EFFECT OF REGULATORY PROSECUTION TO IMPROVE WORKPLACE SAFETY IN ALBERTA

by

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ABSTRACT

According to Canadian Workers' Compensation Boards (WCBs), there are a disturbing number of workplace injuries and fatalities every year (Anonymous, 2017). Literature suggests that various external factors such as economic, regulatory and social factors affect firms', and associated industries' safety culture. Alberta Occupational Health and Safety (OHS) uses many education, compliance and enforcement tools to improve the safety culture of workplaces but the effectiveness of these tools is unknown. To address this, convictions and sentencing from Alberta OHS and their effect on subsequent Workers' Compensation Board Alberta (WCB AB) claim rates have been analyzed to determine the focal firm and spill-over effect. First, comparisons of before sentencing and after sentencing claim rates have been performed using non-parametric statistical tests. Comparison results show a statistically significant difference between the claim rates of sentenced sample and non-sentenced sample across the province. This study also finds that firms in the Municipal Government, Education and Health Services sector show relatively less response to sentencing, and firms located in the center of Edmonton or Calgary and between these two cities are more responsive to sentencing in terms of their change in post-sentencing claim rates. Study on spill-over effect of sentencing shows that claim rates of the firms in the same industry whose firms were sentenced have decreased after two years of sentencing. In addition to spill-over effect, a focal firm effect has also been observed using an exploratory approach of graphical trend analysis of sentenced firms with respect to non-sentenced firms in the same industries and non-sentenced firms in the same industries and same locations whose firms were sentenced. Visual inspection of these trends suggests that sentenced firms' average claim rates show a decreasing trend if two firms' exceptionally high claim rates are removed from a specific year in the post-sentencing

period. In this study, it is presumed that the decreases or changes of firms' claim rates in the post-sentencing period are attributed to sentencing, however, qualitative studies such as surveys or interviews should be performed in the future study to identify the actual reasons behind the decrease or change of firms' claim rates in the post-sentencing period.

PREFACE

This thesis is an original work by Umme Aulia Munira. This thesis has not been previously published anywhere and does not contain any collaborative work.

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my supervisor, Dr. Lianne Lefsrud, for her patience, support and guidance throughout the duration of this project. I deeply thank her for continuously pushing me, throwing challenges at me, and taking a chance on me at the first place. I would also like to express my gratitude to Dr. Heather Eckert for her constant and dedicated support and instructions in developing and reviewing my thesis. I would like to specially thank Dr. Vinay Prasad for his time and valuable suggestions regarding this thesis. I would also like to thank Dr. Arno De Klerk for enlightening me and providing insightful comments on my thesis paper. My sincere thanks also go to my examining committee members; Dr. Heather Eckert, Dr. Joel Gehman, Dr. Arno De Klerk for their feedback and comments in developing and revising this thesis.

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NOMENCLATURE

AB	Alberta
DAF	Dataset with All Firms
DFPCR	Dataset of Firms with Positive average Claim Rate (also who sustained for whole study period)
FTE	Full Time Employee
GoA	Government of Alberta
H_A	Alternate hypothesis
H_O	Null hypothesis
Indlocation /Industry-location	A unique value for each Industry and location combination
KS	Kolmogorov Smirnov test
MWU	Mann-Whitney U test
OHS	Occupational Health & Safety
OLS	Ordinary least square
Sentenced Industry	Industry whose firm gets sentenced
Sentenced Industry-location	Industry-location whose firm gets sentenced
WCB	Workers' Compensation Board

CHAPTER 1 : INTRODUCTION

1.1 Background

According to Canadian workers compensation boards, 852 workers died in 2015 due to work related causes, which is the lowest number since 1999. Alberta ranks second (tied with Newfoundland and Labrador) in terms of the number of deaths per 100,000 workers (Tucker, 2017). Recent statistics from the Government of Alberta show that 144 workers died due to workplace injury or disease and around two out of 100 workers were injured in workplace in 2016 (Government of Alberta, 2017). As recently as 2017, Alberta lost 166 men and women due to workplace injury or illness; which means that one worker had died every 2.2 days in Alberta. The annual claim cost for workplace incidents is over $600 million dollars (Marak, 2015). Hence, reducing the frequency and severity of workplace incidents would have significant health, social, and economic benefits for the residents of Alberta. To prevent such incidents and improve workplace safety in Alberta, Alberta Occupational Health and Safety (OHS) employs a sophisticated suite of education, compliance, and enforcement tools. One such tool is AB Justice Prosecution. If a firm is convicted after prosecution, the convicted firm tries to improve its behavior due to specific deterrence[1]. Besides, this conviction might also create a general deterrence[2] to broader society to encourage improvements so that other firms will not get punished in the future (Johnson, 2018). Thus, regulatory prosecution can improve the overall safety culture that prevents future workplace incidents due to specific and general deterrence.

[1] Specific deterrence is a method of punishment in the criminal justice system intended to discourage criminal behavior in the specific individual charged with the crime.

[2] General deterrence can be defined as the impact of the threat of legal punishment on the public at large.

1.2 Research Gap and Motivation

Occupational health and safety research has detailed the relative influence of organizational (culture) and personal (commitment, motivation, knowledge) factors on improving organizational performance (Reason, Parker, & Lawton, 1998). In a parallel manner, environmental performance research reveals a range of external factors (economic, regulatory and social opportunities and pressures) and internal factors (managerial incentives, organizational culture, organizational identity, and organizational self-monitoring) that affect organization performance (Gunningham, Kagan, & Thornton, 2004). However, there is a dearth of research on when, how, and whether these different factors are effective in promoting a safety culture. The gap indicates the need for a study to determine how one of the external factors, regulatory prosecution, can improve firms' and industries' workplace safety culture. To address this gap, this thesis explores if the sentencing of a firm can reduce the subsequent claim rates of the focal firms as well as firms in the same industry and the same region. Follow-up studies will identify if the changes of WCB claim rates can be attributed to regulatory prosecution i.e. sentencing. These findings might improve the understanding of effectiveness of OHS enforcement as a specific and general deterrent; the findings could also help to create a dialogue to promote preventative health and safety culture as well as mitigate the risks of occupational accidents and injuries. Moreover, since Engineering Safety and Risk Management (ESRM) works to improve workplace safety, it is ESRM's obligation to determine the factors responsible for workplace incidents and to utilize those motivating factors to improve safety culture. Incorporating those factors in regulation might mitigate potential workplace incidents.

1.3 Research Objective

The overall objective of this research is to determine whether regulatory prosecution is an effective tool to improve Alberta workplace safety. To measure the effectiveness of regulatory prosecution, the WCB AB claim rates of convicted firms and their industries from 2005 to 2015 have been analyzed. The more specific objectives of this thesis are given below.

- Identify if the post-sentencing WCB AB claim rates are different than the pre-sentencing WCB AB claim rates for the sentenced firms, sentenced industries and sentenced industry-locations.
- Determine the spill-over effect[3] of OHS convictions, i.e. sentencing as a general deterrent on the firms in the same industry and region whose firms got sentenced.
- Determine the focal-firm effect[4] of OHS convictions, i.e. sentencing as a specific deterrent on the sentenced firms.

1.4 Organization of the Thesis

Chapters of this thesis are designed in such a way so that each chapter can address each of the objectives given above.

Chapter 1- Introduction: This chapter contains information on existing workplace scenario of Alberta, research gap and motivations and research objectives.

Chapter 2- Literature Review: This chapter discusses industrial safety culture and its drivers, conceptual framework to improve overall OHS performance, how Workers' Compensation Board AB and Occupational Health and Safety AB work in Alberta, theoretical

[3] Description of spill-over effect is provided in Section 2.7.2
[4] Description of focal-firm effect is provided in Section 2.7.1

model of how regulatory prosecution can improve workplace safety workplace safety in Alberta and description of related data analyses, and lastly the research questions those have been addressed in later chapters.

Chapter 3- Processing of Data: This chapter contains the sources of data those have been used in this thesis for analysis purpose and how to process those in analysable data through various steps such as cleaning, determining the key dependent variable, merging different datasets etc.

Chapter 4- Comparison of Claim Rates before and after Sentencing using Nonparametric Statistical Tests: First, the distributions of the WCB AB claim rates were observed and based on distributions, before and after sentencing claim rates of sentenced firms, sentenced firms' industries and sentenced firms' industry-locations have been compared using nonparametric statistical tests.

Chapter 5- Spill-over Effect of Sentencing on Industries' and Industry-Locations' Subsequent Claim Rates using Fixed Effect Model of Panel Data: Spill-over effect has been determined using panel data analysis. Fixed effect models have been used to the determine change of average WCB AB claim rates after one year and two years of sentencing for Industries' and Industry-Locations' whose firms got sentenced.

Chapter 6- Exploratory Data Analysis to Observe the Focal-firm Effect of Sentencing with respect to Firms in the same Industry and Firms in the same Industry-Location: This chapter includes an exploratory approach to compare the trends of sentenced firms' average claim rates in pre and post-sentencing period with respect to non-sentenced firms' average claim rates in the sentenced industries and sentenced industry-locations by visual inspection.

Chapter 7- Conclusion and Recommendations for Future Work: The main findings from this study and recommendations for further analyses have been discussed in this chapter.

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CHAPTER 2 : LITERATURE REVIEW

2.1 Evolution of Industrial Safety Culture

Several major incidents in last few decades around the world (i.e. Piper Alpha, BP Macondo, Bhopal, Flixborough) have raised awareness on the effect of organisational, managerial, and human factors on safety outcomes, and the decisive effect of 'safety culture' on those factors. Since the Chernobyl incident in 1986, there has been increased research on the factors that affect workplace safety and how to improve it. As a part of organizational culture, safety culture is one of the primary factors preventing workplace related disasters. If an organization is less attentive to safety issues, it will be reflected in their safety related policies and procedures. One definition of organizational culture is "shared values (what is important) and beliefs (how things work) that interact with a company's people, organizational structures and control systems to produce behavioural norms (the way we do things around here)" (Reason, 2016). Schein et al. (1992) classified organizational culture in three parts; artifacts, espoused values, and underlying assumptions. Artifacts are visible objects though their significance may be different to outsiders. Values reflect an organization's mission, what they stand for and their goals. Underlying values and assumptions are difficult to understand as they are demonstrated through the perceptions, beliefs, and behaviors of members of the organization. Understanding their underlying values and assumptions requires immersion in the organization's culture. An organizational culture can be depicted through the following iceberg model (Figure 2-1) (Schein, 1992 & 1999).

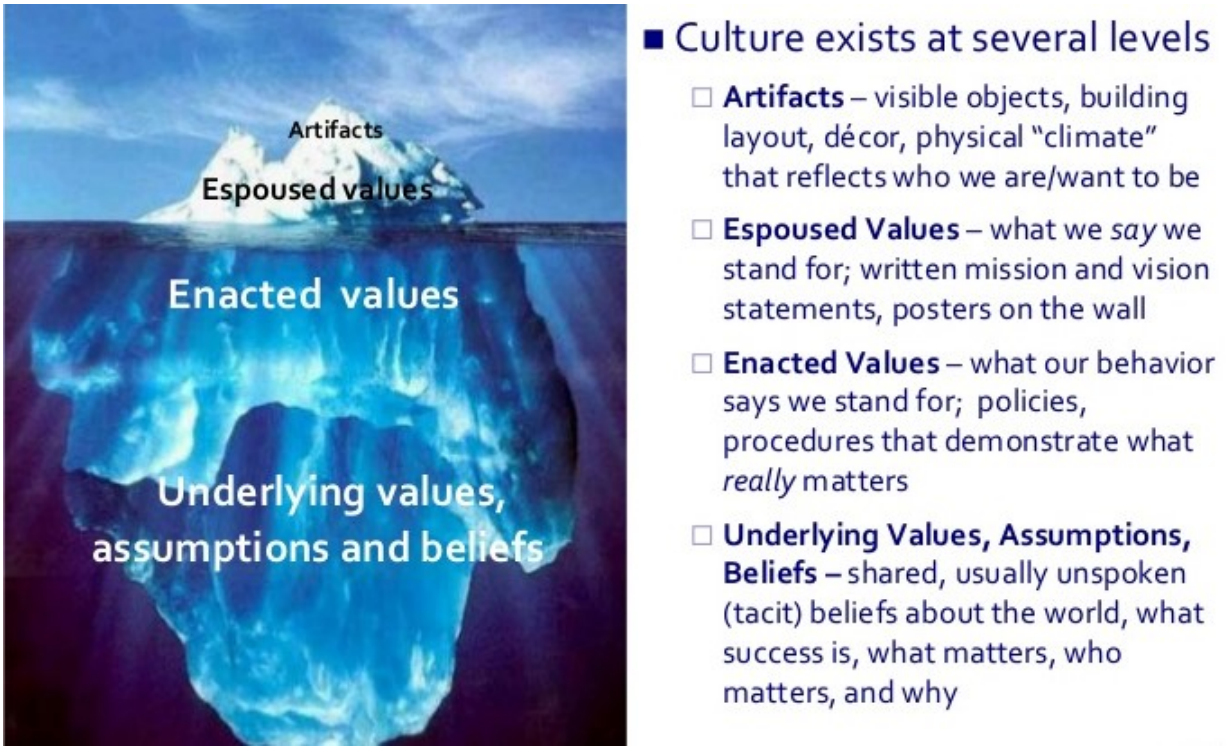

Figure 2-1: Iceberg model for organizational culture (Schein, 1992).

Defining the safety culture remains a confusing and ambiguous concept in both the literature and in industry. Many academics have attempted to clarify the constructs of safety culture to resolve this confusion. Among them, Guldenmund reviewed two decades of safety culture and safety climate literature (1980- 2000) and defined safety culture as "those aspects of the organisational culture which will impact on attitudes and behaviour related to increasing or decreasing risk" (Guldenmund, 2000). According to Guldenmund (2000), safety culture ice berg model can be described as following:

Outer layer – artifacts can be exampled as statements, meetings, inspection reports, dress codes, personal protective equipment, posters, bulletins.

Middle layer – espoused values/attitudes can be exampled as attitudes, policies, training manuals, procedures, formal statements, bulletins, accident and incident reports, job descriptions, minutes of meetings.

Underlying values – basic assumptions are mainly implicit; these must be deduced from artifacts and espoused values as well as through observation.

Agwu et al. (2012) argues that employees' safety culture is a product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the level of commitment, style, and proficiency of an organization's safety management system. He assumes that the inculcation of employees' safety culture on the workforce at the task level using behavior-based safety culture approach (enforcement and education) has an influence on employees' safety performance as well as on company performance: enhancement of productivity, profitability, and loss control through reduction of accident/incident rate (Agwu, 2012).

Cooper (2000) presents a model that recognizes the presence of an interactive or reciprocal relationship between psychological, situational and behavioral factors of safety culture. He claims that organizational culture is the product of multiple goal-directed interactions between people (psychological), jobs (behavioral), and the organization (situational). He suggests that people can neither be deterministically controlled through their environment nor entirely self-determining, but they and their environments influence one another in a perpetual dynamic interplay (Cooper, 2000). In his reciprocal safety culture model, attitudes and perceptions can be assessed through safety climate questionnaires. Actual safety-related behaviors are assessed through checklists developed as part of behavioral safety initiatives. Further, situational features are assessed through safety management systems audits/inspections. This reciprocal framework has the potential to

quantify the relevant components of safety culture and can be measured independently or in combination.

Pidgeon (1998) highlights four theoretical issues based on his review of safety culture research and suggests that, without understanding these issues, safety culture may be a construct that provides cover for talking about safety without requiring the actions that are needed to address issues within the organization (Pidgeon, 1998). Clarke (2000) further argues that safety culture as a concept "remains vague, lacks empirical validation and is used as an 'umbrella term' for all the social and organizational factors that affect accident rate." (Clarke, 2000).

Reason (2016) advocates that organizational accidents can be mitigated only if organizations attend to three different safety systems: the person model, the organization model, and the engineering model. Reason claims that each one of these systems is dynamic and has reciprocal influences on each of the other systems. For example, changes to the technology system may result in changes in the person and/or organization system (Reason, 2016).

The person model of an organization represents individual safety performance and perceptions. The focus of this model is on individual unsafe acts and personal injury accidents. Errors are perceived as being shaped predominantly by psychological factors including inattention, forgetfulness and poor motivations etc. Reason claims that this is the most widely adapted model of safety management because these individual factors are relatively easy to identify.

The organization model of safety management represents factors such as management structure and other organizational factors. This model views error as a consequence rather than as a cause. Reason advocates that in this model, errors occur as the result of latent conditions inherent to the system. These latent conditions produce weaknesses in the systems. Organizational factors

are shaped by societal, regulatory, and cultural influences. There has been an increased focus on organizational factors in safety management in recent years.

The engineering model of safety management represents the non-human components of a system. These could be processes, procedures, equipment and tools, and other machine interfaces. This model views human error as a phenomenon that occurs because of mismatches between the system and the human rather than as a result of purely psychological factors. Organizations that advocate this model are likely to fix the system components before focusing on human behaviors. This model is probably the most difficult to implement because the identification of system factors that result in an error is difficult. However, once those system deficiencies are identified, they may be easy to fix – or at least the fixes may be highly effective once implemented. Although these engineering fixes may cost more initially than other efforts, there is potential to save money in the long term by avoiding possible safety issues that may arise from poorly designed systems.

Some recent researches have also revealed that firms are responsive to economic, regulatory, and social opportunities and pressures (Gunningham et al., 2004). Some of these economic, regulatory, and social practices are implemented by the Occupational Health and Safety (OHS) to prevent workplace incidents and foster a healthy and safe work environment. Among OHS's different practices, financial penalties have been a primary tool in sentencing for victim companies. Since an effective sentence can accomplish more than deterrence, it can educate as to the importance of the underlying regulatory purpose and make a tangible contribution to the preservation and enhancement of the safe work environment.

2.2 Drivers for Changing Safety Culture

While looking for the factors that influence safety culture within and across firms and industries, environmental performance research has identified a range of external factors (economic, regulatory and social opportunities and pressures) and internal factors (managerial incentives, organizational culture, and organizational identity) (Gunningham et al., 2004). According to Cooper (2000), as safety culture is a result of interactions between people (psychological), jobs (behavioral), and the organization (situational), this finding can be triangulated as follows to measure safety culture (Cooper, 2000).

Attitudes and perceptions can be assessed through safety climate questionnaires (individual perceptions = safety climate)

Actual safety-related behaviors can be assessed by checklists developed as part of behavioral safety initiatives

Situational features can be assessed through safety management systems audits/inspections, peer reviews, observations

Choudhry (2007) thinks that for construction industries, positive safety culture is a very useful tool for improving workplace safety. In Choudhry's research, this positive safety culture creates an atmosphere where all employees are supported by their management to be responsible for their own and peers' safety. Organization's management also supports, inspires, and recognizes safe behaviours in positive safety culture(Choudhry, Fang, & Mohamed, 2007).

Thompson et al (1998) presents a model with management support, organizational climate, and safety condition and finds that managers or supervisors play vital roles in promoting workplace

safety. As well, they find that workplace safety can be affected by organizational politics and supervisors' fairness (Thompson, Hilton, & Witt, 1998).

In their study of the drivers responsible for changing the safety culture, Leitão & Greiner (2016) provides a very interesting result. According to the literature, fewer workplace accidents reflect improved safety culture. Leitão & Greiner's (2016) perform a quantitative study on literature to identify the interactions between safety climate and accidents and injuries at work and find association between these two variables. However, this causal relationship is unclear based on scientific evidence (Leitão & Greiner, 2016). According to them, management safety practices, safety training can reduce fatalities and organization's responsibility, safety goals and standards, safety management, and safety communication can reduce accidents.

Leveson (2011) has analyzed several accidents and identified some common factors such as social or organizational factors. According to Leveson (2011), current methods of accident analysis do not identify the underlying causes of the events and the analysis suggests a new approach to prevent future incidents by using **System-Theoretic Accident Model and Processes (STAMP)** (Leveson, 2011) which analyze system accidents due to inadequate control or enforcement of safety-related constraints on the development, design, and operation of the system (N. Leveson, 2004).

Similar to Leveson, Carayon (2015) goes beyond traditional approaches and introduces sociotechnical systems to address potential or emerging risks as opposed to reacting to injuries after-the-fact. According to Carayon (2015), safety culture is also comprised of interactions between people and equipment. A sociotechnical model (illustrated in Figure 2-2) consists of three concentric circles where the first circle represents equipment involving workplace; the second

circle represents socio-organizational context and the third or outer circle represents external environment including economic and demographic factors (Carayon et al., 2015).

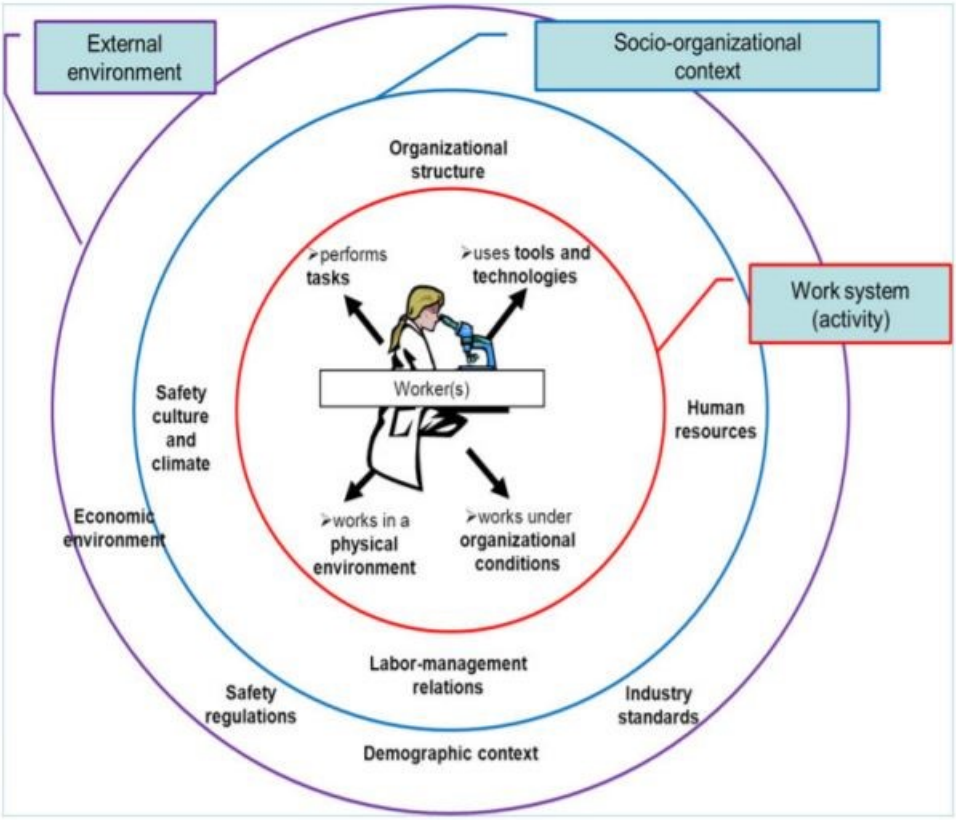

Figure 2-2: Model of sociotechnical system for workplace safety (Carayon et al., 2015).

2.3 Conceptual Framework

Based on the literature, the following conceptual framework can be constructed. For reducing both occupational diseases, accidents and injuries external, internal and personal factors play vital roles in the following way (Figure 2-3).

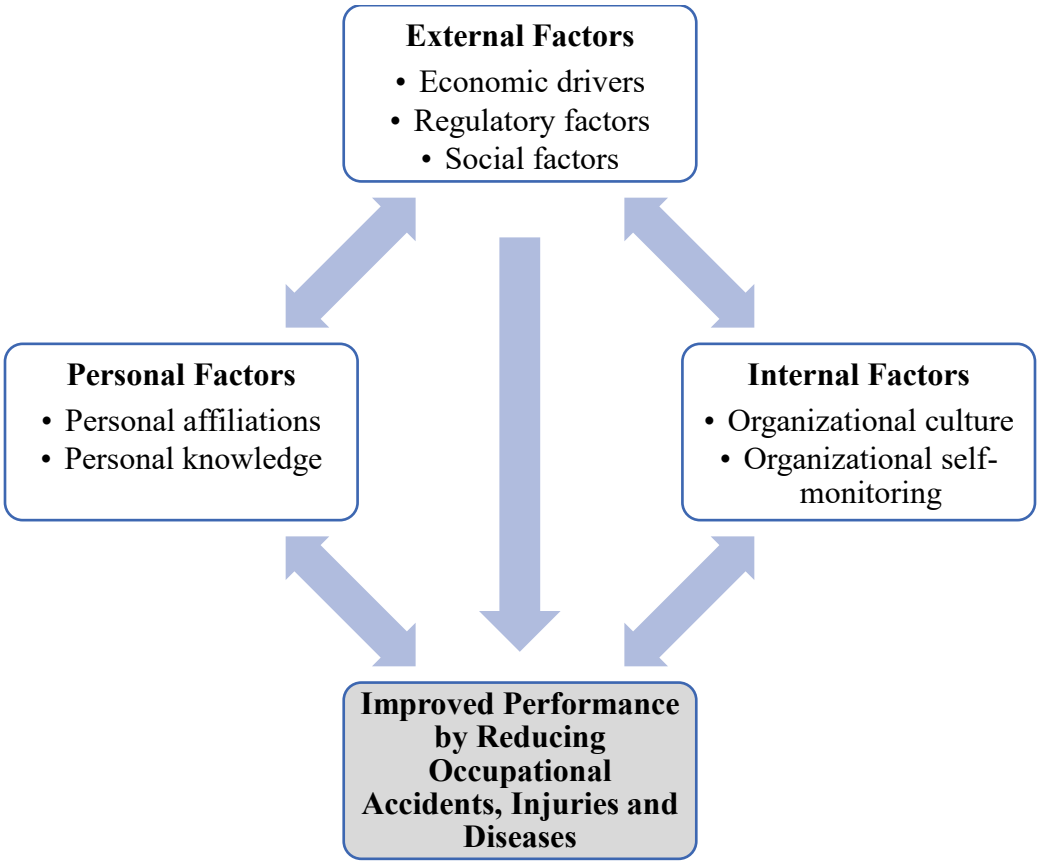

Figure 2-3: Conceptual Framework

External factors, to improve Occupational Health and Safety (OHS) performance can be economic drivers such as Workers' Compensation Board (WCB) Experience Rating[5] or WCB Premium Pricing[6] (Kralj, 1994), regulatory factors such as prosecutions, associated fines, and other penalties (OHS, 2016), and social factor such as social censure or the impact of appearing on a 'noncompliant' list. This thesis has only examined how one of the regulatory factors, a regulatory prosecution can improve overall OHS performance and relations of other factors to improve OHS performance are out of the scope of this thesis.

