complete this Summary page, even if no work-related injuries or illnesses occurred during the year. Remember to review the Log to verify that the entries are complete and accurate before completing this summary.

Using the Log, count the individual entries you made for each category. Then write the totals below, making sure you've added the entries from every page of the Log. If you had no cases, write "0."

Employees, former employees, and their representatives have the right to review the OSHA Form 300 in its entirety. They also have limited access to the OSHA Form 301 or its equivalent. See 29 CFR Part 1904.35, in OSHA's recordkeeping rule, for further details on the access provisions for these forms.

Number of Cases

Total number of deaths	Total number of cases with days away from work	Total number of cases with job transfer or restriction	Total number of other recordable cases
______ (G)	______ (H)	______ (I)	______ (J)

Number of Days

Total number of days away from work	Total number of days of job transfer or restriction
______ (K)	______ (L)

Injury and Illness Types

Total number of . . .
(M)

(1) Injuries ______

(2) Skin disorders ______

(3) Respiratory conditions ______

(4) Poisonings ______

(5) Hearing loss ______

(6) All other illnesses ______

Post this Summary page from February 1 to April 30 of the year following the year covered by the form.

Public reporting burden for this collection of information is estimated to average 58 minutes per response, including time to review the instructions, search and gather the data needed, and complete and review the collection of information. Persons are not required to respond to the collection of information unless it displays a currently valid OMB control number. If you have any comments about these estimates or any other aspects of this data collection, contact: US Department of Labor, OSHA Office of Statistical Analysis, Room N-3644, 200 Constitution Avenue, NW, Washington, DC 20210. Do not send the completed forms to this office.

Establishment information

Your establishment name ______________________

Street ______________________

City ______________ State ____ ZIP ______

Industry description (*e.g., Manufacture of motor truck trailers*)

____

Standard Industrial Classification (SIC), if known (*e.g., 3715*)

___ ___ ___ ___

OR

North American Industrial Classification (NAICS), if known (e.g., 336212)

___ ___ ___ ___ ___ ___

Employment information *(If you don't have these figures, see the Worksheet on the back of this page to estimate.)*

Annual average number of employees ________

Total hours worked by all employees last year ________

Sign here

Knowingly falsifying this document may result in a fine.

I certify that I have examined this document and that to the best of my knowledge the entries are true, accurate, and complete.

____
Company executive / Title

( ) - / /
Phone / Date

Source: U.S. Department of Labor, OSHA (2004)

Appendix 3

Occupational Injury Incidence Rates at Surveyed Agribusiness Retailers

This appendix contains tables that summarize firm-level incidence rates at surveyed agribusiness retailers. Although aggregate TRC and DART incidence rates from the sample of fifteen surveyed agribusiness retailers are relatively consistent from 2012 to 2015, variation exists in firm-level incidence rates from that period.

Table A3.1. Firm-level TRC incidence rates at surveyed agribusiness retailers

Firm	2012	2013	2014	2015
Firm 1	7.5	13.4	11.2	7.1
Firm 2	7.6	9.8	8.6	6.6
Firm 3	10.7	10.1	5.3	6.4
Firm 4	9.8	7.7	6.7	5.5
Firm 5	7.4	7.7	7.4	6.9
Firm 6	6.9	10.1	5.5	7.2
Firm 7	8.8	7.8	5.9	4.8
Firm 8	4.3	5.3	7.4	9.6
Firm 9	6.0	7.0	6.1	5.9
Firm 10	5.8	6.2	9.6	4.0
Firm 11	8.1	4.0	5.6	3.7
Firm 12	6.7	3.2	3.2	6.2
Firm 13	3.1	1.6	7.7	7.3
Firm 14	3.8	4.5	2.4	1.5
Firm 15	2.7	4.1	2.1	3.4

Note: Incidence rates are calculated as (injury cases × 200,000)/total hours worked, representing injuries per 100 full time workers. The firms listed above are sorted by total TRC incident rate from 2012 to 2015.

Table A3.2. Firm-level DART incidence rates at surveyed agribusiness retailers

Firm	2012	2013	2014	2015
Firm 1	7.5	3.8	1.6	4.3
Firm 2	3.8	2.6	3.7	3.3
Firm 3	4.4	3.4	4.4	4.5
Firm 4	3.1	1.9	2.8	2.6
Firm 5	2.9	1.8	3.9	2.5
Firm 6	1.6	2.4	0.6	1.0
Firm 7	3.7	3.9	4.5	2.0
Firm 8	0.0	2.1	3.2	5.3
Firm 9	2.0	3.5	4.0	2.1
Firm 10	2.1	3.1	5.5	1.5
Firm 11	7.1	1.6	1.6	0.7
Firm 12	1.7	1.9	0.8	3.1
Firm 13	0.6	0.0	1.2	2.6
Firm 14	2.7	2.3	1.9	0.5
Firm 15	0.9	0.5	1.3	0.4

Note: Incidence rates are calculated as (injury cases × 200,000)/total hours worked, representing injuries per 100 full time workers. The firms listed above are sorted by total TRC incident rate from 2012 to 2015.

Appendix 4

Joint Classifications of TRC Injuries at Surveyed Agribusiness Retailers

This appendix contains tables that classify injuries at surveyed agribusiness retailers jointly by nature, affected body part, source, and event or exposure. Tables A4.1 through A4.6 detail the injuries at surveyed agribusiness retailers from 2012 to 2015. Each table entry lists the TRC incidence rate per 10,000 full time employees for a joint injury classification. The tables in this appendix account for nonclassifiable injuries and use categories that are comprehensive of all occupational injuries. The nature and event or exposure classifications used in this appendix's tables are identical to those used in tables 2.5 and 2.8. However, the affected body part and source classifications are not the same as those used in tables 2.6 and 2.7. Specifically, rather than using the two-digit classification codes featured in tables 2.6 and 2.7, the affected body part and source classifications used in this appendix are single-digit, division-level classifications defined by the U.S. Department of Labor, BLS (2012).

