OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT IN FASHION AND TEXTILES INDUSTRY: THE VALUE OF SLACK RESOURCES AND OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM

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Occupational Health and Safety Management in Fashion and Textiles Industry: The Value of Slack Resources and Occupational Health and Safety Management System

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CERTIFICATE OF ORIGINALITY

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Abstract

A series of recent high-profile workplace accidents have increased public concern over corporate social responsibility (CSR) practices in the global fashion supply chain. Media and non-government organizations condemn that fashion businesses are pursuing maximum profits while putting worker's health and safety at risk in the production operations. The public condemnation upon occupational health and safety (OHS) issues could hurt consumer's buying intention and consequently the competitiveness of supply chain. Despite most OHS problems often happen in operational settings, current OHS literature lacks an operations management (OM) perspective, with limited implications for operational managers to manage OHS properly so as to achieve sustainable financial performance.

This dissertation first provides a Citation Network Analysis review to the current OHS studies in OM literature. This review enables us to identify the research gap on OHS issues in OM. Based on the two popular safety management theories, normal accident theory (NAT) and high-reliability organization theory (HRT), two empirical studies were conducted to examine the relationship between safety and financial performance. The first empirical study reveals the operational antecedent of safety incidents and the practices of OHS management in the operation processes of fashion and textiles manufacturers. Safety incident is an undesirable circumstance that has the *potential* to cause workplace injuries and illnesses. Results find that tightly coupled operation is a

significant predictor of safety incidents (violation of safety regulations), while retaining financial slack resources could reduce the harm of tightly coupled operations. The second empirical study shows that the adoption of OHSAS 18001, a popular occupational health and safety management system certification, could improve firm's safety and financial performance. The firms operating in complex and tightly coupled settings could benefit more from the adoption.

This dissertation has essential theoretical contributions to OM and safety research scholars. First, the citation network analysis review identifies five major research domains and backbone knowledge structure of each domain objectively. The future research opportunities of OHS topics in OM literature are proposed. Second, the findings from the two empirical studies syntheses NAT-HRT views on safety and financial performance relationship. The results show that tightly coupled operations would encounter higher safety risk, and the slack resources can be a useful buffer for tightly coupled operations. Third, the finding provides evidence to resolve the productivity-safety paradox and the results suggests that improved safety performance caused by OHSAS 18001 adoption leads to improved financial performance, implying that the merit of safety management is larger than its constriants to the operational efficiency.

This dissertation provides several managerial implications to the operations managers in fashion and textiles manufacturers. First, fast fashion manufacturers should be aware that the higher OHS risk in their operation processes results from the tightly coupled operations nature of fast fashion. Second, fast fashion manufacturers should maintain financial slacks to minimize OHS risk. Third, the managers who plan to adopt occupational health and safety management system (i.e., OHSAS 18001 certification) can expect improvement in firm's safety, sales, and productivity performance, especially when the manufacturers are labour and R&D intensive, and the inventory level is volatile.

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1. Introduction

1.1. Research Background

Corporate social responsibility (CSR) greatly associates with a fashion brand's image and consumer's buying intention (Werther & Chandler, 2005). However, a series of recent high-profile occupational health and safety (OHS) scandals have increased public concern over CSR practices in the global fashion supply chain. Media claimed that the operations processes of fashion firms may be putting workers' lives at risk (Dudley et al., 2013). Numerous fashion firm workers are exposed to serious occupational hazards (Hobson, 2013). The safety incidents have negatively affected both workers and firms. For example, the U.S. Occupational Safety and Health Administration (OSHA) issued a US$55,000 fine to Forever 21 for repeatedly violating workplace safety standards (Goodison, 2013). A fire at an Inditex factory in Bangladesh on January 26, 2013, killed at least seven people (Dudley et al., 2013). The 2013 Rana Plaza collapse in Bangladesh killed more than 1,100 people, mostly apparel factory workers (Donaldson, 2015), and brought public condemnation upon the fashion brands associated with the building, among them Benetton, JC Penney, and Wal-Mart (Forbes, 2014). Such examples demonstrate the urgency and inevitability of scholars' investigation on OHS in the fashion and textiles industry.

1.2. Operations management perspective

Scholars have suggested that safety should be treated as a key operational priority in addition to cost, quality, flexibility, delivery, and innovation (Brown, 1996; Pagell et al., 2014). Nowadays, safety is a legal and moral obligation that a fashion firm must fulfill to maintain its survival legitimacy in the industry. Stakeholders of all kinds require firms to demonstrate sound OHS performance by obeying to OHS policy and controlling OHS risk in the operation processes (OHSAS Project Group, 2007). Frequently happened safety incidents indicate the failure of an organization to meet the expectations of stakeholders such as consumer, investor and government. Furthermore, it also represents poorly managed operations of the firm because safety incidents often happen in operational contexts.

However, in the operations management (OM) literature, scholars pay little attention to the OHS topics (Brown, 1996; Das et al., 2008; De Koster et al., 2011; Pagell et al., 2014). The OHS is mostly studied in other academic disciplines such as occupational medicine and ergonomics. The regulation and management systems resulting from this research has been aimed at managing and controlling operational settings to improve the safety of workers. By mostly overlooking the safety of workers, OM scholars have abdicated some control and understanding of the operational setting.

Absent an operational perspective, the understanding of OHS is lack, with limited implications for both the OHS of workers and other operational/financial outcomes (for a full discussion, see Das et al., 2008 or Pagell et al., 2014). Moreover, the literature provides divergent implications regarding how OHS is related to other operational priorities and performances. Therefore, investigating OHS issues is an inevitable task for OM scholars.

This dissertation contributes to the OM literature by addressing OHS issues in the context of fashion and textiles industry. This paper first comprehensively reviews the OHS-related OM literature (study one). The review reveals that the areas of sustainable operations and the effect of occupational health and safety management systems (OHSMSs) are underdeveloped in operations safety literature. Thus, the second study contributes to the sustainable operations domain by determining what types of fashion and textile firms encounter higher OHS risks and how these firms can minimize the risk of safety incidents (study two). Specifically, by synthesizing normal accident theory (NAT) and high reliability organization theory (HRT), this study confirms that fashion firms with tightly coupled operations (e.g., fast fashion firms) record more from safety incidents and those organizational slacks may aid these firms in resolving the safety problems. The third study contributes to the OHSMS domain by revealing how the adoption of OHSAS 18001(a widely used OHSMS certificate) affects manufacturing firms' performance (study three). This study provides evidence that adopting OHSAS 18001 can positively affect a manufacturing firm's operating and financial performance. In addition, we found that firms operating in a complex and tightly coupled environment could benefit more from adopting OHSAS 18001.

The later version of study one, entitled "Occupational health and safety issues in operations management: A Systematic and citation network analysis review", has been published on *International Journal of Production economics*. The later version of study three, entitled “OHSAS 18001 certification and operating performance: The role of complexity and coupling” has been published on *Journal of Operations Management*. The licenses of using the two publications in this dissertation are attached in the appendixes.

2. Study one: Systematic and Citation Network Analysis Literature Review

This study comprehensively reviews the OHS-related OM literature. Along with environmental issues, managing OHS issues is another element of business sustainability (Kleindorfer et al., 2005; Montero et al., 2009). Despite the popularity of sustainable operations management (SOM) research, scholars often pay less attention to OHS management than to environmental management (Das et al., 2008; De Koster et al., 2011; Lo et al., 2014; Seuring &Muller, 2008). Examining the existing knowledge structure of OHS studies and identifying the future research trend in OHS-related OM literature is essential.

Based on our search, no comprehensive and systematic review of OHS topics is found in OM literature. We identified only seven reviews, each of which examined only fractions of the OHS literature. Guldenmund (2000) reviewed 17 safety culture and climate studies from a social and organizational psychology perspective. Choudhry et al. (2007) reviewed safety culture issues in the construction industry. Kleindorfer et al. (2005) reviewed SOM studies but did not prioritize OHS issues. Cohen and Kunreuther (2007) reviewed all Paul Kleindorfer's articles about operations risk management, with OHS identified as a subtopic. Gunasekaran & Spalanzani (2012) reviewed sustainable business development literature, but OHS issues were only part of their focuses. Robson et al. (2007) reviewed the effectiveness of OHS management systems by studying 13 articles from medicine and public policy journals. To comprehend the shortcomings of previous review works, the current study performed a comprehensive and systematic review of OHS-related literature and adopted an OM perspective. Thus, the objectives of this review are:

1. To describe the OHS-related OM articles' nature such as journals, year of publications, methodology, and research context.
2. To identify the major research domain of OHS.
3. To draw a knowledge structure map of each major research domain in the OHS–related OM articles.
4. To identify the research trends and suggest future research opportunities for each research domain from an OM perspective.

2.1. Methodology

The identification of research domains and knowledge structures is the primary limitation of previous systematic literature reviews (SLRs). Both tasks are often performed according to the author's subjective judgment (Colicchia &Strozzi, 2012; Ngai et al., 2007). To address this concern, scholars have attempted to introduce citation network analysis (CNA) into SLRs to pursue an objective approach for research domain identification and classification (e.g., Chen & Redner, 2010; Colicchia & Strozzi, 2012). CNA could be a useful tool in identifying research domains, thereby revealing the evolution of research trends, and mapping the changing paradigms (Hummon & Doreian, 1989; Colicchia & Strozzi, 2012). CNA is based on the assumption that citation networks are not only formless connections between articles but systematic channels transforming scientific knowledge (Hummon & Doreian, 1989). In addition, the researchers in the same field tend to cite each other and add new knowledge in the new research, thus advancing the knowledge of their field (Colicchia & Strozzi, 2012).

This study reviewed the sample articles from seven peer-reviewed journals, namely the *International Journal of Production Economics* (IJPE), *International Journal of Production Research* (IJPR), *Journal of Cleaner Production* (JCP), *Journal of Operations Management* (JOM), *Manufacturing and Service Operations Management* (MSOM), *Production and Operations Management* (POM) and *Safety Science* (SS). Each of these journals is reputable and their scopes, excluding that of SS, fall within the OM discipline. This review included SS because it is the most prestigious journal in the safety discipline (in terms of impact factor and the length of publication) and is interdisciplinary in nature. The articles were located in the Scopus database. The keyword "safety management" was input first. The results of the first keyword search were then narrowed down by adding the keywords "occupational" and "operation." The review period was 1996 to 2012. 128 published articles were found for use as the samples.

The citation and reference data of the sample articles were recorded. Following the common network analysis approach (Wasserman & Faust, 1994), a binary matrix was constructed to record the citation networks of the samples. The be-cited references were recorded in rows, and the samples were recorded in columns. A value of “1” was given if a citation relationship existed between column samples and row references, otherwise “0” was given.

2.2.Descriptive statistics

This section presents the descriptive statistics of the sample articles, including the articles’ journal, year of publication, and type. The descriptive statistics outline the current status of OM literature in OHS topics. A subsample of empirical studies is considered by examining the research methodologies and research contexts (i.e., industry and country) of the papers.

2.2.1. Distribution of articles by journal

Figure 2.1 illustrates the distribution of articles in the seven journals. The six OM journals published 33 of the articles (25.78%), with17 from JCP (13.28%), six from POM (4.69%), five from JOM (3.91%), three from IJPE (2.34%), and one each from IJPR (0.79%) and MSOM (0.79%). Ninety-five articles were from SS (74.22%). The distribution reveals that OHS issues received little attention from the traditional OM journals, despite the call by Brown (1996) for more OHS-related work in the OM discipline is far (De Koster et al., 2011).

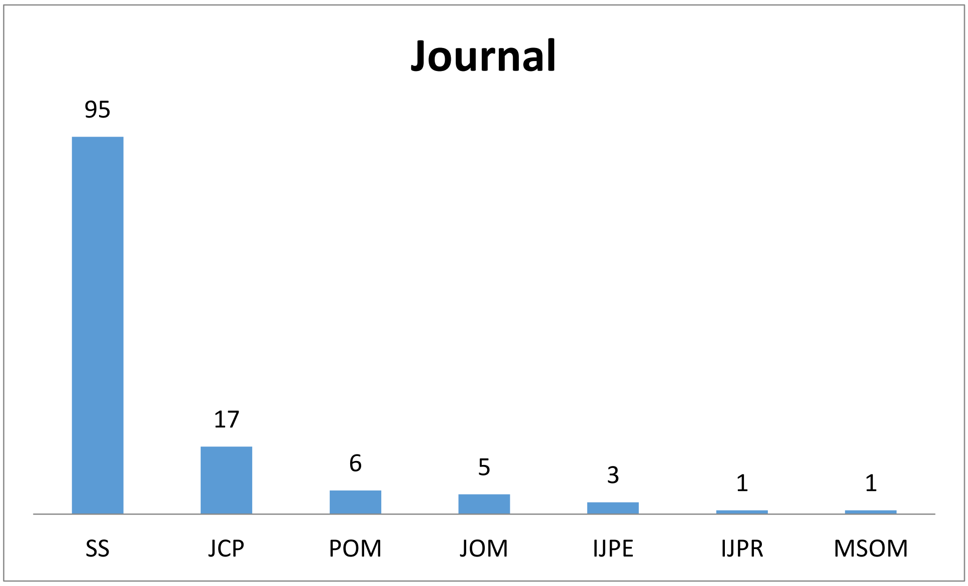

Figure 2-1: Article distribution by journal

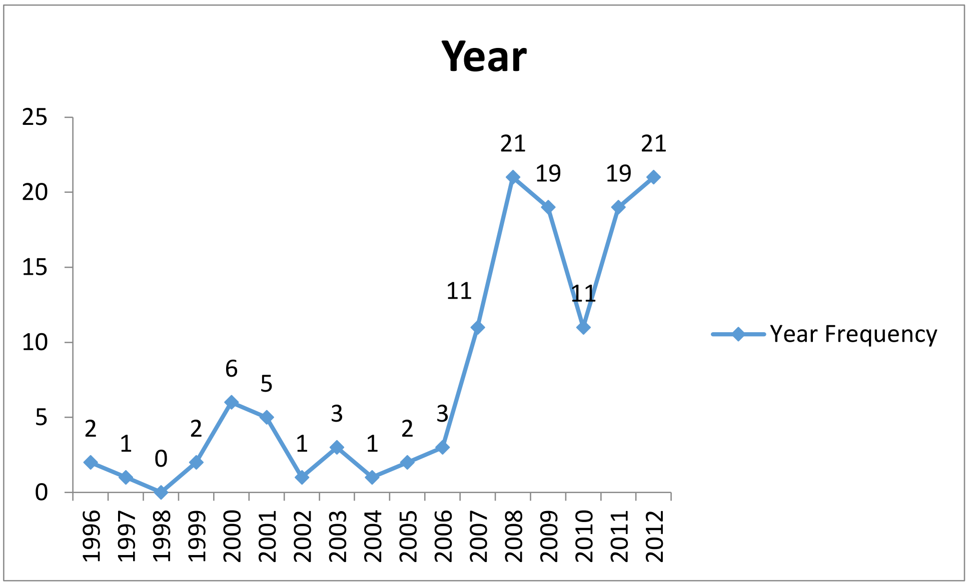

Figure 2-2: Article distribution by year of publication

2.2.2. Distribution of articles by year of publication

Figure 2-2 illustrates the distribution of articles by year from 1996 to 2012. The figure indicates a growing interest among OM scholars in OHS issues in the OM discipline. Researches in OHS increased tremendously in the last six years of the study period, during which 102 (79.68%) of the articles were published.

2.2.3. Distribution of articles by type

Figure 2-3 shows the distribution of article type. Most of the papers (87 articles, 67.97%) are empirical studies. The remaining 41 articles, which do not present any empirical data, comprise 32 conceptual papers (25.00%), six reviews (4.69%), two meta-analyses (1.56%), and one modeling paper (0.78%). Such a high proportion of conceptual papers is unsurprising for an emerging and unexplored research area.

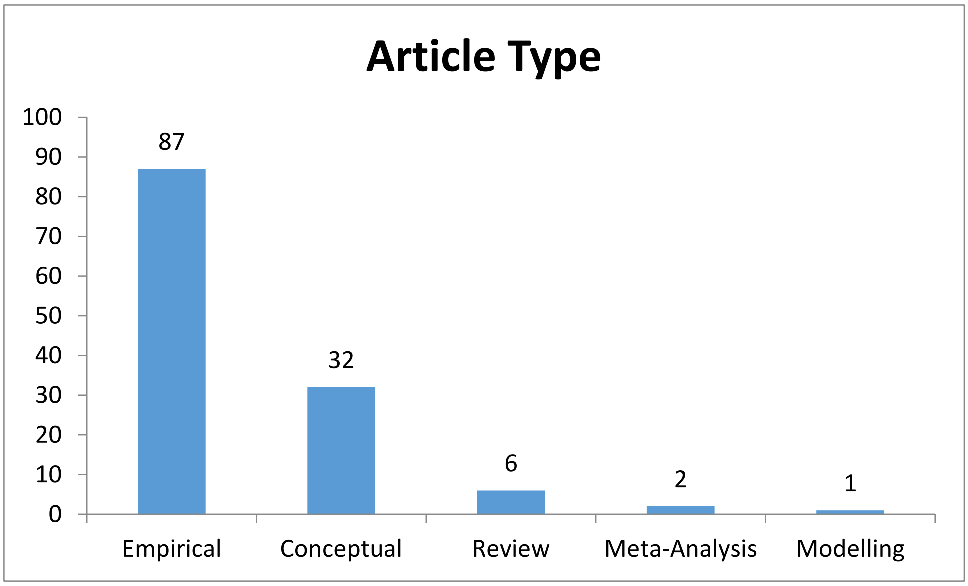

Figure 2-3: Distribution of articles by research strategy

2.2.4. Methodologies in empirical studies

Figure 2-4 presents the data collection methods of the empirical studies. Studies using a self-reported data collection technique comprised 83.91%of the articles, 60 (68.97%) of which used surveys and 13 (14.94%) of which used interviews. For non-self-report data collection, Archival (eight articles) and multisource data (six articles) accounted for 9.19% and 6.90%, respectively.

Figure 2-5 shows the distribution of methodologies used in the empirical studies. Sixty-three articles used statistical analysis (72.41%), 15 examined case studies (17.24%), three provided only the descriptive statistics of surveys, three used qualitative approaches to interpret data, and another three used multiple methodologies (3.45%).

2.2.1. Research context in empirical studies

The empirical studies involve varying contexts in terms of countries and industries. **Table 2-1** lists the five countries most examined by the empirical studies. The United States received the highest focus (15 articles, 17.24%), followed by Norway (11 articles, 12.64%), Spain (nine articles, 10.34%), and Australia and China (five articles each, 5.74%).