[5] WCB Experience Rating: An individual employer's assessment rate that may be increased or decreased based on how many work injuries/diseases have occurred at the employer's place of business.

[6] WCB Premium Pricing: The basic pricing rate at which firms/employers can be assessed for workers' compensation coverage based on their industry and claim history.

2.4 Workers' Compensation Board Alberta and How It Works

The idea of workers' compensation originated in Germany, Great Britain and the United States between the late 1800's and early 1900's. In Canada, Workers' compensation was initiated in the province of Ontario in 1910 by Mr. Justice William Meredith who was appointed to a Royal Commission to study workers' compensation. In 1918, the Workers' Compensation Board of Alberta was set up and at the same time, Alberta Workers' Compensation Act was enacted. In 1919, the Association of Workers' Compensation Boards of Canada (AWCBC) was founded as a non-profit organization with six founding members: Ontario, Nova Scotia, British Columbia, Manitoba, Alberta, and New Brunswick (Anonymous, 2017).

To reduce the impact of workplace injury WCB Alberta focuses on the four fundamentals (King, 2013): Fairness, Return to Work, Financial Stability and Leveraging Prevention. To create a claim in WCB AB, there must be an employer, a worker, an accident and an injury. Once a claim is created, WCB AB examines the reason for the accident (is it work related or not) and the physical condition of the worker (does the worker have any relevant medical history or not). After adjudication, the disability benefits are paid for the duration of the disability and reduced if the worker earns employment income during this recovery time. In case of permanent disability, WCB AB explores retraining options and all modified work options. If workers are unable to earn an income after the accident, they get monthly payments depending on their pre- and post accident income scenario. However, WCB AB always focuses on the potential for modified work as it reduces the disability time as well as the claim costs.

To fund the claims costs, employers' premiums are used; there is no funding from government or contribution from workers. These premiums fund current and future costs of

injuries. Therefore, all members of the group share the insurance cost in case of any individual losses. These premiums vary by industries and by firms determined primarily by the risk any employee is exposed to within a firm and the industry of the firm. Any firm can get a discount of up to 60% or a surcharge as much as 240% depending on its performance with respect to its competitors within the same industry. So, it can be said that 'claim costs drive your premium rate'. If claim costs of a firm increases in a certain year, its premium will be higher in the following year. Hence, firms try to reduce their number of claims i.e. incidents by adopting safety practices that improve the overall safety culture.

2.5 Occupational Health and Safety Alberta

While WCB AB administers a system of workplace insurance, Occupational Health and Safety (OHS) AB is focused on prevention. To promote a safe and healthy workplace, OHS AB mainly works in three ways: prevention, education or information and awareness (Feagan, 2015). At a recent presentation, Alberta OHS presented an overview of its "compliance toolkit" (see green, yellow and red boxes in Figure 2-4 below). From the perspective of the conceptual framework discussed in section 2.3, most of these practices are external regulatory factors, ranging from more proactive and aspirational (such as education materials) to more reactive and punitive (such as prosecutions and publicity). These education, compliance and enforcement practices are being continually evaluated by OHS. However, partners' practices – COAA initiatives and leading indicators, COAA reporting of performance, COR rebates, WCB premium pricing, and Alberta Justice Prosecutions – have not been evaluated (see outlined boxes in Figure 2-4).

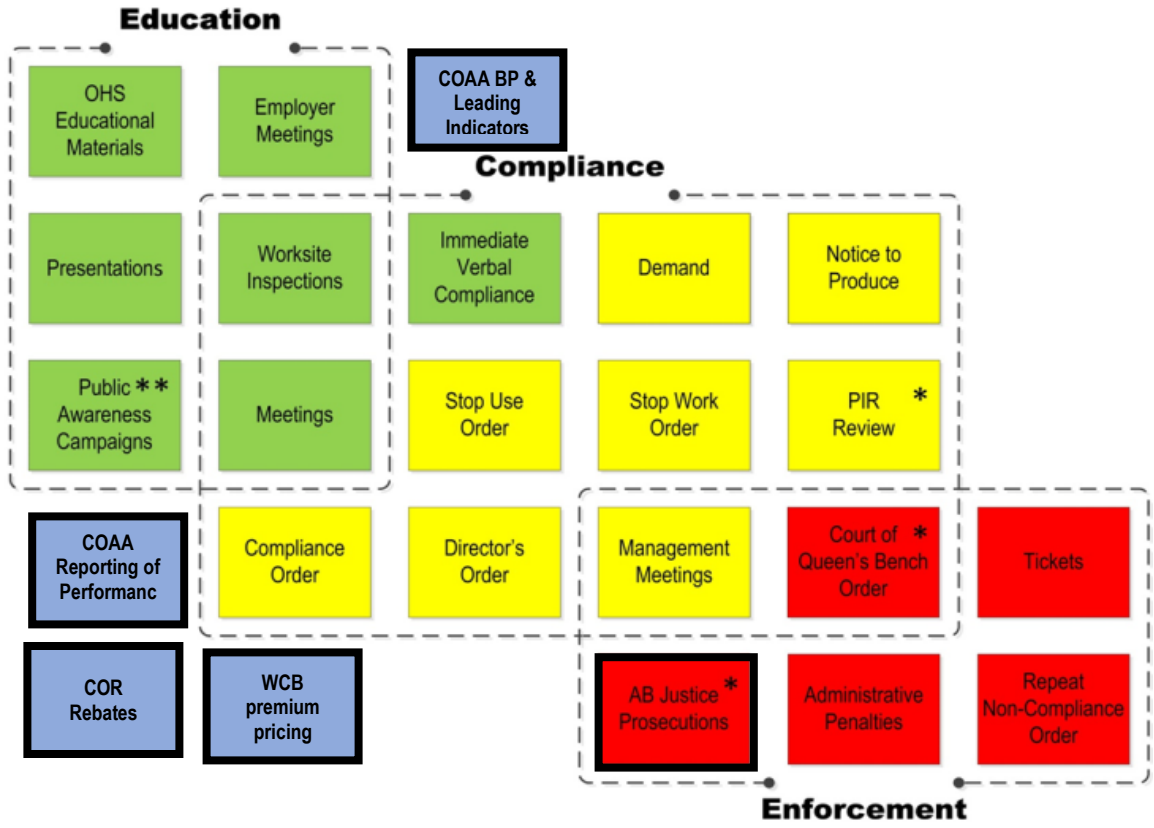

Figure 2-4: Alberta OHS Compliance Toolkit (Feagan, 2015)

Besides these, OHS AB has some proactive strategic programs (Government of Alberta Labor, 2016) such as the Proactive Employer Program (PEP), Proactive Industry Program, Employer Injury and Illness Prevention Program (EIIPP) which help employers understand their legislated health and safety requirements. To identify the most beneficial program for an industry or employer, Alberta OHS has also developed an index to model employer health and safety performance over a 4-year period.

2.5.1 How Does Conviction Occur Under OHS AB Legislation

In case of any fatality occurs, WCB AB and OHS AB work collaboratively in the following manner (Government of Alberta-Labour, 2018).

- Step 1: After a serious incident or fatality takes place at a work site, OHS AB officers investigate the work site to determine the causes and circumstances of the serious incident or fatality.
- Step 2: OHS AB prepares an investigation report summarizing the incident.
- Step 3: OHS AB conducts an enforcement action review of the investigation, to determine if the incident file should be submitted to Alberta Justice for consideration for prosecution.
- Step 4: After incident files are reviewed by Alberta Justice, charges are laid if there is a reasonable likelihood of a conviction, and a prosecution is in the public interest.
- Step 5: If charges are laid, the defendant can be acquitted, be found guilty, or have their charges withdrawn or stayed.
- Step 6: OHS AB publishes fatality investigation reports online after investigations and all court proceedings (if any) are completed. OHS AB also issues educational industry alerts about fatalities at Alberta work sites.

When the Court decides a work site party (defendant) is guilty, the convicted party may be sentenced with following manner (Government of Alberta-Labour, 2018a):

- a fine
- imprisonment
- corporate probation
- creative sentence
- a combination of one or more of the above

Fines can be up to $500,000 and/or up to 6 months in prison per violation for a first offence under the OHS Act Section 74(1). If the defendant continues the first offence, they can also get an extra fine of up to $30,000 per day. Fines for a second or subsequent offence can be up to

$1,000,000 and/or up to 12 months in prison per violation. If the defendant continues the offence, they may also be subject to an extra fine of up to $60,000 for each day which the offence continues. All fines are subject to a 15% Victim Surcharge[7].

Corporate probation includes safety training, public acknowledgment of the offense, third party audit of policies/procedures or any other condition the Court feels appropriate. Terms of probation are usually 6 months to 3 years.

The OHS Act Section 75(1) provides additional powers of the Court to make directions. This type of sentencing diverts funds that would otherwise be paid as fines to third party recipients that promote occupational health and safety. These sentences are often referred to as creative or alternative sentences. Some examples of projects that promote occupational health and safety are: training or educational programs, research programs, scholarships for educational institutions offering studies in OHS and related disciplines, non-profit organizations for worker health and safety initiatives or any other purpose the Court considers appropriate to achieve healthy and safe work sites ("Government of Alberta-Labour," 2018a).

2.6 Workplace Injuries and Fatalities in Alberta

In Canada, firms' report their injuries to the Workers' Compensation Board (WCB) and WCB reports the fatalities and lost time to the government. According to WCB AB, on average 150,000 people are hurt at work every year, of which 28,000 cause time lost from the job, a worker suffers a disabling injury in every 12 minutes and one worker loses life every 3.5 days due to occupational injury and disease (Feagan, 2015). Costs and claim payments for these loss incidents

[7] Victim surcharge is a penalty applied to people convicted of offences, in addition to a conditional discharge, a fine, or a community or custodial sentence, in order to provide compensation for the victims of crime.

was more than half a billion dollars from 2004 to 2015. These incidents not only have the impact on the safety culture of the firms but also have economic and social effects on the focal firms and to the broader society.

In Alberta, Occupational Health Safety (OHS) is already using many tools with a mission to prevent workplace injury and illness by building and strengthening a health and safety culture through partnerships, policy, education, enforcement and innovation (Feagan, 2015). However, the effectiveness of these tools is unknown. Since research suggests that the type of OHS charges, convictions, and sentencing differentially affects focal firms and can create 'spill-overs' to related firms – either in the same industry or geography or both same industry and same geography (Johnson, 2015), this thesis has explored and analysed how these regulatory practices in AB affect firms' and related industries' subsequent claim rates reported to WCB AB.

2.7 How Regulatory Prosecution Can Improve Workplace Safety in Alberta

When a firm is convicted and sentenced, it creates a social suasion (Howard-GRENVILLE, NASH, & COGLIANESE, 2008). Both these sentencing and suasion affect the organizational culture because when an organization gets sentenced, it tries to improve its safety culture to avoid any repetition of those incidents in the future. Besides, social suasion affects the firms of the same industry or geography (Jaffe, Trajtenberg, & Henderson, 1993). Hence, both the organization and the industry try to take actions to prevent any such incidents in future by adopting some management practices which can improve the overall safety culture of sentenced firms as well as firms in the same industry and geography (Johnson, 2015). This improved safety culture should be reflected in their number of incident or accident since a safer workplace should reduce the

probabilities of incidents/accidents. Since firms have to report to WCB AB for any incidents or accidents occur in their firms to create a claim, WCB AB claim rates can be a direct measure to determine the improvement of firms' or industries' safety culture followed by the sentencing and the number of claims reported to WCB AB should be reduced if the firm's overall safety culture improves. Thus, a regulatory prosecution should decrease the subsequent WCB AB claim rate of the sentenced firms (focal-firm effect) and firms in the same industry and geography (Spill-over effect). A theoretical model is demonstrated in Figure 2-4 that shows how the regulatory prosecution can improve workplace safety.

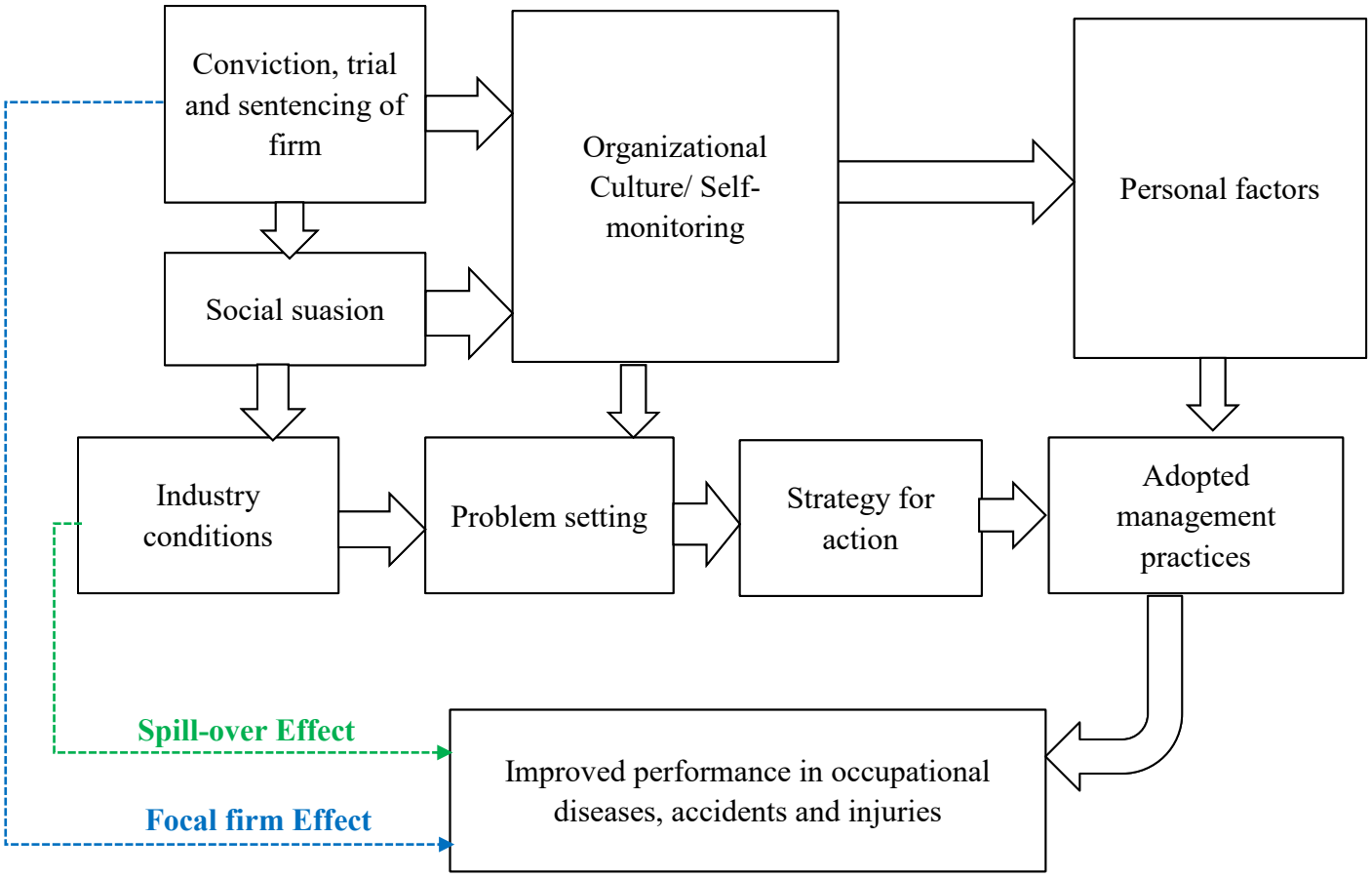

Figure 2-5: Theoretical model of how the regulatory prosecution can improve workplace safety.

2.7.1 Focal-firm Effect

In this thesis context, focal firm effect refers to the effect of sentencing that affects only the sentenced firms to improve their overall safety culture and thus reduce their subsequent claim rates. After trial and sentencing, the sentenced firms try to take some steps to improve their safety culture so that they will not get punishment again.

2.7.2 Spill-over Effect

In this thesis context, spill-over effect is the effect when sentencing of a firm creates a social suasion and that affects the other firms in the same industry or same geography to improve their overall safety culture and thus reduce their subsequent claim rates. Spillover effect occurs for several reasons. For example, publicity of sentenced firms' prosecutions might exert a social pressure on other firms in the same industry. These non-sentenced firms in the same industry may fear to have their performance deficits will be revealed in the future and, thus, improve their compliance in response. In this case, firms that share the same industry and are geographically proximal are more likely to learn from each other (Johnson, 2018).

2.8 Data Analysis

2.8.1 Comparison of before sentencing claim rates and after sentencing claim rates

First, before sentencing claim rates and after sentencing claim rates should be compared to determine if the regulatory prosecution has any effect on the subsequent claim rates of the sentenced firms or the firms in the same industry or same geography or not. If the differences between before sentencing claim rates and after sentencing claim rates are found statistically

significant, it can be said that the regulatory prosecution i.e. sentencing might have an effect on reducing subsequent claim rates of sentenced firms or the firms in the same industry or same geography. Selection of an appropriate statistical comparison test depends on the distribution of the samples (Jaykaran, 2010). Since the before sentencing and after sentencing claim rates are not paired, unpaired t-test or Mann-Whitney U test should be performed for normal or non-normal distributions respectively (Jaykaran, 2010).

2.8.1.1 Test for Normality

An informal approach to test normality is to compare a histogram of the sample data to a normal probability curve. If the histogram of the sample follows the normal probability curve, the distribution of the sample is usually considered normal (Ogunnaike, 2010). Besides histogram, the **Chi-Square Goodness of Fit Test for a normal distribution** can be performed to determine if the sample follow a normal distribution. Chi-Square Test for Normality is defined for the following hypotheses.

H_0: The data follow a normal distribution.

H_A: The data do not follow the normal distribution.

To apply the Chi-Square Test for Normality, first, the expected values are calculated with the sample mean and standard deviation under the normal distribution for every data point in the sample. Then the Chi-Square statistic is determined using the following formula (equation 2.1).

$$X^2 = \sum \frac{(observed - expected)^2}{expected} \quad \text{.....equation 2.1}$$

Then this value is compared with the critical Chi-Square value from a Chi-Square table using the degrees of freedom of the data and the desired alpha level. If the Chi-Square statistic is larger than the table value, the data might not normal.

2.8.1.2 Unpaired t-test

If the distributions of samples follow a normal distribution, the unpaired t-test can be used to compare two samples. The unpaired t method tests the null hypothesis that the population means related to two independent, random samples from an approximately normal distribution are equal (Ogunnaike, 2010). This test is defined for the following hypotheses.

H_0: The population means related to two independent, random samples from an approximately normal distribution are equal

H_A: The population means related to two independent, random samples from an approximately normal distribution are not equal

If the samples are assumed to have equal variances, the test statistic, t is calculated using sample means, pooled sample variance and the number of observations i.e. sample sizes.

If the samples are assumed to have unequal variances, the Behrens-Welch test statistic, d is evaluated using sample means, sample variances and sample sizes.

2.8.1.3 Mann-Whitney U test

The Mann-Whitney test is used as an alternative to a t test when the data are not normally distributed. This test is a test of both location and shape. For two independent samples, it tests whether one sample tends to have different values than the other (Hart, 2001).

Assumptions of the Mann-Whitney:

i. The sample drawn from the population is random.

ii. Independence within the samples and mutual independence is assumed. That means that an observation is in one group or the other (it cannot be in both).

iii. Ordinal measurement scale is assumed

This test assigns numeric ranks to all the observations (considering both the group in one set) beginning with 1 for the smallest value and calculate the test statistic, U (Conover, 1999).

$$U = n_1 n_2 + \frac{n_2(n_2+1)}{2} - \sum_{i=n_1+1}^{n_2} R_i \text{.....equation 2.2}$$

Where U=Mann-Whitney U test, n_1 = Sample size one, n_2= Sample size two and R_i = Rank of the sample size

2.8.1.4 Kolmogorov-Smirnov test

The two-sample Kolmogorov-Smirnov test is one of the most useful and general nonparametric methods for comparing two samples since it is sensitive to differences in both location and shape of the empirical cumulative distribution functions of the two samples. Two sample K-S test checks whether the two data samples come from the same distribution or not. The directional hypotheses of this test are evaluated with the statistics, D (Conover, 1999).

$$D^+ = max_x\{F(x) - G(x)\} \text{..... equation 2.3}$$

$$D^- = min_x\{F(x) - G(x)\} \text{..... equation 2.4}$$

where F(x) and G(x) are the empirical distribution functions for the two samples being compared. The combined statistic is

$$D = \max(|D^+|, |D^-|) \text{..... equation 2.5}$$

2.8.2 Determining Spill-over Effect

A widely-used method for determining spill-over effect is panel data analysis. Panel data (also known as longitudinal or cross-sectional time-series data) is a dataset in which the behavior of entities is observed across time. These entities could be states, companies, individuals, countries, etc.(Torres-Reyna, 2007). Panel data can be balanced or unbalanced. If each entity is observed every year, that would form a balanced panel data. However, if any entity's data is missing in any year, that would be an unbalanced panel data. Samples of balanced and unbalanced panel data are shown in the following tables; Table 2.1 and Table 2.2 respectively.

Table 2-1: Sample Panel Data-balanced

Industry	**Year**	**y**	**x**
1	2005	2.5	0.7
1	2006	3.5	1.7
1	2007	6	2.8
2	2005	1	0.2
2	2006	1.2	1.1
2	2007	1.5	1.5
3	2005	0.5	0.3
3	2006	0.8	2.3
3	2007	0.9	1.2

Table 2-2: Sample Panel Data-unbalanced

Industry	**Year**	**y**	**x**
1	2005	2.5	0.7
1	2006	3.5	1.7
2	2005	1	0.2
2	2006	1.2	1.1
2	2007	1.5	1.5
3	2006	0.8	2.3
3	2007	0.9	1.2

Since with an unbalanced panel, some entity's data do not appear in each time period, this panel might bias the estimates if these missing data are correlated with the idiosyncratic error. An idiosyncratic error is the error that changes over time as well as across entities (Baltagi, 2005).

Panel data with unobserved differences between entities might generate omitted variable bias and so, fixed effect model (FE) or random effect model (RE) are usually used. Fixed effect model assumes that the unobserved differences between firms can be treated as parametric shifts in the regression function (non-random differences in the intercept term) and random effect model assumes that the unobserved differences between firms are randomly distributed, and therefore have their own error.

2.8.2.1 Fixed Effect Model

Among different models of panel data, fixed effect (FE) model is used when the impact of variables that vary over time is analyzed. FE explore the relationship between dependent and

independent variables within an entity over time (Torres-Reyna, 2007). If N entities characteristics are observed over T period, the equation of fixed effect model will be the following.

$Y_{it} = \alpha_i + \beta X_{it} + \varepsilon_{it}$…….. equation 2.6

Where α is the unknown intercept for each entity, i = 1…… N, Y_{it} is the dependent variable for i = 1…. N and t = 1……. T, X_{it} represents the independent variable, β is the coefficient for the independent variable and ε_{it} is the error term.

Since the fixed-effect model controls for all time-invariant differences between the individuals, this model cannot be used to investigate time-invariant causes of the dependent variables (e.g. gender, religion, nationality). Technically, time-invariant characteristics of the individuals should be collinear with the entity. However, fixed-effects models are designed to study the causes of changes within an entity (Kohler & Kreuter, 2005).

2.8.2.2 Random Effect Model

Unlike the fixed-effects model, random effects (RE) model is used if differences across entities have some influence on the dependent variable (between effect). For this model, the variation across entities is assumed to be random and uncorrelated with the independent variables included in the model (Torres-Reyna, 2007). The random effects model is:

$Y_{it} = \alpha + u_i + \beta X_{it} + \varepsilon_{it}$…… equation 2.7

Where α is the unknown intercept, Y_{it} is the dependent variable for i = 1……N and t = 1……. T, X_{it} represents the independent variable, β is the coefficient for independent variable, u_{it} is the between entity error and ε_{it} is the within-entity error term.

Since the random effect model assumes that the entity's error term is not correlated with the independent variable, time-invariant variables play a role as explanatory variables (Torres-Reyna, 2007).

2.8.3 Determining Focal Firm Effect

2.8.3.1 Graphical trend analysis

In the preliminary stage, graphical trend analysis can be performed in an exploratory approach to observe the focal firm effect by using treatment and control groups. The underlying assumption for this trend analysis is that, before treatment, both the treatment and control groups

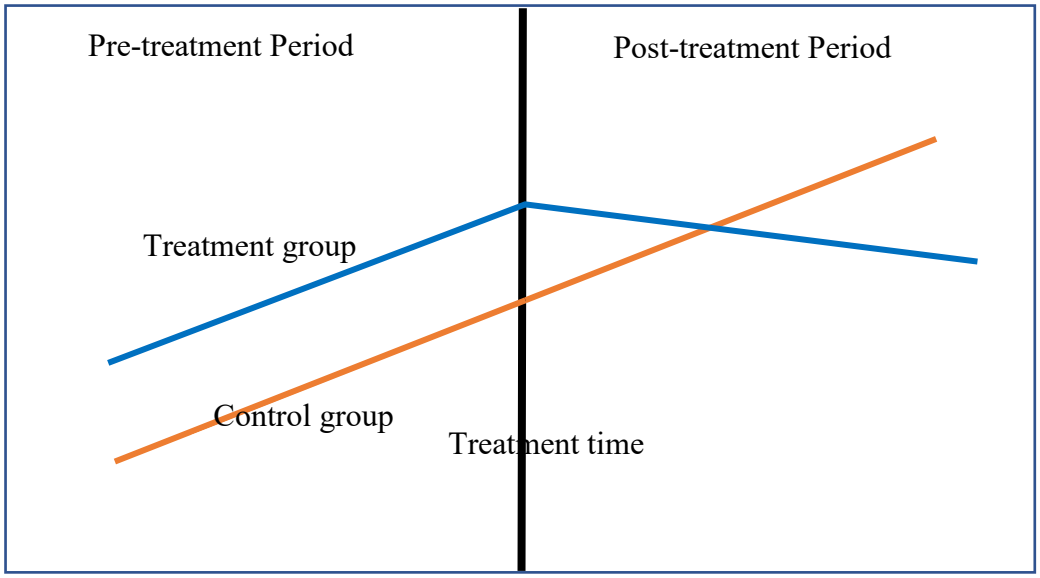

Figure 2-6: Demonstration of graphical analysis

should follow a similar trend. After treatment, if the treatment group follows a different trend than the control ones, the observed differences might be attributed to the treatment (Figure 2-5)(Angrist & Pischke, 2009).