Table A4.1. TRC incidence rates at surveyed agribusiness retailers by nature and affected body part of injury, 2012-2015

Affected body part (BLS code)	Nature (BLS code)					
	Fractures (123)	Sprains, strains, tears (197)	Cuts, lacerations (132)	Bruises, contusions (143)	Nonspecified injuries and disorders (197)	Other and nonclassifiable
Head (1)	1.6	0.0	16.4	5.5	37.4	24.1
Neck, including throat (2)	0.0	3.1	0.8	0.0	2.3	1.6
Trunk (3)	5.5	56.8	0.0	7.8	31.1	10.1
Upper extremities (4)	10.1	52.2	54.5	10.1	48.3	49.8
Lower extremities (5)	8.6	53.7	3.9	10.9	22.6	26.5
Body systems (6)	0.0	0.0	0.0	0.0	0.0	2.3
Multiple body parts (8)	1.6	4.7	0.0	2.3	16.4	20.2
Other body parts and nonclassifiable (9)	0.0	3.9	1.6	0.8	0.0	19.5

Note: Incidence rates are calculated as (injury cases × 20,000,000)/total hours worked, representing injuries per 10,000 full time workers. Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A4.2. TRC incidence rates at surveyed agribusiness retailers by nature and source of injury, 2012-2015

Source (BLS code)	Nature (BLS code)					
	Fractures (123)	Sprains, strains, tears (197)	Cuts, lacerations (132)	Bruises, contusions (143)	Nonspecified injuries and disorders (197)	Other and nonclassifiable
Chemicals and chemical products (1)	0.0	0.0	0.0	0.0	0.0	10.1
Containers, furniture, and fixtures (2)	1.6	14.0	0.0	0.0	6.2	3.9
Machinery (3)	0.0	5.5	0.8	0.0	3.1	4.7
Parts and materials (4)	1.6	4.7	3.1	0.8	3.9	3.1
Persons, plants, animals, and miner. (5)	0.8	10.1	0.0	0.0	1.6	3.1
Structures and surfaces (6)	2.3	6.2	1.6	4.7	6.2	9.3
Tools, instruments, and equipment (7)	2.3	7.0	3.9	0.8	3.9	3.9
Vehicles (8)	3.1	2.3	0.8	2.3	3.1	10.1
Other sources and nonclassifiable (9)	10.9	52.2	5.5	7.0	14.8	11.7

Note: Incidence rates are calculated as (injury cases × 20,000,000)/total hours worked, representing injuries per 10,000 full time workers. Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A4.3. TRC incidence rates at surveyed agribusiness retailers by nature and event or exposure of injury, 2012-2015

Event or exposure (BLS code)	Nature (BLS code)					
	Fractures (123)	Sprains, strains, tears (197)	Cuts, lacerations (132)	Bruises, contusions (143)	Nonspecified injuries and disorders (197)	Other and nonclassifiable
Viol. and other inj. by pers./anim. (1)	0.0	0.0	0.0	0.0	0.8	0.0
Transportation incidents (2)	0.8	0.8	0.8	1.6	0.8	7.0
Fires and explosions (3)	0.0	0.0	0.0	0.0	0.0	0.8
Falls, slips, trips (4)	3.1	19.5	0.8	4.7	5.5	16.4
Exposure to harmful subst./envir. (5)	0.8	0.0	0.0	0.0	0.0	10.9
Contact with objects and equip. (6)	3.9	0.0	9.3	1.6	5.5	10.1
Overexertion and bodily reaction (7)	0.0	35.8	0.0	0.0	13.2	3.9
Nonclassifiable (9)	14.0	45.9	4.7	7.8	17.1	10.9

Note: Incidence rates are calculated as (injury cases × 20,000,000)/total hours worked, representing injuries per 10,000 full time workers. Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A4.4. TRC incidence rates at surveyed agribusiness retailers by affected body part and source of injury, 2012-2015

Source (BLS code)	Affected body part (BLS code)							
	Head (1)	Neck, incl. throat (2)	Trunk (3)	Upper extremities (4)	Upper extremities (5)	Body systems (6)	Multiple body parts (8)	Other and nonclass. (9)
Chemicals and chemical products (1)	7.8	0.0	2.3	3.9	3.9	1.6	5.5	1.6
Containers, furniture, and fixtures (2)	1.6	2.3	19.5	26.5	6.2	0.0	3.9	2.3
Machinery (3)	5.5	0.8	9.3	13.2	2.3	0.0	2.3	1.6
Parts and materials (4)	4.7	1.6	7.0	30.4	7.8	0.0	1.6	0.8
Persons, plants, animals, and miner. (5)	2.3	0.8	9.3	12.5	21.0	0.8	0.8	3.1
Structures and surfaces (6)	3.9	0.8	13.2	21.8	18.7	0.0	8.6	3.1
Tools, instruments, and equipment (7)	4.7	0.0	4.7	23.4	7.8	0.0	3.1	2.3
Vehicles (8)	3.1	0.0	7.0	16.4	4.7	0.0	6.2	7.8
Other sources and nonclassifiable (9)	51.4	1.6	38.9	77.1	53.7	0.0	13.2	3.1

Note: Incidence rates are calculated as (injury cases × 20,000,000)/total hours worked, representing injuries per 10,000 full time workers. Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A4.5. TRC incidence rates at surveyed agribusiness retailers by affected body part and event or exposure of injury, 2012-2015