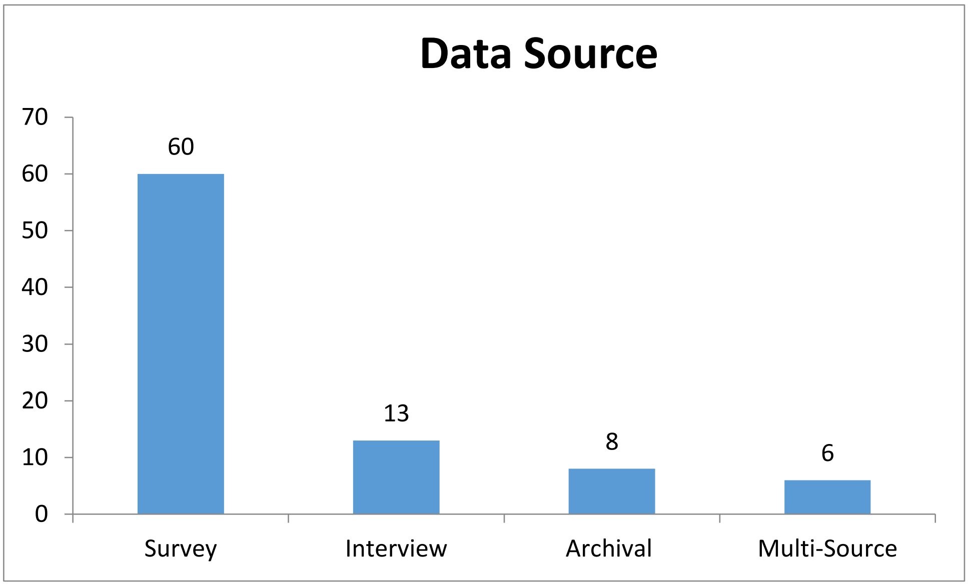

Figure 2-4: Distribution of data collection method in empirical studies

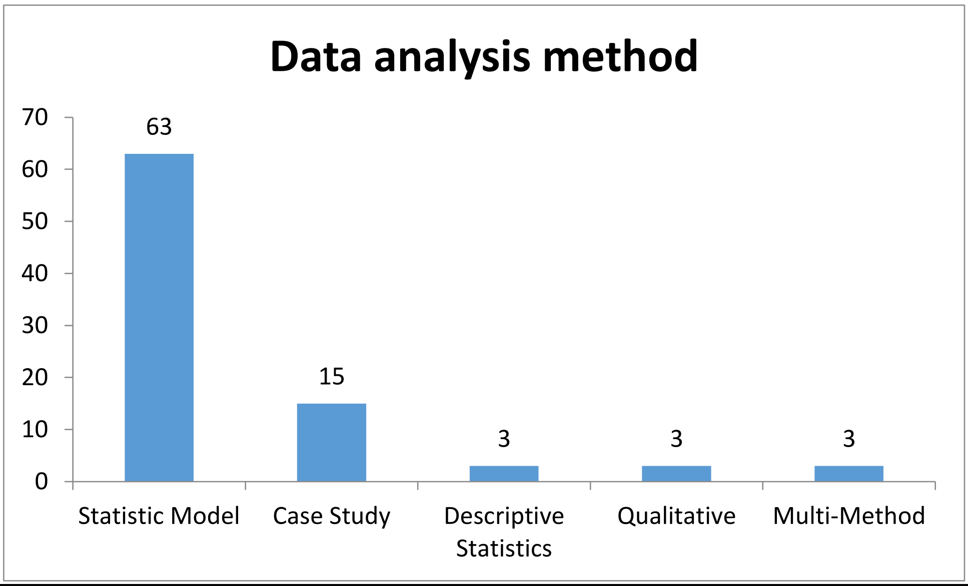

Figure 2-5: Distribution of data analysis method in empirical studies

Table 2-1: Distribution of empirical papers by countries researched

Top 5 Countries	Number
U.S.	15
Norway	11
Spain	9
Australia	5
China	5

Table 2-2: Distribution of empirical papers by industries researched

Top 5 Industries	Number
Multiple-industries	23
Petroleum	11
Construction	10
Manufacturing	8
Chemical	5

Table 2-2 lists the five industries most assessed by the empirical studies.

Twenty-three articles (26.44%) investigate multiple industries context, for example, the manufacturing and service industries. Among the articles with a single-industry context, 13 (14.94%) and 10 (11.49%) examined the petroleum and construction industries, respectively. These two industries are considered more dangerous in the operation processes (Wolf, 2001; Zeng et al., 2008). The manufacturing and chemical industries were studied by eight (6.25%) and five (5.74%) articles, respectively.

2.2.2. Summary

According to the descriptive statistics of the sample articles, we propose several future research directions for OM scholars interested in OHS issues. First, empirical studies are the most popular type of research for OHS issues; mathematical modeling is rarely used but may be useful in answering some research questions. For example, the trade-off between improved OHS performance and labor productivity is an interesting but still unresolved research question. Scholars have widely supposed that OHS practices can improve the safety performance of firms, thus less interruption and absenteeism occur in the operation and productivity increases (e.g., Fernández-Muñiz et al., 2009; Oxenburgh &Marlow, 2005). However, scholars are worried that strict OHS rules and practices will reduce productivity (De Koster et al., 2011). Therefore, the most insightful question to answer may be not whether OHS practices can improve or reduce productivity, but what level of OHS practices can optimize productivity. The optimization technique from modeling could help address this problem.

Second, although using self-reported data to measure OHS constructs is necessary (Guldenmund, 2000, 2007), common method bias, such as social desirability bias, may influence the data analysis results (Pagell & Gobeli, 2009; Podsakoff et al., 2003). For example, interviewees (often operations managers) may not want to be perceived as lacking OHS awareness and may thus provide overly optimistic responses (Smallman & John, 2001). Multiple data collection techniques could help reduce social desirability bias (Doty & Glick, 1998; Pagell & Gobeli, 2009).

Third, OHS issues are well discussed in developed countries but less so in developing countries. More sample articles (81.61%) investigate OHS issues in developed countries, where OHS regulations are tighter, than in developing countries (12.64%), where OHS problems (e.g., sweatshops) are more severe. Numerous leading multinational corporations have outsourced their production to reduce costs. Operating managers and OM scholars will inevitably extend their OHS focus to the developing countries, the OHS-related concerns of which may differ from those in developed countries. For example, the primary incentive for firms in developed countries is to prevent accidents and the interruption of operations (Fernández-Muñiz et al., 2012), whereas the primary incentivefor firms in China is to satisfy customer demands (Law et al., 2006).

Fourth, the studies focusing on fashion and textiles industry are missing in the literature. As a labor intensive industry, the consequences of workplace accidents in fashion and textiles manufacturers can be serious. The disaster of Rana Plaza is a crucial alert for scholars and practitioners to keep a watchful eye on the OHS issues in fashion and textiles industry.

2.3. Classification of research domains

To further examine the OHS knowledge structure, we adopted the Girvan–Newman (2002) clustering algorithm to analyze the citation networks for research domain classification. The algorithm can determine the community structure of a citation network from previous literature (Chen & Redner, 2010). The assumption of the clustering algorithm is that if the different clusters of nodes in a network are connected by a few edges, then a node in a cluster must go along one of these edges to connect to another cluster. Girvan and Newman (2002) defined “edge betweenness” (EB) as the number of shortest paths between pairs of nodes that run along an edge. Therefore, the intercluster edges have higher EBs than do intracluster edges. By removing the intercluster edges each time, we can detect the potential clusters in the network (Girvan & Newman, 2002).

This study avoided predicting the number of clusters before the analysis. We evaluated the network every time that we removed the edge with the highest EB for the optimal classification. Newman and Girvan (2004) proposed using Q-values to estimate the quality of a particular classification in a network. The larger the Q-value, the more optimal the classification (Newman & Girvan, 2004). For more details about Q-value derivation, see Newman Girvan (2004). One form of the calculations is

$$Q = \sum_{S=1}^{k} \left[\frac{m_s}{m} - \left(\frac{d_2}{2m} \right)^2 \right]$$

where k is the number of clusters, s is the cluster, m is the number of edges, m_s is the number of edges in cluster s, and d_s is the sum of the node degree in clusters (Yang et al., 2009). The Girvan–Newman clustering and Q-value calculation was conducted using UCINET6 (Borgatti et al., 2002).

Figure 2-6 shows the Q-value obtained from Girvan–Newman clustering. The value peaks at 24 clusters, indicating that dividing the citation network into 24 clusters is optimal (Q=0.389). The Q-value of 0.389 is within the normal range of 0.3–0.7 (Newman & Girvan, 2004).

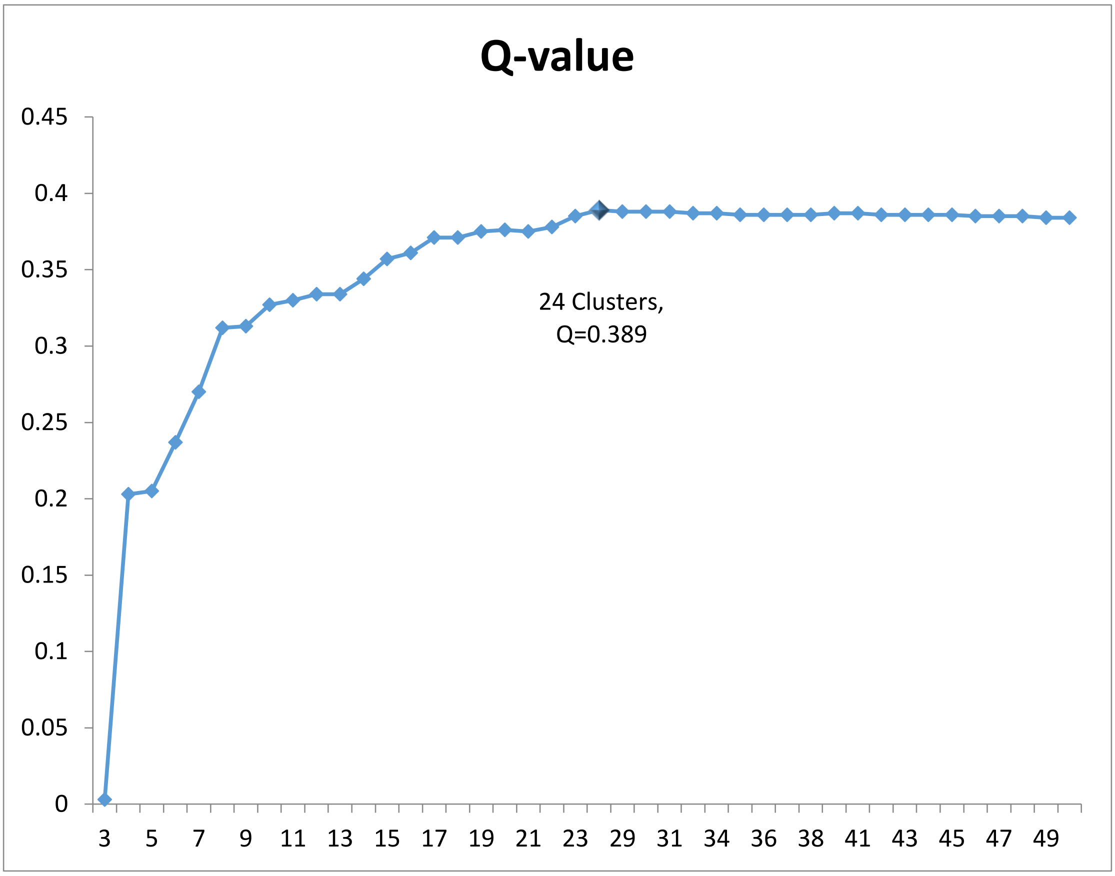

Figure 2-6: Q-Value of Girvan-Newman Clustering

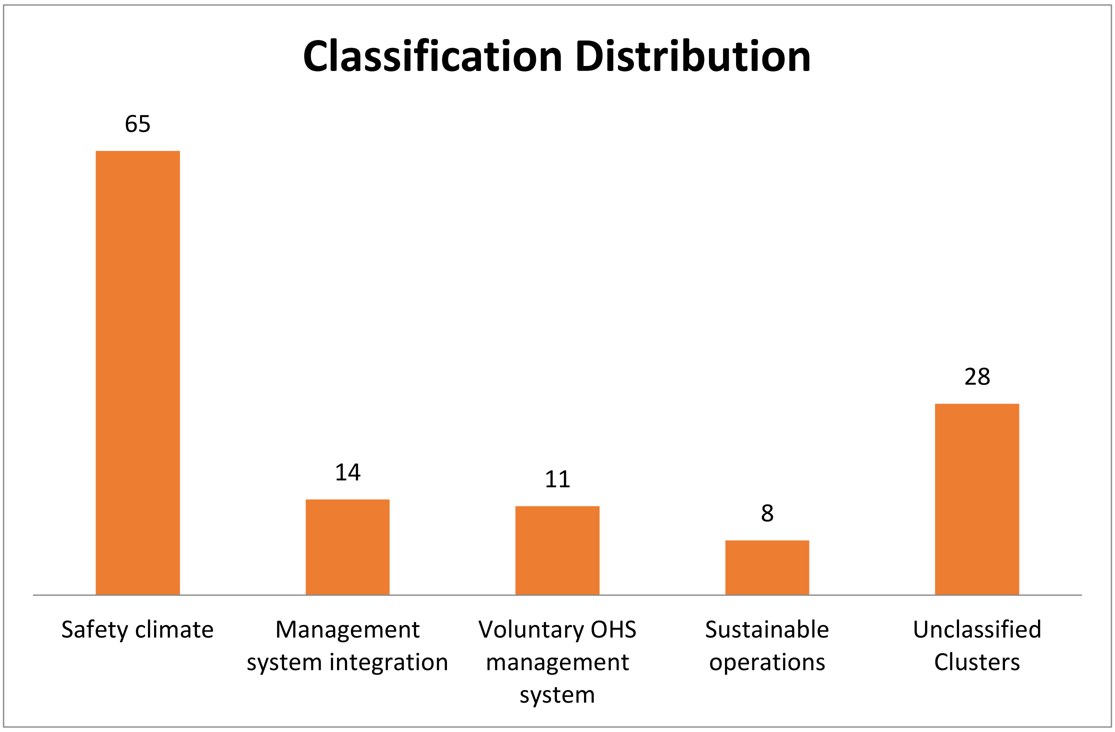

Figure 2-7: Article Classification

Of the 24 clusters, 20 comprises only one or two articles; we categorized these sample articles into "scattered clusters" (with 28 articles, 21.88%). We carefully reviewed these articles and confirmed that no correlations existed among these articles. The other four clusters comprised a total of 100 articles. As shown in **Figure 2-7**, safety climate and culture was the most popular research domain (65 articles, 50.78%), followed by management system integration (14 articles, 10.93%), voluntary OHS management systems (13 articles, 10.16%) and sustainable operations (eight articles, 6.25%). **Appendix A** presents the research domain classification results and a complete list of the sample articles. The citation network of these papers is shown in **Figure 2-8**.

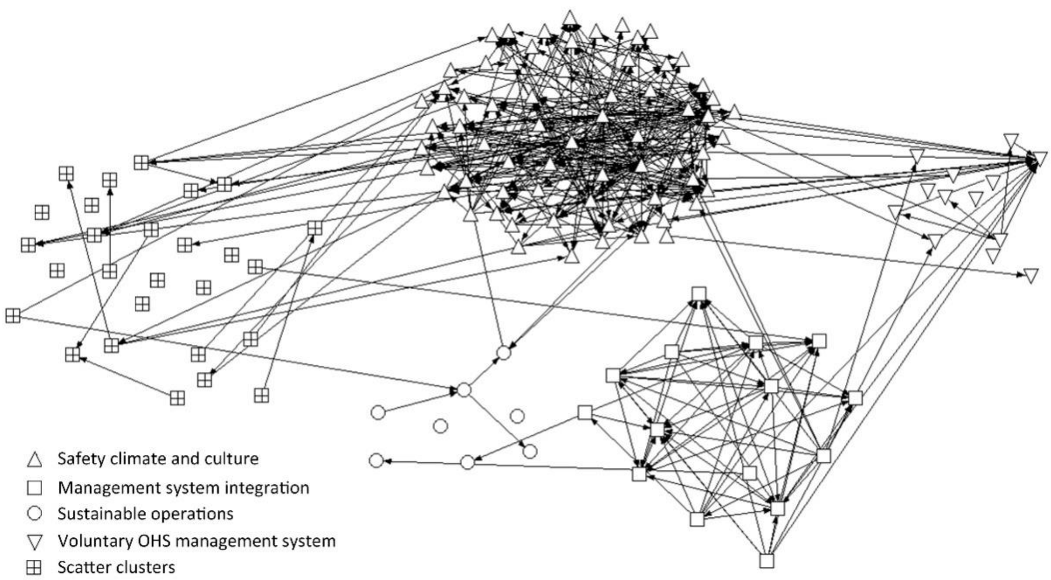

Figure 2-8 Citation network of the sample articles

2.4. Main path analysis of major research domains

We further identified the knowledge structures of the four major research domains (i.e., safety climate and culture, management system integration, voluntary OHS management systems, and sustainable operations). Following the Colicchia and Strozzi (2012) guidelines for main path analysis (MPA), we constructed the knowledge structures by weighting the citations in the clusters and identified the most critical citation path (De Nooy et al., 2005). According to Colicchia and Strozzi (2012), the weighting of a citation can be calculated using the following equation:

$$\mathrm{Weight}_{ij} = \frac{\mathrm{TP}_{ij}}{\mathrm{TSS}_{j}}$$

where TP_{ij} is the total number of paths in network j including the citation i, and TSS_j is the total number of paths between the sources (i.e., articles that do not cite others) and sinks (i.e., articles that are not cited by others) in network j. The weighting can be interpreted as the ratio of actual usage of a path (citation) to the all possible paths that can be used going from the sources to the sinks. MPA is conducted using the software package Pajek 2.05(De Nooy et al., 2005).

2.4.1. Safety climate and culture

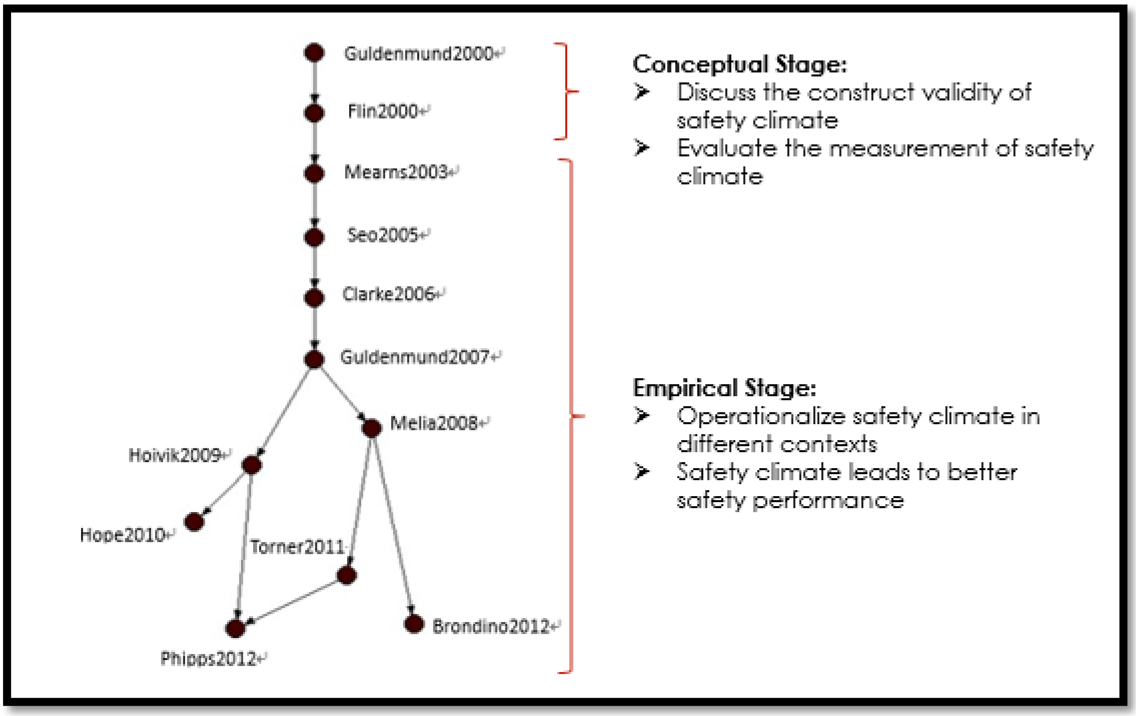

Figure 2-9: Main path of safety climate

Safety climate and culture is the largest research domain we identified in the previous section. Figure 2-9 presents the key milestones of the knowledge development in this domain. The literature usually presents safety climate and safety culture together, such as "safety culture/climate," (Cooper, 2000; Guldenmund, 2000), implying that the two terms are similar. Safety culture is defined as "the product of individualand group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to organization's health and safety management" (Lee, 1996). Safety climate is a "snapshot" of safety culture at a given point of time; more specifically, safety climate is the measurable surface features of safety culture (Cox &Flin, 1998; Flin et al., 2000).

Safety climate is a key indicator of safety performance (Guldenmund, 2000; Zohar, 1980). Studies in the 1980s and 1990s proposed various conceptual models to describe the relationship between safety climate and culture and safety performance (e.g., Cox & Cox, 1992; Eagly & Chaiken, 1993; Glennon, 1982). However, those studies failed to provide solid empirical evidence for the association because the construct validity of safety climate is neglected (Guldenmund, 2000). Therefore, Guldenmund (2000) suggested that an accurate technique for measuring safety climate and culture is critical. Flin et al. (2000) reported that management attitudes toward safety production, safety management systems (e.g., safety policy, equipment, and committees), and risk perception are the top three dimensions of safety climate. These two articles (Guldenmund, 2000; Flin et al., 2000) enabled later safety climate researchers to use empirical data.