2.8.3.2 Difference-in-differences

Difference-in-differences is a popular method for determining causal inference. Here, the treatment outcomes are observed for two groups; treated and control groups for two time periods: pre-treatment and post-treatment. The treated group is exposed to a treatment in the post-treatment period but not in the pre-treatment period. However, the control group is never exposed to the treatment. The difference between the two groups in the pre-treatment period and the difference between the two groups in the post-treatment period are compared to determine the treatment effect (Wooldridge & Imbens, 2007). A simplified diagram has been provided in Figure 2-6.

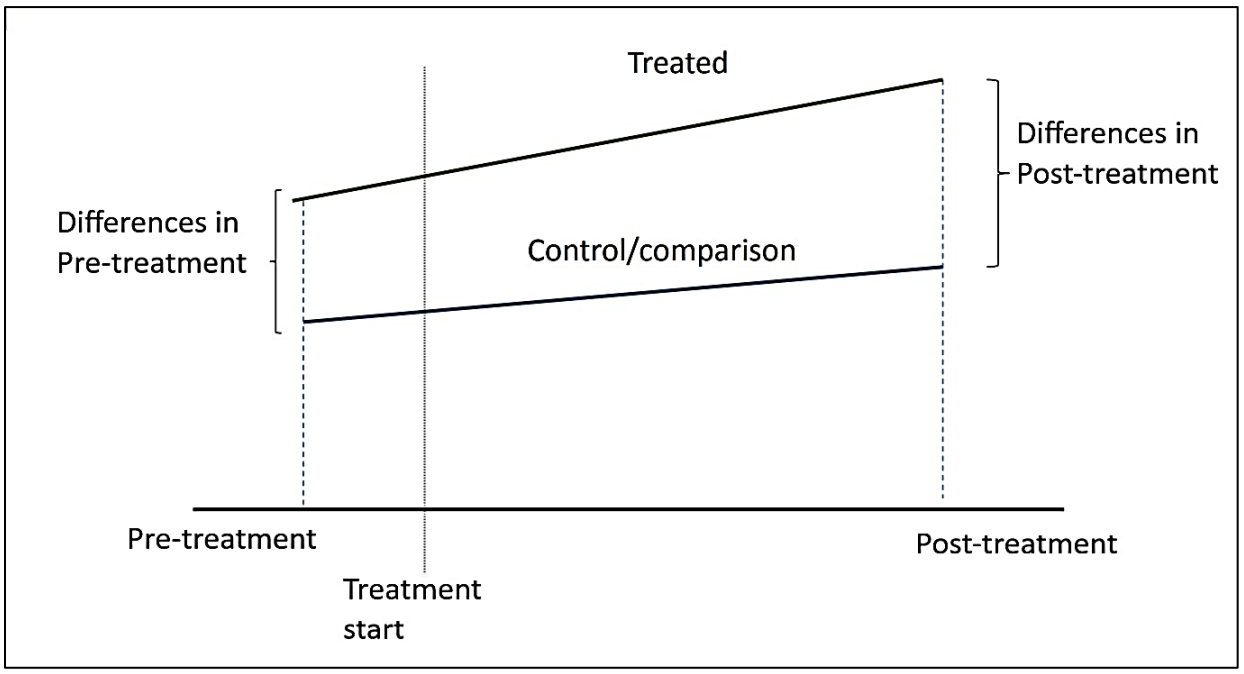

Figure 2-7: Simplified diagram of difference-in-differences (Villa, 2012)

2.9 Research Questions

Based on the theoretical model in section 2.7, this thesis addresses the three following research questions.

RQ-1: Do the WCB AB claim rates before sentencing differ statistically from

i. the claim rates of sentenced firms after sentencing?

ii. the claim rates of sentenced firms after sentencing for each sentenced industry?

iii. the claim rates of sentenced firms after sentencing for each sentenced industry-location?

iv. the claim rates of sentenced firms after sentencing for the whole province, Alberta?

RQ-2: Do sentencing create any spill-over effect by reducing the subsequent WCB AB claim rates of the firms in the same industry and same location whose firms are sentenced?

RQ-3: Do sentencing reduce the sentenced firms' subsequent WCB AB claim rates with respect to non-sentenced firms in the same industry and same geography?

These research questions are discussed in chapter 4, chapter 5 and chapter 6 respectively.

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CHAPTER 3 : PROCESSING OF DATA

3.1 Introduction

The various sources of raw data and the steps for processing these data into analysable data have been discussed in this chapter of thesis. The processing steps include cleaning the data, determining claim rate, merging Workers' Compensation Board (WCB) Alberta data with Government of Alberta (GoA) Labour data and geographical division of province and thereby, the final dataset has been generated and used in further analysis in subsequent chapters of this thesis.

3.2 Sources of Data

Two major datasets have been used in this thesis; one from Workers' Compensation Board (WCB) Alberta and another from Government of Alberta (GoA) Labour.

3.2.1 Data from Workers' Compensation Board (WCB) Alberta

The data from WCB AB consist of three major subsets of data; Employers' information and their claims, Injury statistics and Employers' contact information dated from 2000 to 2016. For this thesis, injury claims those were reported by the employers, their associated industries, their total insurable earnings and their addresses were required due to the nature of this work and therefore, have been extracted from WCB AB's datasets. In this context, the industry average hourly wage data were also required for this research and have been extracted from WCB AB's datasets as well.

3.2.2 Data from Government of Alberta (GoA) Labour

The conviction data from 2005 to 2015 has been collected from GoA Labour. This dataset consists of incident and conviction details that includes the following data fields. However, due to nature of the research questions, among the data fields, only convicted company and date of conviction have been used for further analysis in this thesis.

i. Convicted company
ii. Date of conviction
iii. Location of offence
iv. Date of offence
v. Type of incident
vi. Description
vii. Sentencing type

3.3 Cleaning of Data

WCB AB's data are available from 2000 to 2016 but conviction data from GoA Labour are available for 2005 to 2015. Hence, for this thesis, data from 2005 to 2016 have been used for analysis. WCB AB's data were cleaned by following steps using statistical software STATA 14 (StataCorp, College Station, TX).

i. Convert strings to numeric: Total insurable earning was converted to numeric (float) variables as it was found as a string variable.
ii. Remove duplicates: Many exact duplicate observations were found in each year in terms of all the variables which has been removed from the raw data.

iii. Replacing missing values with zero: According to WCB AB, missing values for employer claim count correspond to a value of zero. Hence, missing values found in that variable are replaced with zeros for further calculations.

iv. Issues with low total insurable earnings: Some firms have been found with exceptionally low insurable earnings and therefore claim rates of these firms were found exceptionally higher. Among those firms, 16 firms were found with low insurable earnings and their reported number of claims were more than zero. According to WCB AB, there are different specific reasons behind their low insurable earnings e.g. small businesses with casual labor, under appeal accounts, earnings of the owner of the business for 1 day of personal coverage and therefore, these firms were treated differently by WCB AB. They are atypical of employers as a whole. Details of those firms and reasons behind their exceptional low total insurable earnings are provided in the supporting information (Appendix A). Thus, these differently treated 16 firms by WCB AB were not considered for further analysis since their circumstances differs from general circumstances of Alberta employers.

v. Accounts related to City of Calgary: According to WCB AB, there are three accounts created in 2014 to assist the City in tracking claims for the respective departments which are Calgary Fire Department, Calgary Police Department and Calgary Transit. These accounts are linked to the main account for all their payroll and all their other claims. Hence, these firms' insurable earnings have shown a magnitude of $1 which is a system requirement of WCB AB that allows them to

produce reports for those accounts. In this thesis, these three firms' number of claims have been added to the main account of City of Calgary.

vi. Claims related to Alberta Health Service: Similar to City of Calgary, Alberta Health Services has all insurable earnings reported to a central account and its claim rates are tracked based on regional operations in five different accounts in separate dataset since 2014. In this thesis, all the number of claims of those accounts are added to the central account to determine Alberta Health Services' claim rates from 2014 to 2016.

vii. Village of Breton- total insurable earnings issue: Total insurable earning of Village of Breton was found $1 for 2015 whereas in other years, the earnings reported in the dataset were reasonably higher. As a consequence, a higher claim rate has been found for this firm in 2015. After addressing and discussing this issue with WCB AB, they confirmed that the amended total insurable earning of Village of Breton is $479674. Hence, that data was corrected based on WCB AB's information.

3.4 Determining Claim Rate

The main dependent variable for this analysis is claim rate. In WCB AB's data, only claim count data is available. To determine claim rate, following equation has been used.

$$Claim\ Rate = \frac{Number\ of\ claim}{FTE\ persons\ years} \quad \text{.....equation (3.1)}$$

FTE persons years can be determined according to the following equation.

$$FTE\ persons\ years = \frac{Insurable\ earnings}{2000 \times Hourly\ wage} \quad \text{..... equation (3.2)}$$

Hence, claim rate has been calculated by using above two equations and the final equation is

$$Claim\ Rate = \frac{Number\ of\ claim \times 2000 \times Hourly\ wage}{Insurable\ earnings} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ equation (3.3)}$$

Where 2000 is the number of working hours in a year. Number of claims, hourly wage and insurable earnings in each year have been found from WCB AB's data.

The dataset for hourly wage consists of industry code, year and industry average hourly wage. This dataset has been first merged with the dataset consisted of Industry Code Description to combine the industries' names. Then average wage datasets for each year have been merged with employers' claim data of WCB AB. All the unmatched observations have been removed for cleaned datasets. After that, a new variable, claim rate has been generated and calculated using the equation (3.3) for each year from 2005 to 2016. Average and standard deviation for number of claims and claim rate are shown in Table 3-1.

Table 3-1: Average and standard deviation for number of claims and claim rate from 2005 to 2016

Year	Number of claims		Claim Rate	
	Average	Standard deviation	Average	Standard deviation
2005	0.477	7.390	0.051	1.097
2006	0.481	7.223	0.050	1.150
2007	0.434	6.218	0.046	1.046
2008	0.410	6.095	0.049	1.139
2009	0.341	5.819	0.044	0.764
2010	0.325	5.756	0.044	0.882
2011	0.361	5.975	0.047	1.234
2012	0.411	6.660	0.049	1.224
2013	0.411	6.964	0.049	1.007
2014	0.408	12.592	0.045	0.525
2015	0.352	12.173	0.049	1.796
2016	0.326	12.598	0.049	1.263

3.5 Merging WCB AB Data with GoA Labour Data

Companies have been identified by company names in the GoA Labour data and, using legal and trade names in WCB AB's dataset. Each of the convicted companies' name in GoA Labour data from 2005 to 2015 has been searched in WCB AB's yearly dataset. Companies whose names have been matched with the legal or trade names in WCB AB's dataset; those companies have been filtered and new sub-datasets have been generated from WCB AB's datasets. Several convicted companies' names those have not been found in WCB AB's dataset, those have been removed from the analysis. This matching has done by following two steps.

Step 1: The dataset of GoA Labour includes 142 sentencing histories from 2005 to May 2016. Out of 142 sentencing, 120 sentenced firms' names have been matched with the legal names or trade names of WCB AB's dataset.

Step 2: Out of 120 matched firms, 89 firms' accounts have been considered for analysis. The remaining 31 firms' addresses are not in Alberta. Out of these 89 firms, one firm has two WCB AB employer accounts and both accounts have been considered for analysis.

Detailed breakdown of matching sentenced firms with WCB AB's dataset is shown in the Table 3-2.

Table 3-2: Number of sentenced firms matched with WCB Alberta accounts

Sentencing Year	Total Sentence	Matched with WCB account	Total sentenced firms in Alberta
2005	11	7	6
2006	10	8	6
2007	12	11	7
2008	21	18	15
2009	8	6	4
2010	9	8	5
2011[8]	20	17	13
2012	9	8	7
2013	12	10	6
2014	12	10	7
2015	7	7	5
2016[9]	11	10	8
Total	142	120	89

3.6 Geographical Division

Using employers' addresses and postal codes provided by WCB AB, latitudes and longitudes have been included in the data set using Geocoder.ca so that firms can be categorized by location to determine spill-over effect. For geographical division, firstly, all the latitudes and

[8] Dreco energy has two employer accounts in WCB database
[9] Sentencing data are available till May 2016

longitudes of the firms have been plotted using data visualization software, Tableau 2018 (Figure 3-1). Figure 3-1 shows that the density of firms is majorly localised in the Edmonton and the Calgary, whole province has been divided into following five divisions based on two major cities; Edmonton and Calgary. Beside that, these five areas have different types of dominant industries in terms of number of firms. Table 3-3 shows that most of the firms in all regions are assigned to Trucking Service, General. Apart from that, Calgary and Edmonton regions have a common dominant industry (Restaurant and Catering) whereas North of Edmonton, South of Calgary and Between Edmonton and Calgary regions have another common dominant industry (Mobile Equipment Operation). However, each of these regions has its own dominant industry; Construction, Residential in Edmonton region, Engineering in Calgary region, Field Production Operators in North of Edmonton region, Oil & Gas - Upstream in South of Calgary and Welding in Between Edmonton And Calgary region. Hence, besides being geographically proximal, firms in the same location should have spill-over effect due to the nature of dominant industries in that location.

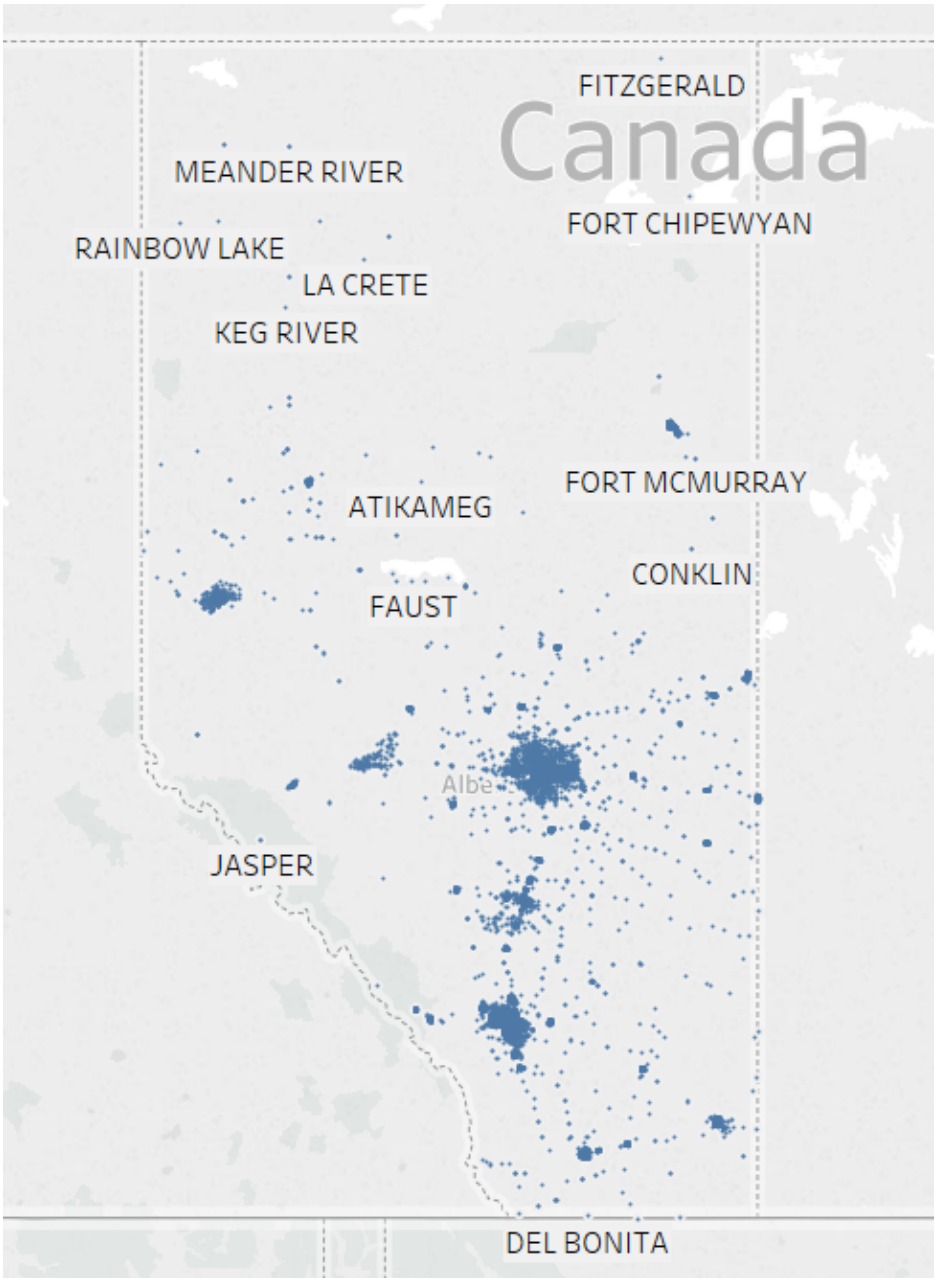

Figure 3-1: Locations of all firms in Alberta

Table 3-3: Three most dominant industries in each location

Location	Three Most Dominant Industries with Respect to Number of Firms	Percentage of Total Employers Represented by Each Industry
Edmonton Region	Trucking Service, General	11%
	Restaurants and Catering	5%
	Construction, Residential	4%
Calgary Region	Engineering	8%
	Trucking Service, General	8%
	Restaurants and Catering	5%
North of Edmonton	Trucking Service, General	10%
	Mobile Equipment Operation	9%
	Field Production Operators	6%
South of Calgary	Trucking Service, General	10%
	Oil & Gas - Upstream	5%
	Mobile Equipment Operation	5%
Between Edmonton And Calgary	Trucking Service, General	8%
	Mobile Equipment Operation	6%
	Welding	6%

Location 1: this location is based on central Edmonton. A square region has been selected 40km from the centre point of Edmonton in north, south, east and west side. Centre of Edmonton has been selected based on its coordinates; 53.5444° N, 113.4909° W. 40km distance from the

centre point has been measured using google maps. In google maps, distances are measure using Haversine formula in spherical coordinate system.

Location 2: this location is based on central Calgary. Similar to Location 1, a square region has been selected 40km from the centre point of Calgary in north, south, east and west side. Centre of Calgary has also been selected based on its coordinates; 51.0486° N, 114.0708° W and 40km distance from the centre point has been measured using google maps using Haversine formula in spherical coordinate system.

Location 3: this location is based on north of Edmonton. Firms whose latitude and longitude are found in north of 53.5444° N (Latitude of Edmonton centre point) except the firms in Location 1 are categorized into this region.

Location 4: this location is based on south of Calgary. Firms whose latitude and longitude are found in south of 51.0486° N (Latitude of Calgary centre point) except the firms in Location 2 are categorized into this region.

Location 5: this location is based on between Edmonton and Calgary. Firms whose latitude and longitude are found in south of 53.5444° N (Latitude of Edmonton centre point) and north of 51.0486° N (Latitude of Calgary centre point) except the firms in Location 1 and Location 2 are categorized into this region.

For better visualization of the locations, color coded map (Figure 3-2) is shown below representing five different regions with five colors.

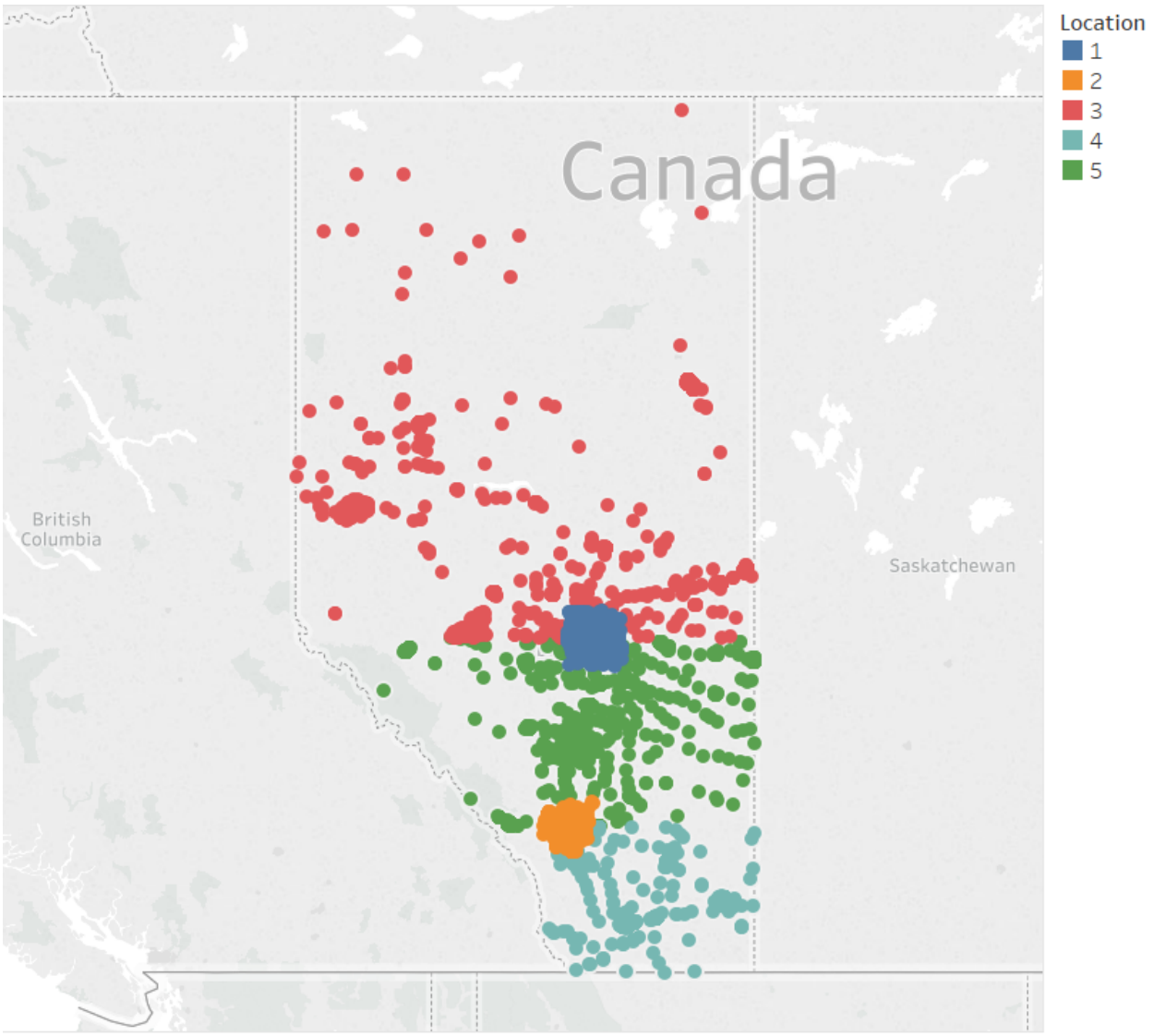

Figure 3-2: Categories of firms based on locations in Alberta. Assorted colors represent different regions.

3.7 Final Datasets

3.7.1 Dataset with all firms (DAF)

This dataset contains all the firms' information from 2005 to 2016. From the summary of claim rate (Table 3-4), it is found that almost 90% firms' claim rates are found zero. Moreover, Table 3-5 shows that only 34.72% firms have been survived for all twelve years from 2005 to 2016. According to WCB AB, the rest of the firms either closed their business after few years of starting their business or new firms have been started business in between 2006 to 2016. Since all the firms are not equally present in dataset and not equally susceptible to incidents/accidents, the dataset with all firms might have a selection bias[10] (Angrist & Pischke, 2009). Hence, although the dataset with all firms (DAF) has been used for all analysis, a subset of DAF has been also taken to observe firms' behaviour upon sentencing who survived the whole study period and had at least one non-zero claim from 2005 to 2016.

[10] Selection bias is a bias in a measure of association due to a sample selection that does not accurately reflect the target population. It can occur when investigators use improper procedures for selecting a sample population as well as because of factors that influence continued participation of subjects in a study. In either case, the final study population is not representative of the target population – the overall population for which the measure of effect is being calculated and from which study members are selected (Alexander, Lopes, Ricchetti-Masterson, & Yeatts, 2015).

Table 3-4: Summary of claim rate for all and non-zero observations

Year	All observations = zero claim rates + non-zero claim rates			Non-zero observations (non-zero claim rate)			% of non-zero observations
	Number of firms	Average claim rate	Standard deviation of claim rates	Number of firms	Average claim rate	Standard deviation of claim rates	
2005	117,820	0.051	1.097	13,016	0.464	3.271	11%
2006	126,896	0.050	1.150	13,743	0.465	3.466	11%
2007	134,514	0.046	1.046	13,719	0.455	3.247	10%
2008	139,035	0.049	1.139	13,691	0.495	3.60	10%
2009	131,840	0.044	0.764	11,701	0.496	2.522	9%
2010	139,642	0.044	0.882	12,587	0.487	2.901	9%
2011	144,299	0.047	1.234	13,530	0.496	4.002	9%
2012	152,163	0.049	1.224	14,783	0.505	3.898	10%
2013	158,211	0.049	1.007	15,871	0.493	3.146	10%
2014	164,424	0.045	0.525	16,410	0.447	1.607	10%
2015	165,985	0.049	1.796	15,649	0.522	5.828	9%
2016	164,288	0.049	1.263	14,328	0.562	4.245	9%

Table 3-5: Number of years' data available in DAF for all firms

Number of year/s data in DAF	Number of firms	% of total firms	Cumulative % of total firms
1	45,099	2.59	2.59
2	90,236	5.19	7.78
3	106,248	6.11	13.89
4	111,392	6.40	20.29
5	113,120	6.50	26.79
6	114,084	6.56	33.35
7	101,521	5.84	39.19
8	93,192	5.36	44.54
9	105,381	6.06	50.60
10	110,130	6.33	56.93
11	145,222	8.35	65.28
12	604,032	34.72	100.00
Total	1,739,657	100	

3.7.2 Dataset of firms with positive average claim rates (DFPCR)

This dataset has been created from DAF, consisting of the firms whose information are available from 2005 to 2016 and whose average claim rate for these 12 years are more than zero. This subset has been created to observe the effect of sentencing for the firms who survived for 12

years and how their claims rates are changing[11]. In this regard, firms' data whose claim rates are zero for every year of these 12 years have been removed since there would be no change in terms of their claims rate. Summary of this dataset is given below in Table 3-6.

Table 3-6: Summary of Dataset of firms with positive average claim rates (DFPCR)

Year	Number of firms	Average claim rate	Standard deviation of claim rates
2005	23,601	0.074	0.448
2006	23,601	0.077	0.378
2007	23,601	0.075	0.362
2008	23,601	0.077	0.523
2009	23,601	0.075	0.431
2010	23,601	0.070	0.323
2011	23,601	0.075	0.317
2012	23,601	0.082	0.481
2013	23,601	0.092	0.582
2014	23,601	0.089	0.537
2015	23,601	0.087	0.602
2016	23,601	0.085	0.721

[11] Follow-on analysis will also examine the survival bias for firms. Given the time constraints of this research, it is outside the scope of this thesis.