Event or exposure (BLS code)	Affected body part (BLS code)							
	Head (1)	Neck, incl. throat (2)	Trunk (3)	Upper extremities (4)	Upper extremities (5)	Body systems (6)	Multiple body parts (8)	Other and nonclass. (9)
Viol. and other inj. by pers./anim. (1)	0.8	0.8	0.0	5.5	3.9	0.0	0.0	2.3
Transportation incidents (2)	1.6	0.0	4.7	2.3	1.6	0.0	3.1	8.6
Fires and explosions (3)	0.0	0.0	0.0	0.8	0.0	0.0	0.8	0.0
Falls, slips, trips (4)	4.7	0.0	14.8	20.2	28.8	0.0	14.0	7.0
Exposure to harmful subst./envir. (5)	6.2	0.0	2.3	6.2	4.7	2.3	6.2	1.6
Contact with objects and equip. (6)	57.6	0.0	0.0	71.6	20.2	0.0	1.6	1.6
Overexertion and bodily reaction (7)	0.0	3.1	40.5	46.7	22.6	0.0	5.5	1.6
Nonclassifiable (9)	14.0	3.9	49.1	71.6	44.4	0.0	14.0	3.1

Note: Incidence rates are calculated as (injury cases × 20,000,000)/total hours worked, representing injuries per 10,000 full time workers. Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A4.6. TRC incidence rates at surveyed agribusiness retailers by source and event or exposure of injury, 2012-2015

Event or exposure (BLS code)	Source (BLS code)								
	Chem. and chemical products (1)	Contain., furniture, and fixt.-tures (2)	Mach-inery (3)	Parts and mater-ials (4)	Persons, plants, animals, and min. (5)	Struct-ures and surfaces (6)	Tools, instrum., and equip. (7)	Vehicles (8)	Other and nonclass. (9)
Viol. and other inj. by pers./anim. (1)	0.0	0.0	0.0	0.0	11.7	1.6	0.0	0.0	0.0
Transportation incidents (2)	0.0	0.8	3.9	0.8	0.0	0.0	0.0	16.4	0.0
Fires and explosions (3)	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.8
Falls, slips, trips (4)	0.0	1.6	2.3	0.8	4.7	49.1	8.6	5.5	17.1
Exposure to harmful subst./envir. (5)	22.6	1.6	0.0	0.0	0.8	0.0	1.6	0.0	3.1
Contact with objects and equip. (6)	3.1	12.5	15.6	29.6	1.6	10.1	20.2	8.6	51.4
Overexertion and bodily reaction (7)	0.8	38.2	4.7	14.8	28.8	3.9	11.7	5.5	11.7
Nonclassifiable (9)	0.0	7.8	7.8	7.8	3.1	5.5	3.9	9.3	155.0

Note: Incidence rates are calculated as (injury cases × 20,000,000)/total hours worked, representing injuries per 10,000 full time workers. Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Appendix 5

Severity of DART Injuries at Surveyed Agribusiness Retailers

This appendix contains tables that complement tables 2.9, 2.10, and 2.11 by describing DART injury severities according to the nature, affected body part, source, and event or exposure of the injury. Tables A5.1 through A5.4 summarize the severity of injuries resulting in days away from work, tables A5.5 through A5.8 summarize the severity of injuries resulting in job transfer or work restriction, and tables A5.9 through A5.12 summarize the severity of all DART injuries (including work time missed due to days away, work restriction, and job transfer). In addition to summarizing the share of injuries in seven severity categories, each injury classification's total number of cases is listed to provide context for the tables. The classifications used in this appendix are the same as those used in appendix 4. That is, the nature of an injury is described by a three-digit classification code while the affected body part, source, and event or exposure of an injury are described by single-digit, division-level classifications defined by the U.S. Department of Labor, BLS (2012).

Table A5.1. Distribution of DAFW injury severity at surveyed agribusiness retailers by nature of injury, 2012-2015

Nature (BLS code)	Cases	Length of absence from work						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Fractures (111)	20	0.0%	0.0%	5.0%	5.0%	25.0%	0.0%	65.0%
Sprains, strains, tears (123)	77	15.6%	11.7%	24.7%	14.3%	11.7%	7.8%	14.3%
Cuts, lacerations (132)	9	11.1%	22.2%	22.2%	22.2%	11.1%	11.1%	0.0%
Bruises, contusions (143)	13	15.4%	7.7%	61.5%	7.7%	7.7%	0.0%	0.0%
Nonspecif. injuries and disorders (197)	32	15.6%	12.5%	18.8%	21.9%	6.3%	3.1%	21.9%
All other natures and nonclassif.	56	16.1%	8.9%	17.9%	10.7%	26.8%	1.8%	17.9%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.2. Distribution of DAFW injury severity at surveyed agribusiness retailers by affected body part of injury, 2012-2015

Affected body part (BLS code)	Cases	Length of absence from work						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Head (1)	14	14.3%	14.3%	21.4%	21.4%	21.4%	0.0%	7.1%
Neck, including throat (2)	2	0.0%	0.0%	50.0%	0.0%	0.0%	50.0%	0.0%
Trunk (3)	51	15.7%	11.8%	27.5%	15.7%	17.6%	2.0%	9.8%
Upper extremities (4)	50	14.0%	10.0%	14.0%	10.0%	16.0%	10.0%	26.0%
Lower extremities (5)	62	6.5%	9.7%	22.6%	14.5%	16.1%	3.2%	27.4%
Body systems (6)	0							
Multiple body parts (8)	17	17.6%	11.8%	23.5%	5.9%	17.6%	0.0%	23.5%
Other body parts and nonclassif. (9)	11	45.5%	0.0%	27.3%	18.2%	0.0%	0.0%	9.1%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.3. Distribution of DAFW injury severity at surveyed agribusiness retailers by source of injury, 2012-2015