Mearns et al. (2003) revealed a negative association between some safety climate elements (e.g., communication) and accident cases. Seo (2005) found that a safer climate can reduce unsafe behavior. Clarke (2006) classified the Mearns et al. (2003) safety climate measurement as an “attitudinal approach” that focuses on measuring employee attitude toward safety. The method of Seo (2005) was classified as a “perceptional approach” that focuses on measuring employee perception of their working environment (e.g., safety policies and practices). The perceptional approach was demonstrated as exhibiting greater predictive power for workplace accidents than did the attitudinal approach (Clarke, 2006).

Guldenmund (2007) studied the safety climate measurement questionnaires of earlier empirical studies and provided three comments on these works. First, the studies were difficult to replicate because they involved too many factors. Second, management and organizational factors caused most of the data variance. Third, the studies investigated various safety management processes with diverse focuses. To help advance the discussion of the safety climate construct, Guldenmund (2007) proposed a unified nine-factor safety management framework comprising(a) risk, (b) hardware design, (c) maintenance, (d) procedures,(e) manpower planning, (f) competence, (g) commitment, (h) communication, and (i) monitoring.

Two branches of knowledge on safety culture emerged after the Guldenmund (2007) framework was proposed. The first branch considered the safety climate in offshore production. Hoivik et al. (2009) and Hope et al. (2010) conducted series studies of safety climates in the offshore petroleum industry. Offshore firms were usually found to have safer climates than do inland firms (Hoivik et al., 2009). A safe climate can reduce the working stress of offshore workers (Hope et al., 2010). The other branch considers the safety climate promotion among the workgroups of an organization. Melia et al. (2008) identified four workgroup levels for safety climate promotion, namely organization, supervisors, coworkers, and workers. Torner (2011) examined the interaction between supervisors and workers and provided suggestions for developing safety climate within the workgroups. Brondino et al. (2012) confirmed that the coworker safety climate influences safety behavior more strongly than does the supervisor safety climate. Phipps and Ashcroft (2012) classified the types of safety climate in health care organizations according to workgroup influences.

In the safety climate context, safety management scholars further developed and validated the safety climate construct according to the suggestions and framework of Guldenmund (2000, 2007). The safety climate construct has been operationalized in several industrial contexts, such as petroleum (e.g., Hoivik et al., 2009; Hope et al., 2010), health care (Phipps & Ashcroft, 2012) and construction (Melia et al., 2008). The association between safety climate and safety performance (i.e., safety behavior and accidents) is well documented. Recent studies have attempted to establish an association between safety climate and product quality, but the connections between safety climate and other operation priorities (e.g., delivery, cost, and flexibility) and the ultimate financial performance are still underdeveloped (Das et al., 2008; De Koster et al., 2011).

2.4.2. Management system integration

Management system integration is the second largest OHS research domain. Figure 2-10 presents the main knowledge structure of this domain. The main management systems discussed in this domain are the quality (ISO 9000), environmental (ISO 14001) and occupational health and safety (OHSAS 18001) management system. OHSAS 18001 is a voluntary OHS management system certification introduced in

1999. By 2010, 56,251 facilities in 116 countries were OHSAS 18001-certified (British Standards Institution, 2011). Many multinational corporations have obtained the certificate (e.g., Apple, Boeing, Cisco Systems, Coca-Cola, HP, Intel, and Texas Instruments) and then requested their suppliers to do likewise. The prevalence OHSAS 18001 adoption raises research interest in the integration of OHS management systems with ISO 9000 and ISO 14000 (De Oliveira & Coelho, 2002).

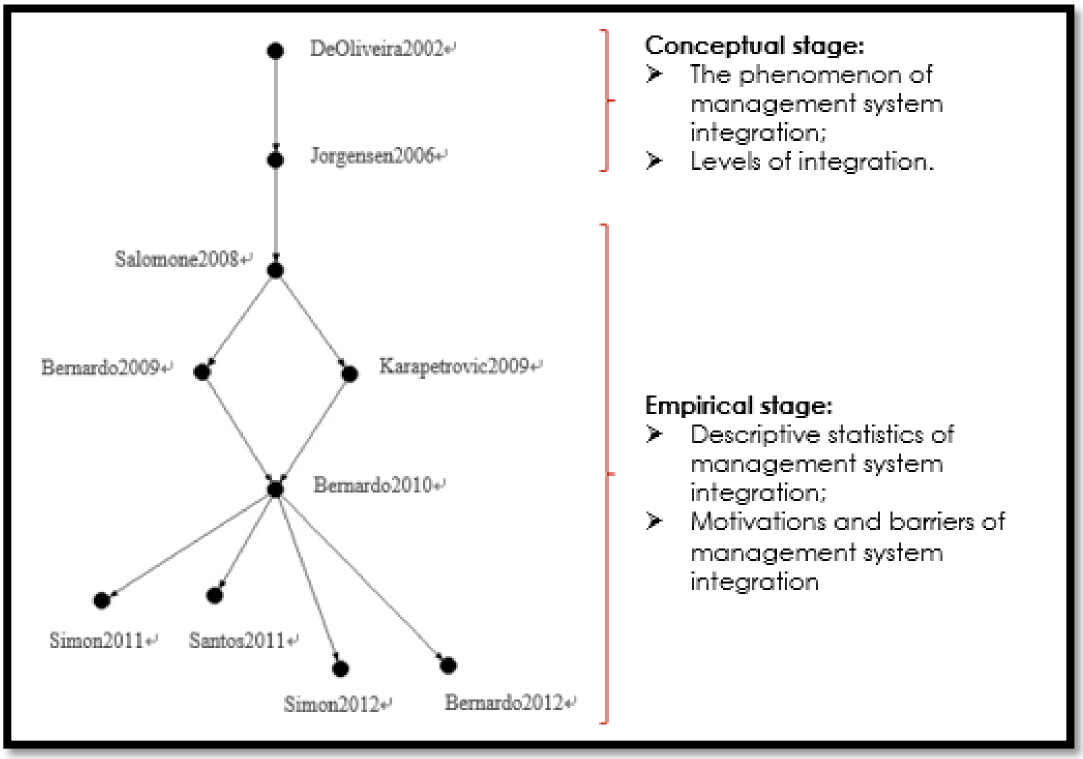

Figure 2-10: Main path of management system integration

Many survey-based researches have been conducted in European countries in management system integration domain. Most European firms, such as those in Italy (Salomone, 2008), Portugal (Santos et al., 2011), and Spain (Karapetrovic & Casadesus, 2009; Simon et al., 2012), tend to integrate management systems into a single system, and the propensity to do this has been increasing (Salomone, 2008;

Simon et al., 2012). The main motivations behind integrating management system are to optimize and unify auditing (internal and external), to reduce documentation and bureaucracy and save time (Salomone, 2008; Santos et al., 2011). Problems encountered during management system integrationarea lack of human resources, integration guideline and compatibility conflicts among the systems (Simon et al., 2012), a higher cost of simultaneous system adoption, and changes in systems because of operational changes (Santos et al., 2011).

The level of integration is also a major focus in management system integration domain. Jorgensen (2006) proposed three levels of system integration, namely the lowest level, “corresponding”; the medium level, “coordinated and coherent”; and the highest level, “strategic and inherent.” Bernardo et al. (2009) used cluster analysis to identify the characteristics of each level empirically. The differences of management system goal, documentation, human resources, and procedures may determine the level of integration (Bernardo et al., 2009). Furthermore, management system auditing was discussed as a key factor in integration level (Bernardo et al., 2010; Simon et al., 2011). The elements (i.e., management system goals, documentation, human resources, procedures, and auditing) have been commonly used in studies measuring system integration level (e.g., Simon et al., 2012). However, the association between integration level and firm performance has not been clearly established.

Scholars have proposed that management system integration may improve internal coordination, which can reduce administrative burdens (Jorgensen et al., 2006), the duplication of planning and execution (Salomone, 2008), and wastage and operating costs, thereby eventually improving efficiency and productivity (De Oliveira & Coelho, 2002; Simon et al., 2012). The propositions are purely theoretical and proving them requires solid empirical evidence. An interesting research avenue is investigating in which contexts integration could yield the most operational benefits.

Finally, OHSAS 18001 is often viewed as the third step in achieving systematic management. However, scholars have long questioned the compatibility of OHSAS 18001 with ISO 9000 and ISO 14000 (De Oliveira & Coelho, 2002). Firms with only ISO 9000 and ISO 14000 achieved higher integration than did firms with all three certificates (Bernardo et al., 2012), suggesting possible OHSAS 18001 incompatibility. Further research into compatibility between the three systems is required.

2.4.3. Voluntary OHS management system

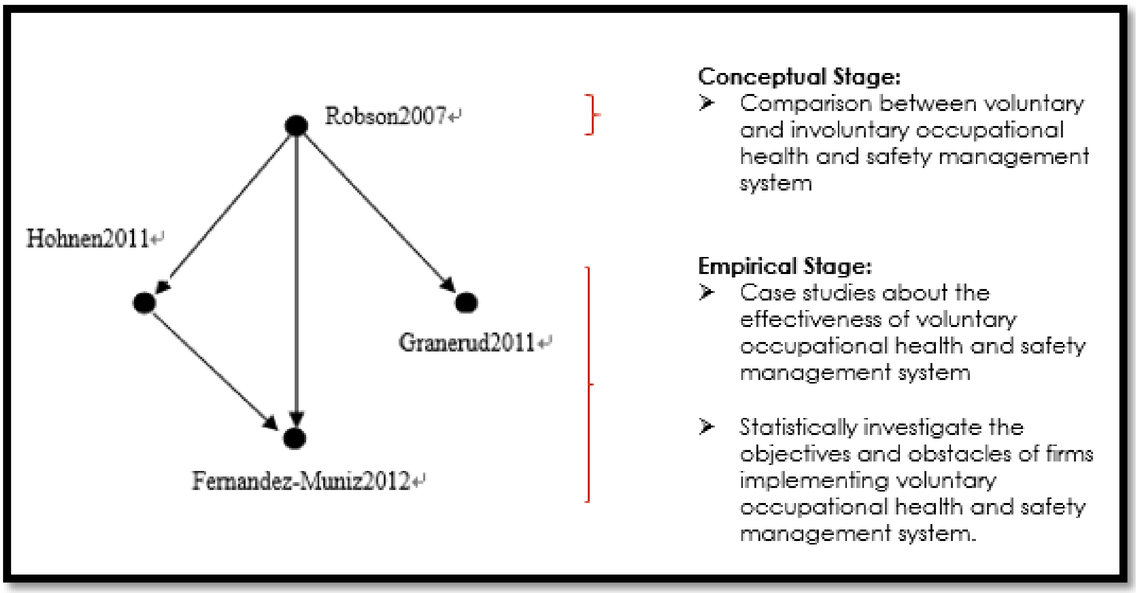

Figure 2-11: Main path of voluntary OHS management system

The articles of voluntary OHS management systems constitute the third largest OHS research domain. A voluntary OHS management system requires a proactive and internally integrated OHS program that incorporates safety evaluation and continuous improvement (Robson et al., 2007). Several international certifications, such as OHSAS 18001, CSA Z1000, and ANSI Z10, exist for firms with voluntary OHS management systems that can maintain a safe workplace. The voluntary OHS management system domain mainly considers the effectiveness of voluntary OHS management systems. Figure 2-11 shows the main path of this domain.

In most developed countries (e.g., Canada, the U.S., and Spain), OHS regulations are tight, thus requiring firms to adopt OHS systems. Basic OHS management systems have been widely implemented to protect workers. The effectiveness of basic OHS management system has been discussed at the policy level (e.g., Gray, 1981; Gray &

Jones, 1991). With the increasing adoption of voluntary OHS management systems (e.g., OHSAS 18001), scholars have begun to study the effectiveness of voluntary OHS management systems (Robson et al., 2007). Two case studies challenged the positive effect of OHS management systems. Granerud and Rocha (2011) found that adopting OHSAS 18001 exerted little effect on the organization learning toward continuous improvement. Hohnen and Hasle (2011) reported that firms acquire OHS management system certification mainly to render their OHS performance auditable. Such audits are mainly used to fulfill the demands of external stakeholders (e.g., governments and markets) rather than making technical improvements (Hohnen & Hasle, 2011). However, a survey by Fernandez-Muniz et al. (2012) found that firms also expect and favor continuous improvement when adopting OHS management systems.

The articles in the voluntary OHS management system research domain could not prove the effectiveness of voluntary OHS management system (Robson et al., 2007). The main obstacle in this domain is the methodology's rigorousness (Robson et al., 2007). Longitudinal studies such as panel data analysis and event study approaches, should be used to investigate the change in safety and operating performance after adopting OHS management system (e.g., OHSAS 18001).

2.4.4. Sustainable operations

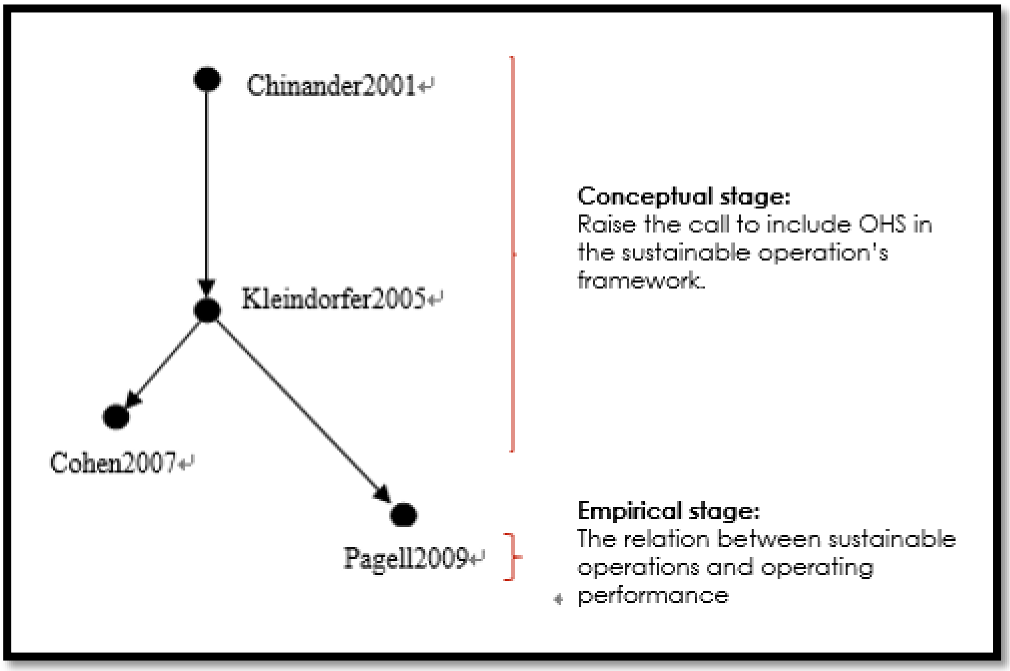

Figure 2-12: Main path of sustainable operations

Sustainable operations represent the final research domain of the sample articles (Figure 2-12). Despite the popularity among firms of using environment, health, and safety (EHS) programs to achieve sustainable operations, environmental management was the primary sustainable operations research (e.g., Chinander, 2001). Kleindorfor et al. (2005) suggested that the environmental and OHS areas should be integrated into a complete EHS framework. Cohen and Kunreuther (2007) further suggested integrating EHS into the framework of operations risk management because the EHS management may reduce operations risk. Pagell and Gobeli (2009) revealed the relationship between EHS and operating performance. Environmental and safety performance are operationalized by the proxy variables of toxic releases and violation of OSHA regulations, respectively. A positive relationship between EHS management and operating performance was demonstrated (Pagell and Gobeli, 2009), thus the balance and integration of the two management systems is an interesting research opportunity (Cohen & Kunreuther, 2007; Kleindorfer et al., 2005; Pagell & Gobeli, 2009).

Poorly managed EHS may place firms at great risk (Cohen & Kunreuther, 2007; Klassen & Vereecke, 2012). However, the risks have not been clearly identified. The risk assessment technique, risk perception of employees and management, and risk management skills of EHS require further research to guide the practices of the industry (Cohen & Kunreuther, 2007). Past studies have addressed the correlation but not the causation between EHS and operating performance (Pagell & Gobeli, 2009). Longitudinal research techniques are necessary to provide further evidence of causality (Pagell & Gobeli, 2009). In addition, a rigorous research design and statistical control are required to minimize the likelihood of endogeneity problems. For example, large corporations usually have more resources to initiate EHS management.

2.5. Summary

This study systematically reviewed the OM-related OHS issues from 128 articles. The Girvan–Newman algorithm was used to analyze the citation network of sample articles (Girvan & Newman, 2002) and four major research domains were identified, namely safety climate, management system integration, OHS management systems, and sustainable operations. The knowledge structures of each domain were explored using MPA (Colicchia & Strozzi, 2012; De Nooy et al., 2005). The research development and trend of each domain were analyzed, and future research directions were proposed.

Although OHS issues are critical to the image of fashion supply chain, the review shows that fashion and textiles industry is an overlooked context for OHS research. In addition, the CNA results indicate that the sustainable operations and voluntary OHS management systems domains are underdeveloped. Extending these research domains would provide new insights for safety operations scholars and operation managers. Therefore, the following studies contribute to these two domains by addressing the following research questions:

1) What are the operational antecedents of safety incidents?
2) How can firms minimize the likelihood of safety incidents in operations?
3) Whether adopting OHS management system leads to financial benefits?

Addressing the research questions should provide essential implications for the operation managers in fashion and textiles manufacturing firms to improve OHS and consequently financial performance.

3. Study two: Value of slack resources in fashion and textile firms with tightly coupled operations

This study contributes to the sustainable operations literature by revealing the operational antecedents of safety incidents and how to reduce safety incidents in fashion and textile manufacturers. This study draws from relevant organization theories about safety (i.e., NAT and HRT) and develops an OHS theoretical framework in operational settings. The implications for fashion and textiles manufacturers are discussed.

3.1.Theoretical background and hypothesis development

Depending on the level of analysis, the safety research are based on various theory foundations. At employee level, scholars normally build on psychological theories such as safety consciousness (Barling et al., 2002) and cognitive dissonance (Das et al., 2007). At team (group) level, the literature mainly based on the group culture theory such as the safety climate concept proposed in Zohar's (1980) article (Zohar and Luria, 2005). At organizational level, NAT and HRT are the two most commonly used theories in safety research viewing organizational processes as a complex interactive system (e.g., Brown, 1996; Brown et al., 2000; De Koster et al., 2011; Lo et al., 2014). This dissertation investigates OHS from an organizational angle, thus, we review the contrasting views of NAT and HRT theories and follow the Shrivastava et al. (2009) proposition of synthesizing the theories. We further develop a safety theoretical framework by discussing the relationship between slack resources and safety performance.

3.1.1. NAT and HRT

In the founding NAT literature, Perrow (1984) analyzed the Three Mile Island nuclear disaster and argued that accidents are inevitable, regardless of control mechanisms. Specifically, the key premises of NAT are that (a) safety failures can easily occur in complex and tightly coupled contexts. It is because workers have insufficient time and understanding to react correctly in dangerous situations, thereby causing accidents; and b) the additional redundancy in a system aimed at compensating for accidents increase complexity,thereby increasing the likelihood of accidents (Leveson et al., 2009; Sagan, 1995).

HRT scholars criticize NAT that accidents are rare in some industries despite their complex and tightly coupled operations (e.g., the nuclear energy, and aircraft industries). Thus, it implies that accidents are controllable (Leveson et al., 2009; Perrow 1984). HRT argues that organizations with collective mindfulness regarding safety can have a long record of accident-free operation (LaPorte et al., 1991; Roberts et al., 2001; Weick et al., 1993; Weick et al., 2008). The content of safety mindfulness includes a preoccupation with failure, sensitivity to operations, deference to experience, reluctance to simplify interpretation, and commitment to resilience (Weick et al., 2008). Collective mindfulness can increase an organization's capability to discover and manage unexpected dangerous situations (Weick et al., 2008).

NAT and HRT are often viewed as competing theories (Wolf, 2001, Rijpima, 1997; Shrivastava et al., 2009). However, Shrivastava et al. (2009) noted that considering time renders the two theories complimentary. These scholars proposed that organizations that are not constantly mindful would overtime drift (Snook, 2000) across the boundaries of reliable behavior into accident-causing behavior. Restated, an organization can stay highly reliable as long as it maintains mindfulness and does not drift from the prescribed behavior. However, maintaining high reliability is difficult because drift or entropy are normal states in organizations.