Both the datasets have following variables (Table 3-7) for analysis.

Table 3-7: Variables and their descriptions in final datasets

Variable Name	Description	Type
Employer Account	Employer's individual identity by individual numbers specified by WCB AB	Numeric
Year	Year for which the employers/firms rated by WCB AB	Numeric
City	Name of the city or town where the employer's office is located	String
Industry Code	A code for the specific industry in which the employer operates	Numeric
Industry Code Description	Name of the industries which are coded as Industry Code	String
Claim Rate per FTE	WCB AB claim rate per full time employee for a specific employer and a specific year	Floating
Location	Mutually exclusive and exhaustive partitions of the province coded numerically from 1 to 5	Numeric
Indlocation	A unique value for each Industry Code and location combination code numerically	Numeric
Sentencing	Coded as 0 if the employer account does not get sentenced in that year and coded as 1 if the employer account gets sentenced in that year	Binomial

References

Alexander, L. K., Lopes, B., Ricchetti-Masterson, K., & Yeatts, K. B. (2015). *Selection Bias*.

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CHAPTER 4 : COMPARISON OF CLAIM RATES BEFORE AND AFTER SENTENCING USING NONPARAMETRIC STATISTICAL TESTS

4.1 Introduction

In this chapter, firms' claim rates before and after sentencing have been compared for the whole province (Alberta), sentenced firms, sentenced industries and sentenced industry-locations. For comparison, first, the probability density functions of claim rates have been observed. To test normality, chi square goodness of fit test for normal distribution has been performed. Since, the probability density functions of the claim rates for all individual subsets do not follow normal distribution, a non-parametric approach has been followed to compare their claim rates. Here, Mann–Whitney U test has been performed to determine if randomly selected claim rate from the sample before sentencing is different from a randomly selected claim rate from the sample after sentencing. Since the sentenced and non-sentenced samples of sentenced firms were not independent, unpaired t-test had been performed to compare them.

The chapter begins with describing the datasets used for this chapter, a flowchart of how the comparisons have been conducted for each group, description of statistical tests used for these analyses, followed by the results and discussions.

4.2 Data and Method

4.2.1 Data

In this chapter, datasets generated in Chapter 3; Dataset with all firms (DAF) has been used to generate individual sentenced firms, industries and sentenced industry-locations subsets according to Figure 4-1. The pre and post sentencing period claim rates comparisons have conducted for all three subsets; SSF-AF, SSI-AF and SSIL-AF as well as for Dataset with all firms (DAF). DAF has been used to compare the claim rates across the province. SSF-AF, SSI-AF and SSIL-AF have been used to compare the claim rates for sentenced firms, sentenced industries and sentenced industry-locations respectively.

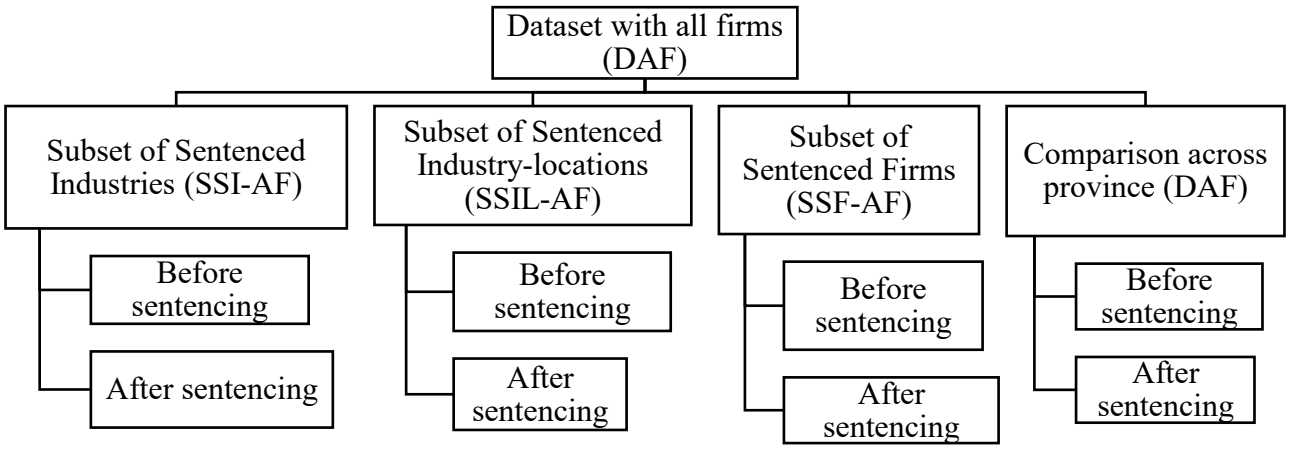

Figure 4-1: A schematic flowchart to generate subsets of data for comparison claim rates before and after sentencing

For comparing pre and post sentencing period claim rates, datasets are defined in the following manner as in Table 4-1.

Table 4-1:Datasets for comparing before and after sentencing claim rates

Datasets	Before sentencing datasets	After sentencing datasets
SSI-AF	Sentenced firms' claim rates before the sentencing year + All firms' claim rates in the sentenced industries for all years	Sentenced firms' claim rates after the sentencing year
SSIL-AF	Sentenced firms' claim rates before the sentencing year + All firms' claim rates in the sentenced industry-locations for all years	Sentenced firms' claim rates after the sentencing year
SSF-AF	Sentenced firms' claim rates before the sentencing year	Sentenced firms' claim rates after the sentencing year
DAF	Sentenced firms' claim rates before the sentencing year + All firms' claim rates in the province for all years	Sentenced firms' claim rates after the sentencing year

4.2.2 Method

Comparison of pre and post sentencing period claim rates have been conducted based on distribution of claim rates using below schematic diagram[12] (Figure 4-2).

[12] For comparison of sentenced firms, paired t-test has been performed since the data sets were not independent.

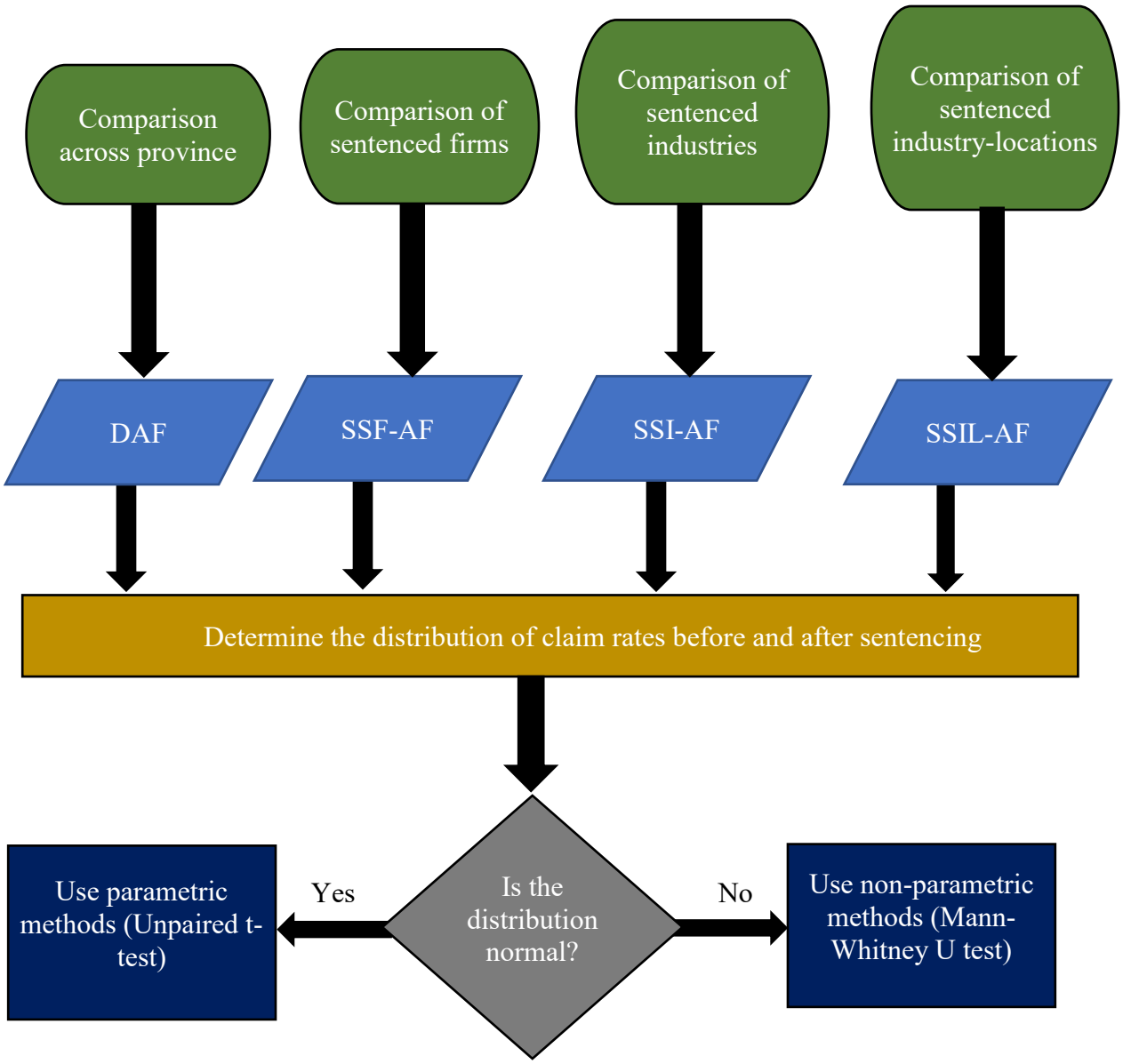

Figure 4-2: Flowchart of choosing appropriate test for comparison

4.2.2.1 Test for Normal Distribution

After generating all the datasets, their probability density distributions have been observed through histograms and to test normal distributions of claim rates, chi square goodness of fit test for normality has been conducted for all subsets of data. A probability density distribution is given below (Figure 4-3(a)) for DAF before and after claim rates. It is clear from Figure 4-3 (a) that the

distributions do not follow the normality. Since the distribution in regular scale is highly right skewed and very unclear to observe, the claim rates have been converted into natural logarithmic scale for better visualisation (Figure 4-3(b)).

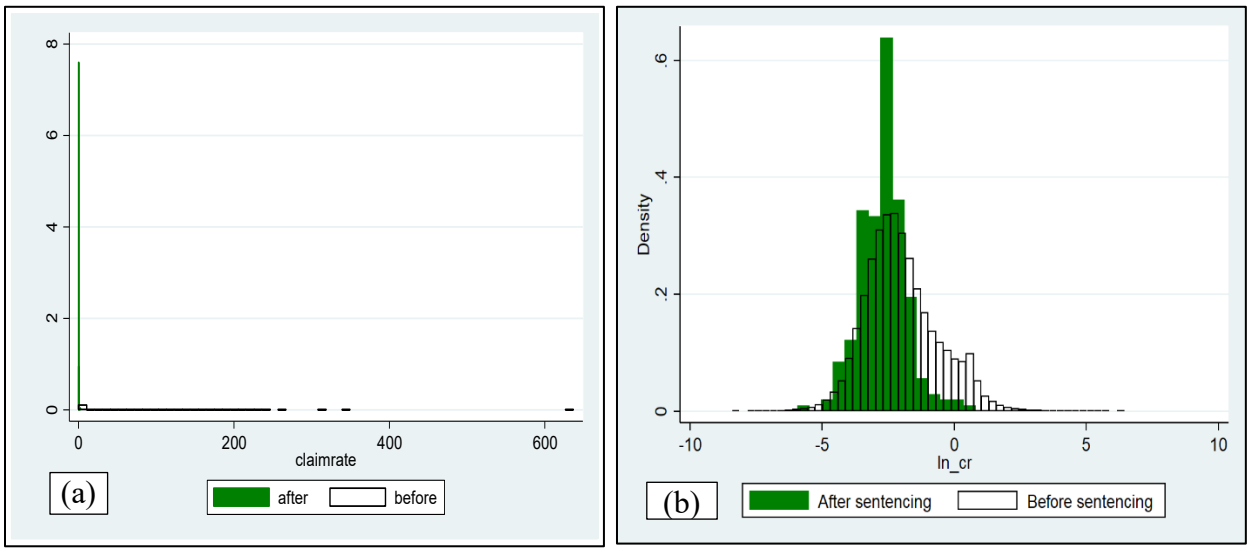

Figure 4-3: Histograms of claim rates before and after sentencing of all firms across the province, (a) regular scale (b) natural logarithmic scale

To test normality, chi square goodness of fit test for normal distribution (also known as Pearson chi square normality test) has been performed using R 3.5.0 which is defined for the hypothesis as below.

H_0: the data follow a normal distribution

H_A: the data do not follow the normal distribution

Results from this test have shown that null hypothesis has been rejected by all the subsets of data at 5% significance level which concludes that all the subsets' probability distributions do not follow normal distribution[13].

4.2.2.2 Non-parametric Statistical Tests

Since the claim rates of the datasets do not follow normal distribution, non-parametric approaches have been followed for their comparison. Nonparametric techniques are applicable generally because they impose few restrictions on the data. They are known as "distribution free" methods because they do not rely on any specific distributional characterization for the underlying population. The **Mann-Whitney-U test** is very popular for comparing two independent populations with identical (but potentially shifted apart) continuous distributions (Ogunnaike, 2010). It is the nonparametric equivalent of the two-sample t-test. Hence for comparison of claim rates, Mann-Whitney-U test has been performed using statistical software, STATA 14 to test the null hypothesis that the two groups (i.e. before sentencing and after sentencing) have the same distribution or, alternatively, whether one group has larger (or smaller) values than the other (Jaykaran, 2010)(McKnight & Najab, 2010)(Ogunnaike, 2010). The null hypothesis and alternate hypothesis for the comparison of all the datasets of this study are given below in a generic form.

H_0: claim rates before sentencing and after sentencing have the same distribution

H_A: claim rates before sentencing has larger (or smaller) values than claim rates after sentencing

In this thesis, for all statistical analyses, the significance level has been considered as 5%. So, significance level found more than 5% has been considered for failing to reject the null hypothesis.

[13] Test for lognormal distribution has also been performed by Anderson–Darling test but the samples do not follow lognormal distribution either.

Besides Mann-Whitney-U test, two sample **Kolmogorov–Smirnov (K-S) test** has also been applied to compare the before and after sentencing claim rates for across the province and for sentenced firms' comparison using STATA 14[14]. This is a nonparametric test of the equality of continuous, one-dimensional probability distributions that can be used to compare two samples. The two-sample K–S test is one of the most useful and general nonparametric methods for comparing two samples, as it is sensitive to differences in both location and shape of the empirical cumulative distribution functions of the two samples. The null distribution of this statistic is calculated under the null hypothesis that the samples are drawn from the same distribution. For this thesis, the two samples are defined as before sentencing claim rates and after sentencing claim rates with the following hypotheses.

H_0: distributions of claim rates for after sentencing group and before sentencing group are equal

H_A: distributions of claim rates for after sentencing group and before sentencing group are not equal

4.3 Results and Discussions

4.3.1 Result of comparing claim rates before and after sentencing across the province

Results of comparison of before and after sentencing claim rates across the province have shown in Table 4-2. Two types of non-parametric tests; Mann-Whitney U (MW-U) test and Kolmogorov–Smirnov (K-S) test have shown similar result that claim rates before sentencing are different than claim rates of after sentencing of the firms. Since both MW-U test and K-S test have

[14] Even though the samples do not follow the normal distribution, unpaired t-tests have also been performed to compare the means of the claim rates for before and after sentencing. The results from t-tests are provided in Appendix-B

found differences in firms' before sentencing and after sentencing claim rates, it can be said that there might be an effect of sentencing that changed the sentenced firms' subsequent claim rates in the whole province. Since this difference in post-sentencing claim rates might be greater or smaller than the pre-sentencing claim rates, it cannot be commented if sentencing has positive or negative effect on the claim rates. To identify the root-cause behind post-sentencing claim rate changing, scope of the analysis should be narrowed down within sentenced firms, industries or locations. Hence, those analyses results have been shown in later sections.

Table 4-2: Comparison of before and after sentencing claim rates across the province

Alternate Hypothesis	Before sentencing claim rates are different than after sentencing claim rates	
Tests	Mann-Whitney U test	K–S test
Rejection of null hypothesis at 5% significance level	Yes	Yes

4.3.2 Result of comparing claim rates before and after sentencing for sentenced firms

Comparison of before and after sentencing claim rates for sentenced firms have been performed using paired t-test since the samples are dependent (Table 4-3). Here, Table 4-3 shows the comparison result between the sentenced firms' before sentencing and after sentencing claim rates. According to paired t test, there is no differences between the before sentencing and after sentencing claim rates of sentenced firms. Since the comparison samples do not follow normal distribution, this comparison result of paired t test might not valid. More in-depth analysis can be done to determine the trend of post-sentencing period claim rates for sentenced firms to find out

the type of effect (positive or negative) for sentencing. Hence, a detailed graphical analysis has been performed to observe the effect of sentencing on the sentenced firms' post sentencing claim rates in Chapter 6 using an exploratory approach.

Table 4-3: Comparison of before and after sentencing claim rates for sentenced firms

Alternate Hypothesis	Before sentencing claim rates are different than after sentencing claim rates
Tests	Paired t test
Rejection of null hypothesis at 5% significance level	No

4.3.3 Result of comparing claim rates before and after sentencing for sentenced industries and industry-locations

Table 4-4 and Table 4-5 show comparison of before and after sentencing claim rates for sentenced industries and sentenced industry-locations respectively. From 2005 to 2015, a total of 39 sentenced industries' samples and 52 sentenced industry-locations' samples have been compared. Out of 39 sentenced industries, 26 industries' firms' claim rates are found statistically different by Mann-Whitney U test for their before sentencing and after sentencing samples (Table 4-4). These 39 industries are from six different sectors defined by WCB. Percentages of sentenced industries' whose post-sentencing claim rates have been changed in a sector have shown in Figure 4-4. It shows that most of the sectors' industries' claim rates have changed whereas no industries from Municipal Government, Education and Health Services have changed their claim rate after sentencing.

For sentenced industry-locations, out of 52 sentenced industry-locations, 31 industry-locations' firms' claim rates are found statistically different by Mann-Whitney U test for before and after sentencing samples (Table 4-5). This result shows that firms in same industries, but different locations act differently after sentencing. For example, firms from industry: Mobile Equipment Dealers have been sentenced six times from different locations, but post-sentencing claim rates have been changed for the firms located in Edmonton region only. Figure 4-5 shows percentages of sentenced industry-locations whose post-sentencing claim rates have been changed in different locations. It shows that percentage of post-sentencing claim rates change of sentenced industry-locations' firms' is relatively less who are in the North of Edmonton and South of Calgary.

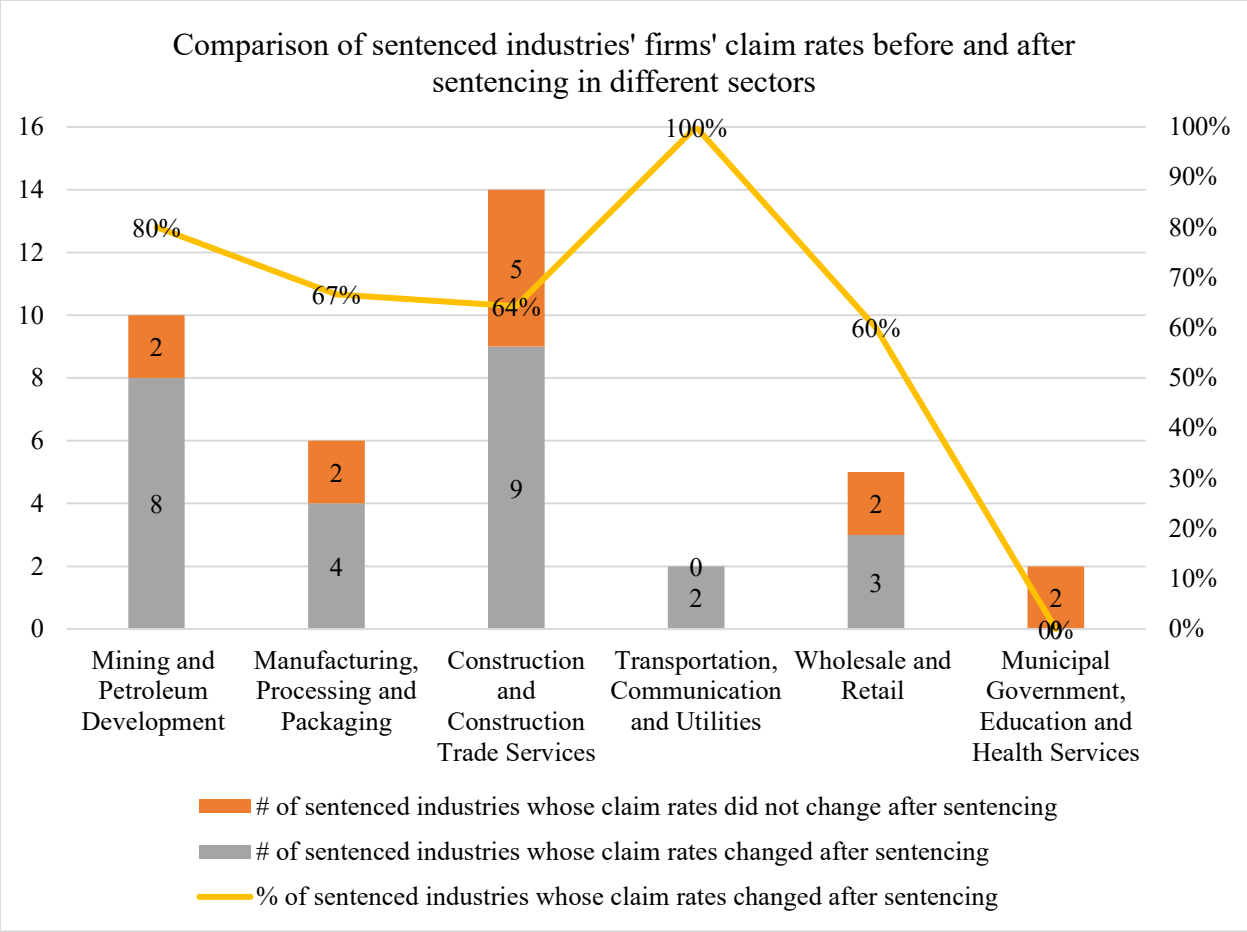

Figure 4-4: Comparison of sentenced industries' firms' claim rates before and after sentencing in different sectors.

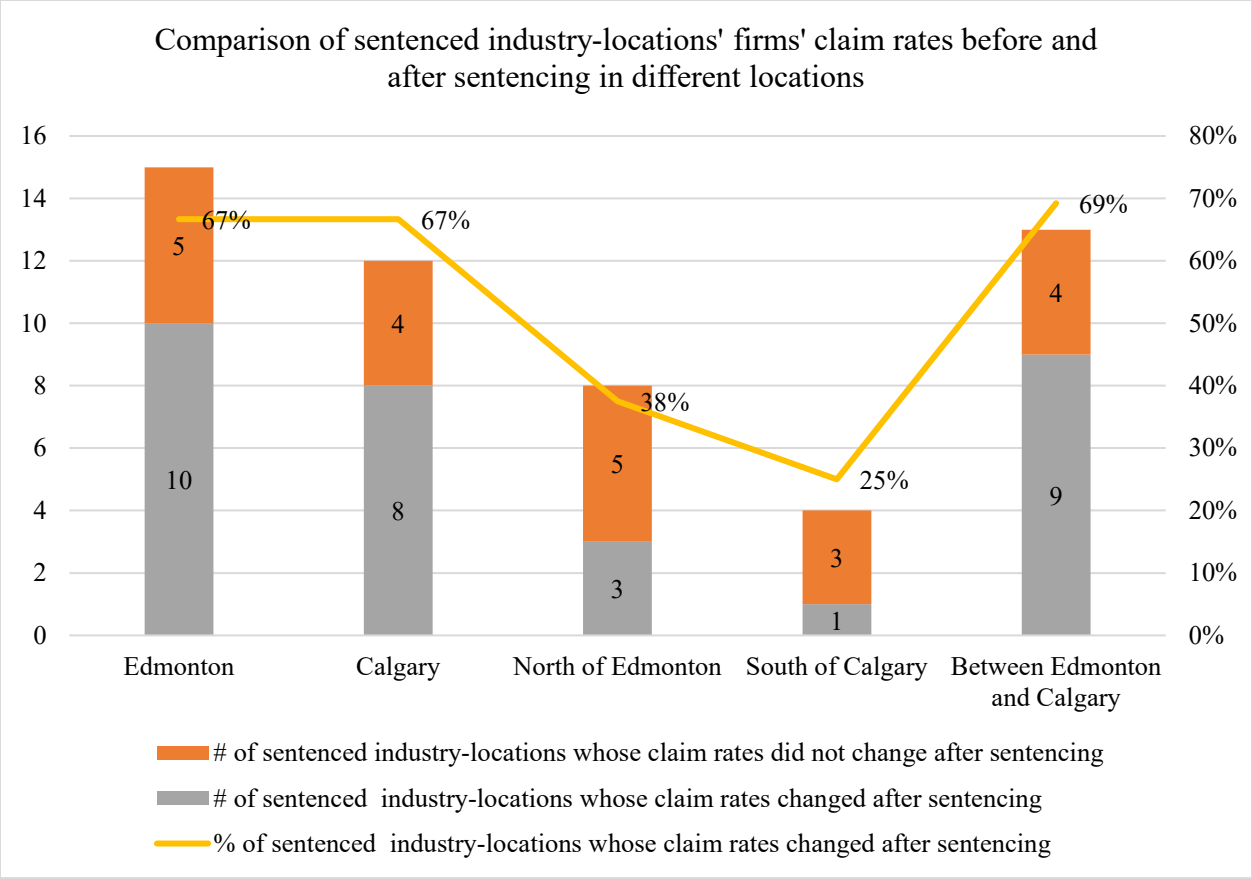

Figure 4-5: Comparison of sentenced industry-locations' firms' claim rates before and after sentencing in different locations.

As discussed in Section 2.7, these changes in post-sentencing claim rates might be attributed to the spill-over effect of sentencing. MW-U test performed in this chapter only suggests that the before sentencing claim rates are either different or same as after sentencing claim rates, but it does not test if before sentencing claim rates are greater than after sentencing claim rates or not. To determine the type of effect (positive or negative) of sentencing, an analysis of spill-over effect of sentenced industries and industry-locations has been performed in Chapter 5 using a fixed effect model of panel data. However, a qualitative analysis such as survey, interview or case studies should be done in future to find out if the changes of post-sentencing claim rates are effect of sentencing or not.