Source (BLS code)	Cases	Length of absence from work						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Chemicals and chemical products (1)	12	41.7%	0.0%	16.7%	8.3%	25.0%	0.0%	8.3%
Containers, furniture, and fixtures (2)	26	19.2%	15.4%	7.7%	15.4%	15.4%	3.8%	23.1%
Machinery (3)	13	15.4%	15.4%	38.5%	15.4%	0.0%	0.0%	15.4%
Parts and materials (4)	12	16.7%	8.3%	16.7%	25.0%	25.0%	0.0%	8.3%
Persons, plants, animals, and miner. (5)	16	6.3%	12.5%	25.0%	18.8%	6.3%	6.3%	25.0%
Structures and surfaces (6)	21	9.5%	9.5%	38.1%	9.5%	0.0%	4.8%	28.6%
Tools, instruments, and equipment (7)	11	0.0%	9.1%	18.2%	18.2%	36.4%	0.0%	18.2%
Vehicles (8)	23	8.7%	4.3%	21.7%	13.0%	21.7%	4.3%	26.1%
Other sources and nonclassifiable (9)	73	13.7%	11.0%	21.9%	11.0%	17.8%	6.8%	17.8%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.4. Distribution of DAFW injury severity at surveyed agribusiness retailers by event or exposure of injury, 2012-2015

Event or exposure (BLS code)	Cases	Length of absence from work						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Viol. and other inj. by pers./anim. (1)	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Transportation incidents (2)	14	21.4%	0.0%	28.6%	7.1%	21.4%	0.0%	21.4%
Fires and explosions (3)	1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Falls, slips, trips (4)	38	13.2%	7.9%	28.9%	15.8%	10.5%	2.6%	21.1%
Exp. to harmful subst./environ. (5)	13	38.5%	0.0%	15.4%	7.7%	23.1%	0.0%	15.4%
Contact with objects and equip. (6)	21	14.3%	9.5%	23.8%	14.3%	23.8%	4.8%	9.5%
Overexertion and bodily reaction (7)	48	14.6%	10.4%	16.7%	18.8%	10.4%	4.2%	25.0%
Nonclassifiable (9)	71	8.5%	14.1%	22.5%	11.3%	18.3%	7.0%	18.3%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.5. Distribution of DJTR injury severity at surveyed agribusiness retailers by nature of injury, 2012-2015

Nature (BLS code)	Cases	Length of job transfer and work restriction						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Fractures (111)	17	0.0%	0.0%	5.9%	5.9%	35.3%	5.9%	47.1%
Sprains, strains, tears (123)	80	1.3%	2.5%	12.5%	23.8%	21.3%	10.0%	28.8%
Cuts, lacerations (132)	14	0.0%	0.0%	14.3%	50.0%	14.3%	14.3%	7.1%
Bruises, contusions (143)	11	9.1%	0.0%	27.3%	27.3%	9.1%	9.1%	18.2%
Nonspecif. injuries and disorders (197)	35	2.9%	5.7%	11.4%	14.3%	17.1%	11.4%	37.1%
All other natures and nonclassif.	37	5.4%	0.0%	5.4%	27.0%	27.0%	10.8%	21.6%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.6. Distribution of DJTR injury severity at surveyed agribusiness retailers by affected body part of injury, 2012-2015

Affected body part (BLS code)	Cases	Length of job transfer and work restriction						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Head (1)	6	33.3%	0.0%	16.7%	33.3%	16.7%	0.0%	0.0%
Neck, including throat (2)	0							
Trunk (3)	43	0.0%	7.0%	9.3%	20.9%	32.6%	9.3%	20.9%
Upper extremities (4)	79	0.0%	1.3%	7.6%	29.1%	15.2%	12.7%	34.2%
Lower extremities (5)	46	2.2%	0.0%	23.9%	10.9%	21.7%	8.7%	30.4%
Body systems (6)	0							
Multiple body parts (8)	13	7.7%	0.0%	0.0%	23.1%	30.8%	7.7%	30.8%
Other body parts and nonclassif. (9)	7	14.3%	0.0%	0.0%	42.9%	14.3%	14.3%	14.3%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.7. Distribution of DJTR injury severity at surveyed agribusiness retailers by source of injury, 2012-2015

Source (BLS code)	Cases	Length of job transfer and work restriction						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Chemicals and chemical products (1)	2	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
Containers, furniture, and fixtures (2)	14	0.0%	0.0%	7.1%	35.7%	21.4%	14.3%	21.4%
Machinery (3)	7	0.0%	0.0%	14.3%	0.0%	28.6%	42.9%	14.3%
Parts and materials (4)	14	0.0%	0.0%	21.4%	35.7%	14.3%	0.0%	28.6%
Persons, plants, animals, and miner. (5)	7	14.3%	0.0%	14.3%	0.0%	14.3%	14.3%	42.9%
Structures and surfaces (6)	29	6.9%	3.4%	3.4%	20.7%	24.1%	6.9%	31.0%
Tools, instruments, and equipment (7)	22	0.0%	0.0%	22.7%	18.2%	18.2%	9.1%	31.8%
Vehicles (8)	12	8.3%	0.0%	0.0%	33.3%	16.7%	8.3%	33.3%
Other sources and nonclassifiable (9)	87	1.1%	3.4%	11.5%	24.1%	21.8%	10.3%	27.6%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.8. Distribution of DJTR injury severity at surveyed agribusiness retailers by event or exposure of injury, 2012-2015

Event or exposure (BLS code)	Cases	Length of job transfer and work restriction						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Viol. and other inj. by pers./anim. (1)	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Transportation incidents (2)	5	20.0%	0.0%	0.0%	0.0%	20.0%	20.0%	40.0%
Fires and explosions (3)	0							
Falls, slips, trips (4)	41	4.9%	2.4%	7.3%	26.8%	22.0%	12.2%	22.0%
Exp. to harmful subst./environ. (5)	3	0.0%	0.0%	0.0%	33.3%	66.7%	0.0%	0.0%
Contact with objects and equip. (6)	25	4.0%	0.0%	20.0%	32.0%	16.0%	8.0%	20.0%
Overexertion and bodily reaction (7)	33	3.0%	3.0%	9.1%	24.2%	18.2%	6.1%	36.4%
Nonclassifiable (9)	86	0.0%	2.3%	12.8%	19.8%	23.3%	11.6%	30.2%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.9. Distribution of DART injury severity at surveyed agribusiness retailers by nature of injury, 2012-2015