This study follows Rijpma (1997) and Shrivastava et al. (2009) in investigating the connection between NAT and HRT. Synthesizing the theories would suggest that mindfulness of safety is key to preventing accidents (Weick et al., 2008), yet worker mindfulness often drifts from reliable behavior to unsafe behavior, leading to safety incidents (Shrivastava et al., 2009; Snook, 2000).

3.1.2. Tightly coupled operations and safety incidents

NAT predicts that safety incidents increase with coupling (Perrow, 1984). The drift of mindfulness often occurs, particularly in tightly coupled production processes in which workers are usually under productivity pressure (Brown et al., 2000; Lo et al., 2014). When the operation elements are tightly coupled, the operational slack between elements is minimal (Perrow, 1984; Pagell et al., 2014). Operational slack is excess input for the output (Hendricks et al., 2009; Modi & Mishra, 2011). Removing slack means limiting the time that workers have to accomplish tasks; under such circumstances, workers may take safety shortcuts (an example of drift) to meet operational objectives (Pagell et al., 2014). Slack can create buffers for stochastic demand, stochastic processes, and unexpected failure in a firm's operations (Lo et al., 2014). Slack can also keep supply chains running by compensating any disruption. Thus, the workers do not have to deal with the unexpected circumstances hurriedly, allowing them to work as planned and reducing the likelihood of mindfulness drift. According to this discussion, we hypothesize:

H1: Tightly coupled operations have a higher likelihood of safety incidents.

3.1.3. Role of financial slack

HRT scholars highlighted the value of slack resources in preventing safety incidents (Rijpma, 1997). Slack resources can support failing parts in operations to avoid safety incidents (LaPorte et al., 1991). However, coupling inherently is correlated with operational slack inversely (Perrow, 1984); in tightly coupled operations, operational slack is minimal and increasing it could loosen coupling and reduce firm efficiency (Modi and Mishra, 2011; Pagell et al., 2014). Therefore, this study investigated whether financial slack can reduce the risk of safety incidents in firms with tightly coupled operations while maintaining the firms' tightly coupled nature.

Financial slack refers to the level of liquidity that is available to a firm (Kraatz & Zajac, 2001). Liquidity pressure often places productivity pressure on workers (Nickell and Nicolitsas, 1999). Operations safety and productivity are in conflict because productivity increases coupling, which could cause role overload among workers (Brown, 1996, Brown et al., 2000). Workers with productivity pressure may abandon mindfulness and take shortcuts to catch up with production objectives (Brown et al., 2000; Brown, 1996; De Koster et al., 2011). Therefore, maintaining sufficient financial slack provides a buffer from unexpected cash flow interruptions, thus preventing liquidity pressure transforming into productivity pressure on workers and maintaining safety mindfulness among workers. Considering this discussion, we posit the following:

H2: Financial slack negatively moderates the relationship between tightly coupled operations and the likelihood of safety incidents.

Figure 3-1 illustrates the theoretical framework of this study.

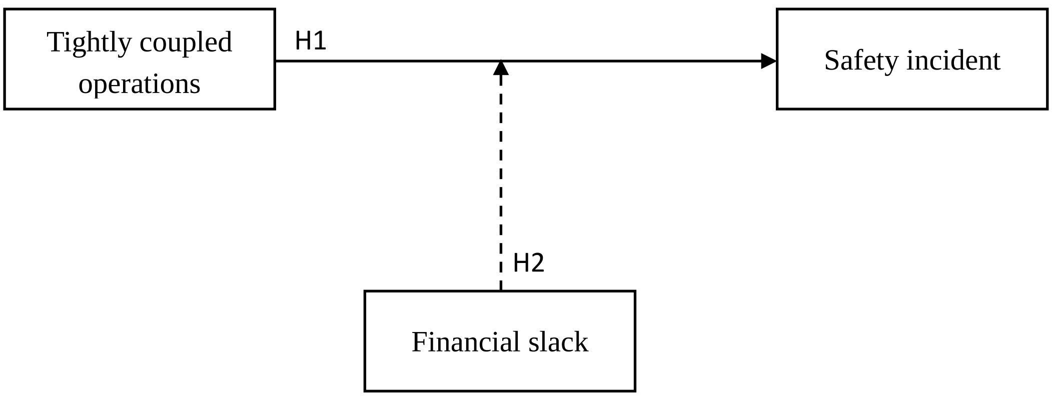

Figure 3-1 Theoretical framework

3.2.Methodology

This study samples U.S.-listed fashion and textile firms. Following Fan & Lo (2012), fashion and textile industry firms were identified according to their three-digit Standard Industry Classification (SIC) codes. The dependent variable of this study was the likelihood of a safety incident. OSHA regulation violation has been used a standard measurement of safety incidents and safety performance (e.g., Pagell and Gobeli, 2008; Lo et al., 2014). Violation data is locatable by firm name in the OSHA violation database by the firm name (OSHA, 2015). The database contains the inspected violation record by OSHA. The information includes the violating firm's name, industry, location, the violation date and types. The types of violation include serious violation, willful violation, repeat violation and other violation. According to OSHA's (2015) definition, a serious violation is that the exist of workplace hazard that would result in employee's death or serious physical harm; a willful violation is that employer purposefully disregard to comply with a legal requirement; a repeat violation would be cited by OSHA if the firm has been cited for the same violation previously; a other violation is the violation which is not serious in nature.

Appendix B illustrates an example of OSHA violation record. A violation can span different types, for example, a violation can be serious and repeat at the same time. We followed the previous literature and treated all types as equal (Pagell and Gobeli, 2009). We identified 634 violation records from 1990 to 2013. The firms with safety violations spanned several fashion and textile sectors,including cotton, manmade fiber, and silk fabric mills (SICs 221 and 222); carpet and rug manufacturers (SIC 227); paper mills[1] (SICs 262 and 267); synthetic fiber manufacturers (SIC 282); textile machinery firms (SIC 355); doll and toy makers (SIC 394); and miscellaneous fashion and textile producers (SIC 308 and SIC 274). Figure 3-2 illustrates the distribution of violations by SIC code. We used whether a firm violated an OSHA regulation in a focal year *t* ("1" = yes and "0" = no) as the dependent variable in a logistic regression analysis. We collected firm financial data from the Compustat database and consolidated it with the OSHA data. 2097 firm-year observations were analyzed.

[1] Paper is a kind of non-woven fabric

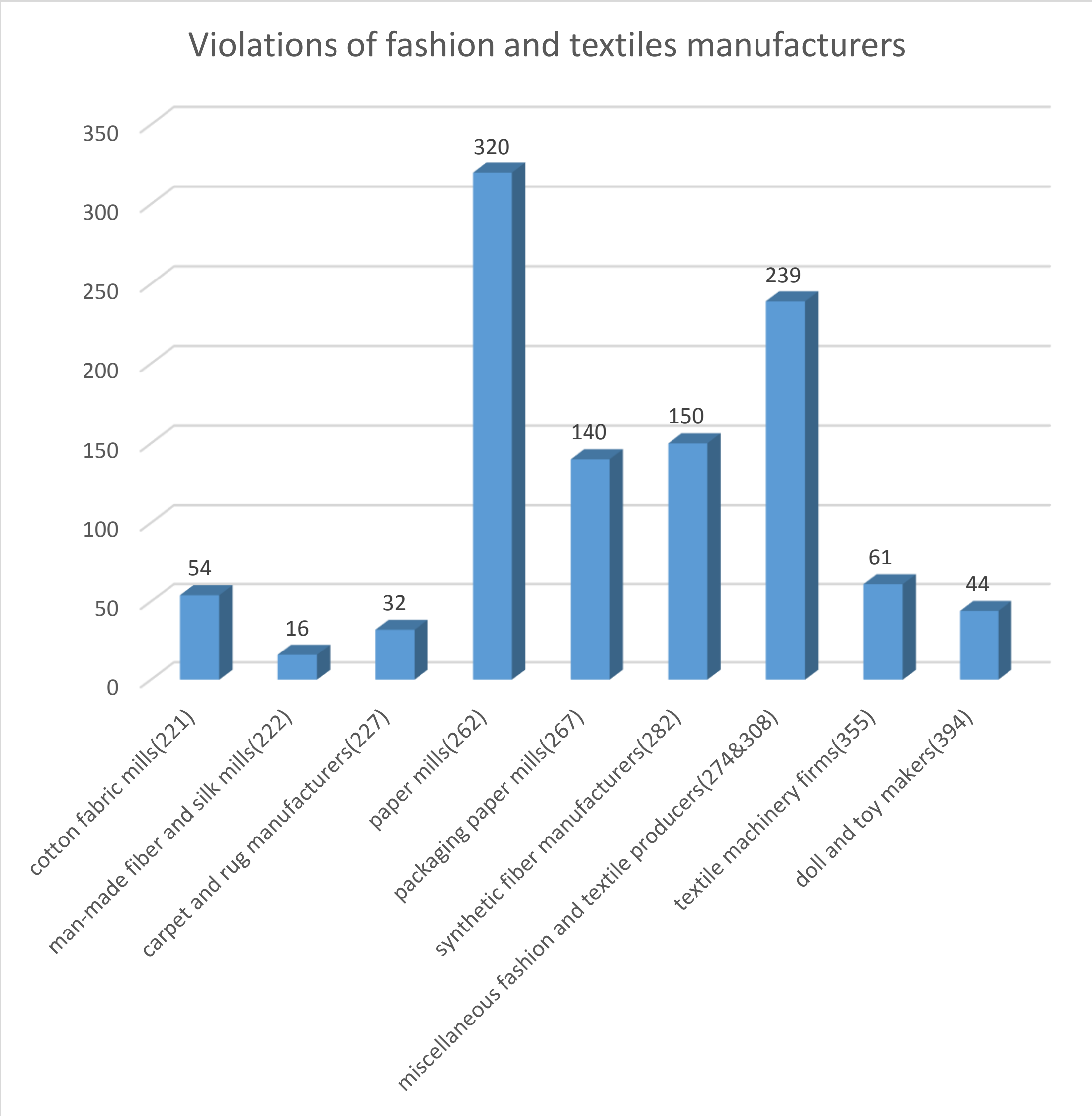

Figure 3-2 Violations of fashion and textiles manufacturers

3.2.1. *Independent variable*

To test **H1**, we follow the previous literature in using the lack of inventory buffer as an indicator of tightly coupled operations (Hendricks et al., 2009). Previous studies reported that tightly coupled operations (e.g., fast fashion firms) usually have a shorter inventory days than do more loosely coupled operations (e.g., nonfast fashion firms) (Hayes & Jones, 2006). Thus, inventory days would be an appropriate proxy indicator for measuring the level of coupling. We reversed the scale of the indicator in the analysis because the longer inventory days means the looser coupling.

To test **H2**, we used three dimensions of financial slack, namely unabsorbed, absorbed, and unborrowed (Palmer & Wiseman, 1999). Unabsorbed slack is a firm's financial liquidity measured using the quick ratio. The calculation is current assets minus inventories then scaled by current liabilities. Absorbed slack is the recoverable absorbed resources that can be easily redeployed to other areas when necessary and is measured using the ratio of selling, administrative, and general expense to sales (SG&A). Unborrowed slack is the remaining financing ability of a firm and is measured using the financial leverage (equity/debt, reversed scale) (Palmer & Wiseman, 1999).

3.2.2. Control variable

This study uses control variables to increase the robustness of the analysis. First, we control firm size according to number of employees. Second, we control firm performance according to return on assets (ROA) and labor productivity (operating income per employee). Third, we control a firm research and development (R&D) intensity. Fourth, we control firm violation history according to number of prior violations. In addition, we include the dummy variables of industry, year, and state of the firm. We use the natural logarithm to correct the skewness of the number of employees, inventory days, and financial leverage. The independent variables have a 1-year lag (t-1) of the dependent variable.

3.3.Results

Table 3-1 contains the descriptive statistics and correlations of the variables. Table 3-2 shows the logistic regression results. Model 1 includes all the control variables. Model 2 present the results for **H1**, predicting that firms with tightly coupled operations have a higher likelihood of safety incidents. The coefficient of inventory days (reversed scale) is positive ($p < .05$), thus **H1** is supported. Because of the correlations among the interaction terms (tightly coupled operations and financial slack resources), we test **H2** in three separate models (Model 3 to 5). **H2** predicts that financial slack negatively moderates the relationship between tightly coupled operations and the likelihood of safety incidents. Model 3 shows that the coefficient of the interaction term between inventory days (reversed scale) and the quick ratio is negative ($p < .01$). Model 4 shows that the coefficient of the interaction term between inventory days (reversed scale) and SG&A is marginally negative ($p < .1$). However, the coefficient of the interaction term between inventory days (reversed scale) and financial leverage (reversed scale) is insignificant ($p > 0.1$). In general, **H2** is supported. The average variance inflation factor (VIF) of the independent variables is 1.467, and no individual VIF exceeds 10. Thus, collinearity is not a concern in the logistic regression analysis.

Table 3-1 Descriptive statistics and correlations

		Mean	S.D.	1	2	3	4	5	6	7	8
1	Violation	0.135	0.117								
2	Firm Performance	0.047	0.038	.089**							
3	Firm Size	0.242	4.150	.253**	.381**						
4	R&D Intensity	5.090	1206.409	-.013	-.131**	-.133**					
5	Productivity	7.687	2802.310	.090**	.676**	.351**	-.274**				
6	Unabsorbed Slack	1.581	3.013	-.091**	.002	-.294**	.146**	-.018			
7	Absorbed Slack	0.359	13.787	-.022	-.211**	-.087**	.007	-.058**	.004		
8	Unborrowed Slack	-0.203	1.134	-.079**	.117**	-.271**	.080**	.041	.527**	-.082**	
9	Operational Coupling	4.306	0.481	-.072**	.017	-.098**	-.088**	.017	.000	.098**	.023

**: $p < 0.01$, two-tail test

N=2097

Table 3-2 Logistic regression results for fashion and textiles manufacturers

	Model 1		Model 2		Model 3		Model 4		Model 5	
	b		b		b		b		b	
Firm Performance	1.418		1.335		1.359		1.299		1.376	
	(1.311)		(1.301)		(1.292)		(1.297)		(1.329)	
Firm Size	0.515	***	0.535	***	0.533	***	0.539	***	0.538	
	(0.076)		(0.077)		(0.077)		(0.077)		(0.077)	
R&D Intensity	-0.003		-0.007		-0.005		-0.008		-0.003	
	(0.016)		(0.015)		(0.021)		(0.014)		(0.019)	
Productivity	-0.003		-0.002		-0.002		-0.002		-0.003	
	(0.006)		(0.006)		(0.005)		(0.006)		(0.006)	
Absorbed Slack	-0.082		-0.098		-1.421	**	-0.098		-0.085	
	(0.122)		(0.124)		(0.567)		(0.124)		(0.119)	
Unabsorbed Slack	-1.857		-1.205		-1.543		-3.725		-1.472	
	(1.191)		(1.191)		(1.243)		(2.789)		(1.238)	
Unborrowed Slack	0.011		0.004		-0.022		0.003		1.314	
	(0.105)		(0.106)		(0.107)		(0.106)		(0.853)	
Operational Coupling			0.412	**	0.849	**	0.489	**	0.322	*
			(0.228)		(0.289)		(0.220)		(0.237)	
Operational Coupling X					-0.291	**				
Absorbed Slack					(0.113)					
Operational Coupling X							-0.522	*		
Unabsorbed Slack							(0.387)			
Operational Coupling X									0.312	
Unborrowed Slack									(0.202)	
Intercept	-4.943	***	-3.311	**	-1.344		-2.937	*	-3.758	**
	(1.338)		(1.603)		(1.806)		(1.624)		(1.627)	
Chi^2	534.788	***	538.031	***	543.799	***	538.769	***	540.413	***
Cox & Snell R^2	22.51%		22.63%		22.84%		22.66%		22.72%	
Nagelkerke R^2	41.17%		41.39%		41.78%		41.44%		41.55%	

Note: N=2097; DV=Violation in a focal year (1=violation, 0= no violation);
***,**,* indicates significance at 0.01,0.05 and 0.1 level;
two-tail test for control variables, one-tail test for hypothesis testing
Standard error in parentheses.
Dummy variables of year, industry and state included in the analysis

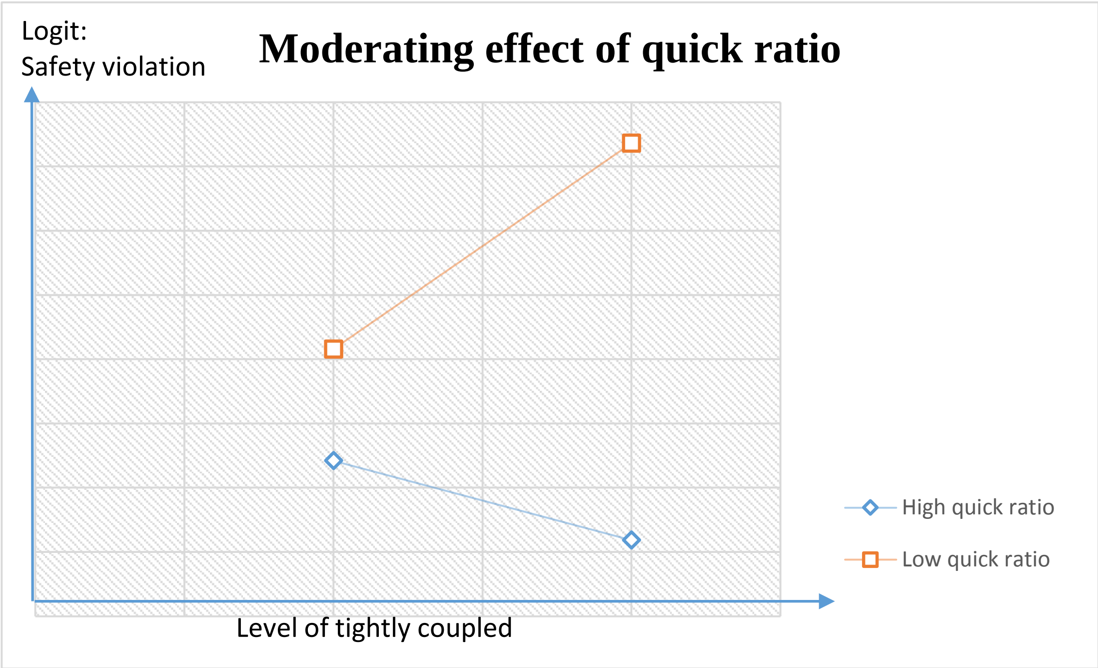

Figure 3-3 Moderating effect of quick ratio

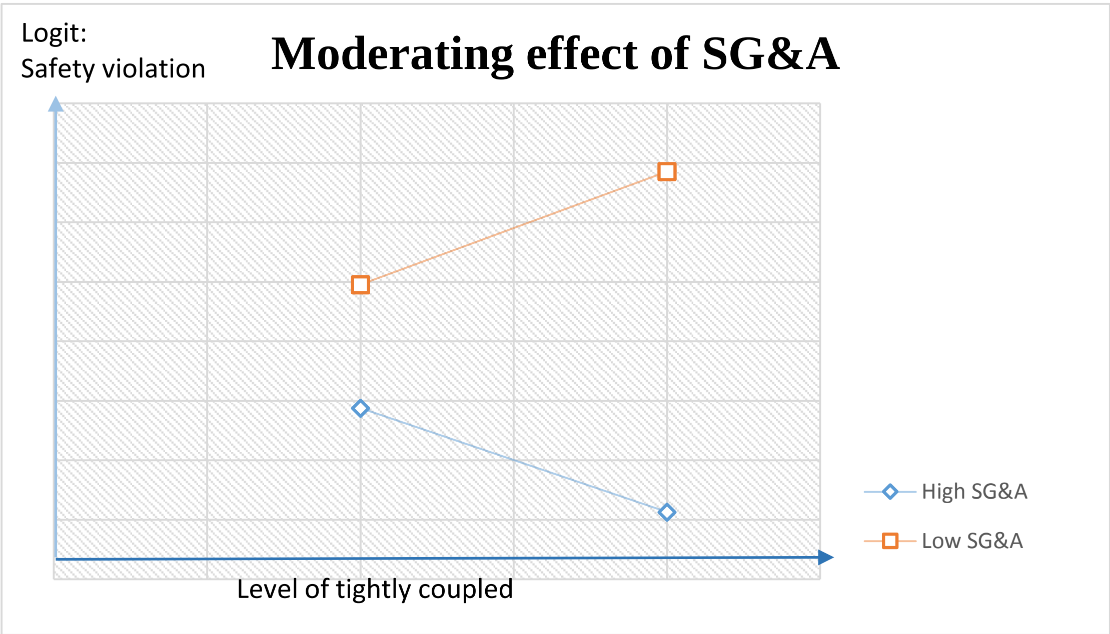

Figure 3-4 Moderating effect of SG&A

3.4. Discussion and summary

By sampling fashion and textile firms, this study investigated the association between tightly coupled operations and safety incidents. The results reveal that firms with tightly coupled operations (as indicated by short inventory days) face a greater risk of safety incidents. A 1-unit decrease in inventory days (natural logged) associates with the increase of the likelihood of a safety incident by 33.75%. In addition, this study revealed the role of financial slack in moderating the safety risk brought by tightly coupled operations. The results suggest that unabsorbed and absorbed slack can aid firms with tightly coupled in reducing safety incidents. **Figures 3-3** and **3-4** illustrate the moderating effects of the quick ratio and SG&A, respectively. They show the relation between inventory days (reversed) and the likelihood of violation when the quick ratio and SG&A are above or below the means by one standard deviation (Cohen et al., 2013).