Table 4-4: Comparison of before and after sentencing claim rates for sentenced industries

Alternate Hypothesis		Before sentencing claim rates are different than after sentencing claim rates
Rejection of null hypothesis at 5% significance level for each industry	**Industry Name**	**Mann-Whitney U test**
	Boring - horizontal/angular	Yes
	Brick/masonry contracting	Yes
	Caisson operations	Yes
	Cities	No
	Cleaning services - mobile pressure	Yes
	Concrete products mfg.	No
	Construction, industrial	Yes
	Construction, residential	No
	Continuing care facilities	No
	Drilling - oil/gas wells	Yes
	Drilling, rathole/rig anchor	Yes
	Drug stores	Yes
	Drywall/plaster/stucco/etc.	Yes
	Farm implement dealers	No
	Floor coverings - sell/install	No
	Hardware/auto parts stores/etc.	Yes
	Heating systems-fab/install	Yes
	Industrial/oilfield equipment rent	No
	Machining	No
	Mobile equipment dealers	Yes
	Mobile equipment operation	Yes
	Oil & gas - upstream	Yes
	Oil sands operations	Yes
	Oilfield downhole services	No

Alternate Hypothesis		Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Mann-Whitney U test**
Rejection of null hypothesis at 5% significance level for each industry	Oilfield maintenance & construction	Yes
	Paving/surfacing	Yes
	Pipeline construction	Yes
	Pulp mills	Yes
	Residential general contractor	No
	Roofing	Yes
	Sawmills/planning mills	Yes
	Scrap/salvage dealers	Yes
	Siding/eavestrough - fab. /inst.	No
	Steel/metal fabrication	Yes
	Trucking service, general	Yes
	Utilities - electric and natural gas	Yes
	Vacuum removal, wet & dry waste	Yes
	Well casing services	No
	Well service with service rigs	No

Table 4-5: Comparison of before and after sentencing claim rates for sentenced industry-locations

Alternate Hypothesis			Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Location**	**Mann-Whitney U test**
Rejection of null hypothesis at 5% significance level for each industry-location	Boring - horizontal/angular	Between Edmonton and Calgary	Yes
	Brick/masonry contracting	Edmonton	Yes
	Caisson operations	Edmonton	Yes
	Cities	Between Edmonton and Calgary	No
	Cleaning services - mobile pressure	Edmonton	Yes
	Concrete products mfg.	Calgary	Yes
	Construction, industrial	Edmonton	Yes
	Construction, industrial	South of Calgary	No
	Construction, residential	North of Edmonton	No
	Continuing care facilities	Calgary	No
	Drilling - oil/gas wells	Calgary	Yes
	Drilling, rathole/rig anchor	Between Edmonton and Calgary	Yes
	Drug stores	Edmonton	Yes
	Drywall/plaster/stucco/etc.	Calgary	Yes
	Drywall/plaster/stucco/etc.	Edmonton	No
	Farm implement dealers	Between Edmonton and Calgary	No
	Floor coverings - sell/install	Edmonton	No
	Hardware/auto parts stores	Calgary	Yes

Alternate Hypothesis			Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Location**	**Mann-Whitney U test**
Rejection of null hypothesis at 5% significance level for each industry-location	Heating systems-fab/install	South of Calgary	Yes
	Industrial/oilfield equip. rent	North of Edmonton	No
	Machining	Edmonton	No
	Mobile equipment dealers	Edmonton	Yes
	Mobile equipment operation	Between Edmonton and Calgary	Yes
	Mobile equipment operation	Calgary	No
	Mobile equipment operation	Edmonton	Yes
	Mobile equipment operation	North of Edmonton	No
	Mobile equipment operation	South of Calgary	No
	Oil & gas - upstream	Calgary	Yes
	Oil sands operations	North of Edmonton	Yes
	Oilfield downhole services	Calgary	Yes
	Oilfield maintenance & construction	Between Edmonton and Calgary	Yes
	Paving/surfacing	Between Edmonton and Calgary	Yes

Alternate Hypothesis			Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Location**	**Mann-Whitney U test**
Rejection of null hypothesis at 5% significance level for each industry-location	Pipeline construction	Between Edmonton and Calgary	Yes
	Pulp mills	Between Edmonton and Calgary	Yes
	Residential general contractor	Edmonton	No
	Roofing	Edmonton	No
	Roofing	North of Edmonton	No
	Sawmills/planning mills	North of Edmonton	Yes
	Scrap/salvage dealers	Edmonton	Yes
	Siding/eavestrough - fab. /inst.	Calgary	No
	Siding/eavestrough - fab. /inst.	South of Calgary	No
	Steel/metal fabrication	Between Edmonton and Calgary	No
	Steel/metal fabrication	Calgary	Yes
	Steel/metal fabrication	Edmonton	Yes
	Trucking service, general	Between Edmonton and Calgary	Yes
	Trucking service, general	Calgary	Yes
	Trucking service, general	North of Edmonton	No
	Utilities - electric and natural gas	Edmonton	Yes

Alternate Hypothesis			Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Location**	**Mann-Whitney U test**
Rejection of null hypothesis at 5% significance level for each industry-location	Vacuum removal, wet & dry waste	Between Edmonton and Calgary	Yes
	Well casing services	Calgary	No
	Well casing services	North of Edmonton	Yes
	Well service with service rigs	Between Edmonton and Calgary	No

4.4 Conclusion

Since conviction and sentencing might affect the sentenced firms as well as firms in the same industries' and locations' subsequent claim rates (Johnson, 2018), there should be a change or difference in those firms' before sentencing and after sentencing claim rates. In this chapter, nonparametric tests have been performed to compare the before sentencing and after sentencing claim rates of sentenced firms, sentenced industries, sentenced industry-locations and across the province.

Comparison of before and after sentencing claim rates across the province have found statistically significant differences in firms' before sentencing and after sentencing claim rates. For sentenced firms, no difference has been found between the before sentencing claim rates and after sentencing claim rates according to paired t test.

For sentenced industries, out of 39 sentenced industries, 26 industries' firms' before sentencing claim rates are found statistically different from their after sentencing claim rates. It is also found that industries assigned to Municipal Government, Education and Health Services sector by WCB did not show any changes in their firms' claim rates after sentencing of any firm in the same industry. However, other sectors' industries' firms' claim rates have been changed relatively in higher percentage after sentencing of any firms in the same industry.

For sentenced industry-locations, out of 52 sentenced industry-locations, 31 industry-locations' firms' claim rates are found statistically different for before and after sentencing samples. It is also found that firms who are located in the North of Edmonton and South of Calgary are relatively less responsive to change their claim rates after sentencing of any firm in the same industry-location.

Since these differences in post-sentencing claim rates might be greater or smaller than the pre-sentencing claim rates, detailed analyses have been performed in Chapter 5 and Chapter 6 to find out the real trends of these samples after sentencing. However, qualitative analysis such as case studies, surveys, interviews can be performed in future with individual firms to find out the root cause behind their post sentencing period claim rate changes. Based on those qualitative analyses' results, it can be concluded that if these changes in post sentencing claim rates are attributed to sentencing or not.

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CHAPTER 5 : SPILL-OVER EFFECT OF SENTENCING ON INDUSTRIES' AND INDUSTRY-LOCATIONS' SUBSEQUENT CLAIM RATES USING FIXED EFFECT MODEL OF PANEL DATA

5.1 Introduction

In this chapter, eight panel data have been generated using the datasets of Chapter 3. These panel datasets have been used to determine spill over effect of sentencing on sentenced firms' associated industries' and industry-locations' subsequent average claim rates. Here, sentencing of a firm of an industry or industry-location lagged one year and two years have been used as independent variables and average claim rate of that industry or industry-location have been used as dependent variable. Fixed effect model has been used to identify if there are any industry specific or industry-location specific variables that might influence the firms' claims rate.

5.2 Empirical Models and Data

Based on the theoretical model presented in Section 2.7, the following models (shown in Table 5-1) have been used to estimate the spill-over effects of sentencing on subsequent claim rates (after 1 year and 2 years) of firms in the same industries and firms in the same industry-locations who were sentenced in Alberta from 2005 to 2015.

Table 5-1:Models to estimate spill-over effect of sentencing.

Lag years	Models used for Industries	Models used for Industry-Locations
1 year	$AICR_{it} = \alpha_i + \beta isen_{it-1} + \varepsilon_{it} \ldots$ (5.1)	$AILCR_{it} = \alpha_i + \beta ilsen_{it-1} + \varepsilon_{it} \ldots$ (5.4)
1 and 2 years	$AICR_{it} = \alpha_i + \beta_1 isen_{it-1} + \beta_2 isen_{it-2} + \varepsilon_{it} \ldots$ (5.2)	$AILCR_{it} = \alpha_i + \beta_1 ilsen_{it-1} + \beta_2 ilsen_{it-2} + \varepsilon_{it} \ldots$ (5.5)
anytime within 2 years	$AICR_{it} = \alpha_i + \beta_3 isen_{it-1,2} + \varepsilon_{it} \ldots\ldots$ (5.3)	$AILCR_{it} = \alpha_i + \beta_3 ilsen_{it-1,2} + \varepsilon_{it} \ldots\ldots$ (5.6)

Here, subscripts i denotes industry code for industries' models and indlocation for industry-locations model, and t denotes year.

Average Industry Claim Rate ($AICR_{it}$) is average of claim rates of all firms in a specific industry for a specific year

Average Industry-location Claim Rate ($AILCR_{it}$) is average of claim rates of all firms in a specific industry-location for a specific year

$$isen_{it-1} = \begin{cases} 1 \; if \text{ any firm of } i^{th} \text{ industry was sentenced one year ago} \\ 0 \; if \text{ any firm of } i^{th} \text{ industry was not sentenced one year ago} \end{cases}$$

$$ilsen_{it-1} = \begin{cases} 1 \; if \text{ any firm of } i^{th} \text{ industry} - \text{location was sentenced one year ago} \\ 0 \; if \text{ any firm of } i^{th} \text{ industry} - \text{location was not sentenced one year ago} \end{cases}$$

$$isen_{it-2} = \begin{cases} 1 \; if \text{ any firm of } i^{th} \text{ industry was sentenced two years ago} \\ 0 \; if \text{ any firm of } i^{th} \text{ industry was not sentenced two years ago} \end{cases}$$

$$ilsen_{it-2} = \begin{cases} 1 \; if \text{ any firm of } i^{th} \text{ industry} - \text{location was sentenced two years ago} \\ 0 \; if \text{ any firm of } i^{th} \text{ industry} - \text{locations was not sentenced two years ago} \end{cases}$$

$$isen_{it-1,2} = \begin{cases} 1 \; if \; isen_{it-1} = 1 \\ 1 \; if \; isen_{it-2} = 1 \\ 0 \; if \; isen_{it-1} = \; 0 \; and \; isen_{it-2} = 0 \end{cases}$$

$$ilsen_{it-1,2} = \begin{cases} 1 \; if \; ilsen_{it-1} = 1 \\ 1 \; if \; ilsen_{it-2} = 1 \\ 0 \; if \; ilsen_{it-1} = \; 0 \; and \; ilsen_{it-2} = 0 \end{cases}$$

ε_{it} is the error term

α_i is unobserved time-invariant individual effect for industries or industry-locations

$\beta, \beta_1, \beta_2, \beta_3$ are the coefficients those measure magnitude of the spillover effect of sentencing

Two datasets generated in Chapter 3; Dataset with all firms (DAF) and Dataset of firms with positive average claim rates (DFPCR) have been used to generate eight panel datasets according to Figure 5-1 and Figure 5-2. All the datasets constitute unbalanced panels spanning over the period 2005 to 2016. The number of industries and industry-locations per year varies year to year which refers to unbalanced panel data. Since the missing data of unbalanced panel might be correlated with the idiosyncratic errors (Wooldridge, 2012), industries or industry-locations which are not present in all those years have been removed to generate balanced panel data. Equation 5.1, 5.2 and 5.3 have been used for Industry Panel Data- All Firms (IPD-AF) and Industry Panel Data of firms with Positive average Claim Rate (IPD-PCR) datasets and equation 5.4, 5.5 and 5.6 have been used for Industry-location Panel Data- All Firms (ILPD-AF) and Industry-location Panel Data of firms with Positive average Claim Rate (ILPD-PCR) datasets for both unbalanced and balanced panels. Summary of these datasets are provided in Table 5-2.

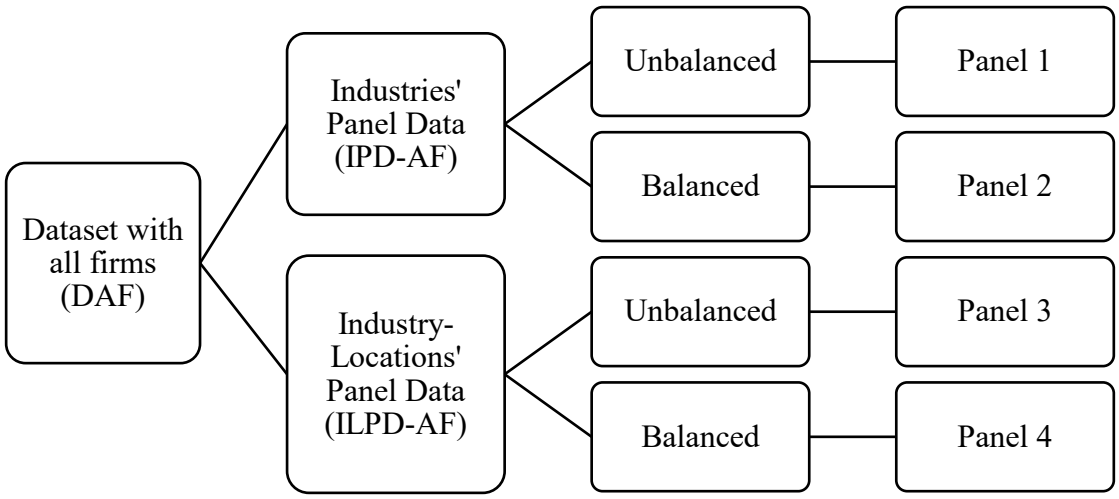

Figure 5-1: Generating panel data using DAF

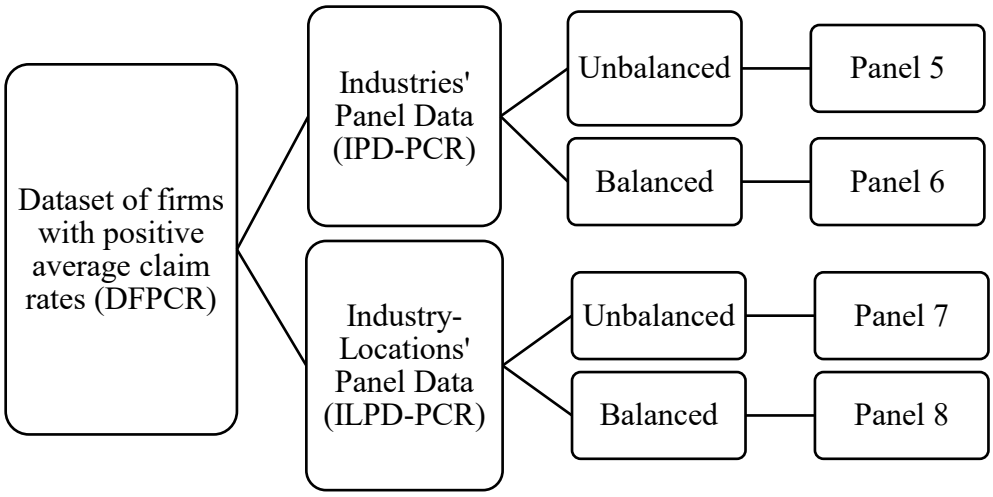

Figure 5-2: Generating panel datasets using DFPCR

Table 5-2: Summary statistics of variables

Variables	Datasets	Number of observations	Mean	Standard deviation	Min	Max
Average Claim Rate	Panel 1	4,085	0.046	0.115	0	3.693
	Panel 2	3,864	.0456	0.116	0	3.693
	Panel 3	18,499	0.043	0.198	0	12.4
	Panel 4	16,872	0.043	0.203	0	12.4
	Panel 5	3,989	0.063	0.104	0	4.518
	Panel 6	3,828	0.063	0.102	0	4.518
	Panel 7	15,693	0.063	0.127	0	4.518
	Panel 8	14,724	0.063	0.123	0	4.518
Sentencing	Panel 1	4,085	0.018	0.132	0	1
	Panel 2	3,864	0.019	0.135	0	1
	Panel 3	18,499	0.004	0.066	0	1
	Panel 4	16,872	0.005	0.069	0	1
	Panel 5	3,989	0.012	0.108	0	1
	Panel 6	3,828	0.012	0.11	0	1
	Panel 7	15,693	0.003	0.057	0	1
	Panel 8	14,724	0.003	0.058	0	1

5.3 Method

Panel data analysis is conducted instead of Ordinary Least Square method to estimate equation 5.1, 5.2, 5.3, 5.4, 5.5 and 5.6 to account for heterogeneity across industries and industry-locations using STATA 14. Fixed effect model has been used since the research objective is to determine the spillover effect within a specific industry or within a specific industry-location. A test for heteroscedasticity has been conducted for all datasets using Breusch-Pagan test which shows the existence of heteroscedasticity in the error terms of Ordinary Least Square (OLS) estimates (Breusch & Pagan, 1979). The results of Breusch-Pagan test are provided in supporting information (Appendix C) and details about this issue is discussed in section 5.4.3. To address this, robust standard error has been used instead of standard error while using fixed effect models (Williams, 2015).

5.4 Results and Discussion

5.4.1 Estimates of sentencing effects on subsequent Industries' and Industry-locations' average WCB AB claim rates

Table 5-3 shows the fixed effect estimates of sentencing effects on industries' subsequent average WCB AB claim rates (after 1 year and 2 years)[15]. Balanced and unbalanced panels have showed almost identical results in terms of sentencing effect on subsequent claim rates that implies the non-existence of idiosyncratic error i.e. errors are not changing over time as well as across industries or industry-locations. For all panel data, no significant effect has been found in industries' average WCB AB claim rates after one year of sentencing at 5% significance level. For

[15] In this regression analysis, sentencing lagged three, four and five years also used for both industry level and industry-location level, but the coefficients are found statistically insignificant at 5% level.

Panel 1 and Panel 2 (sourced from DAF) have shown significant and negative relation with the sentencing of any firm and that firm's industries' average claim rates after two years of sentencing. Results show that if any firm got sentenced, that firm's associated industries' average claim rate decreased by 0.0092 per FTE after two years which will decrease around 14,000 claims per year[16]. These claims can save up to 58.27 million dollars per year[17]. Panel 5 and Panel 6 (sourced from DFPCR) did not show any statistically significant change of average claim rates after one year or two years of sentencing though they have shown negative relations between the sentencing and subsequent claim rates. Similarly, industries' firms who were sentenced within last two years did not show any statistically significant change of average claim rates after sentencing although negative relations have been found between the sentencing and subsequent claim rates.

Table 5-4 shows the fixed effect estimates of sentencing effects on industries' subsequent average WCB AB claim rates (after 1 year and 2 years). Pattern of results are almost similar to the industry level results. No significant effect has been found in industry-locations' average WCB AB claim rates after one year of sentencing for all panel data. Unlike industry level results, no significant association has been found between sentencing of a firm and the associated industry-location's average claim rates for all panel data after two years. Similar results have been found for industry-locations' firms who were sentenced within last two years; no statistically significant change of average claim rates has been found after sentencing.

For the datasets with all firms, the small spill-over effect has been found after two years of sentencing. Hence, it can be said that if a firm got sentenced, other firms in the same industry are affected by that two years later. This indicates that sentencing of a firm decreases the subsequent

[16] Number of avoided claims has been estimated using average total insurable earnings and average hourly wage in 2016.

[17] Cost of avoided claims has been estimated using the average claim cost in 2016.

claim rate of other firms in the same industry. Decreasing the claim rate can be done by reducing the chances of accident/incidents or hiding their accident/incidents to WCB AB. In this context of research, it is assumed that firms are not hiding the claim counts. Hence, decreasing the claim may be attributed to the adopting safety practices by the firms in the same industry to improve their safety culture to reduce the chances of accident/incidents. Thus, sentencing or regulatory prosecution appears to be improving the overall safety culture. This can be tested with follow up case studies.

In terms of industry-locations, no significant changes have been found after one or two years of sentencing. Since industry level results show that sentencing of a firm decreases the subsequent claim rate of other firms in the same industry after two years, this indicates that sentencing of a firm decreases the subsequent claim rate of other firms in the same industry but not in the same location. This might happen due to inappropriate geographical divisions. In the current version of thesis, the location variable is defined based on firms within 40 km from the centre of Edmonton and Calgary. Defining the location in some other ways such as firms those are located more closely within 10 km of the sentenced firms might show actual spill-over effect.

Table 5-3: Fixed effect estimates of sentencing effects on Industries' subsequent WCB AB claim rates (after 1 year and 2 years)

	$AICR_{it} = \alpha_i + \beta isen_{it-1} + \varepsilon_{it}$				$AICR_{it} = \alpha_i + \beta_1 isen_{it-1} + \beta_2 isen_{it-2} + \varepsilon_{it}$				$AICR_{it} = \alpha_i + \beta_3 isen_{it-1,2} + \varepsilon_{it}$			
Datasets	Panel 1	Panel 2	Panel 5	Panel 6	Panel 1	Panel 2	Panel 5	Panel 6	Panel 1	Panel 2	Panel 5	Panel 6
$isen_{it-1}$	0.0058 (0.008)	0.0058 (0.008)	-0.0014 (0.005)	-0.0014 (0.005)	0.007 (0.008)	0.007 (0.008)	-0.0002 (0.005)	-0.0002 (0.005)	-	-	-	-
$isen_{it-2}$	-	-	-	-	-0.009 (0.004) *	-0.009 (0.004) *	-0.005 (0.005)	-0.005 (0.005)	-	-	-	-
$isen_{it-1,2}$	-	-	-	-	-	-	-	-	-0.002 (0.006)	-0.002 (0.006)	-0.007 (0.004)	-0.007 (0.004)
Constant	0.046 (0.00) *	0.046 (0.00) *	0.063 (0.00) *	0.063 (0.00) *	0.045 (0.00) *	0.045 (0.00) *	0.064 (0.00) *	0.063 (0.00) *	0.046 (0.00) *	0.046 (0.00) *	0.064 (0.00) *	0.063 (0.00) *
F-Stat	0.57	0.57	0.08	0.08	2.73	2.73	0.57	0.57	0.07	0.07	3.11	3.1
Sample size	4085	3864	3989	3828	3356	3220	3294	3190	3,718	3,542	3636	3509

Dependent variable is the Average Industry Claim Rate.

$isen_{it-1}$ is sentencing of any firm of the industry lagged one year;

$isen_{it-2}$ is sentencing of any firm of the industry lagged two years;

$isen_{it-1,2}$ is sentencing of any firm of the industry within last two years;

Figures in parentheses are robust standard error.

* Significant at the 5% level.

Table 5-4: Fixed effect estimates of sentencing effects on Industry-locations' subsequent WCB claim rates (after 1 year and 2 years)

	$AILCR_{it} = \alpha_i + \beta ilsen_{it-1} + \varepsilon_{it}$				$AILCR_{it} = \alpha_i + \beta_1 ilsen_{it-1} + \beta_2 ilsen_{it-2} + \varepsilon_{it}$				$AILCR_{it} = \alpha_i + \beta_3 ilsen_{it-1,2} + \varepsilon_{it}$			
Datasets	Panel 3	Panel 4	Panel 7	Panel 8	Panel 3	Panel 4	Panel 7	Panel 8	Panel 3	Panel 4	Panel 7	Panel 8
$ilsen_{it-1}$	0.015 (0.017)	0.015 (0.017)	0.002 (0.009)	0.002 (0.009)	0.0164 (0.018)	0.0164 (0.018)	0.002 (0.009)	0.002 (.009)	-	-	-	-
$ilsen_{it-2}$	-	-	-	-	-0.011 (0.006)	-0.012 (0.006)	-0.001 (0.007)	-0.002 (0.008)	-	-	-	-
$ilsen_{it-1,2}$	-	-	-	-	-	-	-	-	0.0014 (0.011)	0.0008 (0.011)	0.0015 (0.007)	0.0012 (0.007)
Constant	0.042 (0.00) *	0.043 (0.00) *	0.063 (0.00) *	0.063 (0.00) *	0.042 (0.00) *	0.042 (0.00) *	0.064 (0.00) *	0.064 (0.00) *	0.043 (0.00) *	0.043 (0.00) *	0.063 (0.00) *	0.063 (0.00) *
F-Stat	0.80	0.78	0.06	0.06	3.04 *	3.44 *	0.05	0.06	0.01	0.01	0.04	0.03
Sample size	18499	16872	15993	14724	15078	14060	12882	12270	16801	15466	14289	13497

Dependent variable is the Average Industry-location Claim Rate.

$ilsen_{it-1}$ is sentencing in any firm of the industry-location lagged one year;

$ilsen_{it-2}$ is sentencing in any firm of the industry-location lagged two years;

$ilsen_{it-1,2}$ is sentencing of any firm of the industry-location within last two years;

Figures in parentheses are robust standard error.

* Significant at the 5% level.

5.4.2 Low Variability in Data

The statistically insignificant change of average claim rates for sentenced industry-locations' firms as well as for panel 5, 6, 7, 8 might also happen due to very small spill-over effect and insufficient variation of data. The insignificant coefficient means that the null hypothesis cannot be rejected that the estimated coefficient is equal to zero. Table 5-5 and Figure 5-3 shows that variability in data in terms of sentencing is very low. Even for the panels sourced from DFPCR (Panel 5, 6, 7, 8), % of sentenced industries are found very small with respect to total number of industries. If the data would have more variability, the estimation of coefficient would be more precise which might lead to significant p values. In further research, tests for variability can be performed or pseudo panel data can be used as an alternative (Frethey-Bentham, 2011).