Nature (BLS code)	Cases	Length of absence from work, work restriction, and job transfer						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Fractures (111)	29	0.0%	0.0%	0.0%	0.0%	20.7%	10.3%	69.0%
Sprains, strains, tears (123)	131	6.9%	6.9%	15.3%	17.6%	17.6%	13.0%	22.9%
Cuts, lacerations (132)	20	5.0%	0.0%	20.0%	45.0%	10.0%	10.0%	10.0%
Bruises, contusions (143)	20	5.0%	0.0%	50.0%	20.0%	10.0%	5.0%	10.0%
Nonspecif. injuries and disorders (197)	55	9.1%	7.3%	16.4%	14.5%	14.5%	9.1%	29.1%
All other natures and nonclassif.	77	14.3%	5.2%	9.1%	18.2%	27.3%	2.6%	22.1%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.10. Distribution of DART injury severity at surveyed agribusiness retailers by affected body part of injury, 2012-2015

Affected body part (BLS code)	Cases	Length of absence from work, work restriction, and job transfer						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Head (1)	19	21.1%	10.5%	21.1%	26.3%	15.8%	0.0%	5.3%
Neck, including throat (2)	2	0.0%	0.0%	50.0%	0.0%	0.0%	50.0%	0.0%
Trunk (3)	78	5.1%	7.7%	16.7%	19.2%	29.5%	5.1%	16.7%
Upper extremities (4)	108	5.6%	3.7%	8.3%	21.3%	15.7%	11.1%	34.3%
Lower extremities (5)	85	4.7%	4.7%	20.0%	12.9%	14.1%	11.8%	30.6%
Body systems (6)	0							
Multiple body parts (8)	26	11.5%	3.8%	15.4%	11.5%	19.2%	7.7%	30.8%
Other body parts and nonclassif. (9)	14	42.9%	0.0%	14.3%	7.1%	14.3%	7.1%	14.3%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.11. Distribution of DART injury severity at surveyed agribusiness retailers by source of injury, 2012-2015

Source	Cases	Length of absence from work, work restriction, and job transfer						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Chemicals and chemical products (1)	13	38.5%	0.0%	7.7%	7.7%	38.5%	0.0%	7.7%
Containers, furniture, and fixtures (2)	33	15.2%	6.1%	6.1%	18.2%	18.2%	6.1%	30.3%
Machinery (3)	18	11.1%	11.1%	27.8%	11.1%	5.6%	16.7%	16.7%
Parts and materials (4)	22	9.1%	4.5%	18.2%	18.2%	27.3%	0.0%	22.7%
Persons, plants, animals, and miner. (5)	20	5.0%	10.0%	20.0%	10.0%	5.0%	15.0%	35.0%
Structures and surfaces (6)	39	5.1%	2.6%	17.9%	17.9%	15.4%	10.3%	28.2%
Tools, instruments, and equipment (7)	28	0.0%	0.0%	17.9%	25.0%	21.4%	7.1%	28.6%
Vehicles (8)	28	10.7%	3.6%	14.3%	10.7%	25.0%	3.6%	32.1%
Other sources and nonclassifiable (9)	131	5.3%	6.1%	13.7%	19.8%	18.3%	11.5%	25.2%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Table A5.12. Distribution of DART injury severity at surveyed agribusiness retailers by event or exposure of injury, 2012-2015

Event or exposure (BLS code)	Cases	Length of absence from work, work restriction, and job transfer						
		1 day	2 days	3-5 days	6-10 days	11-20 days	21-30 days	> 30 days
Viol. and other inj. by pers./anim. (1)	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Transportation incidents (2)	15	26.7%	0.0%	20.0%	6.7%	20.0%	6.7%	20.0%
Fires and explosions (3)	1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Falls, slips, trips (4)	64	7.8%	3.1%	17.2%	17.2%	18.8%	14.1%	20.3%
Exp. to harmful subst./environ. (5)	15	33.3%	0.0%	6.7%	13.3%	33.3%	0.0%	13.3%
Contact with objects and equip. (6)	39	10.3%	2.6%	15.4%	30.8%	12.8%	7.7%	20.5%
Overexertion and bodily reaction (7)	68	10.3%	5.9%	13.2%	14.7%	17.6%	4.4%	33.8%
Nonclassifiable (9)	129	1.6%	7.0%	15.5%	17.1%	19.4%	10.9%	28.7%

Note: Injuries are classified according to the U.S. Department of Labor, BLS (2012).

Appendix 6

Characteristics of Surveyed Agribusiness Retailer Employees by Age

This appendix contains tables that summarize the age distribution of several characteristics of surveyed agribusiness retailer employees. The four employee characteristics summarized in tables A6.1 through A6.4 are tenure with current employer, department of primary employment, managerial status, and employment status. Only employees with complete responses to the University of Minnesota Occupational Safety and Health Survey are included in this analysis. The data in this appendix's tables display several age-related trends.

Table A6.1. Age distribution of surveyed agribusiness retailer employees by tenure

Tenure	Age				
	< 30 years	30-39 years	40-49 years	50-59 years	> 59 years
< 1 years	48.5%	20.3%	14.1%	14.4%	2.6%
1-4 years	35.8%	23.7%	14.5%	17.5%	8.5%
5-9 years	16.5%	23.9%	23.1%	23.9%	12.6%
10-19 years	2.5%	22.3%	22.8%	34.1%	18.3%
> 19 years	0.0%	1.6%	16.6%	55.8%	26.0%

Note: The table summarizes the age distribution of employees in a tenure category. Therefore, each row sums to 100%.