3.4.1. Theoretical contributions

This study enriches the literature concerning social issues by investigating the operational antecedent of safety incidents in operations. Answering the call from Shrivastava et al. (2009), we synthesized NAT and HRT. Having drawn from NAT (Perrow, 1984; Wolf, 2001), this study provides evidence that fashion and textile firms with tightly coupled operations encounter the higher risk of safety incidents. In such operations, workers' safety mindfulness could drift, and safety shortcut may be taken to meet tight production objectives (Brown et al. 2000).

In addition, in drawing from HRT, our findings suggest that financial slack can buffer workers from productivity pressures. For example, when a firm is encountering stochastic demand, the manager can utilize the financial slacks to fulfil the demand by purchasing from suppliers. Thus the managers do not necessary to push workers to meet the urgent production goal. Following Palmer and Wiseman's research model (1999), this study tested three dimensions of financial slack, namely unabsorbed, absorbed, and unborrowed. The results reveal that unabsorbed and absorbed slack can negatively moderate the positive impact of tightly coupled operations on safety incidents in fashion and textile firms. However, unborrowed slack was not found to exert such a moderating effect, possibly because our samples are listed fashion and textile firms for which debt may be not a major financing approach;listed firms may obtain financing from the stock market to handle operational matters.

3.4.2. Managerial implications

The findings of this study provide insightful managerial implications for fashion and textile firms. Safety accidents could disrupt a firm's operations, diminish employee morale, and lower the overall firm profitability in the long run. They could also hurt fashion and textile firms' sustainable competitiveness by damaging brand reputations (Fernandez-Muniz et al., 2009). The prevailing fashion business models, such as fast fashion, zero inventory, and just-in-time, emphasize operational efficiency by removing slack from between processes (Cachon & Swinney, 2011; Grunwald &

Fortuin, 1992), with minimal lead time from product design to retail (Cachon & Swinney, 2011). Our results address the recent concern regarding the sustainability issues of fast fashion (Shephard & Pookulangara, 2013). Operational managers should be aware that workers' safety mindfulness may easily drift away because of the tightly coupled nature of fast fashion increasing the risk of safety incidents.

The current findings also guide operation managers in reducing the risk of safety incidents in tightly coupled operations. The study apparently offer operational managers implications of slacks resources management. Aligning a firm's slack resources based on the value and priority of each dimension of slacks could help the firm achieve better safety performance in the long run. Unabsorbed slack is the most critical dimension the managers should pay attention to, followed by absorbed slack and unborrowed slack. In the past decades, fashion and textiles manufacturers in China (or in other developing countries) often have limited slack resources, and they need to maximize productivity at all cost. Although redundant slack often means inefficient to manufacturers, managers of fashion and textiles manufacturers should maintain a sufficient level of financial slack to prevent workers from encountering productivity pressure and thus enable them to maintain safety mindfulness.

3.4.3. Further analysis: generalizability of results

The results of primary research models (Table 3-2) in this study include fashion and textiles manufacturers. We further examine whether the results can be extended to the manufacturers in other industries. We extend the sample to all United States listed manufacturing firms (SIC code 2000 to 3999). The violation data for all manufacturers is further collected from OSHA's database. We find 11196 violations from 1394 firms in the period of 1990 to 2014. The distribution of violation by three digit SIC is presented in Appendix C. The frequency of fashion and textiles manufacturers is similar to other manufacturers (t = 0.496, p > 0.1). Figure 3-6 presents the distribution of violation by year.

A logistic regression analysis was conducted to the data of all manufacturers. Table 3-3 shows that the regression results are similar to the results of fashion and textiles manufacturers (Table 3-2), suggesting that the implications of this study not only limit to fashion and textiles industry, but also to the whole manufacturing industry. The operational managers of manufacturing firms should pay additional attention to the potential OHS problems in the operations when the operations processes are tightly coupled. The managers should retain unabsorbed and absorb financial slack to cope with the OHS risk brought by the tightly coupled operation processes.

3.4.4. Further analysis: alternative measure of operational coupling

We used inventory day in this study to indicate the level of operational coupling in operations. However, according to Hendricks et al. (2009) and Modi and Mishra (2011), sales to machinery, plant and property ratio (SOP) could be an alternative measure for operational coupling. SOP indicates the level of assets utilization in a firm's operation. Higher level of utilization means little capacity slack thus indicating a tighter coupled operation. Table 3-4 shows that the results are similar to Table 3-3 when we were using SOP as an alternative measure of operational coupling.

3.4.5. Further analysis: Disaggregated violation types

We followed the previous literature to treat all the types of violation as equal (Pagell and Gobeli, 2009), while we examine whether our results only capture the effect from one dominating type of violation by disaggregated the violation types. We replaced the dependent variable to different types of violation according to OSHA's database, i.e., serious violations, repeated violations, willful violations and other violations. Table 3-5 shows that the results are consistent to Table 3-3 across serious violation, repeated violation and other violations. Therefore, our results do not depend on one dominating type of violation.

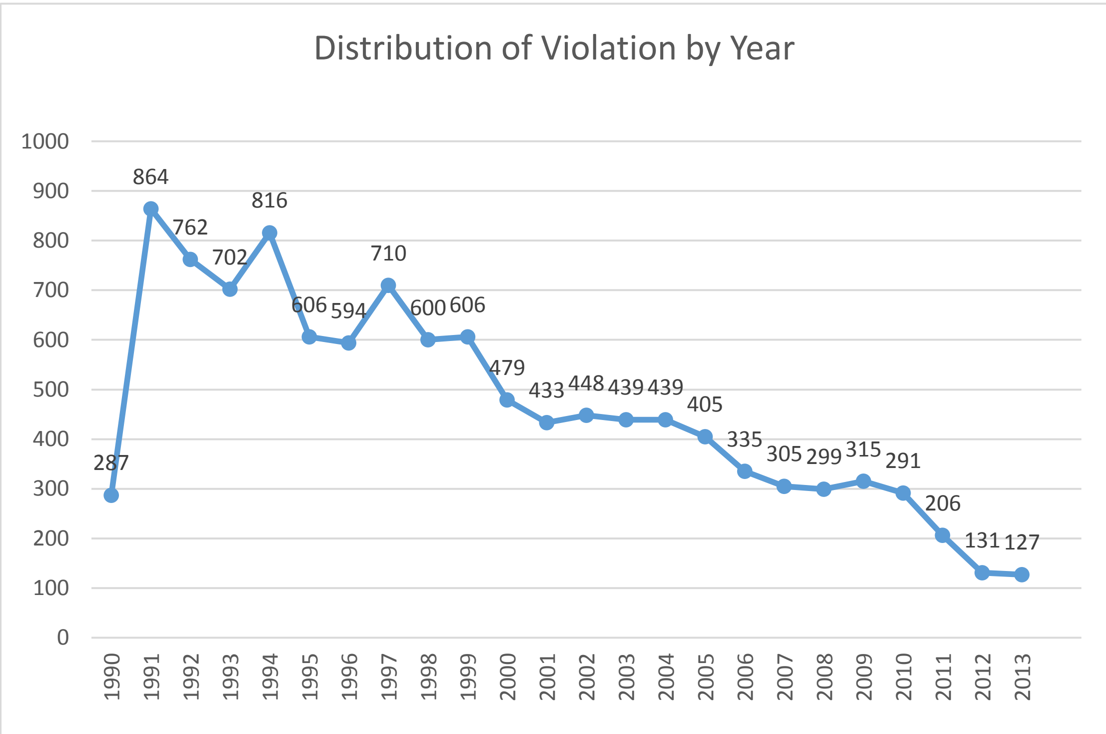

Figure 3-5 Distribution of violation by year

Table 3-3 Logistic regression results for all manufacturers

N=43507

	Coef.		S.E.
Control variables included			
Unabsorbed Slack	-0.0919	**	0.0379
Absorbed Slack	-0.9788	***	0.2571
Unborrowed Slack	-0.1708	*	0.1012
Operational Coupling	0.1386	***	0.0311
Operational Coupling X Unabsorbed Slack	-0.0156	**	0.0069
Operational Coupling X Absorbed Slack	-0.0933	**	0.0309
Operational Coupling X Unborrowed Slack	0.0534		0.0234
Intercept	-18.6773		
Cox & Snell R^2	13.53%		
Nagelkerke R^2	28.25%		

Note: DV=Violation in a focal year (1=violation, 0= no violation);
***,**,* indicates significance at 0.01,0.05 and 0.1 level;

Table 3-4 Alternative measures of operational coupling

N=43507

Variables at year t-1	Coef.		S.E.
Control variables Included			
Unabsorbed Slack	0.040		0.034
Absorbed Slack	0.004		0.036
Unborrowed Slack	0.043		0.054
Sales to plant, equipment and property (SOP)	0.137	**	0.07
SOP X Unabsorbed Slack	-0.063	**	0.029
SOP X Absorbed Slack	-1.315	***	0.142
SOP X Unborrowed Slack	-0.042		0.042
Intercept	-20.274		
Cox & Snell R^2	16.90%		
Nagelkerke R^2	34.10%		

Note: DV=Violation in a focal year (1=violation, 0= no violation);
***,**,* indicates significance at 0.01,0.05 and 0.1 level;

Table 3-5 Disaggregate violation types

N=43507	Serious violation			Repeat violation			Willful violation			Other violation		
Variable (at t-1)	Coef.		Std. error	Coef.		Std. error	Coef.		Std. error	Coef.		Std. error
Control variable included												
Quick Ratio	-0.237	***	0.086	-0.488	**	0.240	0.274		0.454	-0.234	**	0.093
Selling, Administrating, and General Expense	-0.814	***	0.263	-1.165	***	0.449	-0.047		1.674	-0.769	***	0.277
Financial Leverage (reversed)	0.392	***	0.140	0.882	*	0.482	-1.146		0.892	0.339	**	0.137
Inventory Days(reversed)	0.214	***	0.052	0.394	**	0.157	0.119		0.391	0.203	***	0.05
Inventory Days(reversed) X Quick Ratio	-0.043	**	0.018	-0.091	**	0.042	0.062		0.121	-0.04	**	0.02
Inventory Days(reversed) X SG&E	-0.079	***	0.026	-0.135	***	0.049	0.001		0.191	-0.076	***	0.028
Inventory Days(reversed) X Leverage(reversed)	-0.091	***	0.032	-0.202	*	0.111	0.234		0.216	-0.079	**	0.031
Intercept	-9.15		57.71	-2.228		59.283	-4.4		56.916	-9.306		57.256
Cox & Snell R^2	0.104			0.009			0.004			0.103		
Nagelkerke R^2	0.249			0.173			0.281			0.241		
Chi^2	4765.047			406.995			174.856			4707.722		

Note: *,**,* indicates significance at 0.01,0.05 and 0.1 level;**

4. Study three: Impact of OHS management systems on the operating and financial performance of manufacturing firms

Study one demonstrated that the effectiveness of voluntary OHS management systems is a major research domain in OHS literature, yet the domain is underdeveloped. The current study contributes to this research domain by examining how OHS management systems affect firm operating and financial performance.

Study two revealed that slack resource could be effective to cope with OHS risk for firms; however, such OHS management is often not visible to the customers. Fashion and textiles manufacturing firms are encountering increasing pressure from multiple stakeholders to manage OHS issues systematically and transparently. These pressures come from within and outside the fashion supply chain. The collapse of the Rana Plaza textile factory in Bangladesh caused more than 1,100 deaths and questioning of the real costs of low-cost suppliers (Donaldson, 2015). Furthermore, Wal-Mart (Reuters, 2007), Gap, and Next (*The Observer*, 2010) have garnered substantial negative publicity regarding the working conditions at their supplier factories. Beyond their human toll, these events can seriously damage a fashion firm's brand image and brand equity and customers' purchase intentions. Hence, some multinationals in fashion and textiles industry (e.g., Nike and Adidas) now request that their suppliers obtain OHSMS certificationto ensure that OHS considerations are managed systematically and transparently. OHSAS 18001 is the favored certification because it requires auditing by an independent organization.

4.1. Occupational Health and Safety Assessment Series (OHSAS)

OHSAS includes OHSAS 18001 and OHSAS 18002, the former one is the OHS management standard, and the latter one is the guideline for implementing OHSAS 18001. OHSAS 18001 is the most popular externally certified OHSMS (Fernández-Muñiz et al., 2012). The certification was introduced in 1999 (OHSAS 18001:1999) and issued the second edition in 2007 (OHSAS 18001:2007). It grew from 8399 certifications in 2003 to 56,251 in 2009 (a compound annual growth rate of 37.46%) (OHSAS Project Group, 2011). Over the same period, ISO 14000 certifications grew from 64,996 to 222,974 (and now are at 267,457) and ISO 9000 certifications exceeded a million (International Organization for Standardization, 2012). So whilst OHSAS 18001 could become the de-facto safety standard because of its rapidly growth, although today it is relatively rare compared to other certifications such as ISO 9001. OHSAS 18001 is compatible with quality management system (e.g., ISO 9001) and environmental management system (e.g., ISO 14001) because they all obey plan-do-check-act cycle aiming continuous improvement.

OHSAS 18001 has some similarities with other external certifications while it has a uniqueness that could influence firm performance differently. Firms would be motivated to adopt ISO 9000 and ISO 14000 certifications by customer demand. However, many firms may have been actively managing OHS because of the firms' values and existing safety regulations. Thus, OHSAS 18001 is typically adopted to augment or replace existing systems, some of which already enable firms to far exceed regulatory requirements. In addition,although ISO 9000 clearly benefits customers directly and ISO 14000 links to resource efficiency, there is a lack of research investigating the financial consequences for safety (see Veltri et al., 2013) in general and safety certifications specifically.

This study evaluated two facets of operating performance. First, because OHSAS 18001 is intended to improve safety, we examined the safety facet of operating performance. Second, we assessed traditional financial and operating outcomes such as sales growth, labor productivity, and ROA. To clearly differentiate the two facets, we used the terms safety performance and financial performance for the remainder of the dissertation. This study considered a) whether OHSAS 18001 adoption affect firm operational and financial performance? And b) what contextual factors influence the impact of OHSAS 18001 adoption?

The answers to these questions have crucial theoretical and managerial implications for the practitioners in fashion and textiles industry. The first question was answered by conducting a long-horizon event study analysis of the long-term impact of OHSAS 18001 on firm performance. To answer the second question, we used OLS regressions to analyze the contextual factors that influence the relationship between OHSAS 18001 adoption and firm performance.

4.2. Theoretical background and hypothesis development

In general, two contradictory propositions exist in the literature regarding the impact of OHSMS. The first school of thought posits that implementing effective OHS practices can improve a firm's operational process through improved safety performance (Das et al., 2008; De Koster et al., 2011). Fernández et al. (2009) note that a sophisticated OHSMS can reduce interruptions (e.g., accidents and absenteeism) in the production processes. A safer working environment fulfills workers' basic safety needs, allowing them to pursue operational goals (Das et al., 2008).

Moreover, workplace injuries and illnesses exert direct costs and indirect costs. The direct costs include workers compensation, medical treatment (Loeppke et al., 2007), and insurance premiums (Starr & Whipple, 1984). The indirect costs include overtime wages, labor turnover, new employee training, lost working days (Oxenburgh & Marlow, 2005), and reputational damage (De Koster et al., 2011). Effectively implementing an OHSMS could help reduce both direct and indirect costs in the long term.

The preceding discussion may suggest that improved safety performance should eventually improve a firm's profitability (Robson et al., 2007); however, this relationship is largely unexplored empirically in both the safety and operations literature (Brown, 1996; Das et al., 2008; De Koster et al., 2011). Furthermore, a second school of thought posits that OHSMS implementation could negatively affect financial performance. Brown (1996) proposed that employee safety awareness may conflict with productivity, and De Koster et al. (2011) suggested that strict safety procedures may constrain a firm productivity; these conclusions agree with the numerous safety researchers who have proposed that a trade-off exists between a firm's operational effectiveness and workplace safety (e.g., Brenner et al., 2004; Ford & Tetrick, 2008; Godard, 2004; Landsbergis et al., 1999; Lewchuck et al., 2001; Parker 2003; Pate-Cornell & Murphy, 1996; Zohar, 2002; Zohar & Luria, 2005)

Both schools of thought lack empirical support because previous studies have failed to address the missing link between safety and financial performance (Das et al., 2008). With CSR concerns from customers and supply chain partners increasing, both academics and practitioners must understand the financial implications of OHSMS. This study takes the first step in achieving this by examining OHSAS 18001 adoption in manufacturing firms. This specific study subject and context was selected because of OHSASs' relative popularity and because manufacturing is one of the most dangerous sectors for workers in the U.S.

The conflicting propositions of the relationship between safety and productivity in many ways mirror the larger organizational theory debate between proponents of NAT (Perrow, 1981; 1984) and HRT (Weick et al., 1999). NAT proposes that accidents in complex and tightly coupled systems are more likely to happen. Since operations that transform raw materials to end product are tightly coupled and complex system

(Shrivastava et al. 2009), NAT suggests that accidents are inevitable in manufacturing firms and that the risk of a safety incident increases with increasingly complex or tighter coupled operations (Wolf, 2001).

The coupling component of NAT provides a theoretical underpinning for the proposition that firms must balance safety and productivity. For example, when workers have slack, they can have more time to work safely; however, as slack decreases, workers would have cavalier attitude and take shortcuts, which endangering their safety (McLain, 1994; Brown et al., 2000). Slacks are a critical means of reducing coupling in operations (Wolf, 2001). Hence, as Wolf (2001) noted, operating with slack increases the risk of accidents although it buttresses many operational best practices, such as lean production. The NAT view for the trade-off perspective would be that improving productivity increases coupling, thus increasing the risk of an accident.

HRT posits that safety incidents are preventable if organizations give OHS a strategic priority; the highly reliable organizations would pay careful attention to design the processes, continuous learning, training, and construct safety culture (Weick et al., 1999; Reason 1998). High reliability benefits safety and consequently financial outcomes (e.g. Weick et al., 1999). Highly reliable organizations could keep safety incidents free for a long time and reduce other unwanted forms of variance such as late deliveries. HRT then seems to provide the foundation for arguments that associate improved safety with improved financial performance.

Based on Leveson (2004) and Rasmussen (1997), Shrivastava et al. (2009) conclude that "the higher the ability to control transformation processes, the higher the level of safety in the workplace" (P.1380). Critical to the present research is that Shrivistava et al., (2009) align NAT and HRT and noted that as complexity increases and coupling gets tighter, the OHS risk is more salient so the need for control increases. The control of transformation processes is also a fundamental component of operations management. We propose that increased processes control will improve financial and safety performance, but that maintaining control is difficult because of drift of mindfulness. We are not suggesting that all accidents are preventable or that OHSAS 18001 can prevent drift, nor is our goal to prove the relative merits of NAT or HRT. Rather, we use the two theories to explain the disparate findings on the safety–productivity trade-off and to develop hypotheses.