Table 5-5: Number of total industries, industry-locations and % of sentenced firms' industries and industry-locations

Year	Panel 1		Panel 5		Panel 3		Panel 7	
	Number of Industry	% of sentenced industry	Number of Industry	% of sentenced industry	Number of Industry-location	% of sentenced industry-location	Number of Industry-location	% of sentenced industry-location
2005	348	1.1%	335	0.9%	1554	0.39%	1306	0.23%
2006	348	1.7%	335	0.6%	1558	0.39%	1311	0.15%
2007	347	2.0%	335	0.9%	1555	0.45%	1310	0.23%
2008	346	3.5%	334	2.7%	1557	0.96%	1308	0.84%
2009	341	1.5%	332	0.9%	1535	0.33%	1307	0.23%
2010	335	1.5%	329	1.2%	1528	0.33%	1310	0.31%
2011	335	3.6%	330	3.0%	1532	0.85%	1310	0.76%
2012	334	0.9%	329	0.9%	1524	0.46%	1304	0.38%
2013	334	2.1%	330	1.2%	1529	0.46%	1304	0.31%
2014	334	2.1%	331	0.9%	1524	0.46%	1303	0.23%
2015	339	1.2%	331	0.9%	1531	0.26%	1303	0.23%

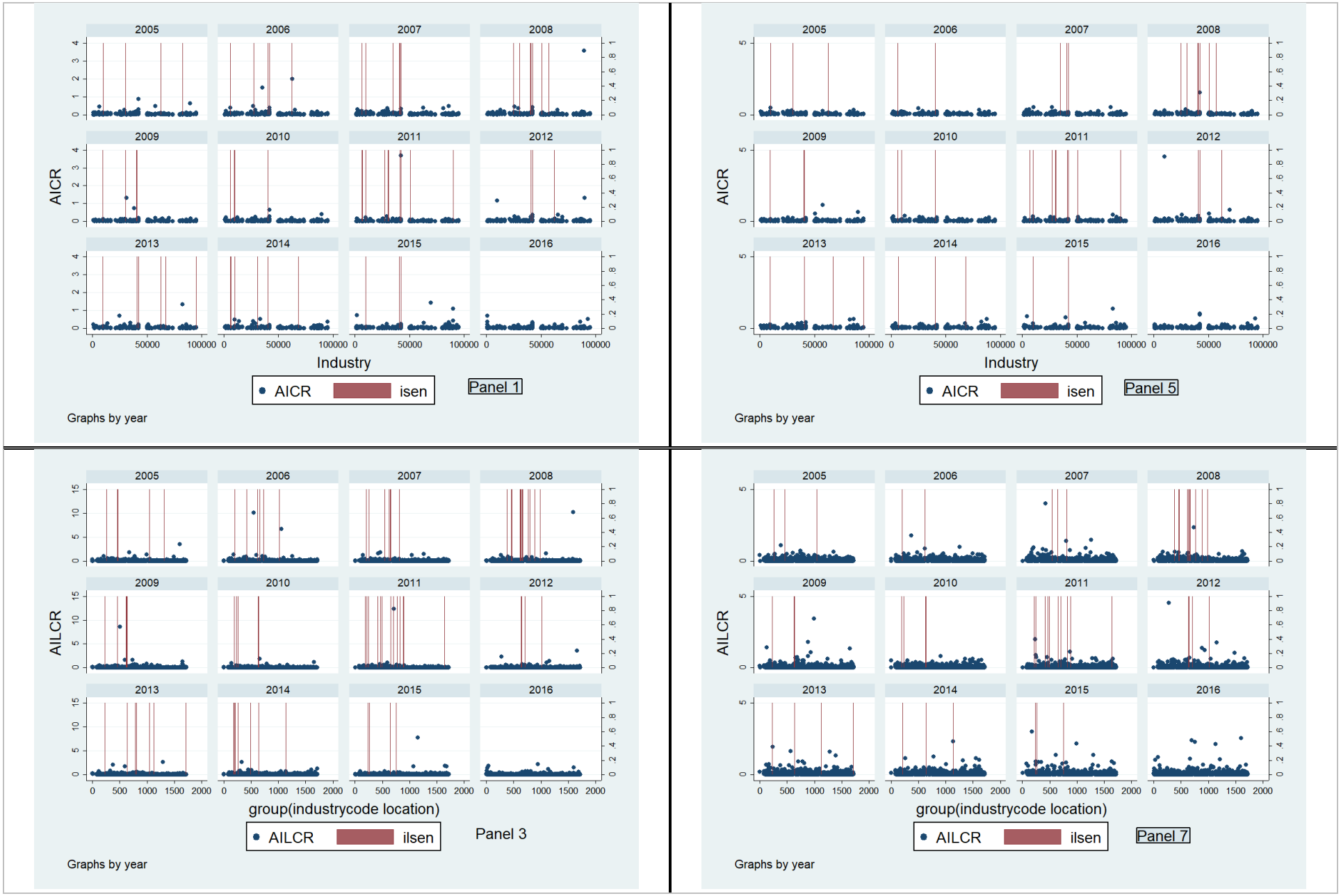

Figure 5-3: Plot of average claim rates and sentencing for industries and industry-location

5.4.3 Heteroscedasticity in Data

In section 5.3, it is also mentioned that the error terms of data from OLS estimate has been shown heteroscedasticity. It might happen due to different sub-population since the data have different industries (Construction, mining, oil and gas etc.) and locations (Edmonton, Calgary, north of Edmonton etc.). The effect of sentencing on subsequent claim rates can be different from one industry to another or one location to another. For example, in the following diagram (Figure 5-4) three different industries show different trend lines which refer that the residual values will also be dispersed differently, and the standard errors will become biased. This in turn leads to bias in test statistics and confidence intervals. To address heteroscedasticity in terms of the standard errors, robust standard errors have been used here to correct the bias of standard errors and thus it is valid for the inferences of the models. But this does not remove heteroscedasticity from the data, it just addresses one of the effects of having heteroscedasticity by adjusting the standard error. Hence, the actual effect of sentencing can be unobserved.

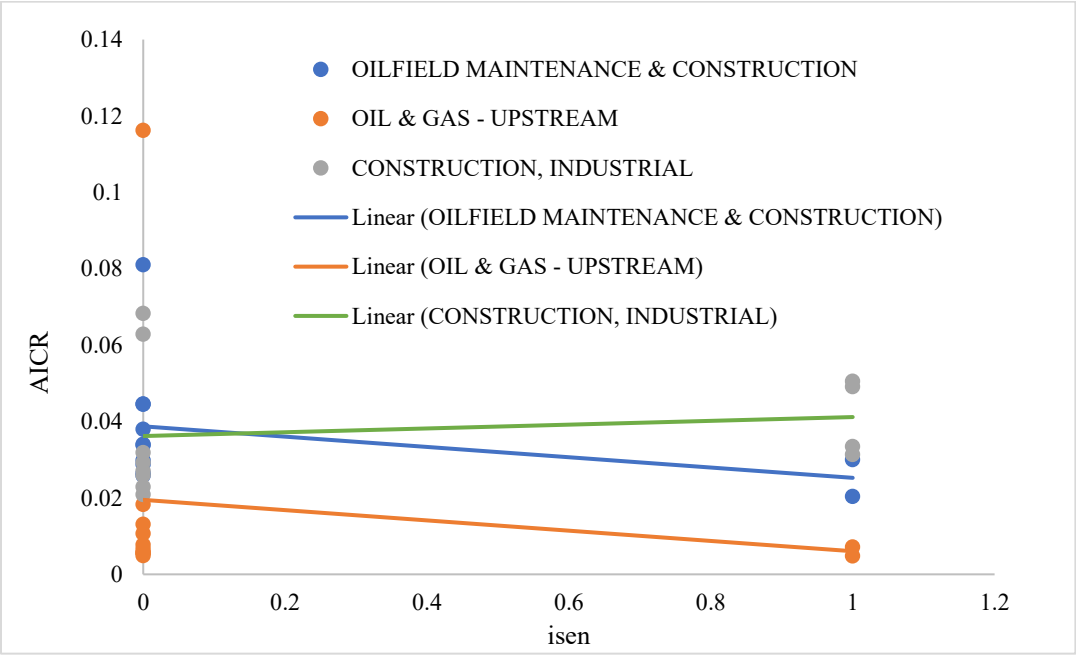

Figure 5-4: Illustration of heteroscedasticity

5.4.4 Probability of Type II error

Since no statistically significant change in WCB AB's claim rate has been found for the panels sourced from DFPCR as well as for industry-locations levels, the probability of type II error might be high. The power and sample size analyses of these panels show that the sample size for a power of 0.80 (i.e. probability of type II error = 20%) of an alpha of 0.05 should be almost double than the existing sample sizes. Hence, the probability of rejecting the null hypothesis of estimated coefficient is equal to zero (which is actually false) becomes high due to low sample size. Incorporating other prosecution data or using pseudo panel might address this issue which can be studied in further analysis.

5.5 Conclusion

In summary, when a firm is convicted and sentenced, it creates a social suasion. This social suasion affects the firms of the same industry and same geography. In this stage, firms in the same industry and geography try to take actions to prevent any such incidents by adopting some management practices which may improve the overall safety culture (Christian, Bradley, Wallace, & Burke, 2009). Results from this chapter have shown that effects of sentencing after one year on WCB AB's claim rate are not statistically significant at 5% significance level. However, after two years of sentencing, industries' average claim rates significantly decrease which provide a proof of spill-over effect. Estimation from this result shows that around 14,000 claims can be avoided per year in the same industry whose firms get sentenced. These avoided claims would cost 58 million dollars per year for industry level. However, it can be said that, after sentencing, the firms in the same industry might need one year to get the desired result out of newly adopted safety practices. This is not surprising, considering that firms will be changing their management systems.

No statistically significant change in WCB AB's claim rate has been found for the firms with average positive claim rates and those which sustained from 2005 to 2016 after one or two years of sentencing. This might happen due to inadequate variation in the data to identify the actual effect. Total number of industries whose firms were sentenced are only 39 from 2005 to 2015 whereas total number of industries are around 320 each year. Incorporating more prosecution data from other provinces might address this issue.

The small or statistically insignificant spill-over effect which has been found for the firms in the same industry and same location whose firms got sentenced might be due to improper divisions of group of firms. There might be a spill-over effect on a certain group of firms but those are not correctly defined in this study. By defining the group in some other ways such as very closely related industries or firms which are located within 10 km of the sentenced firms might show actual spill-over effect.

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CHAPTER 6 : EXPLORATORY DATA ANALYSIS TO OBSERVE THE FOCAL-FIRM EFFECT OF SENTENCING WITH RESPECT TO FIRMS IN THE SAME INDUSTRY AND FIRMS IN THE SAME INDUSTRY-LOCATION

6.1 Introduction

This chapter contains an exploratory data analysis to observe if the trends of average claim rates have changed for sentenced firms after sentencing with respect to control groups. Here, firms who were sentenced between 2007 to 2013 are considered as treatment group; firms in the same industry whose firms were sentenced between 2007 to 2013 are considered as Control group-1 and firms in the same industry and same location whose firms were sentenced between 2007 to 2013 are considered as Control group-2. Trends of group means in pre-sentencing periods and post-sentencing periods have been observed and compared with trends of control groups to identify any observable differences in post-sentencing period.

6.2 Data & Method

6.2.1 Time period

For this chapter, a five-year window has been created for each sentencing event; two years preceding the sentencing year, sentenced year and two years followed by the sentencing year as shown in Table 6-1. Since, both the data from WCB AB and GoA Labour are available from 2005

to 2015 and 2003, 2004, 2016 and 2017 (bold and yellow highlighted in Table 6-1) are out of scope of this thesis, only firms sentenced between 2007 to 2013 are considered for this analysis (green shaded cells in Table 6-1).

Table 6-1: Defining pre and post sentencing periods

Sentenced years	**Code years**				
	-2	-1	0	+1	+2
2005	**2003**	**2004**	2005	2006	2007
2006	**2004**	2005	2006	2007	2008
2007	2005	2006	2007	2008	2009
2008	2006	2007	2008	2009	2010
2009	2007	2008	2009	2010	2011
2010	2008	2009	2010	2011	2012
2011	2009	2010	2011	2012	2013
2012	2010	2011	2012	2013	2014
2013	2011	2012	2013	2014	2015
2014	2012	2013	2014	2015	**2016**
2015	2013	2014	2015	**2016**	**2017**
	Pre-sentencing Period		**Sentenced year**	**Post-sentencing Period**	

6.2.2 Treatment Group and Control Groups

Treatment group contains firms who were sentenced between 2007 to 2013 whereas control groups are considered in the following 2 ways.

i. Control group-1: firms in the same industry whose firms were sentenced between 2007 to 2013
ii. Control group-2: firms in the same industry and same location whose firms were sentenced between 2007 to 2013

Two major datasets generated in Chapter 3; Dataset with all firms (DAF) and Dataset of firms with positive average claim rates (DFPCR) have been used to create treatment and control groups as illustrated in Figure 6-1 and Figure 6-2. For the treatment and control groups sourced from DAF, some firms have been found who opened or closed their business in between this five-year window. To compare the same firms' data in the pre and post-sentencing periods, firms only who were opened this five-year period have been considered for this analysis.

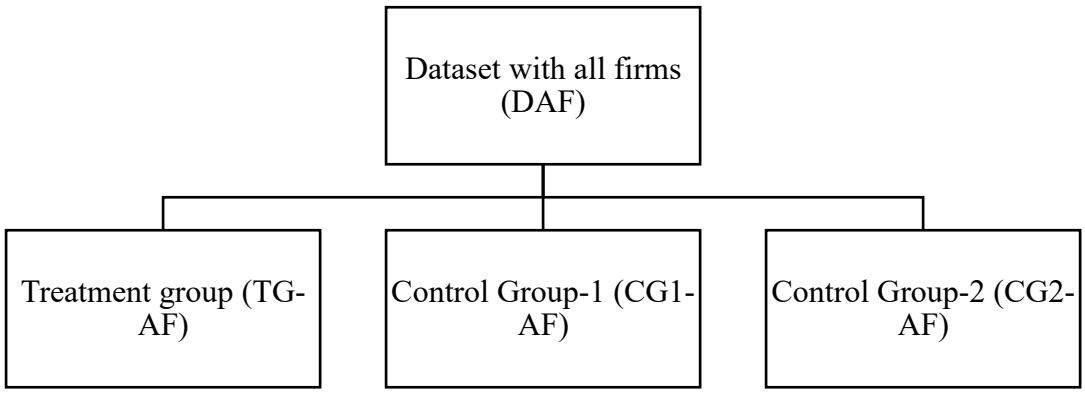

Figure 6-1: Generating Treatment and Control Groups using DAF

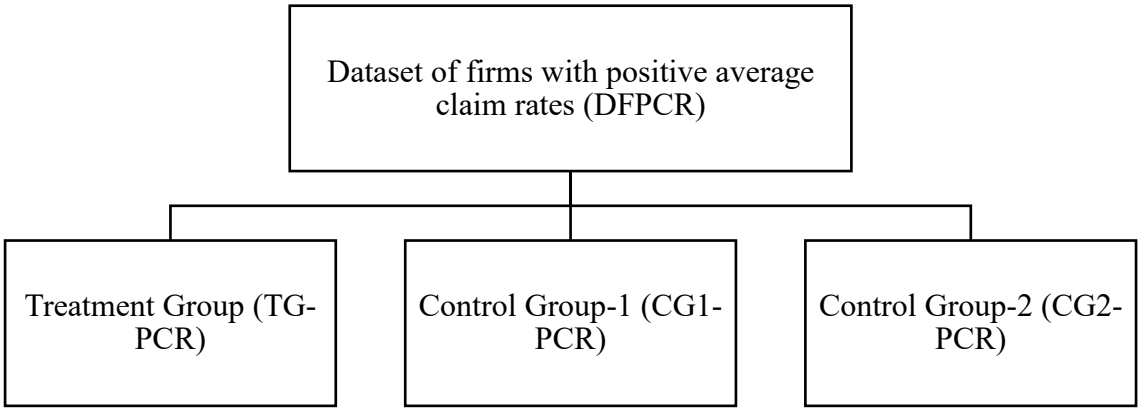

Figure 6-2: Generating Treatment and Control Groups using DFPCR

For all treatment and control groups, average claim rates are calculated for every code year (-2, -1, 0, +1 and +2) to compare the trends of average claim rates in the pre and post-sentencing periods using graphical analysis. Although there is a time lag between date of incident and date of sentencing, this study only explores the effect of sentencing. Summary statistics of the treatment groups and control groups are provided in Table 6-2.

Table 6-2: Summary statistics of treatment groups and control groups

Groups	Code years	Sourced from DAF			Sourced from DFPCR		
		Sample size	Mean	Standard deviation	Sample size	Mean	Standard deviation
Treatment group	-1	46	0.074	0.143	39	0.061	0.059
	-2	46	0.071	0.092	39	0.072	0.086
	0	46	0.081	0.199	39	0.057	0.064
	1	46	0.136	0.378	39	0.115	0.356
	2	46	0.045	0.052	39	0.05	0.051
Control group-1	-1	33,193	0.05	1.329	7,422	0.089	0.351
	-2	33,193	0.049	0.49	7,422	0.09	0.328
	0	33,193	0.049	0.37	7,422	0.105	0.608
	1	33,193	0.045	0.304	7,422	0.094	0.351
	2	33,193	0.053	0.622	7,422	0.103	0.602
Control group-2	-1	15,728	0.052	1.89	3,824	0.073	0.234
	-2	15,728	0.047	0.57	3,824	0.081	0.305
	0	15,728	0.045	0.259	3,824	0.093	0.314
	1	15,728	0.048	0.382	3,824	0.102	0.6
	2	15,728	0.058	0.853	3,824	0.109	0.829

6.3 Results and Discussion

6.3.1 Results for Datasets Sourced from DAF

Figure 6-3 and Figure 6-4 show the pre and post sentencing period trends of average claim rates of treatment group and control groups using dataset sourced from DAF. In the pre-sentencing period, control group 1 and 2 and treatment group show almost similar trend. In the post-sentencing period, both the control groups' trends have shifted slightly with respect to their pre-sentencing

periods' trends. On the other hand, in the post-sentencing period, the treatment group has shown a spike just after the treatment year at code year = +1. However, in the next year (at code year = +2), the average claim rate for treatment group has decreased even below the control groups' ones.

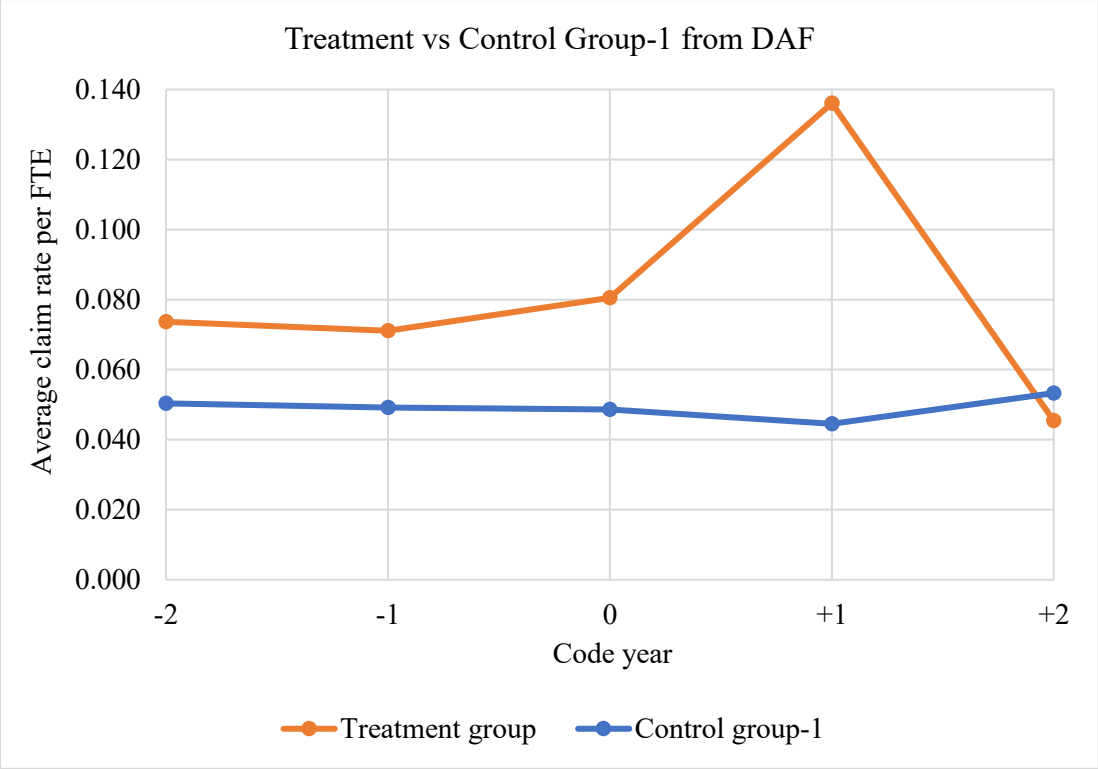

Figure 6-3: Graphical trend analysis of treatment group and control group-1 from DAF

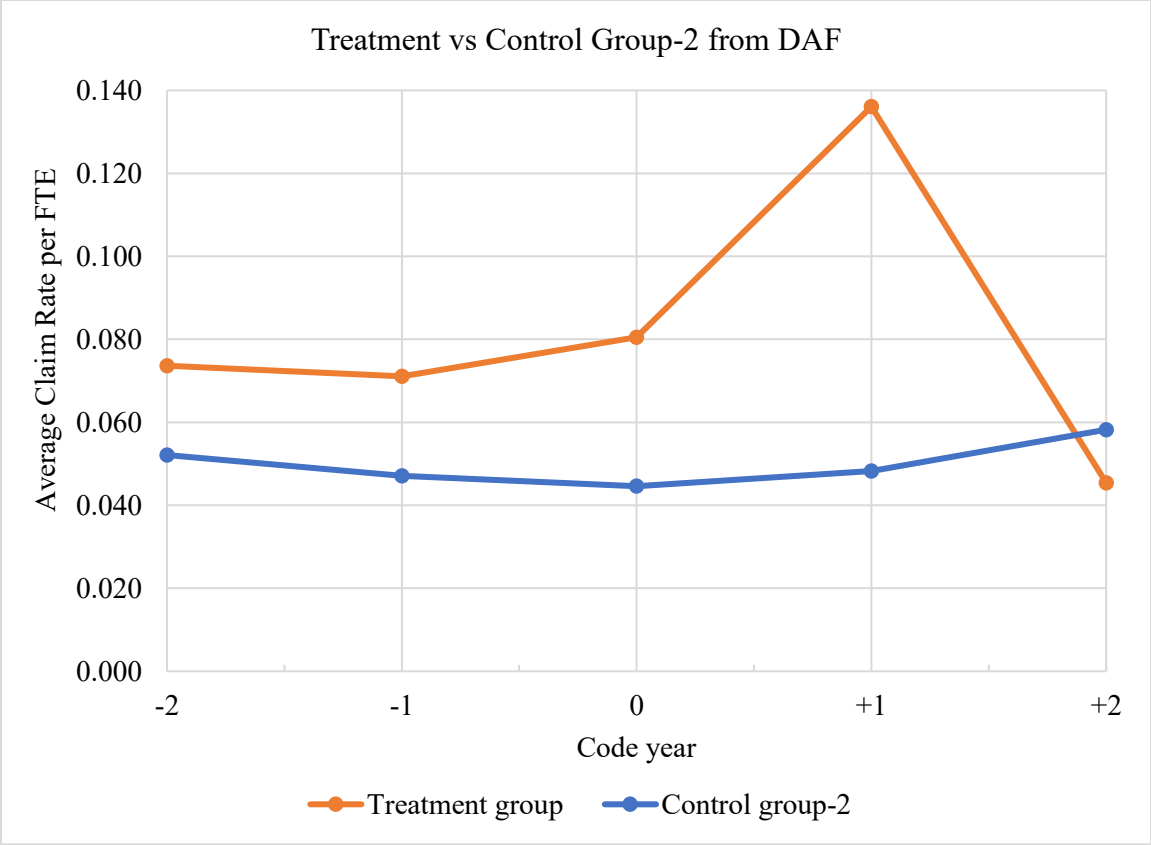

Figure 6-4: Graphical trend analysis of treatment group and control group-2 from DAF

The spike at code year = +1 for treatment group tells that the average claim rates of sentenced firms become relatively high in the year followed by the sentenced year than other years. As depicted in Table 6-2 both the average and standard deviation at this code year are higher than other code years (average = 0.136 and standard deviation = 0.378). Frequency distribution of claim rates of treatment group (Figure 6-5) shows that it is a highly right skewed distribution with a long tail. This long tail consists of three discrete bars with four observations; one is Sure-Form Construction Ltd.'s (SFC) in bin = (0.84 to 0.96), two are BGB Enterprises' (BGBE) in bin = (1.32 to 1.44) and another is Cee - Cee Roofing's (CCR) in bin = (2.16 to 2.28). Out of these four observations, two observations are found in code year = +1 that might have created the spike at that code year in Figure 6-3 and 6-4. Due to these two observations, the actual treatment effect

might be unobserved. Hence, to observe the post-sentencing trend without these two observations, graphical trends are observed and discussed by excluding these observations one by one from the left tail in the later sections.

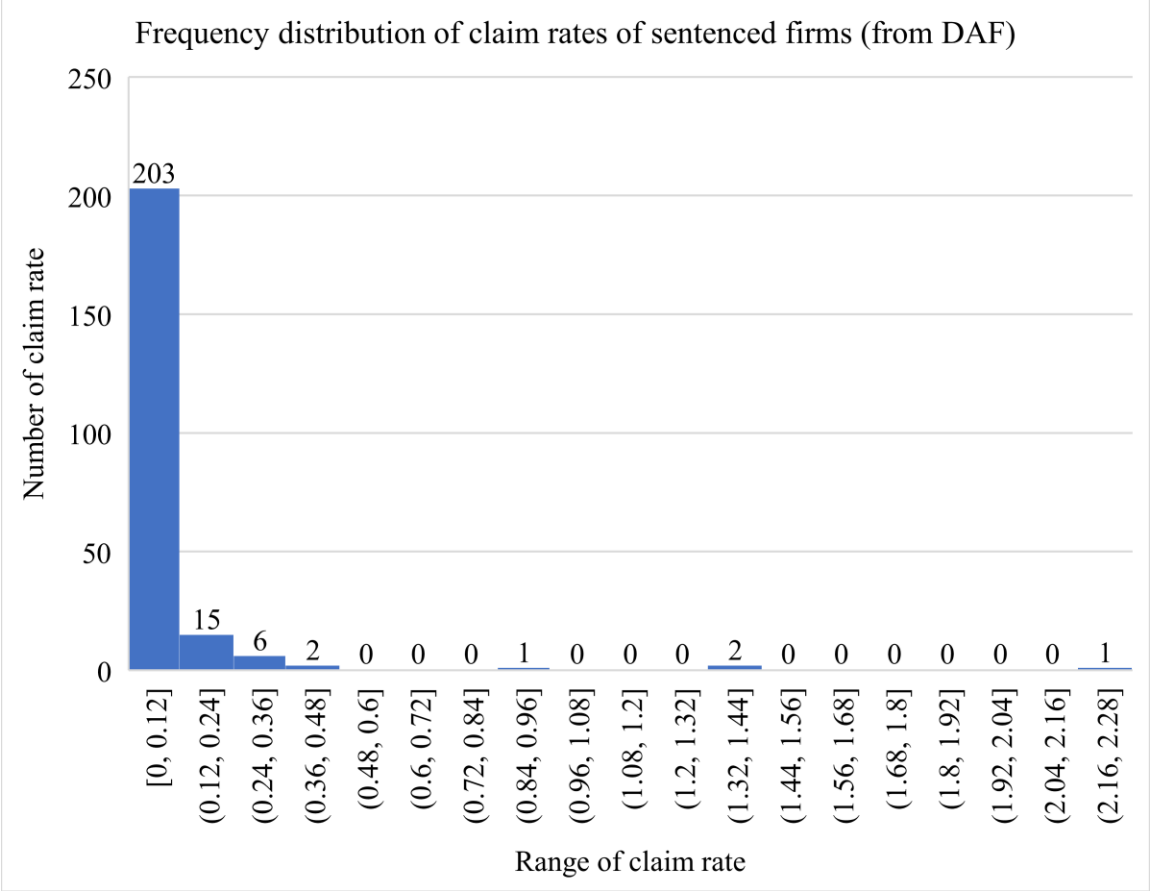

Figure 6-5: Frequency distribution of claim rates of treatment group (from DAF)

6.3.1.1 Excluding Cee - Cee Roofing (CCR)'s Claim Rate from Code year = +1

Figure 6-6 and Figure 6-7 show the pre and post sentencing period trends of average claim rates of treatment group and control groups excluding CCR's claim rate from code year = +1. Since all other data are same, trends of control groups and the pre-sentencing period trend of treatment group remained unchanged. The only difference has been found in the post-sentencing period's trend of treatment group. The average of claim rate at code year = +1 has decreased to

0.089 per FTE from 0.136 per FTE. However, this claim rate of CCR at code year=+1 has increased the average claim rate by 35%. Hence, a qualitative analysis such as case study should be performed to find out the reasons behind this firm's high claim rate just followed by the sentencing.