Table A6.2. Age distribution of surveyed agribusiness retailer employees by department

Department of primary employment	Age				
	< 30 years	30-39 years	40-49 years	50-59 years	> 59 years
Agronomy/crop production	25.7%	24.0%	15.3%	22.3%	12.8%
Auto/tire shop	25.9%	18.5%	18.5%	29.6%	7.4%
Corporate/financial	13.2%	21.4%	23.6%	28.6%	13.2%
Energy	5.7%	14.9%	23.7%	38.7%	17.0%
Feed	17.2%	18.2%	19.7%	31.8%	13.1%
Grain/beans	22.6%	19.1%	16.7%	30.0%	11.7%
Nonagricultural retail	48.3%	11.8%	13.3%	16.7%	9.9%
Transportation/trucking	8.2%	16.4%	20.0%	35.5%	20.0%
Other	18.6%	18.6%	22.5%	31.0%	9.3%

Note: The table summarizes the age distribution of employees working in a particular department. Therefore, each row sums to 100%.

Table A6.3. Age distribution of surveyed agribusiness retailer employees by managerial status

Managerial status	Age				
	< 30 years	30-39 years	40-49 years	50-59 years	> 59 years
Managerial	11.6%	19.1%	24.3%	33.6%	11.4%
Nonmanagerial	25.6%	19.6%	15.9%	25.3%	13.5%

Note: The table summarizes the age distribution of employees in a managerial category. Therefore, each row sums to 100%.

Table A6.4. Age distribution of surveyed agribusiness retailer employees by employment status

Employment status	Age				
	< 30 years	30-39 years	40-49 years	50-59 years	> 59 years
Full time	19.5%	20.9%	19.1%	29.5%	11.1%
Part time	52.1%	11.4%	9.6%	11.4%	15.6%
Seasonal	16.8%	8.4%	12.6%	16.8%	45.3%

Note: The table summarizes the age distribution of employees in an employment category. Therefore, each row sums to 100%.

Appendix 7

Characteristics of Surveyed Agribusiness Retailer Employees by Tenure

This appendix contains tables that summarize the tenure distribution of several characteristics of surveyed agribusiness retailer employees. The four employee characteristics summarized in tables A7.1 through A7.4 are age, department of primary employment, managerial status, and employment status. Only employees with complete responses to the University of Minnesota Occupational Safety and Health Survey are included in this analysis. Although the tenure-related trends displayed in this appendix are similar to the age-related trends displayed in the previous appendix, nuanced differences exist for several characteristics.

Table A7.1. Tenure distribution of surveyed agribusiness retailer employees by age

Age	Tenure				
	< 1 year	1-4 years	5-9 years	10-19 years	> 19 years
< 30 years	32.6%	51.3%	13.9%	2.2%	0.0%
30-39 years	15.5%	38.4%	22.7%	22.2%	1.2%
40-49 years	11.7%	25.5%	23.8%	24.7%	14.4%
50-59 years	7.8%	20.2%	16.2%	24.2%	31.6%
> 59 years	3.0%	20.6%	18.0%	27.3%	31.1%

Note: The table summarizes the tenure distribution of employees in an age category. Therefore, each row sums to 100%.

Table A7.2. Tenure distribution of surveyed agribusiness retailer employees by department

Department of primary employment	Tenure				
	< 1 year	1-4 years	5-9 years	10-19 years	> 19 years
Agronomy/crop production	12.7%	30.9%	21.0%	21.4%	14.1%
Auto/tire shop	18.5%	29.6%	14.8%	14.8%	22.2%
Corporate/financial	25.1%	45.8%	19.7%	5.9%	3.4%
Energy	12.3%	26.4%	18.5%	22.9%	19.8%
Feed	17.2%	22.2%	13.3%	22.7%	24.6%
Grain/beans	11.1%	30.8%	20.7%	19.7%	17.7%
Nonagricultural retail	17.1%	31.1%	14.8%	20.6%	16.3%
Transportation/trucking	11.2%	49.1%	15.5%	14.7%	9.5%
Other	16.8%	26.0%	19.1%	21.4%	16.8%

Note: The table summarizes the tenure distribution of employees working in a particular department. Therefore, each row sums to 100%.

Table A7.3. Tenure distribution of surveyed agribusiness retailer employees by managerial status

Managerial status	Tenure				
	< 1 year	1-4 years	5-9 years	10-19 years	> 19 years
Managerial	5.5%	23.1%	19.3%	26.7%	25.4%
Nonmanagerial	18.0%	34.6%	18.2%	17.1%	12.1%

Note: The table summarizes the tenure distribution of employees in a managerial category. Therefore, each row sums to 100%.

Table A7.4. Tenure distribution of surveyed agribusiness retailer employees by employment status

Employment status	Tenure				
	< 1 year	1-4 years	5-9 years	10-19 years	> 19 years
Full time	12.5%	30.0%	19.1%	21.2%	17.3%
Part time	34.1%	47.1%	14.1%	2.9%	1.8%
Seasonal	23.4%	37.8%	15.3%	18.0%	5.4%

Note: The table summarizes the tenure distribution of employees in an employment category. Therefore, each row sums to 100%.

Appendix 8

Background Characteristics of Surveyed Agribusiness Retailer Employees

This appendix contains tables that summarize the backgrounds of surveyed agribusiness retailer employees. Survey advisory board members suggested that employee backgrounds influence occupational safety at their firms. Three employee background characteristics are examined here: agricultural background, workplace distance from childhood home, and educational attainment. Tables A8.1 through A8.5 indicate that the aforementioned background characteristics vary by age, tenure with current employer, department of primary employment, managerial status, and employment status. Only employees with complete responses to the University of Minnesota Occupational Safety and Health Survey are included in this analysis.