4.2.1. Direct effects of OHSAS 18001 adoption

We follow Shrivastava et al. (2009) in incorporating aspects of both NAT and HRT in our hypotheses. OHSAS 18001 adoption should inculcate the attributes of a highly reliable organization. OHSAS 18001 should then, on average, improve safety performance.

OHSAS 18001 aims to certify that a firm's OHSMS can develop and maintain a safe workplace; protecting workers from accidents and illness (British Standards Institution, 2012). Certification requires firms to follow plan-do-check-act cycle to manage OHS issues. OHSAS 18001 certified firms should set up OHS policy, plan OHS relative procedure, and establish safety controls to maintain OHS (Fernández-Muñiz et al., 2012). In addition, the firms should construct proper measure to safety performance, and periodically review its effectiveness to enhance safety performance continuously. If any safety incident happens to the firm, the incident investigation shall be conducted, and corrective action shall be taken to prevent the same incidents happen in the future. According to HRT's premise, the processes control should aid firms' operations achieving high reliability in terms of operations safety.

H1. OHSAS 18001 adoption positively affects a firm's safety performance

Adopting OHSAS 18001 should enable increased control of processes and hence increase safety and financial performance. Other effective OHS management practices (e.g., retain financial slack) could achieve the same outcomes; however, OHSAS 18001 is externally certified, and certification may have a legitimating value in the marketplace that noncertified OHS practices. Previous literature suggests that ISO 9001 and 14001 were both adopted to gain legitimacy (Boiral, 2007; Qi et al., 2011) and hence it is possible that OHSAS 18001 can have a similar effect.

From an institutional perspective, adopting OHSAS 18001 may enable firms to gain legitimacy from major customers (Meyer & Scott, 1983; Staw & Epstein, 2000; Suchman, 1995). Previous research has shown that ISO 9000 and ISO 14000 are both adopted partially for legitimating reasons (Boiral, 2007; Qi et al., 2011; Wiengarten et al., 2013) and hence OHSAS 18001 certification likely has a similar effect. In this study, adopting OHSAS 18001 was interpreted as a signal of a firm's commitment to health and safety management, which giving the entire supply chain increased legitimacy. One possible benefit of OHSMS adoption is improved sales performance because it may satisfy customers' CSR expectations (Law et al., 2006; Stigzelius & Mark-Herbert, 2009). Thus, we propose:

H2: OHSAS 18001 adoption positively affects a firm's sales performance.

HRT suggests that OHSAS 18001 could improve productivity through two mechanisms. First, increased control of processes reduces variance and nonproductive tasks such as rework. Second, as demonstrated by previous studies, adopting OHSMS can be an effective tool in improving safety performance (e.g., De Koster et al., 2011; De Oliveira & Coelho, 2002; Loeppke et al., 2007). Fewer accidents and illnesses among workers can reduce absenteeism and labor turnover (De Koster et al., 2011; Mclain, 1995). Moreover, safety, rather than efficiency or product quality, is often a worker's highest priority; in an unsafe setting, workers will focus on being safe rather than pursuing managerial goals (Das et al., 2008). Hence, a safe work environment allows workers to prioritize quality and efficiency goals instead of being preoccupied with safety (Brown, 1996; Das et al., 2008). Subsequently, firm efficiency can be improved. Thus, we hypothesize the following:

H3: OHSAS 18001 adoption positively affects a firm's labor productivity.

Furthermore, if adopting OHSAS 18001 improves a firm's sales performance and labor productivity. It is likely enabling firm to achieve economic of scale and consequently to improve a firm's overall profitability. We thus posit the following:

H4: OHSAS 18001 adoption positively affects a firm's profitability.

4.2.2. Contextual factors in OHSAS 18001 adoption effectiveness

The second research question is "Do contextual factors influence the impact of OHSAS 18001 adoption?" The synthesis by Shrivstava et al. (2009) of NAT and HRT would suggest that as complexity increases and coupling becomes tighter, the adoption of OHSAS 18001 would become more valuable. Firms with complex (high-tech and labor-intensive) and tightly coupled (more inventory and less inventory volatility) operation processes could be assumed to benefit most from OHSAS 18001.

High-tech firms are usually more dynamic (Fine, 1999) and technologically complex (Singh, 1997) than low-tech firms. Workers at firms in high-tech settings have less time or slack to adapt to changes because their firms' production processes can be rapidly changing and complicated. Hence, high-tech settings tend to be more complexity, thus increasing the risk of accidents and system failures (Perrow, 1984; Singh, 1997). In such settings, OHSAS 18001's potential to form the foundation of a highly reliable organization and increase control could be of greater benefit.

Similarly, as labor intensity increases, a firm's operations become more variable and complex (Swink & Jacobs, 2012). Labor-intense firms' production processes are often complicated and not automated; therefore, these firms rely heavily on workers in their operations. Variability and complexity increase the odds of accidents (Perrow, 1984), and high levels of labor intensity increase the potential impact of each accident on the system. Effectively adopting OHSAS 18001 should continually improve working conditions and reduce turnover as well as recruitment and training costs, and improve overall labor productivity (De Koster et al., 2011; Mclain, 1995). Additionally, adopting OHSAS 18001 may enable a firm to recruit higher-quality workers compared to non-adopters because skilled workers have more power to bargain for more desirable welfare and working conditions (Cahuc et al., 2006; Lawrence, 1982). These benefits will be most valuable to firms that are relatively more labor intensive.

H5: As operational complexity (R&D and labor intensity) increases the benefit of OHSAS 18001 certification also increases.

NAT predicts that as coupling increases the risk of safety incident also increases

(Perrow, 1984). One essential mean of decoupling in a manufacturing setting is via the use of inventory buffers. Inventory can buffer for stochastic demand and processes (Minner, 2001). It can also keep the supply chain running when disruptions occur (Hendricks et al., 2009). Inventory creates slack for the workers allowing them to do production as planned and reduce the likelihood of *drift*. Thus, we use inventory as an indicator of coupling. Low levels of inventory often associates with high levels of coupling. Coupling increases (inventory decreases) the risk of safety incident increases, hence OHSAS 18001is more valuable under such context.

The assumption that inventory loosing coupling is based on firms are holding the correct inventory. However, firms may do a poor job with forecasting and planning so that they may have the wrong inventory. Those firms will make more frequent set-ups, spend time that for maintenance and expediting, and have to move more parts in and out storage, which would increase coupling. Holding the wrong inventory, as evidenced by increased inventory volatility, may increase the operational coupling. Thus, the operations have higher risk of safety incidents, hence make OHSAS 18001 more valuable

H6: As operational coupling increases (more inventory volatility and lower inventory level), the benefit of OHSAS 18001 certification also increases.

Figure 4-1illustrates our research framework and related hypotheses.

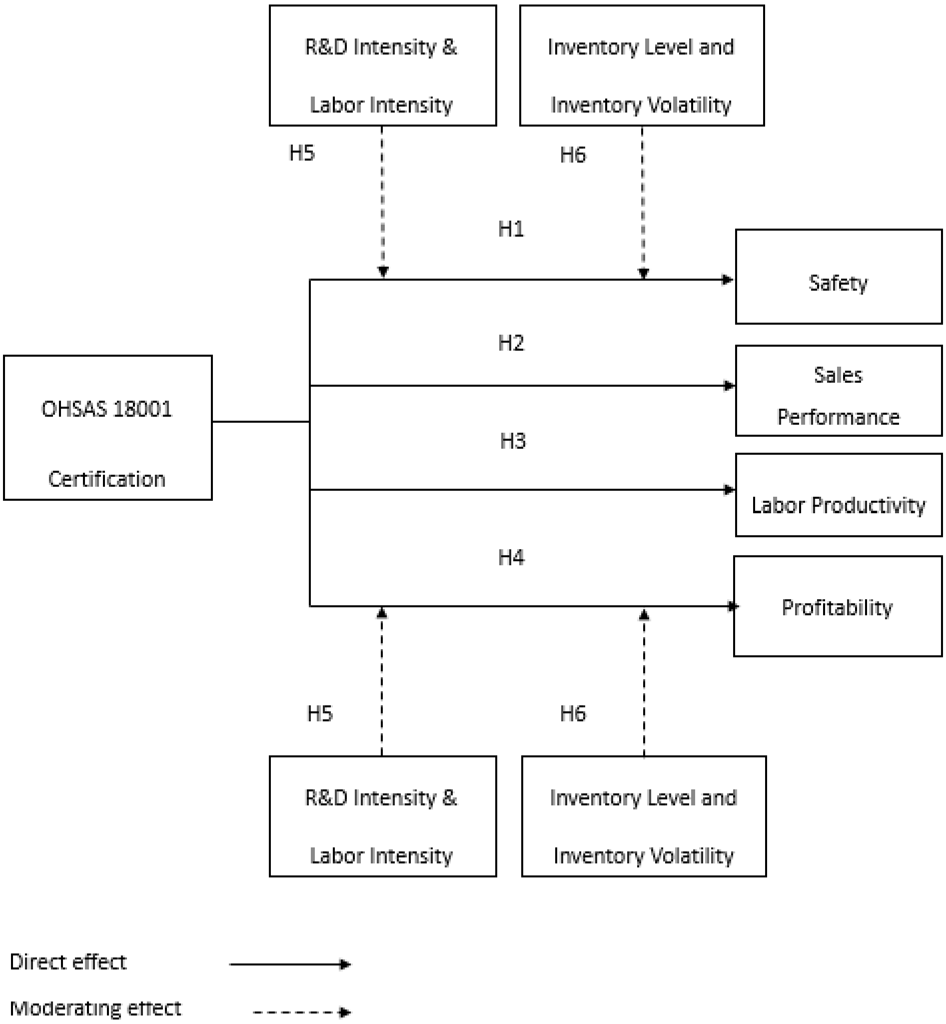

Figure 4-1: The research framework

4.3. Methodology

This research sampled all U.S.-listed manufacturing firms (SIC 2000–3999). We collected financial data from Standard and Poor's COMPUSTAT database and industry characteristics data (e.g., labor working hours and wages) from the U.S. Census Bureau (2013).

OHSAS 18001 certification data were collected from the companies' official websites, annual reports (from the U.S. Securities and Exchange Commission filing system) and media reports (from Factiva). This research follows the practice of previous certification literature (e.g., Corbett et al., 2005; Yeung et al., 2011) by examining only the first OHSAS 18001 certification. If we found no OHSAS 18001 certification information on a firm's website or in annual or media reports, the firm was considered a non-adopter.

In total, 374 of 8477 U.S.-listed manufacturing firms (both active and inactive) were identified as having obtained at least one OHSAS 18001 certification between1999 and 2011. Of the 374 firms, 78 were discarded from the analysis because no information from the year of their first certification was available. Additionally, 85 firms without financial data from the OHSAS 18001 adoption period (i.e., firms that obtained OHSAS 18001 before being listed) were also discarded. Therefore, 211 firms were analyzed.

Adoption patterns in the sample followed the overall OHSAS 18001 adoption trend. From 1999 to 2004, 71 of the sample firms (35.6%) obtained certification. OHSAS 18001 certification is increasingly popular in the sample period, with 140 firms (64.4%) obtaining certification from 2005 to 2011. Despite this increase, OHSAS adoption is relatively rare (particularly compared with ISO 9000 and 14000 certification), like in the general population. Firms in the electronics industry (SIC: 36) obtained the most OHSAS 18001 certifications, followed by chemical product (SIC: 28) and industrial machinery manufacturing (SIC: 35) firms.

4.3.1. *Event study approach for longitudinal analysis*

To explore the causal relationship between OHSAS 18001 adoption and financial performance, we used a long-horizon event study approach. Consequently, this research defined the event year (year 0) as the year when a firm first acquired OHSAS 18001 certification and the base year as the year when the firm was free from the impacts of implementing OHSAS 18001. On average, firms required 6–18 months to implement a management certification before registration (Corbett et al., 2005; Lo et al., 2009, 2012). Thus, we defined year -2 as the base year, meaning that the adopting firms had not begun the implementation process. Because we are interested in the long-term impact of OHSAS 18001, this research investigated the abnormal performance changes over the four years from the start of the adoption process (i.e., year -1, year 0, year 1, and year 2).

We matched each sample firm with a portfolio of comparable control firms according to three control factors: industry, performance, and firm size. Following Barber and Lyon (1996), two-digit SIC codes were used to match firms and industries. Comparable control firms were those with 90%–110% of a sample firm's prevent performance (i.e., the firm's sales, labor productivity, and ROA in year -2). To control for firm size, we matched each sample firm to control firms within 50%–200% (a factor of 2) of the sample firm's total assets (Hendricks & Singhal, 2008). On average, each sample firm was matched with 28.25 control firms, and 97.15% of the samples matched with five or more control firms. Following this matching process, we estimated the abnormal change of performance of sample firms compared with the control group. The formula used to calculate the abnormal performances was:

$$AP_{(t+j)} = PS_{(t+j)} - EP_{(t+j)}$$

$$EP_{(t+j)} = PS_{(t+i)} + (PC_{k(t+j)} - PC_{k(t+i)})$$

where AP is the abnormal performance, PS is the actual performance, EP is the expected performance of sample firms, PC is the median performance of control firms, *t* is the OHAS 18001 adoption year, *i* is the base year (*i*= -2), and *j* is the final comparison year (*j* = -1, 0, 1 or 2). For the firm financial indicators, we used return-on-assets (ROA) for profitability, sales growth for sales performance, and the ratio of operating income to number of employees for labor productivity. The financial data were collected from the COMPUSTAT database. To determine safety performance, this study used the number of OSHA regulation violations as a proxy indicator (Pagell & Gobeli, 2009). The violation data were collected from OHSA's violation database (OSHA, 2015). The number of violation was scaled by the number of employees. Thus, the final measure is a ratio of violations per 10,000 employees in a focal year.

We conducted the Wilcoxon sign-rank (WSR) test and sign test to examine abnormal performance. Following common practice (e.g., Hendricks & Singhal, 2008; Yeung et al., 2011), we will mainly discuss the results of the WSR test, which is less influenced by outliers than the parametric *t*-test.

4.3.2. Cross-sectional analysis of contextual factors

When testing H5 and H6, both abnormal safety and abnormal ROA were used as dependent variables. We used abnormal ROA (rather than labor productivity and sales growth) as the dependent variable for economic performance in the cross-sectional analysis because it represents overall operational effectiveness. This is consistent with previous research (e.g., Swink & Jacobs, 2012). To make this study consistent with and comparable to other studies using similar methodology (e.g., Hendricks & Singhal, 2008), we used the OLS approach to test H5 and H6.

The OLS regression models are as follows:

$$AP_k = \beta_0 + \beta_1 (PP_k) + \beta_2(FSize_k) + \beta_3(Year_k) + \beta_4(ISO\ 9001_k) + \beta_5(ISO\ 14001_k) + \beta_6(ISize_{kh}) + \beta_7 (Wage_{kh}) + \beta_8 (Union_{kh}) + \beta_9 (Hour_{kh}) + \beta_{10}(RD_k) + \beta_{11}(LI_k) + \beta_{12}(IV_k) + \beta_{13}(IL_k) + e_k$$

Where k refers to the k^{th} sample firm and h refers to the h^{th} industry that the k^{th} firm operates in. The outcome variable AP_k is either abnormal ROA or abnormal safety performance. RD_k is the firm's R&D intensity, which is the ratio of R&D expense to total assets (Naveh & Marcus, 2005; Russo & Fouts, 1997). LI_k is a firm's labor intensity, which is the ratio of the number of employees to total assets of the firm (Dewenter & Malatesta, 2001). These two indicators are the independent variables for H5. IV_k is a firm's yearly inventory volatility, which is the ratio of the standard deviation of the firm's inventory by each financial quarter and its mean quarterly inventory value in the year (Steinker & Hoberg, 2013). IL_k refers to the average inventory scaled by total assets. IV_k and IL_k are the independent variables for H6.

To ensure the rigorousness of the model, we controlled for several firm- and industry-level factors that could impact the sample firms' abnormal performance. First, more profitable firms could have more resources to achieve higher profitability in the future; therefore, we controlled firms' ROA in year -2 (PP_k). Second, we controlled for firm size because larger firms could have more resources but also have more difficulty in coordinating with employees when implementing OHSAS 18001 (Douglas & Fredendall, 2004). Firm size ($FSize_k$) is the natural logarithm of the number of employees employed by the firm in year -2 (Kull & Wacker, 2010). Finally, institutional theory suggests that the motivation for and outcomes of certification could differ between early and late adopters (Westphal et al., 1997; Zhu & Sarkis, 2007); therefore, we controlled for the year of OHSAS 18001 certification ($Year_k$). The firm-level variables were based on data from year -2.

Furthermore, the sample firms may have adopted an integrated management system including ISO 9001, ISO 14001, and OHSAS 18001. Therefore, we created two dummy variables to indicate whether the firm also received ISO 9001 or ISO 14001 certification during the same event study period (year -2 to year +2). The dummy variables were coded as 0 for firms without ISO 9001 or ISO 14001 and 1 for firms with ISO 9001 or ISO 14001.

Industry-level control variables were also used in the model. First, we controlled for the size of each sample firm's industry *h* ($ISize_{kh}$). Various proxies exist for industry size, including industry output (Moomaw, 1988), number of firms (Weiss, 1963), and number of employees (Rushing, 1967). We used the number of employees (Rushing, 1967) because my research focuses on workers and worker-related outcomes. Second, we controlled for the average production worker's wages in the industry ($Wage_{kh}$), which is the normalized annual wage per production worker. We also controlled for the influence of labor unions in the industry ($Union_{kh}$). Production workers are more likely to be unionized in dangerous industries (Hirsch & Berger, 1983), and unionized workers can collectively bargain with employers to obtain higher risk premiums than nonunionized workers. Therefore, firms in industries with high levels of union influence would encounter extra operations and administrative costs (Freeman & Medoff, 1981; Olson, 1981). We used the ratio of the number of workers covered by collective agreements to the total number of workers in the industry to indicate labor union influence. Finally, we used the industry-average working hours of production workers to control for the association between health and safety problems and long working hours ($Hour_{kh}$) (Spurgeon et al., 1997). All industry-level control variables were based on data from year -2.

4.4. Results

We compared the safety performance and three financial performance indicators of sample firms with their industries and control firms. We conducted paired-sample *t*-tests and the certified firms (0.089 violations per 10,000 employees) exhibited significantly safer performance compared to their industry 2 years (year -2) before certification (0.641 violations per 10,000 employees, $p < .001$). Not only was their violation propensity lower than industry norms, this group had less variance in violations, suggesting greater control of safety processes and safety outcomes before OHSAS certification. However, when compared with the matched control firms' safety performance, no significant difference existed, indicating that using the ROA control portfolio to measure safety is appropriate. Before certification, the sample and control firms exhibited a significantly safer performance (in ROA) than did their industry on average.

4.4.1. Event study analysis results

Table 4-1 contains the results of the cumulative abnormal performance analysis and **Table 4-2** presents those of the year-to-year abnormal performance analysis. We followed convention in event studies and used the largest available sample for each period and dependent variable (e.g., Corbett et al., 2005, Swink & Jacobs, 2012). The sample varied across tests for two reasons. The primary reason for different sample sizes was missing data. Firm data may be missing information on one or more of the performance outcome variables in any given period. This problem was more common for firms with more recent certifications (2010 and 2011). It is because COMPUSTAT database may not contain year 1 or year 2 financial data. The secondary reason for different sample sizes is survivor bias from firms that were closed or delisted after being certified in year -2. Four firms in the sample were delisted over the event horizon. The results for each hypothesis remained the same after removing these four delisted firms. The results revealed the impact of OHSAS certification on all four dimensions of the sample firms' abnormal operational performance.

The sample firms' abnormal safety performance (H1) was significantly safer (according to the WSR tests) compared with the control firms in the implementation period (year -2 to year 0) at the 1% level. Adopting OHSAS 18001 increased abnormal safety performance for the sample firms even though they (and the controls) were already performing more safely than the industry average before certification. This demonstrated that OHSAS certification was not only a ceremonial action, thus supporting H1.