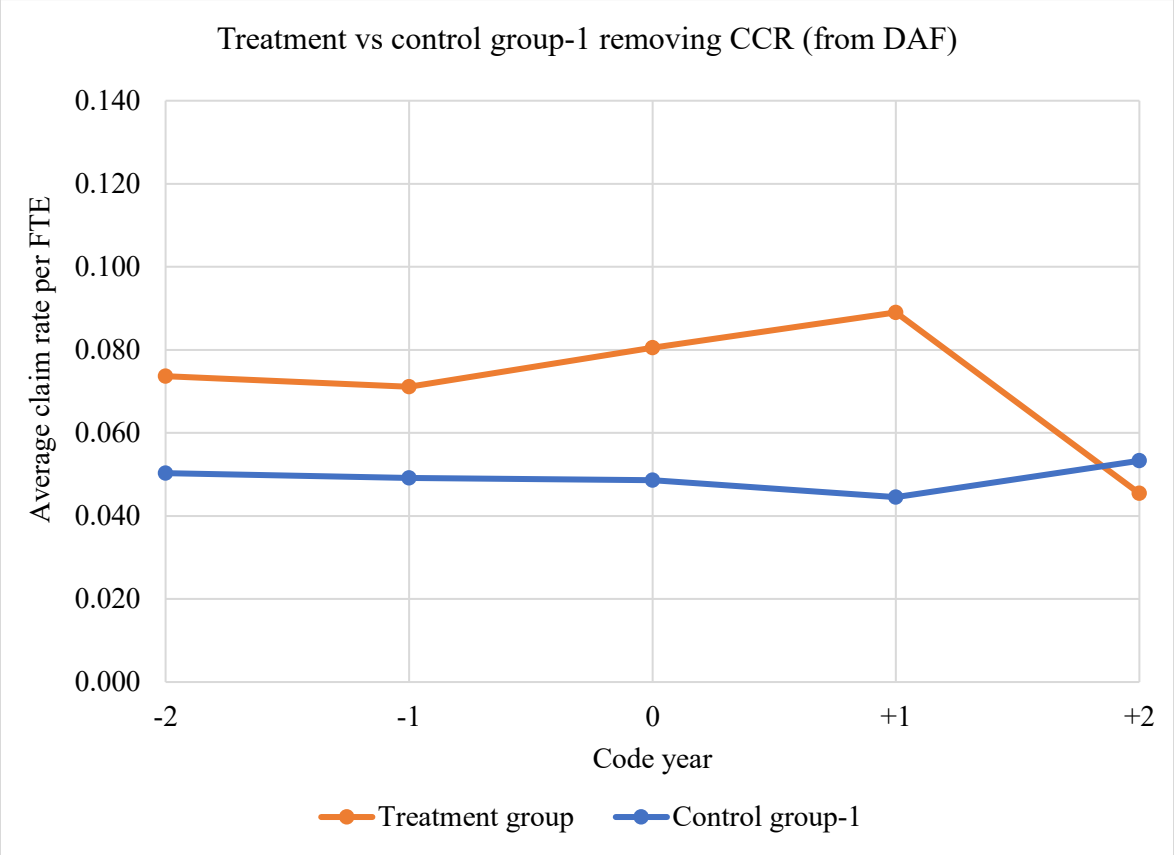

Figure 6-6: Graphical trend analysis of treatment group and control group-1 (from DAF) excluding CCR's claim rate from code year = +1

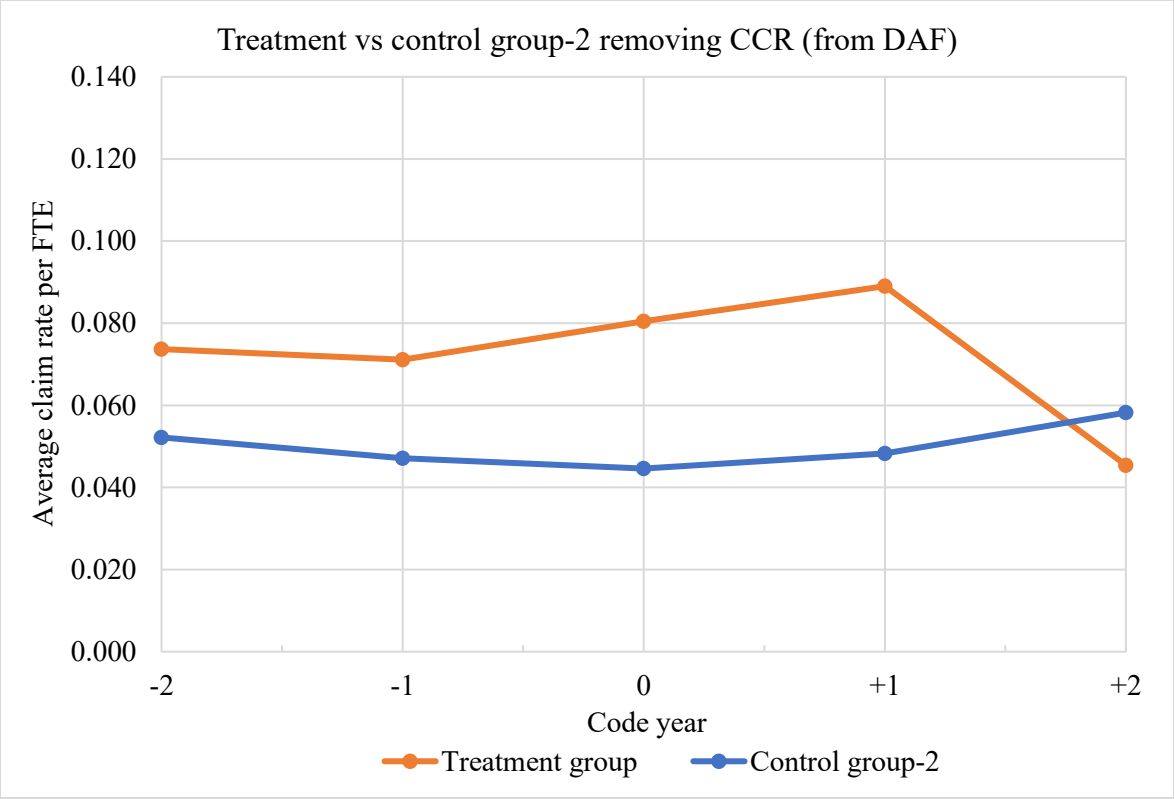

Figure 6-7: Graphical trend analysis of treatment group and control group-2 (from DAF) excluding CCR's claim rate from code year = +1

6.3.1.2 Excluding both Cee - Cee Roofing (CCR)'s and BGB Enterprise (BGBE)'s Claim Rates from Code year = +1

Figure 6-8 and Figure 6-9 show the pre and post sentencing period trends of average claim rates of treatment group and control groups excluding CCR's and BGBE's claim rates from code year = +1. Trends of control groups and the pre-sentencing period trend of treatment group are same as Figure 6-6 and 6-7 for control group-1 and control group-2 respectively. These graphs show that the average of claim rate at code year = +1 has decreased to 0.074 per FTE from 0.136 per FTE which is around 46% decrease of average claim rate at that code year. Removing only BGBE's claim rate has decreased the average claim rate by 17% at code year = +1. Hence, besides,

Cee - Cee Roofing (CCR), a qualitative analysis such as case study should be performed for BGB Enterprise (BGBE) as well to determine the factors for its high claim rate at that year.

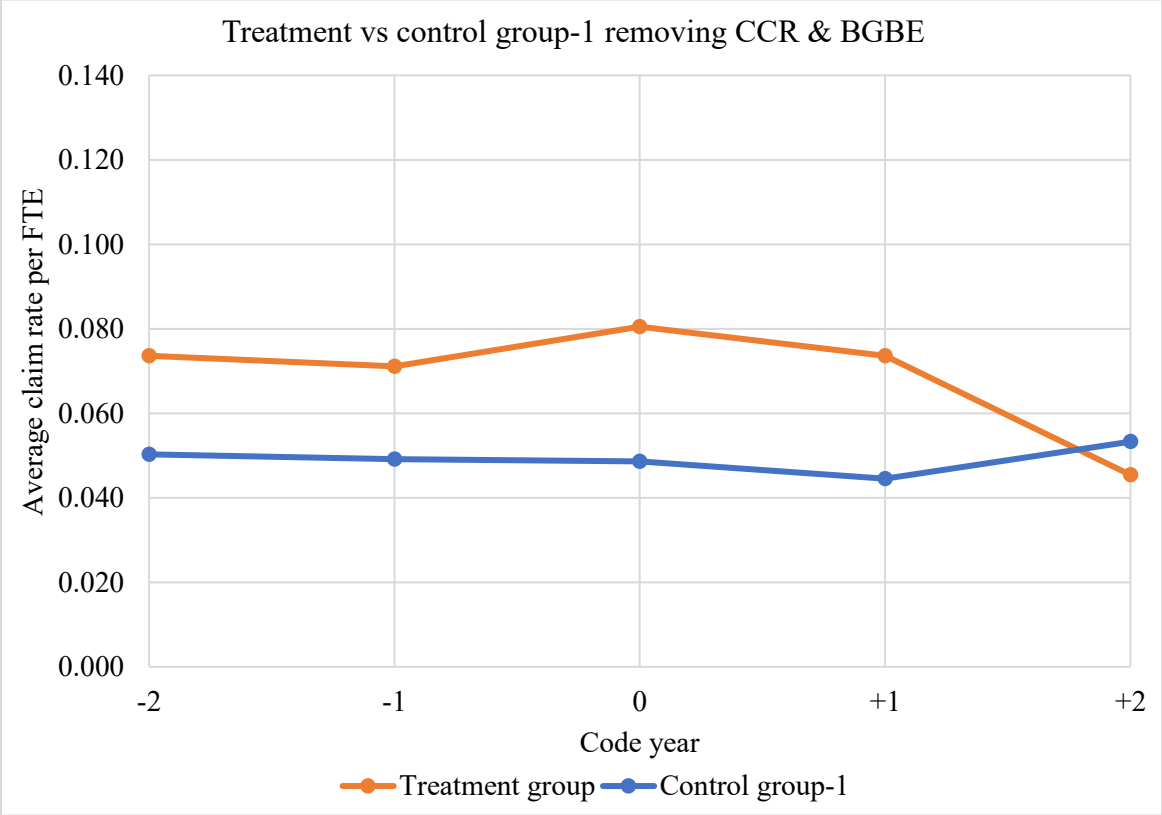

Figure 6-8: Graphical trend analysis of treatment group and control group-1 (from DAF) excluding CCR's and BGBE's claim rates from code year = +1

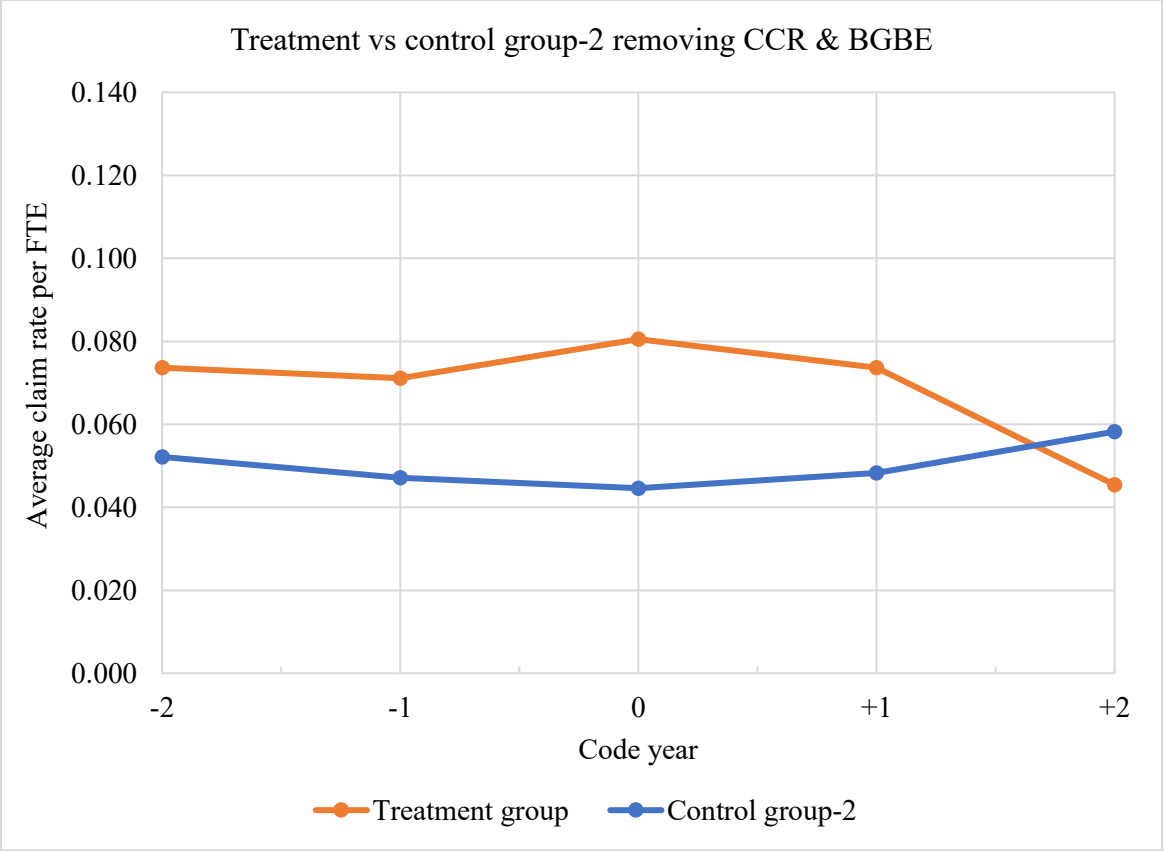

Figure 6-9: Graphical trend analysis of treatment group and control group-2 (from DAF) excluding CCR's and BGBE's claim rates from code year = +1

After removing two firms' claim rates from code year = +1, treatment group's trend in the post-sentencing period shows a decreasing trend whereas Control Group-1 and Control group-2 show slight increasing trends in that period. This decreasing trend of average claim rate of treatment group in post-sentencing period suggests that there might be an effect for treatment i.e. sentencing. In Figure 6-8 and 6-9, it is shown that treatment group and control groups are following the similar trend in their pre-sentencing period from code year = -2 to code year = -1 and treatment group's average claim rate is higher than the control groups in pre-sentencing period. However, from code year = -1 to code year = 0, trends of treatment group and control groups are diverged in different directions. In post-sentencing period, treatment group's average claim rate shows a

decreasing trend, but the control groups' trends have found in opposite direction. Since the trends of the two groups are almost similar in pre-sentencing period, it can be commented that in the absence of treatment (a sentence) they would continue to be the same. Hence, any post-sentencing difference between them might therefore be attributed to sentencing. However, to get more clarification regarding this attribution to sentencing, qualitative analyses (interview, case study or survey) on treatment group i.e. sentenced firms can be performed.

6.3.2 Results for Datasets Sourced from DFPCR

Figure 6-10 and Figure 6-11 show the pre and post sentencing period trends of average claim rates of treatment group and control groups using dataset sourced from DFPCR. These trends show relatively higher average claim rates than the trends from DAF datasets because of removal of firms with zero claim rates. Table 6-3 shows that percentages of non-zero observations have become relatively higher for control groups than treatment group for the datasets sourced from DFRCR.

Table 6-3: Percentage of Non-zero Observations in Trend Analysis.

	Percentage of non-zero observations	
	Datasets from DAF	Datasets from DFPCR
Sentenced firms (Treatment group)	70%	78%
Sentenced industries (Control group-1)	12%	34%
Sentenced industry-locations (Control group-2)	13%	35%

Here in Figure 6-10 and Figure 6-11, both the control groups' average claim rates show a slight upward trend for these five years whereas treatment group's average claim rates show

fluctuations. Since pre-sentencing trends of control groups and treatment group do not follow the similar trend for these datasets, the treatment effect cannot be compared as compared in section 6.3.1. However, looking into Figure 6-10 and Figure 6-11, trends of control groups and treatment group from code year = -2 to code year = -1 are found increasing which is almost similar specially for control group-2. At sentenced year (code year = 0), the treatment group's average claim rate has decreased whereas the control groups' ones have increased. The observed differences of trends of average claim rates between control groups and treatment group after code year = +1 might be an effect of incident since incidents usually occurred before some years of sentencing. Treatment group might act differently by adopting some safety measures that leads to low claim rates after incidents or few years of incidents. However, effect of incident is out of scope of this thesis. In the post-sentencing period, control group-1's trend is found flat and control group-2 shows gradual increase. On the other hand, in the post-sentencing period, the treatment group has shown a spike at code year = +1 then decreased again at code year = +2 which was also found in the previous section (section 6.3.1).

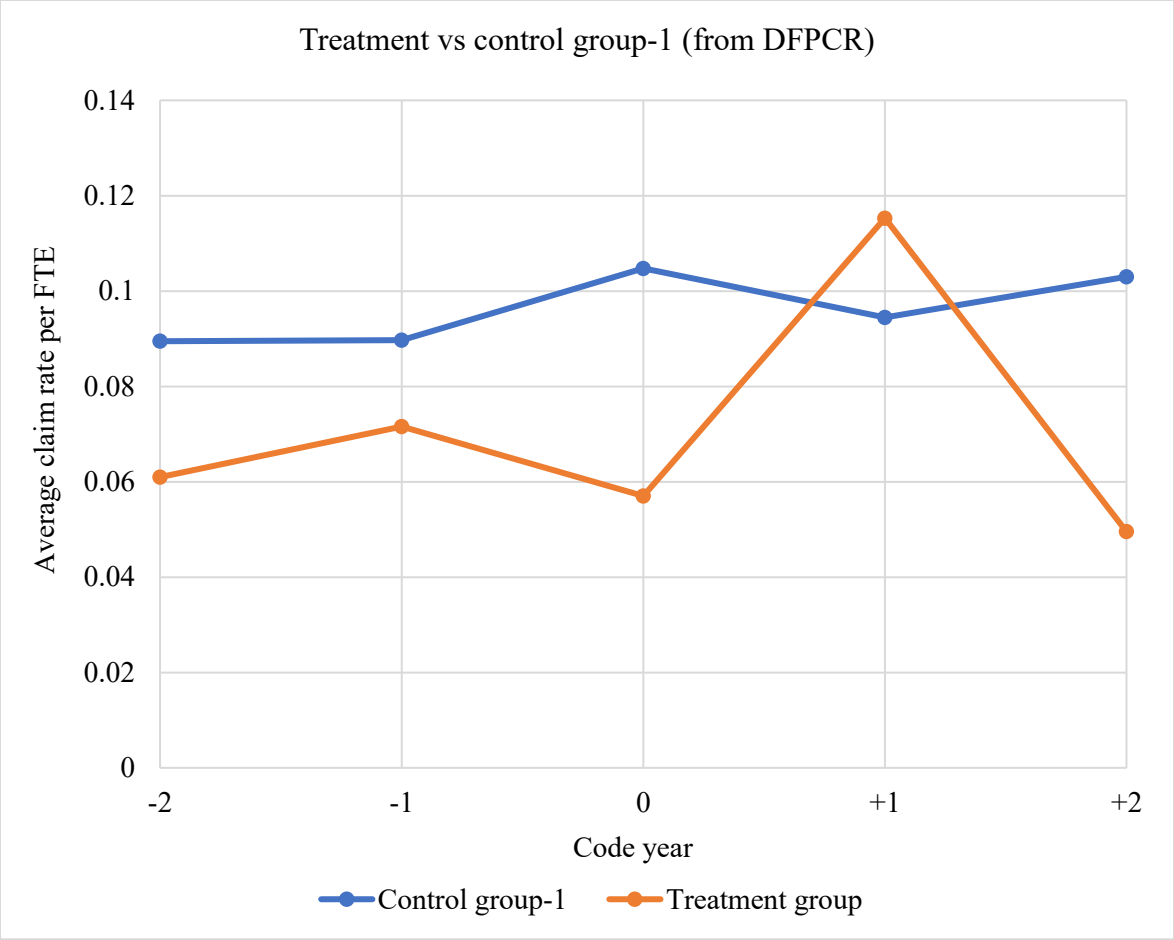

Figure 6-10: Graphical trend analysis of treatment group and control group-1 from DFPCR

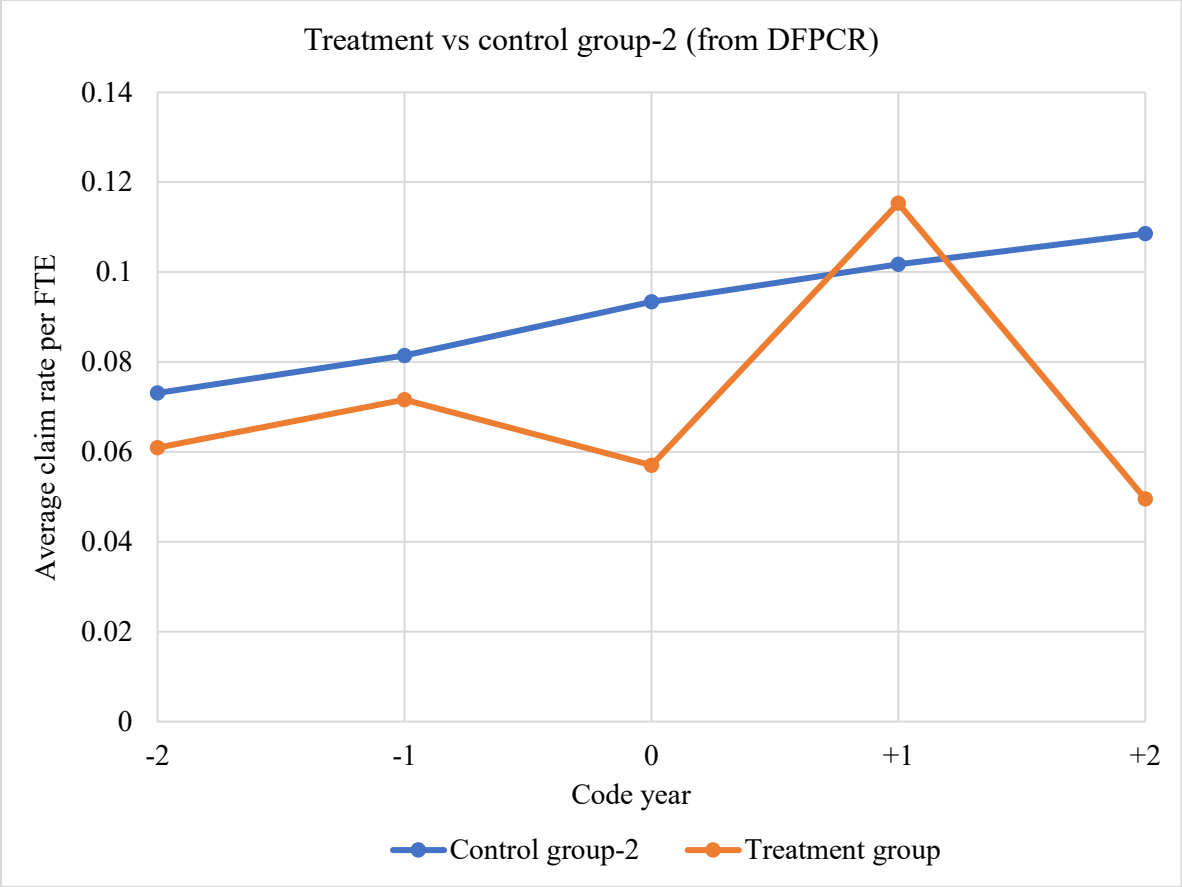

Figure 6-11: Graphical trend analysis of treatment group and control group-2 from DFPCR

Since the spike at code year = +1 for treatment group found in section 6.3.1 due to two firms' high claim rates, similar study has also been performed for this section as well. The averages and standard deviations of this group in Table 6-2 shows that the average and standard deviation at this code year are higher than other code years (average = 0.115 and standard deviation = 0.356). Frequency distribution of claim rates of treatment group sourced from DFPCR (Figure 6-12) shows that it is a highly right skewed distribution with a long tail which is also found for the treatment group sourced from DAF. This long tail consists of only one discrete bar with one observation; Cee - Cee Roofing's (CCR) in bin = (2.2 to 2.3). This same observation also creates the spike in Figure 6-3 and 6-4 at code year = +1. Since due to this observation, the actual treatment effect

might be unobserved, in the later section, graphical trends are observed and discussed by excluding this observation.