Table A8.1. Background characteristics of surveyed agribusiness retailer employees by age

Background characteristic	Age				
	< 30 years	30-39 years	40-49 years	50-59 years	> 59 years
Agricultural background					
Little or no ag. knowledge	14.5%	15.2%	15.4%	7.8%	7.9%
Ag. knowledge in nonrural community	7.9%	7.5%	10.8%	5.3%	5.2%
Ag. knowledge in rural community	29.5%	28.2%	30.3%	26.5%	24.3%
Grew up on a farm	48.0%	49.1%	43.5%	60.4%	62.5%
Workplace distance to childhood home					
< 20 miles	59.7%	53.4%	53.5%	52.4%	52.4%
20-50 miles	23.8%	21.9%	18.1%	20.8%	17.2%
> 50 miles	16.5%	24.7%	28.4%	26.8%	30.3%
Maximum education level					
Did not complete high school	3.1%	2.7%	3.2%	3.0%	2.6%
High school diploma	24.0%	30.7%	24.9%	40.9%	41.6%
Some college	30.0%	28.2%	33.0%	28.2%	26.2%
Associate's degree	17.0%	18.5%	18.6%	13.5%	10.5%
Bachelor's degree	24.2%	15.7%	17.0%	12.6%	16.1%
Professional or graduate degree	1.8%	4.2%	3.2%	1.8%	3.0%

Note: The table summarizes the background characteristics of employees in a particular age category, so columns sum to 100% for each characteristic group.

Table A8.2. Background characteristics of surveyed agribusiness retailer employees by tenure

Background characteristic	Tenure				
	< 1 year	1-4 years	5-9 years	10-19 years	> 19 years
Agricultural background					
Little or no ag. knowledge	21.0%	15.3%	11.5%	7.3%	4.0%
Ag. knowledge in nonrural community	9.5%	8.6%	7.9%	4.6%	4.3%
Ag. knowledge in rural community	26.3%	31.3%	25.1%	27.1%	24.8%
Grew up on a farm	43.2%	44.8%	55.5%	61.0%	66.9%
Workplace distance to childhood home					
< 20 miles	50.5%	51.3%	52.4%	56.7%	64.4%
20-50 miles	21.6%	22.9%	20.7%	19.6%	17.8%
> 50 miles	27.9%	25.7%	26.9%	23.7%	17.8%
Maximum education level					
Did not complete high school	5.1%	2.7%	2.3%	2.9%	2.5%
High school diploma	27.6%	29.8%	27.9%	37.8%	40.8%
Some college	33.0%	28.9%	33.5%	24.2%	25.8%
Associate's degree	15.6%	15.0%	15.3%	16.7%	16.6%
Bachelor's degree	16.2%	20.4%	18.4%	16.0%	12.6%
Professional or graduate degree	2.5%	3.3%	2.6%	2.4%	1.8%

Note: The table summarizes the background characteristics of employees in a particular tenure category, so columns sum to 100% for each characteristic group.

Table A8.3. Background characteristics of surveyed agribusiness retailer employees by department

Background characteristic	Department of primary employment								
	Agro-nomy/ crop prod.	Auto/ tire shop	Corp-orate/ finan-cial	Energy	Feed	Grain/ beans	Nonag. retail	Trans-port./ truck-ing	Other
Agricultural background									
Little or no ag. knowledge	4.9%	22.2%	17.6%	10.8%	7.6%	12.1%	33.0%	11.2%	19.1%
Ag. knowledge in nonrural community	5.7%	11.1%	6.2%	7.9%	4.5%	7.4%	15.8%	6.9%	6.9%
Ag. knowledge in rural community	23.8%	40.7%	30.4%	28.6%	30.3%	28.4%	28.6%	34.5%	26.7%
Grew up on a farm	65.7%	25.9%	45.8%	52.7%	57.6%	52.1%	22.7%	47.4%	47.3%
Workplace distance to childhood home									
< 20 miles	55.5%	55.6%	44.1%	57.6%	64.1%	56.0%	48.3%	58.6%	45.8%
20-50 miles	22.0%	22.2%	26.4%	18.7%	17.7%	18.3%	21.7%	23.3%	16.0%
> 50 miles	22.4%	22.2%	29.5%	23.6%	18.2%	25.7%	30.0%	18.1%	38.2%
Maximum education level									
Did not complete high school	2.3%	11.1%	0.4%	0.5%	4.5%	5.4%	3.9%	4.3%	3.8%
High school diploma	29.6%	33.3%	16.3%	40.4%	38.4%	40.1%	25.6%	47.4%	31.3%
Some college	25.5%	29.6%	26.0%	32.5%	26.8%	30.7%	45.8%	35.3%	17.6%
Associate's degree	17.8%	14.8%	18.9%	13.3%	16.2%	12.1%	12.8%	6.9%	21.4%
Bachelor's degree	22.3%	7.4%	34.4%	11.8%	12.1%	10.1%	7.9%	3.4%	21.4%
Professional or graduate degree	2.4%	3.7%	4.0%	1.5%	2.0%	1.6%	3.9%	2.6%	4.6%

Note: The table summarizes the background characteristics of employees working in a particular department, so columns sum to 100% for each characteristic group.

Table A8.4. Background characteristics of surveyed agribusiness retailer employees by managerial status

Background characteristic	Managerial status	
	Managerial employees	Nonmanagerial employees
Agricultural background		
Little or no ag. knowledge	9.5%	13.0%
Ag. knowledge in nonrural community	5.3%	7.8%
Ag. knowledge in rural community	27.2%	27.8%
Grew up on a farm	58.0%	51.4%
Workplace distance to childhood home		
< 20 miles	58.0%	51.4%
20-50 miles	27.2%	27.8%
> 50 miles	5.3%	7.8%
Maximum education level		
Did not complete high school	0.4%	3.8%
High school diploma	25.5%	34.6%
Some college	26.5%	29.8%
Associate's degree	16.4%	15.5%
Bachelor's degree	28.2%	13.8%
Professional or graduate degree	3.0%	2.5%

Note: The table summarizes the background characteristics of employees in a particular managerial category, so columns sum to 100% for each characteristic group.