Table 4-1Results of sample firms' cumulative abnormal performance

	Pre-certification (year -2 to year 0)				Post-certification (year 0 to year 2)				Full event window (year -2 to year 2)			
	N	Median	Percentage	Mean	N	Median	Percentage	Mean	N	Median	Percentage	Mean
Safety Performance[a, b]	194	-0.00	41.23%	-0.21	163	-0.00	39.26%	-0.03	163	-0.00	45.40%	-0.20
Statistic		-2.67**	3.14**			-1.69+	2.93**			-1.14	2.07*	
Sales Growth	180	0.63	51.67%	-0.31	148	2.10	56.08%	2.66	148	1.95	56.76%	2.92
Statistic		0.27	0.53			1.69+	1.58			1.65+	1.65+	
Labor Productivity	177	2.26	58.19%	4.82	143	-0.09	49.65%	2.62	143	3.11	58.74%	7.18
Statistic		2.39*	2.11*			-0.69	0.00			2.55*	2.01*	
ROA	194	0.82	58.24%	1.04	163	0.71	54.60%	0.83	163	1.41	58.94%	1.68
Statistic		2.83**	2.23*			1.801+	1.097			3.27**	2.59**	

Note: Z-statistics for WSR test (median) and sign test (percentage)

Percentage indicates the percentage of firms achieving positive abnormal changes in safety performance, sales growth, labor productivity and ROA;**, *, + note a statistically significant difference from 0 at 0.01, 0.05 and 0.1 levels (two-tail)

[a]The percentage of negative safety performance between sample and control firms in the pre-certification, post-certification and the full event window period are22.09%,20.86%,and30.67%, respectively.

[b]The absolute number of violations in the pre-certification, post-certification and the full event window period are-41.80, -4.89, and -32.60per 10,000 employee, respectively.

Table 4-2Results of sample firms' year-to-year abnormal performance

	year -2 to year -1				year -1 to year 0				year 0 to year 1				year 1 to year 2			
	N	Median	%	Mean	N	Median	%	Mean	N	Median	%	Mean	N	Median	%	Mean
Safety Performance[a, b]	211	>-0.01	30.81%	-0.12	194	>-0.01	30.41%	-0.08	180	>-0.01	31.11%	-0.03	163	>-0.01	26.30%	0.10
Statistic		-2.26**	3.25**			-2.90**	3.60**			-1.78+	3.07**			-0.52	1.79+	
Sales Growth	197	1.48	54.31%	0.31	180	0.86	51.67%	0.97	165	2.60	58.18%	3.63	148	-0.91	47.29%	-0.69
Statistic		0.55	1.29			0.47	0.60			2.35*	2.28*			-0.66	-0.50	
Labor Productivity	192	1.58	56.50%	2.04	177	1.97	57.63%	2.53	160	2.10	56.88%	3.34	143	0.45	51.75%	0.55
Statistic		1.79+	1.66+			1.68+	1.95+			2.05*	1.66+			0.07	0.33	
ROA	211	0.42	55.92%	1.01	194	0.73	56.19%	0.73	180	0.54	58.33%	0.51	163	0.76	57.06%	1.03
Statistic		2.93**	1.65+			1.89+	1.65+			2.30*	2.16*			1.89+	1.72+	

Note: Z-statistics for WSR test (median) and sign test (percentage)

Percentage indicates the percentage of firms achieving positive abnormal changes in safety performance, sales growth, labor productivity and ROA;**, *, + note a statistically significant difference from 0 at 0.01, 0.05 and 0.1 levels (two-tail)

[a] The percentage of negative safety performance between sample and control in the period of year -2 to year -1, year -1 to year 0, year 0 to year 1 and year 1 to year 2 are15.16% , 12.89%,15.00% and 16.64%, respectively.

[b] The absolute number of violations in the period of year -2 to year -1, year -1 to year 0, year 0 to year 1 and year 1 to year 2 are-25.32, -15.52, -5.4 and 16.3 per 10,000 employee, respectively.

H2 predicts that OHSAS certification significantly affects a firm's sales performance. The results in Table 4-1 indicated that the cumulative abnormal sales growth from year -2 to year 0 was not statistically significant, whereas the results from year 0 to year 2 and year -2 to year 2 were statistically significant. For example, the median (mean) change from year -2 to year 2 was 1.95% (2.92%), which was significant at the 10% (5%) level. In this period, 56.76% of the sample firms achieved positive abnormal change. Table 4-2 indicated significant abnormal sales growth in year 0 to year 1 but not in the years before or after certification. In year 0 to year 1, the median (mean) change was 2.60% (3.63%), which was significant at the 5% (5%) level. In total, 58.18% of the sample firms achieved positive abnormal change in this period. This result suggested that obtaining certification provided the firms opportunities to attract new customers, indicating that OHSAS 18001 positively affected the sample firms' long-term abnormal sales performance and supporting H2.

H3 predicts that OHSAS certification significantly affects a firm's labor productivity. This hypothesis is based on actual changes in processes, not just signaling. Thus, the improvement should occur in all periods. The cumulative abnormal labor productivity results in Table 4-1 were significantly positive in the pre-implementation period and the full event window (year -2 to year 0 and year -2 to year 2, respectively). For example, from year -2 to year 2, the median (mean) change was 3.11 US dollars thousand (7.18 thousand US dollars), which was significant at the 5% (1%) level. In this period, 58.74% of the sample firms achieved positive abnormal change. Table 3 shows that the sample firms exhibited significant abnormal labor productivity in the years they began to implement OHSAS 18001 (year -2 and year -1). The median (mean) abnormal increase was 1.58 thousand US dollars (2.04 thousand US dollars), which was significant at the 10% (5%) level. In this period, 56.50% of the sample firms achieved positive abnormal change. Abnormal labor productivity continued to be significant in year -1 to year 0 and year 0 to year 1. These results suggested that adopting OHSAS 18001 significantly and positively affected the sample firms' long-term abnormal labor productivity, supporting H3.

H4 predicts that OHSAS certification significantly affects a firm's profitability. Tables 4-1 and 4-2 reveal that the abnormal change in ROA was significantly positive in all year-to-year and cumulative observation periods. For example, from year -2 to year 2, the median (mean) abnormal ROA was 1.41% (1.68%), which was significant at the 1% (1%) level. In this period, 58.94% of the sample firms achieved positive abnormal change. These results suggested that implementing OHSAS 18001 significantly and positively affected the sample firms' long-term abnormal profitability, supporting H4.

4.4.2. Endogeneity tests

Other factors that affect changes in financial performance and that were not captured in the matching process may exist. Therefore, we conducted additional tests to ensure that the relationship between OHSAS 18001 adoption and financial performance improvement is endogeneity-free. First, we performed *t*-tests on the sample and control firms' year -2 R&D intensity and labor intensity. The results indicated no significant differences ($p > .1$). Subsequently, we conducted similar tests for the all indicators from year -3 to year -2 by using the same sample and control firms (see Table 4-3). With this test, we examined whether the impact of OHSAS18001 on abnormal performance during the event period was actually driven by the superiorly performing firms. Table 5 reveals no significant change among all performance indicators from year -3 to year -2. The performance changes appeared only after the firms began implementing OHSAS 18001 in year -2. In conclusion, these tests suggest that the causal relationship is not due to a systematic bias in firm performance before OHSAS 18001 adoption.

Table 4-3Results of systematic bias tests

	Year -3 to year -2			
	N	Median	Percentage	Mean
Safety Performance	204	0.00	26.07%	0.02
Statistic		1.46	0.28	
Sales Growth	192	0.56	52.82%	1.44
Statistic		0.99	0.79	
Labor Productivity	186	0.92	53.44%	1.28
Statistic		1.44	0.87	
ROA	204	0.34	52.45%	-0.23
Statistic		0.67	0.63	

Note: Z-statistics for WSR test (median) and sign test (percentage), Percentage indicates the percentage of firms achieving positive abnormal changes in safety performance, sales growth, labor productivity and ROA

4.4.3. *Cross-sectional analysis*

Table 4-4 shows the correlations between the variables in the regression analysis and Table 4-5 displays the results of the regression analysis of the contextual factors under which firms may benefit more from adopting OHSAS 18001. The control models contain the firm- and industry-level controls, the complexity model includes the controls and R&D intensity and labor intensity (H5), and the full model includes inventory volatility, inventory level (H6), and all the other indicators. The results showed that firms of higher R&D intensity and labor intensity achieve higher profitability and safety performance after OHSAS certification ($p < .05$). Thus, H5 is supported. The complexity variables improve the explanatory power of the abnormal ROA model by 3.1% (according to adjusted R-square) and that of the abnormal safety performance model by 18.5%.

Inventory volatility but not inventory level is a significant predictor of firms' abnormal ROA. By contrast, inventory level but not inventory volatility is a significant predictor of firms' abnormal safety performance. These two variables improve the explanatory power of the abnormal ROA model by 3.4% and that of the abnormal safety performance model by 2%. H6 (coupling) is thus supported, but the mechanism by which coupling increases (inventory level vs. volatility) determines the relationship with a specific dependent variable.

Table 4-4 Correlation of the variables in regression analysis. N=163 **,*,+indicate statistically significant at 0.01, 0.05, and 0.1 levels (two-tail)

		Mean	S.D.	1	2	3	4	5	6
1	**ROA (%)**	13.78	0.06						
2	**Violation**	0.01	0.02	-0.130+					
3	**Size**	3.2	1.39	0.048	-0.072				
4	**Year of adoption**	2004.8	2.5	0.054	-0.068	0.038			
5	**R&D Intensity**	0.05	0.04	0.094	-0.096	-0.078	-0.143+		
6	**Labor Intensity**	3.92	2.44	-0.006	0.038	-0.146	-0.246**	0.147+	
7	**ISO 9000**	0.03	0.17	0.024	-0.053	-0.2	-0.003	0.180*	-0.043
8	**ISO 14000**	0.25	0.43	0.045	0.239**	-0.015	-0.041	-0.072	-0.04
9	**Inventory Volatility**	0.28	0.51	-0.003	-0.027	-0.045	-0.234	0.004	-0.167
10	**Inventory Level**	0.12	0.06	-0.008	0.082	0.232**	0.034	-0.054	0.325**
11	**Industry Size**	12.19	0.69	-0.043	0.073	0.055	-0.008	0.017	-0.044
12	**Industry Wage Level**	0.69	0.98	0.013	-0.055	0.051	0.015	-0.044	0.158
13	**Length of Working Hour (Industry)**	0.13	0.93	0.066	-0.036	0.009	-0.174*	-0.008	0.08
14	**Labor Union Influence (Industry, %)**	15.32	10.51	-0.201*	-0.024	0.187*	0.022	-0.026	-0.036

		7	8	9	10	11	12	13	14
8	**ISO 14000**	-0.191*							
9	**Inventory Volatility**	-0.061	-0.025						
10	**Inventory Level**	0.001	-0.038	0.062					
11	**Industry Size**	0.092	0.092	-0.018	0.125				
12	**Industry Wage Level**	-0.116	-0.274**	0.093	0.146+	-0.165*			
13	**Length of Working Hour (Industry)**	-0.252**	-0.223**	0.149	-0.194*	-0.181*	0.339**		
14	**Labor Union Influence (Industry, %)**	-0.371**	-0.175*	0.114	-0.041	-0.127*	0.350**	0.332**	

Table 4-5Estimated coefficients from regression analysis for the indicators in year -2

	Dependent Variable: Abnormal ROA (year -2 to year 2)			**Dependent Variable: Abnormal Safety Performance (year -2 to year 2)**		
	Control Model	**Complexity Model**	**Full Model**	**Control Model**	**Complexity Model**	**Full Model**
Intercept	-7.391^{+}	-8.798*	-11.704**	8.315	8.902	11.029
	[-1.841]	[-2.205]	[-2.883]	[0.978]	[1.154]	[1.356]
	(4.014)	(3.990)	(4.060)	(8.504)	(7.714)	(8.134)
Prior performance	-0.042	-0.053	-0.059	0.656^{+}	0.563	0.421
	[-0.567]	[-0.715]	[-0.819]	[1.740]	[1.630]	[1.203]
	(0.075)	(0.074)	(0.073)	(0.377)	(0.346)	(0.350)
Size	-0.007*	-0.005	-0.005	0.007	-0.001	0.003
	[-1.974]	[-1.561]	[-1.440]	[1.011]	[-0.144]	[0.419]
	(0.003)	(0.003)	(0.004)	(0.007)	(0.007)	(0.007)
Year of adoption	0.004^{+}	0.004*	0.006**	-0.004	-0.005	-0.006
	[1.850]	[2.207]	[2.885]	[-1.019]	[-1.191]	[-1.391]
	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)
ISO 9000	-0.016	-0.024	-0.015	0.069	0.074	0.069
	[-0.560]	[-0.845]	[-0.552]	[1.150]	[1.340]	[1.261]
	(0.028)	(0.028)	(0.028)	(0.060)	(0.055)	(0.055)
ISO 14001	-0.003	-0.001	0.002	-0.003	-0.015	-0.010
	[-0.288]	[-0.049]	[0.210]	[-0.125]	[0.652]	[-0.417]
	(0.012)	(0.011)	(0.011)	(0.025)	(0.022)	(0.023)
Size (Industry)	0.002	0.001	0.001	0.026^{+}	0.028*	0.024^{+}
	[0.260]	[0.138]	[0.131]	[1.714]	[2.080]	[1.710]
	(0.007)	(0.007)	(0.007)	(0.015)	(0.014)	(0.014)
Wage Level (Industry)	-0.002	-0.001	-0.002	0.007	0.002	0.004
	[-0.320]	[-0.191]	[-0.302]	[0.681]	[0.193]	[0.349]
	(0.005)	(0.005)	(0.005)	(0.011)	(0.010)	(0.010)
Union Influence (Industry)	<-0.001	<0.001	<0.001	-0.001	-0.002^{+}	-0.002*
	[-0.246]	[0.516]	[0.446]	[-1.268]	[-1.968]	[-1.987]
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Length of working hour (Industry)	0.004	0.008	0.007	0.004	0.002	0.007
	[0.745]	[1.414]	[1.246]	[0.313]	[0.150]	[0.647]
	(0.006)	(0.006)	(0.006)	(0.012)	(0.011)	(0.011)
R&D intensity		0.262*	0.255*		-0.343**	-0.302**
		[2.333]	[2.303]		[-2.691]	[-2.316]
		(0.112)	(0.111)		(0.127)	(0.131)
Labor intensity		0.004^{+}	0.005*		-0.007**	-0.009**
		[1.830]	[2.271]		[-3.485]	[-3.975]
		(0.002)	(0.002)		(0.002)	(0.002)
Inventory volatility			0.026**			-0.021
			[2.754]			[-1.029]

			(0.009)			(0.021)
Inventory level			-0.029 [-0.372] (0.078)			0.345* [2.071] (0.166)
R^2	5.6%	9.7%	14.1%	6.9%	25.5%	28.4%
Incremental R^2		4.1%	4.4%		18.6%	2.9%
Adjusted R^2	0.1%	3.2%	6.6%	1.7%	20.2%	22.2%
Incremental adjusted R^2		3.1%	3.4%		18.5%	2.0%
Incremental F-test		3.43*	3.79*		19.38**	2.54+

Note: **,*,+indicate statistically significant at 0.01, 0.05, 0.1 levels (two-tail)

Prior performance: ROA at year -2 in abnormal ROA model; Violation rate at year -2 in abnormal violation model

t-statistics in the bracket; standard error in the parenthesis

N = 163

4.5. Discussion and summary

This research examined how adopting OHSAS 18001 affects firm performance and considers contextual factors. We found that OHSAS 18001 significantly improves performance in safety, sales, labor productivity, and profitability. The firms in our sample that adopted OHSAS 18001 already exhibited above-average safety performance at the time they decided to seek certification, yet adoption still improved safety further. In addition, compared with similar firms in terms of industry, size, and ROA, the sample firms improved in labor productivity, sales, and profit after certification. Although we cannot say the firms adopted OHSAS 18001 because they viewed doing so as an easy means of gaining legitimacy or because they believed that their existing OHSMSs were insufficient, the results demonstrate unequivocally that adoption improved safety and financial performance.

The results of this study demonstrated not only that OHSAS 18001 adoption benefits safety and financial performance but revealed the pattern of how this certification improves profitability. This knowledge explains how adoption both enables firms to improve their processes and signal their achievements to the market. Specifically, we found that the legitimating component of adoption has a fairly narrow window, which opens only after certification. Sales increases are associated with certification, not the improvements in safety and productivity that occur because of improved processes. However, productivity and safety improvements accrue throughout the full event window. From a managerial perspective our results suggest that immediately after the implementation process begins, firms can expect improvements in productivity and safety but that these improvements will not translate directly into increased sales until the certification is officially announced to the public.

4.5.1. *Theoretical contributions*

OHSAS 18001, like ISO 9000 and ISO 14000, could be adopted as a legitimate tool, with our results showing that adopting firms reported sales growth after adoption, even though these firms had above-average safety performance before adoption. The results show that gaining OHSAS 18001 certification is an effective marketing tool to gain legitimacy among customers and that non adopters struggle to signal that they manage safety effectively. Adopters can obtain new contracts from clients who had been concerned about the firms' safety performance. The sales growth occurs only after certification, thus improvements in internal processes during the implementation period do not drive sales; rather, obtaining the actual certification seems to be driving the sales growth, supporting the notion that firms use OHSAS certification as a signal or legitimating tool.

Given the relatively low rates of OHSAS 18001 adoption, the improved financial performance finding is critical. This sample of early adopters who were already performing well in safety demonstrates the efficacy of OHSAS 18001 adoption. This result informs the debate on creating more responsible organizations by showing that, contrary to the supposition of many safety researchers (e.g. Zohar, 2002), improve a firm's safety and financial performance simultaneously is possible. In addition, if adoption improved both safety and financial performance for early adopters who were already above average in safety, it would likely have larger impacts on later adopters. We posit that as the standard becomes more popular, the safety and productivity gains evidenced in our sample will remain or even increase but that the ability to generate sales growth from adoption will quickly dissipate.

The findings suggest that adopting OHSAS 18001 does not require a trade-off between safety and financial performance. The NAT–HRT synthesis suggests that adopting OHSAS 18001 would inculcate many of the attributes of a highly reliable organization, thereby reducing the odds of drift and improving safety and productivity.

We have strong evidence of this supposition; in the sampled firms, adopting OHSAS 18001 improved safety control and outcomes. In addition, this increased control improved labor productivity throughout the full event window. These results provide solid empirical evidence that safety and operational improvements are compatible, likely because of the reduction of direct and indirect costs that are associated with workplace accidents and illnesses and improved labor absenteeism and turnover (De Koster et al., 2011). Our results support the proposition that OHS practices can improve firm efficiency (e.g., De Koster et al., 2011; Fernández-Muñiz et al., 2009).

In line with the HRT–NAT syntheses, our analysis suggested that adopting OHSAS 18001 will most benefit firms that have complex or highly coupled production processes. Previous studies on OHSMS mainly examined only one or a few industries (e.g., Brown et al., 2000; Das et al., 2008, De Koster et al., 2011), providing limited insight into manufacturing. Contingency theory considers that a management practice (e.g., OHSMS) may not be beneficial universally because of the differences between firms and industries (Morgan, 2007).

We explored contingencies in the cross-sectional analysis, with a focus on industrial settings that NAT would suggest have the greatest risk of accidents and failures. The production processes of high-tech firms are complex (Fine, 1999; Singh, 1997), making identifying hazardous situations difficult for workers. The regression results indicate that the benefits of OHSAS adoption increase with R&D intensity.

Labor-intensive firms also benefit more than average from adoption. Labor-intensive processes are generally more complex and not automated. Thus, labor-intensive firms are highly reliant on their workers and highly sensitive to absenteeism and turnover caused by workplace injury and illness. The results indicate that OHSAS 18001 adoption, though effective in all settings, are more effective in the complex or highly coupled settings found in high-tech and labor-intensive firms. In addition, the results indicate that firms with high inventory volatility benefit more from OHSAS adoption, which suggests that OHSAS can cope with the coupling process brought by holding wrong inventory.

4.5.2. *Managerial implications*

In our samples, investing in safer operations increased productivity and profitability. The empirical evidence provides a relevant reference for senior managers of manufacturing firms who are considering adopting OHSAS 18001, even in firms with effective internally generated safety management systems. Management can expect that adoption will improve performance, particularly when the firm is operating in dynamic and complex circumstances. Furthermore, because OHSAS 18001 certification is still relatively rare, we posit that these benefits, particularly the sales increases, will accrue mainly to early adopters.