Table A8.5. Background characteristics of surveyed agribusiness retailer employees by employment status

Background characteristic	Employment status		
	Full time employees	Part time employees	Seasonal employees
Agricultural background			
Little or no ag. knowledge	11.0%	28.2%	6.3%
Ag. knowledge in nonrural community	6.7%	12.4%	7.2%
Ag. knowledge in rural community	27.3%	30.6%	29.7%
Grew up on a farm	55.0%	28.8%	56.8%
Workplace distance to childhood home			
< 20 miles	54.0%	54.7%	60.4%
20-50 miles	21.1%	17.6%	21.6%
> 50 miles	24.8%	27.6%	18.0%
Maximum education level			
Did not complete high school	2.6%	6.5%	4.5%
High school diploma	31.8%	27.6%	45.9%
Some college	28.5%	35.3%	27.0%
Associate's degree	16.1%	15.9%	10.8%
Bachelor's degree	18.5%	10.6%	10.8%
Professional or graduate degree	2.6%	4.1%	0.9%

Note: The table summarizes the background characteristics of employees in a particular employment category, so columns sum to 100% for each characteristic group.

Appendix 9

Predicted Probabilities from Safety Climate Model

This appendix contains tables summarizing predicted probabilities of a maximal rating of safety climate based on different values of explanatory values from the safety climate model. Safety climate model coefficients reported in table 6.1 can be used to calculate predicted probabilities for dependent variable outcomes. Equation (5.3) outlines how such probabilities are calculated. In this appendix, predicted probabilities represent the likelihood of survey respondent *i* at business location *j* expressing the maximal safety climate rating (SC_{ij} = 4). Predicted probabilities were calculated by assigning a variety of values to an explanatory variable while holding all other explanatory variables constant at their mean. The probabilities listed in each row indicate how the probability of a maximal rating of safety climate changes as an explanatory variable changes in value. The eight safety system variables at the top of each table are scaled so that increasing values represent increasing frequency or quantity. Increasing values of agricultural background signify greater childhood familiarity with agriculture. Increasing values of childhood home distance signify greater distance between one's workplace and childhood home. Increasing values of education signify greater educational attainment. Because the explanatory variables are not scaled identically, some explanatory variables do not have probabilities listed in certain columns. Table A9.1 contains predicted probabilities for managerial employees and table A9.2 contains predicted probabilities for nonmanagerial employees.

Table A9.1. Predicted probabilities of maximal safety climate rating based on managerial safety climate model estimates

Explanatory variable	Value of explanatory variable					
	1	2	3	4	5	6
Discipline	0.514	0.594	0.671	0.742		
Inspections	0.451	0.563	0.671	0.766		
Investigations	0.602	0.630	0.657	0.683		
Meetings	0.719	0.692	0.665	0.636	0.607	
Modified duty	0.522	0.593	0.660	0.723		
Off-the-job	0.597	0.641	0.683	0.722		
Recognition	0.574	0.632	0.688	0.739		
Training	0.644	0.655	0.667	0.678	0.690	
Agricultural background	0.731	0.706	0.680	0.653		
Childhood home distance	0.653	0.673	0.692			
Education	0.652	0.660	0.667	0.674	0.682	0.689

Note: The table shows predicted probabilities of a maximal rating of safety climate for different values of a single explanatory variable given that all other explanatory variables are held constant at their mean.

Table A9.2. Predicted probabilities of maximal safety climate rating based on nonmanagerial safety climate model estimates

Explanatory variable	Value of explanatory variable					
	1	2	3	4	5	6
Discipline	0.451	0.498	0.545	0.591		
Inspections	0.358	0.449	0.543	0.634		
Investigations	0.360	0.433	0.509	0.585		
Meetings	0.523	0.533	0.544	0.555	0.565	
Modified duty	0.454	0.497	0.539	0.581		
Off-the-job	0.452	0.503	0.555	0.606		
Recognition	0.381	0.471	0.564	0.653		
Training	0.524	0.533	0.541	0.549	0.558	
Agricultural background	0.582	0.565	0.547	0.530		
Childhood home distance	0.526	0.555	0.584			
Education	0.553	0.549	0.545	0.541	0.537	0.533

Note: The table shows predicted probabilities of a maximal rating of safety climate for different values of a single explanatory variable given that all other explanatory variables are held constant at their mean.

Appendix 10

Reference DMUs from Safety Efficiency Model

Table A10.1. Reference DMUs for inefficient DMUs from safety efficiency model

Inefficient DMU	Efficient DMU					
	Firm 8, 2012	Firm 13, 2013	Firm 15, 2013	Firm 6, 2014	Firm 7, 2014	Firm 15, 2014
Firm 2, 2012						X
Firm 3, 2012						X
Firm 4, 2012						X
Firm 5, 2012						X
Firm 6, 2012						X
Firm 7, 2012					X	X
Firm 9, 2012				X	X	X
Firm 10, 2012						X
Firm 12, 2012			X			X
Firm 13, 2012		X	X			X
Firm 14, 2012						X
Firm 15, 2012		X	X			X
Firm 1, 2013			X			X
Firm 2, 2013						X
Firm 3, 2013						X
Firm 4, 2013					X	X
Firm 5, 2013						X
Firm 6, 2013						X
Firm 7, 2013					X	X
Firm 8, 2013	X					X
Firm 9, 2013					X	X
Firm 10, 2013						X
Firm 12, 2013						X
Firm 14, 2013						X
Firm 1, 2014		X	X			X
Firm 2, 2014						X
Firm 3, 2014						X
Firm 4, 2014					X	X
Firm 5, 2014						X
Firm 8, 2014						X
Firm 9, 2014					X	X
Firm 10, 2014						X
Firm 12, 2014		X	X			X
Firm 13, 2014			X			X

Note: X indicates a reference DMU for a technically inefficient DMU. Two of the eight efficient DMUs serve as a reference DMU for no firm but themselves and are therefore excluded from this table. Firm numbers are the same as those used in appendix 3.