This finding could provide insights for practitioners and certification bodies. Operations managers, who are not yet facing stakeholder pressure to adopt OHSAS

18001, can assess their firms' own levels of complexity and coupling to understand the likely benefits of adoption more deeply. Certification and standard development organizations (e.g., BSI and ISO) would be well-served by tailoring OHSAS to various settings, particularly the high-tech segment. Whereas managers of labor-intensive firms would hopefully already know the benefits of protecting their workforce, managers at high-tech firms do not receive such obvious signals from stakeholders and may be unaware of the benefits. Standard-setting organizations can facilitate this process by adapting the certification to dynamic industries.

The results also provides implication for the managers of retail brand to select suppliers. The managers should prioritize the manufacturers who adopted OHSAS 18001. First, such selection can lower the risk of brand dilution from the supplier's OHS scandal as the manager can expect the good safety performance of the suppler. Second, the OHSAS certified suppliers can have higher productivity to ensure the product delivery.

To yield clearer implication to fashion and textiles manufacturers, Figure 4-2 and Figure 4-3 illustrates the comparison of the influences of OHSAS adoption between fashion and textiles manufacturers and general manufacturers. Based on our search, the OHSAS adopters span several fashion and textiles subsectors, including fashion and accessories brands (e.g. LVMH group), household textiles manufacturers (e.g. Mohawk Industries Inc.), medical or protective apparel manufacturers (e.g. Steris

Corp.), synthetic fiber manufacturers (e.g. A. Schulman Inc., Lyondell Basell Industries and Celanese Corp.), dye and coating manufacturers (e.g. Flint Group), and beauty and cosmetic manufacturers (e.g. L'Oreal Group and Avon Products Inc.).

In the full event window (year -2 to year 2), OHSAS adoption improves the safety performance of fashion and textiles manufacturers (mean = - 0.51 violations per 10

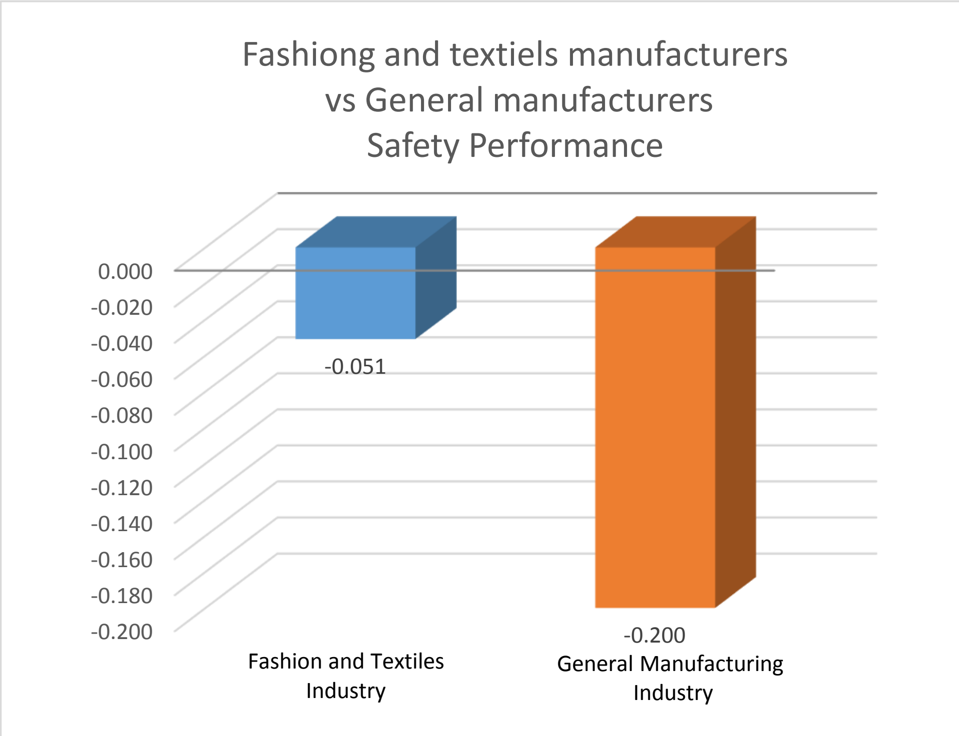

Figure 4-2 Safety performance

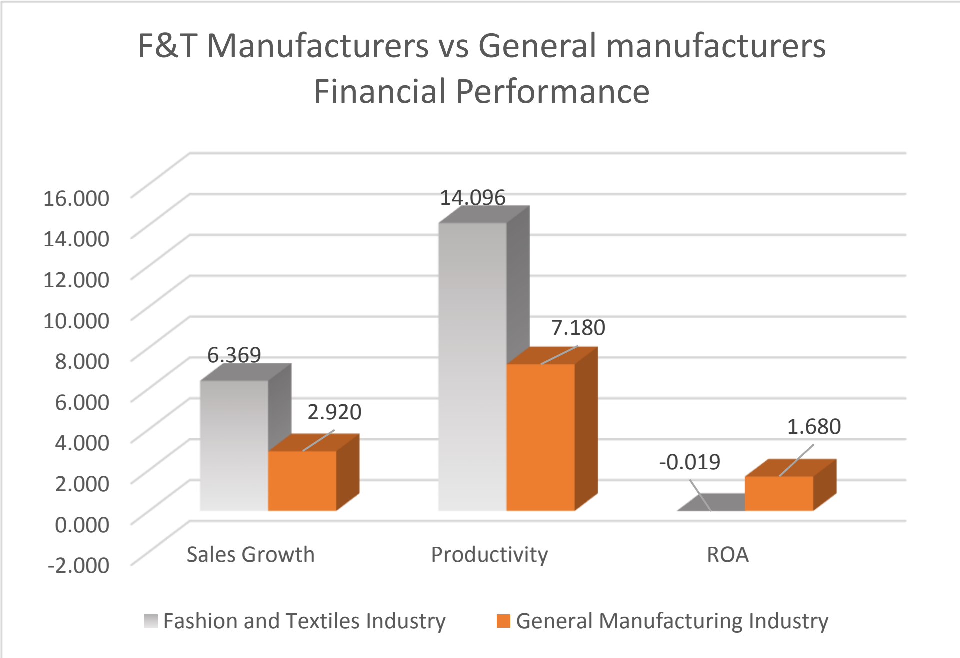

Figure 4-3 Financial performance

thousand workers) while the magnitude is insignificantly lower than to the other manufacturers (mean = - 0.20 violations per 10 thousand workers, $p > 0.1$). However, fashion and textiles manufacturers (6.37%) are able to achieve higher sales growth than other manufacturers (2.92%) relying on OHSAS adoption ($p < 0.05$). The figure suggests that the signaling effect of OHSAS certification is essential for fashion and textiles manufacturers. The sales of fashion brands rely heavily on their brand image. As consumers and NGOs nowadays are paying more attention to the ethical issues in fashion supply chain, any scandals on OHS issues would damage the fashion retailers' brand equity (Fan & Lo, 2012). Therefore, fashion retailers would require supplier to obey code of conducts to control supplier's OHS performance (Welford & Young, 2002). Fashion and textiles manufacturers who adopted OHSAS certification can signal fashion retailers, and consumers that the OHS is properly managed in the production and OHS scandal would not happen.

The safer workplace and higher sales growth consequently lead to better labor productivity (about 14 thousand US dollar per worker) of fashion and textiles manufacturers than overall manufacturing industry ($p < 0.05$). However, the improved safety and sales performance do not lead to better ROA for fashion and textiles manufacturers. The abnormal ROA of fashion and textiles manufacturers (-0.02%) is lower compared to the abnormal ROA of other manufactures (1.68%, $p < 0.05$). The diminished merit of OHSAS to ROA may come from the additional assets (e.g., safer machineries, production material and personal protection equipment) purchased for safer production (Fan & Lo, 2012). Therefore, managers should be aware that OHSAS 18001 adoption apparently can improve the workplace safety for fashion and textiles manufacturers. In addition, it is an effective tool to obtain legitimacy from fashion retailers and gain benefits for sales growth and labor productivity. However, managers should notice that the OHSAS 18001 adoption may make the firm more ponderous in terms of heavy assets, which could consequently diminish the merit to ROA.

5. Conclusions, Limitations and future research direction

This dissertation contributes to the OM literature by investigating OHS issues in the operations of manufacturing firms, especially in fashion and textiles industry. The systematic citation network analysis review (study one) describes the demography of the relevant articles published in seven peer-reviewed OM journals. We then identified four main research domains based on the citation network of the articles, namely safety climate, system management system integration, voluntary OHS management system, sustainable operations. In addition, we performed main path analysis to identify the knowledge structure for the main research domains and conclude that sustainable operations and voluntary OHS management system are two underdeveloped domains. Thus, we conducted two empirical studies to enrich the literature in these two domain.

The first empirical studies (study two) contributes to sustainable operations domain by investigating the operational antecedents of safety incidents. We draw from the synthesis view between NAT and HRT and finds that high operational coupling level (indicated by short inventory days) associates with higher likelihood of operational incidents, while financial slacks (in terms of unabsorbed and absorbed slacks) can attenuate the relation between operational coupling and financial slacks.

The second empirical studies (study three) contributes to voluntary OHS management system domain by investigating the impacts of OHSAS 18001 (a popular OHS management system certification) adoption on manufacturing firms' performance. We find that OHSAS 18001 adoption can improve the firms' safety performance, sales performance, labour productivity and profitability. In addition, the firms operating in highly complex (indicated by R&D and labour intensity) and tightly coupled (indicated by inventory level and volatility) settings can benefit more from the adoption.

The two empirical studies take measures to increase the confidence of causal relations. In the regression models of study two, the independent variables have one-year lag to the dependent variables, and several control variables are included to rule out alternative explanations. The event study method used in study three ensures that the sample firms and control firms are highly similar. Thus, the research design increases the confidence that the abnormal performance of sample firms are come from the OHSAS 18001 adoption (the treatment).

This dissertation has some limitations. First, though CNA analyzes articles more objective than does a systematic review, the journal initial selection was somewhat subjective. Second, negative citations (citations given to an article in the process of criticizing it) may exist in the citation network, though this is generally considered a minor problem in citation analysis (Pilkington & Meredith, 2009). Third, current CNA treats every citation with equal importance. However, the significance of every citation to an article can be different. For example, some citations are significant for an article to build a backbone framework, whereas some citations simply provide "utility" for a small part of the article (Pilkington & Meredith, 2009). Rather than using a binary matrix to record citation network data, future research may analyze and assign a value to each citation. For example, a value of "2" or "1" could be assigned to citations that are "significant" or just a "utility" to the article. Fourth, the article search results may be sensitive to the keyword used. For example, we found eight more articles when we used "social sustainability", "triple bottom lines" and "sweatshop" as the primary keyword instead of "safety management". However, the OHS-related content is a minor part in these additional articles. Fifth, despite it is not able to identify the main path in the scattered clusters, future research can explore the research opportunities from the articles in the cluster.

Sixth, the studies in this dissertation examine only U.S.-listed firms, and the effectiveness of a management practices such as slack resources and OHSAS 18001 adoption might vary in countries with different cultural contexts (Kull & Wacker, 2010) or where government regulations differ. Seventh, listed firms are usually large firms that have more slack resources and basic OHSMSs in place; this is a supposition that seems to be confirmed by the above-average safety performance of the sample firms. Thus, the results could differ in private firms. Furthermore, firms in export-oriented economies (e.g., China, Hong Kong, and India) may adopt OHSAS 18001 mainly to fulfill customer requirements and have no intention of improving working conditions. Therefore, the impact of OHSMS might depend on the motivations of the adopting firms. Future research should address these limitations.

Eighth, following the theory premise of NAT, this dissertation reveals that tightly coupled operation is a critical operational antecedent of safety incident. We will investigate whether complex operation can also lead to more safety incidents because NAT suggests that complexity would be another operational antecedent of safety incident.

In addition, our results capture the evidence that adopting OHSAS 18001 can benefit sales performance by gaining legitimacy, which implies that the adoption could be driven by external institutional pressures (DiMaggio and Powell, 1983). One limitation of our studies is that the institutional pressures are not controlled in the OLS analysis. Future studies can investigate the impacts of institutional pressures on the OHSAS 18001 adoption behavior and effects, including coercive pressures (e.g., government regulation and customer requirement), mimetic pressures (e.g., industry peers' adoption) and normative pressures (e.g., the number of certification body of OHSAS).

Finally, nowadays there are several popular CSR related certifications on the market, for example, GRI (business sustainability reporting), SA 8000 (social accountability), ISO 50000 (energy management) and ISO 26000 (social responsibility). OHSAS 18001 adoption apparently aids firm demonstrating its commitment on the OHS part of CSR and gaining financial benefit. The benefit is also found in quality management certificate ISO 9000 (Corbett et al., 2005) and environmental management certificate ISO 14000 (Lo et al., 2012). Future research can examine whether the firm can gain similar benefits when adopting other CSR related certifications.

6. Appendices

Appendix A: Classification results

Research Domain	Articles
Safety Climate and Culture	Brondino et al. (2012);Brown (1996); Brown et al. (2000); Burt et al. (2008); Choudhry et al. (2007); Clarke (2006); Colley and Neal (2012); Cooper (2000); Cox and Cheyne (2000); Das et al. (2008); De Koster et al. (2011); Dov (2008); Eid et al. (2012); Ek et al. (2007); Fernandez-Muniz et al. (2009); Findley et al. (2007); Flin (2007); Flin et al. (2000); Glendon and Litherland (2001); Guldenmund (2000); Guldenmund (2007); Gyekye and Salminen (2009); Hahn and Murphy (2008); Hale et al. (1997); Haukelid (2008); Havold (2010); Havold and Nesset (2009); Hoivik et al. (2009); Hoivik et al. (2009); Hope et al. (2010); Hovden et al. (2008); Hudson (2007); Idris et al. (2012); Kapp (2012); Kath et al. (2010); Keren et al. (2009); Kongsvik et al. (2010); Kongsvik et al. (2012); Larsson et al. (2008); Lin et al. (2008); Lofquist et al. (2011); Ma and Yuan (2009); Martinez-Corcoles et al. (2011); McDonald et al. (2000); McFadden and Hosmane (2001); Mearns et al. (2003); Mearns and Yule (2009); Mearns and Reader (2008); Melia et al. (2008); Mohamed et al. (2009); Nielsen et al. (2008); Niskanen et al. (2012); Pfeiffer and Manser (2010); Phipps and Ashcroft (2012); Pousette et al. (2008); Reniers et al. (2011); Rundmo and Hale (2003); Seo (2005); Shannon and Norman (2009); Tharaldsen et al. (2008); Torner (2011); Vinodkumar and Bhasi (2009); Vinodkumar and Bhasi (2011); Wang and Liu (2012); Zhou et al. (2008)

Management Systems Integration	Armenti et al.(2011); Bernardo et al.(2009); Bernardo et al. (2010); Bernardo et al. (2012); De Oliveira and Coelho (2002); Fresner and Engelhardt (2004); Jorgensen (2008); Jorgensen et al.(2006); Karapetrovic and Casadesus (2009); Salomone (2008);Santos et al.(2011); Simon et al.(2011); Simon et al. (2012); Zeng et al. (2007);
Voluntary OHS Management System	Badri et al. (2012); Bottani et al. (2009); Fernandez-Muniz et al. (2012); Frick (2011); Goh et al. (2010); Goh and Love (2012); Granerud and Rocha (2011); Hohnen and Hasle (2011); Leka et al. (2011); Makin and Winder (2008) Robson et al. (2007); Walters (2011); Zeng et al. (2008)
Sustainable Operations	Chinander (2001); Cohen and Kunreuther (2007); Gunasekaran and Spalanzani (2012); Klassen and Vereecke (2012); Kleindorfer et al. (2005); Montero et al. (2009); Pagell and Gobeli (2009); Zhao et al. (2012)
Scattered Clusters	Akcil (2006); Arezes and Miguel (2008); Blewett and O'Keeffe (2011); Carroll and Fahlbruch (2011); Celik (2010); Choi et al. (2011); Choudhry and Fang (2008); Cuny and Lejeune (2003); Duijm et al. (2008); Ferjencik (2010); Hopkins (1999); Kjellen (2007); Lee et al. (2011); Lindqvist et al. (1999); Mohaghegh and Mosleh (2009); Mohaghegh and Mosleh (2009); Newnam and Vonschuckmann (2012); Nenonen (2011); Oz et al. (2010); Rundmo T.(1996); Sato Y.(2012); Schonbeck M., Rausand M., Rouvroye J.(2010); Siemsen et al. (2009); Skjerve et al., (2012); Smallman and John (2001); Williams et al. (2007); Wolf (2001); Yang (2012)

Appendix B: Samples of violation record

Firm name	State	Industry	Violation Date	Serious Violation	Other Violation	Repeat Violation	Willful Violation
SAPPI DBA S D WARREN CO	ME	2621	1991/7/12	1	1	0	0
SAPPI DBA S D WARREN CO	ME	2621	1992/8/6	1	0	1	0
SAPPI DBA S D WARREN CO	ME	2621	1992/6/12	1	0	0	0
SAPPI DBA S D WARREN CO	ME	2621	1992/3/6	1	1	1	0
SAPPI DBA S D WARREN CO	ME	2621	1993/4/8	1	0	0	0
SAPPI DBA S D WARREN CO	ME	2621	1993/1/7	1	1	0	0
SAPPI DBA S D WARREN CO	ME	2621	1997/6/26	0	1	0	0
SAPPI DBA S D WARREN CO	ME	2621	1997/4/3	1	0	0	0
SAPPI, INC.	ME	2621	2004/12/1	1	1	0	0
SAPPI, INC.	ME	2621	2004/1/22	1	1	0	0
SAPPI DBA S D WARREN CO	ME	2621	2008/5/7	1	0	0	0
SMITH & WESSON CORPORATION	ME	3484	2008/6/10	1	0	0	0
SMITH & WESSON CORPORATION	ME	3484	2011/8/15	1	0	1	0
SCOTT PAPER COMPANY, WORLD WIDE DIV.	ME	2621	1990/4/5	1	1	1	0
PEPSI BOTTLING GROUP	ME	2086	2005/8/3	1	1	0	0
PEPSI BOTTLING GROUP	ME	2086	2008/2/8	0	1	0	0
WEYERSHAUSER	ME	2653	1994/7/7	1	1	0	0
BAILEY MANUFACTURING CORP.	ME	2421	1990/7/18	1	1	0	0

Appendix C: Distribution of violations by three-digit SIC

SIC		SIC		SIC		SIC		SIC	
200	82	**253**	276	**299**	2	**348**	17	**382**	158
201	256	**254**	13	**301**	114	**349**	73	**384**	171
202	57	**259**	10	**302**	11	**351**	75	**385**	2
203	142	**260**	100	**305**	13	**352**	52	**386**	13
204	171	**261**	27	**306**	37	**353**	158	**387**	1
205	45	**262**	320	**308**	239	**354**	88	**391**	14
206	57	**263**	278	**310**	3	**355**	61	**393**	4
207	9	**265**	194	**314**	18	**356**	260	**394**	44
208	553	**267**	140	**322**	75	**357**	131	**395**	11
209	14	**271**	24	**323**	21	**358**	174	**399**	17
210	3	**272**	2	**324**	20	**359**	12		
211	1	**273**	2	**325**	16	**360**	36		
220	31	**275**	59	**326**	1	**361**	17		
221	54	**276**	25	**327**	38	**362**	106		
222	16	**277**	12	**329**	40	**363**	93		
225	21	**278**	14	**331**	619	**364**	110		
227	32	**279**	1	**332**	9	**365**	30		
230	40	**280**	17	**333**	125	**366**	69		
232	23	**281**	115	**335**	326	**367**	377		
233	11	**282**	150	**336**	18	**369**	96		
234	1	**283**	173	**339**	36	**371**	798		
239	33	**284**	113	**341**	112	**372**	341		
240	306	**285**	112	**342**	52	**373**	17		
242	143	**286**	50	**343**	19	**374**	95		
243	54	**287**	57	**344**	98	**375**	15		
245	147	**289**	99	**345**	36	**376**	19		
251	296	**291**	155	**346**	100	**379**	41		
252	24	**295**	2	**347**	7	**381**	33		

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