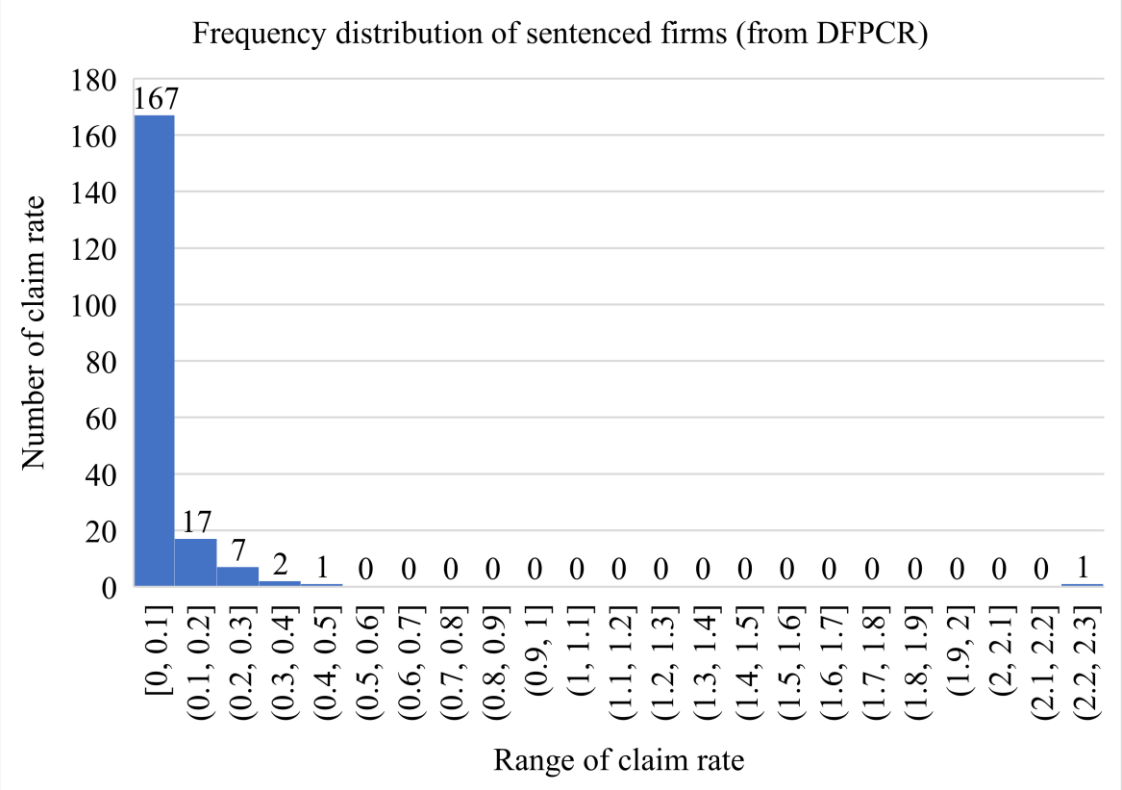

Figure 6-12: Frequency distribution of claim rates of treatment group (from DFPCR)

6.3.2.1 Excluding Cee - Cee Roofing (CCR)'s Claim Rate from Code year = +1

Figure 6-13 and Figure 6-14 show the pre and post sentencing period trends of average claim rates of treatment group and control groups excluding CCR's claim rate from code year = +1. Removing only one claim rate from code year = +1 has decreased the average of claim rate by 49% from 0.115 per FTE to 0.059 per FTE. As mentioned in section 6.3.1.1, a qualitative analysis should be performed to find out the reasons behind this firm's high claim rate just followed by the sentencing.

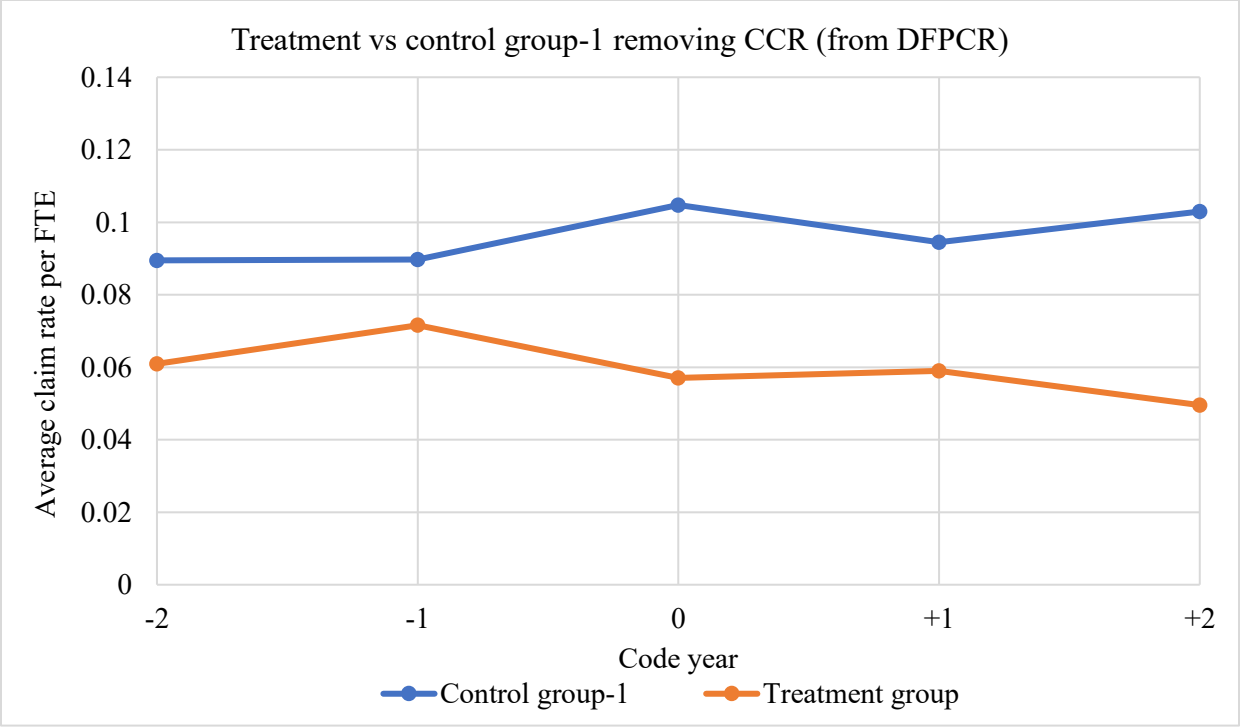

Figure 6-13: Graphical trend analysis of treatment group and control group-1 (from DFPCR) excluding CCR's claim rate from code year = +1

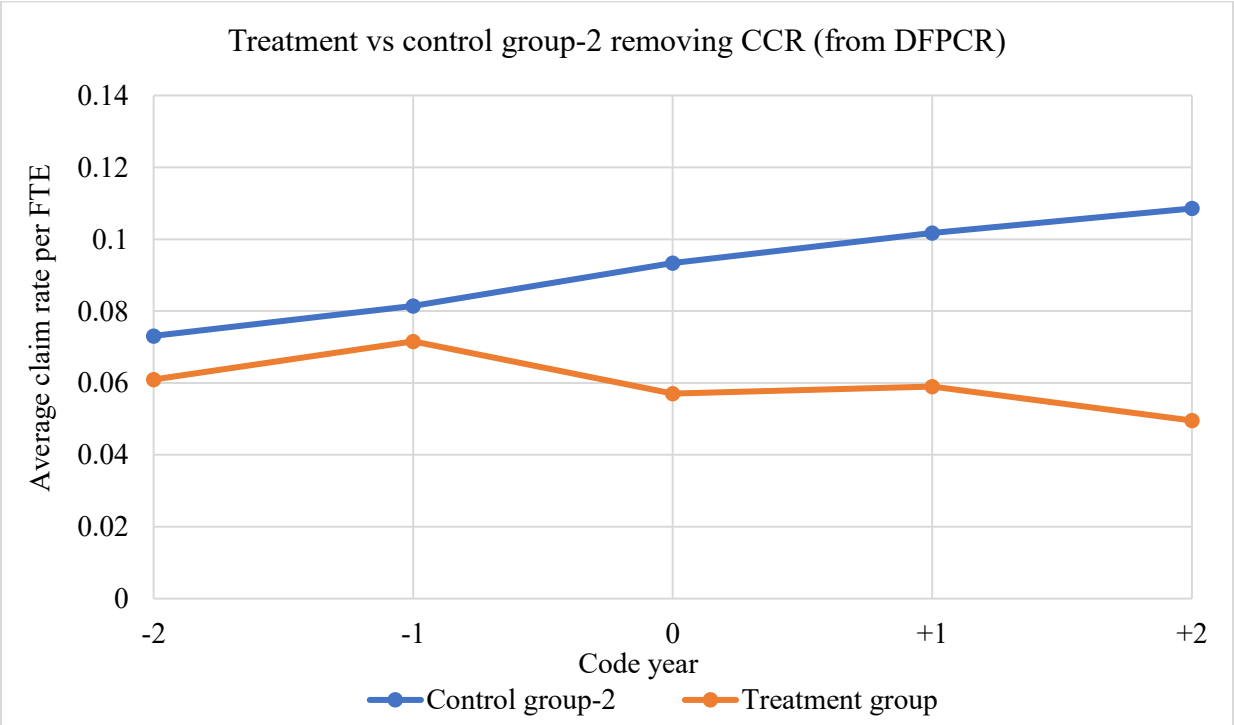

Figure 6-14: Graphical trend analysis of treatment group and control group-2 (from DFPCR) excluding CCR's claim rate from code year = +1

It is noticeable from Figure 6-13 and Figure 6-14 that trends of treatment group and control groups are totally opposite in post-sentencing period specially for control group-2. Since trends of control groups and treatment group are not similar in pre-sentencing period, it cannot be said that the different directions of trends of these groups in post-sentencing period are attributed to sentencing. However, the similar trends of control groups and treatment group from code year = -2 to code year = -1 and different trends of these groups after code year = -1 suggests that there might be an effect of incident since incidents occur some years before the sentencing. DFPCR is consisted of the firms who survived for whole study period and literature suggests that surviving firms pay more attention to the critical aspects of their external environment in crisis [2]. When an incident occurs, the survived sentenced firms might pay more attention so that the effect of incident does not affect much their external environment such as regulatory prosecution. However, this effect of incident is out of the scope of this thesis and can be studied in future.

6.4 Conclusion

After conviction and sentencing, sentenced firms try to take actions to prevent any such incidents by adopting some management practices which improve the overall organizational safety culture (HOWARD-GRENVILLE, NASH, & COGLIANESE, 2008). Graphical trend analyses using dataset DAF have shown that two firms'; Cee Cee Roofing's and Barry Gordon Buchanan Enterprise Ltd.'s post-sentencing claim rates skewed the average claim rate just after the sentenced year. However, removing those firms' claim rates from that year has showed a decreasing and different trend of average claim rate in post-sentencing period with respect to control groups' trends. Since treatment group and control groups have shown similar trends in pre-sentencing period, the different trend of treatment group i.e. sentenced firms' might be attributed to sentencing. The decreasing trend of sentenced firms' average claim rate in post-sentencing period

suggests that sentenced firms' might have adopted some management practices to improve their safety culture after sentencing which decreased their claim rates in post-sentencing period.

Graphical analyses using DFPCR could not compare the average claim rates of the pre and post-sentencing period since trends of control groups and treatment group in pre-sentencing period were not similar. These graphs have also found high average claim rate in post sentencing period due to Cee Cee Roofing's high claim rate in code year = +1. Removing that observation has shown decreasing and different trend for treatment group with respect to control groups. Since for this dataset, similar pre-sentencing trends have been found from code year = -2 to code year = -1 and after that the treatment group's trend has been deviated and decreased with respect to control groups' trends, it can be said that there might be an effect of incident. Usually incident occurs few years before of sentencing and hence, firms who survived for long time (firms in dataset, DFPCR) might try to adopt better safety practices well before the sentencing occurs (D'aveni & Macmillan, 1990). This effect of incident can also be studied in future since it is out of scope of this thesis.

Apart from effect of incident, in future, a statistical analysis can be performed in difference-in-differences approach to determine if the trends of treatment group and control groups are statistically different in post-sentencing period. Moreover, qualitative analyses should be performed to find out the factors behind the Cee Cee Roofing's and Barry Gordon Buchanan Enterprise Ltd.'s high claim rates and other sentenced firms' low average claim rates in pos-sentencing period.

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CHAPTER 7 : CONCLUSION AND RECOMMENDATIONS FOR FUTURE WORK

7.1 Research Gap and Contributions

OHS AB has been employing different education, compliance, and enforcement tools to deter future offences which as a result, should improve overall workplace safety culture in AB (Feagan, 2015). However, there is lack of researches to determine the effectiveness of these tools for specific and general deterrence. To address this gap, this thesis explores the efficacy of sentencing for the focal firms as well as firms in same industry and same geography in terms of subsequent WCB AB's claim rates. The objectives of this thesis have been defined in three research questions mentioned in Section 2.9.

In this study, the first research question has been addressed in chapter 4. Nonparametric tests have been performed to compare the before and after sentencing claim rates of sentenced firms, sentenced industries, sentenced industry-locations and across the province. Results have found statistically significant differences between before and after sentencing claim rates across the province. Comparison of before and after sentencing claim rates of sentenced industries' firms has showed that 67% sentenced industries' firms' claim rates have been changed and similar comparison for sentenced industry-locations' firms has showed that 59.6% sentenced industry-locations' firms' before sentencing claim rates are statistically different from their after sentencing samples. Moreover, the firms' industries who are assigned to Municipal Government, Education and Health Services sector by WCB AB are found irresponsive to sentencing in terms of their after sentencing claim rates with respect to other sectors' sentenced industries. In terms of locations,

firms who are located in the Edmonton and Calgary region as well as between these two regions are found relatively more responsive to change their claim rates after sentencing of any firm in the same industry-location.

The second research question is about spill-over effect of sentencing and has been addressed in Chapter 5. Results of spill-over effect using panel data analysis show that if a firm gets sentenced, the assigned industries' average claim rates significantly decrease after two years of sentencing. Since no significant changes of claim rates has been found after one year of sentencing, it can be said the firms in the same industry whose firms got sentenced might change their management systems to incorporate new safety practices and adopt those practices which might need that one-year time lag to observe the actual spill-over effect. However, for the firms with non-zero claims and those who sustained in the whole study time length did not show any spill-over effect after one or two years. Inadequate variation of data might be the reason behind this. Similar results i.e. no significant changes have been found for the firms in the same industry-locations whose firms were sentenced. This might happen due to inappropriate divisions of group of firms. Since in this study, the location variable has been defined based on central Edmonton and Calgary, dividing the groups of firms in more geographically proximal way might show the actual spill-over effect for the sentenced industry-locations.

The third research question is about focal-firm effect and has been addressed in Chapter 6 using graphical trend analysis. However, statistical analysis using Difference-in-Differences has been recommended for future work. Trends from Chapter 6 show that post-sentencing claim rates of Cee Cee Roofing's and Barry Gordon Buchanan Enterprise Ltd. skews the average claim rate of focal firms i.e. sentenced firms just after the sentenced year. Without these two firms' claim rates in that year, average claim rate of sentenced firms shows a decreasing and different trend in

post-sentencing period with respect to control groups' (non-sentenced firms in the same industries and in the same industry-locations) trends. Since all the groups of firms have shown similar trends in pre-sentencing period, sentenced firms' different trend in post-sentencing period might be attributed to sentencing. This different and decreasing trend of sentenced firms' average claim rate in post-sentencing period might happen due to the adopted management practices to improve their safety culture after sentencing which decreased their claim rates in post-sentencing period. However, further study using difference-in-differences might show if this change statistically significant and qualitative analysis such as case study might suggest if the changes in subsequent claim rates are attributed to sentencing or not.

7.2 Limitations of this Thesis

In this study, WCB AB claim rates have been used as an indicator of improved safety performances of firms presuming that all incidents/accidents in the firms are reported to WCB AB. WCB AB has many processes to ensure that incidents/accidents are reported; however, the completeness of this data remain a limitation.

Another limitation of this study is that the causes for reducing the subsequent claim rates after sentencing have been presumed. However, to determine the root cause behind this reduced claim rates, other qualitative approaches such as surveys, interviews or case studies need to be performed.

Other limitation of this study is insufficient variation of data for sentencing. Since all the convicted firms' data did not match with the WCB AB dataset, only the matched convicted firms are considered in this thesis. It is also found that only 34.72% firms were present for whole study period which represents survival bias.

7.3 Recommendations for Future Works

7.3.1 Qualitative Analyses

Since results from Chapter 4 have found that firms in different sectors and different locations have responded differently, a qualitative analysis using case-study approach by choosing firms from different sectors and locations can be studied in future to determine the underlying reasons for their different responses. Robson et al. (2016) also determined the factors responsible for improving OHS performances in a similar manner (Robson, 2016).

Since a spill-over effect of sentencing has been found for the firms who are in the same industry as sentenced firms, another qualitative analysis can also be performed by surveys to determine if this effect attributed to sentencing or not. A similar analysis can be performed for sentenced industry-locations if any spill-over effect is found using more variable panels.

7.3.2 Difference-in-differences and Case-studies for Focal-Firm Effect

Since trends of Chapter 6 have given a hint that there might be a focal firm effect, a statistical analysis should be performed using the difference-in-differences approach to find out if the decrease in the post-sentencing period is significantly different from the pre-sentencing period. Follow-up studies using case-studies or surveys might identify if focal firm effect can be attributed to sentencing. However, another qualitative analysis such as interview or case-study should be performed for BGB Enterprise ltd. as well as Cee Cee Roofing to determine the factors for their high claim rates just after their sentencing.

7.3.3 Study of Other External, Internal and Personal Factors

In this thesis, effect of only regulatory prosecution has been examined. However, in future study, effect of other factors such as economic, social, organizational and personal factors to improve workplace safety and how these factors are related to each other can also be studied.

7.3.4 Selection and Survival Bias

In this study, two types of datasets have been used since all the firms are not equally present in dataset and not equally susceptible to incidents/accidents. Dataset with all firms, DAF might have the susceptibility bias whereas DFPCR might have the survival bias. Although focal firm and spill-over effect have been examined for both of the datasets, their comparative study has not been performed in this thesis which can be addressed in further analysis.

7.3.5 Incorporation of Data from Other Jurisdictions

Results from Chapter 5 show insignificant spill-over effect for sentenced industry-locations as well as for panels sourced from dataset, DFPCR which might be due to the insufficient variation of data. Hence, in further analysis, data from other jurisdictions such as environmental prosecution data can also be considered to determine if increase of variability show any significant spill-over effect.

7.3.6 Different Ways of Grouping the Firms for Spill-over Effect

Results from Chapter 5 show insignificant spill-over effect for sentenced industry-locations which might due to inappropriate grouping of firms. In the future, similar fixed-effect estimates can also be determined for the same industry and varying geographic regions similar to Johnson et al. (2018) (Johnson, 2018).

7.3.7 Effects of Incidents

When an incident occurs, the typical duration of investigation and prosecution would take around 2 to 5 years, but this time lag has not been considered for this study. Since incidents/accidents might trigger the focal firms to improve their overall safety culture, effects of incidents should be also examined in the future study.

7.3.8 Different Outcome Variables or Type of Punishments

In this study only WCB claim rates has been considered as outcome variable. In future study, different outcome variables like parts of body injured, age of injured workers, occupation of injured workers can also be studied. As mentioned in Section 2.5.1, the convicted party may be sentenced with a fine or imprisonment or corporate probation or creative sentence or a combination of one or more of these. In this thesis, regulatory prosecution has been considered as a whole only. In future study, these different types of punishments can be studied to determine which one might be the most effective.

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APPENDIX A - REASONS BEHIND LOW INSURABLE EARNINGS OF 16 FIRMS IN WCB AB DATASET

Year	Legal name	Reasons behind low insurable earnings
2005	Wilsons' independent operations contracting ltd.	Earnings of the owner of the business for 1 day of personal coverage
2005	1317205 Alberta ltd.	No profit groups with casual labor
2006	Red light lounge ltd.	Activate the account for the purpose of charging claim
2007	M F contractors ltd	No profit groups with casual labor
2008	TUT's trucking ltd.	No profit groups with casual labor
2009	A. Roth construction (1987) ltd.	No profit groups with casual labor
2009	Valley roadways ltd.	Earnings of the owner of the business for 1 day of personal coverage
2011	Aya contracting ltd.	Earnings of the owner of the business for 1 day of personal coverage
2012	Shauna J L'Hirondelle	No profit groups with casual labor
2012	665125 Alberta ltd.	Activate the account for the purpose of charging claim
2012	1620525 Alberta ltd.	Activate the account for the purpose of charging claim
2013	Strike group Inc.	No profit groups with casual labor
2013	Front row centre players society	Under appeal account
2015	979873 Alberta ltd.	No profit groups with casual labor
2015	Lucky 13 contracting ltd.	Activate the account for the purpose of charging claim
2016	Lee Embury	Earnings of the owner of the business for 1 day of personal coverage

APPENDIX B: RESULTS OF UN-PAIRED T-TEST

Table A 1: Comparison of before and after sentencing claim rates for across the province and sentenced firms using unpaired t-test.

Alternate Hypothesis	Before sentencing claim rates are different than after sentencing claim rates	
Rejection of null hypothesis at 5% significance level	Across the province	Yes
	Sentenced firms	No

Table A 2: Comparison of before and after sentencing claim rates for sentenced industries using unpaired t-test

Alternate Hypothesis		Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Unpaired t- test**
Rejection of null hypothesis at 5% significance level for each industry	Oil & gas - upstream	No
	Oilfield maintenance & construction	No
	Vacuum removal, wet & dry waste	No
	Oil sands operations	No
	Drilling - oil/gas wells	No
	Cleaning services - mobile pressure	Yes
	Well service with service rigs	No
	Drilling, rathole/rig anchor	No
	Oilfield downhole services	No
	Well casing services	Yes
	Sawmills/planning mills	Yes
	Pulp mills	Yes
	Steel/metal fabrication	No
	Machining	No
	Concrete products mfg.	No
	Construction, industrial	No
	Construction, residential	Yes
	Residential general contractor	No
	Paving/surfacing	Yes
	Mobile equipment operation	No
	Pipeline construction	No

Alternate Hypothesis		Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Unpaired t- test**
Rejection of null hypothesis at 5% significance level for each industry	Brick/masonry contracting	No
	Boring - horizontal/angular	No
	Heating systems-fab/install	No
	Roofing	No
	Floor coverings - sell/install	Yes
	Drywall/plaster/stucco/etc.	No
	Siding/eavestrough - fab. /inst.	Yes
	Caisson operations	No
	Trucking service, general	No
	Utilities - electric and natural gas	No
	Farm implement dealers	Yes
	Mobile equipment dealers	Yes
	Scrap/salvage dealers	Yes
	Hardware/auto parts stores/etc.	No
	Drug stores	No
	Continuing care facilities	No
	Industrial/oilfield equipment rent	No
	Cities	No

Table A 3: Comparison of before and after sentencing claim rates for sentenced industry-locations using unpaired t-test

Alternate Hypothesis			Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Location**	**Unpaired t- test**
Rejection of null hypothesis at 5% significance level for each industry-location	Oil & gas - upstream	Calgary	No
	Oilfield maintenance & construction	Between Edmonton and Calgary	No
	Vacuum removal, wet & dry waste	Between Edmonton and Calgary	No
	Oil sands operations	North of Edmonton	No
	Drilling - oil/gas wells	Calgary	No
	Cleaning services - mobile pressure	Edmonton	Yes
	Well service with service rigs	Between Edmonton and Calgary	No
	Drilling, rathole/rig anchor	Between Edmonton and Calgary	Yes
	Oilfield downhole services	Calgary	No
	Well casing services	Calgary	No
	Well casing services	North of Edmonton	n/a

Alternate Hypothesis			Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Location**	**Unpaired t- test**
Rejection of null hypothesis at 5% significance level for each industry-location	Sawmills/planning mills	North of Edmonton	Yes
	Pulp mills	Between Edmonton and Calgary	Yes
	Steel/metal fabrication	Edmonton	No
	Steel/metal fabrication	Calgary	No
	Steel/metal fabrication	Between Edmonton and Calgary	No
	Machining	Edmonton	No
	Concrete products mfg.	Calgary	No
	Construction, industrial	Edmonton	No
	Construction, industrial	South of Calgary	Yes
	Construction, residential	North of Edmonton	Yes
	Residential general contractor	Edmonton	No
	Paving/surfacing	Between Edmonton and Calgary	Yes
	Mobile equipment operation	Edmonton	Yes
	Mobile equipment operation	Calgary	Yes

Alternate Hypothesis			Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Location**	**Unpaired t- test**
Rejection of null hypothesis at 5% significance level for each industry-location	Mobile equipment operation	North of Edmonton	Yes
	Mobile equipment operation	South of Calgary	Yes
	Mobile equipment operation	Between Edmonton and Calgary	No
	Pipeline construction	Between Edmonton and Calgary	Yes
	Brick/masonry contracting	Edmonton	No
	Boring - horizontal/angular	Between Edmonton and Calgary	No
	Heating systems-fab/install	South of Calgary	No
	Roofing	Edmonton	n/a
	Roofing	North of Edmonton	No
	Floor coverings - sell/install	Edmonton	Yes
	Drywall/plaster/stucco/etc.	Edmonton	Yes
	Drywall/plaster/stucco/etc.	Calgary	No
	Siding/eavestrough - fab. /inst.	Calgary	n/a

Alternate Hypothesis			Before sentencing claim rates are different than after sentencing claim rates
	Industry Name	**Location**	**Unpaired t- test**
Rejection of null hypothesis at 5% significance level for each industry-location	Siding/eavestrough - fab. /inst.	South of Calgary	Yes
	Caisson operations	Edmonton	No
	Trucking service, general	Calgary	Yes
	Trucking service, general	North of Edmonton	No
	Trucking service, general	Between Edmonton and Calgary	No
	Utilities - electric and natural gas	Edmonton	No
	Farm implement dealers	Between Edmonton and Calgary	Yes
	Mobile equipment dealers	Edmonton	Yes
	Scrap/salvage dealers	Edmonton	Yes
	Hardware/auto parts stores	Calgary	No
	Drug stores	Edmonton	No
	Continuing care facilities	Calgary	No
	Industrial/oilfield equip. rent	North of Edmonton	No
	Cities	Between Edmonton and Calgary	No

For three industry-locations' data, unpaired t test could not be performed since there was only one firm's data in their after sentencing samples. Their results have been shown as not applicable (n/a) in Table 4-4.

APPENDIX C: RESULTS OF BREUSCH-PAGAN TEST FOR HETEROSCEDASTICITY

Table A 4: Results of Breusch-Pagan test for H_O: Constant variance

	Lag 1 year		Lag 2 years	
	Chi^2	Prob > chi^2	Chi^2	Prob > chi^2
Panel 1	19.80	0.0000	28.26	0.0000
Panel 2	20.30	0.0000	28.47	0.0000
Panel 3	12.35	0.0004	35.24	0.0000
Panel 4	13.06	0.0003	34.97	0.0000
Panel 5	15.92	0.0001	15.75	0.0001
Panel 6	15.58	0.0001	15.45	0.0001
Panel 7	15.52	0.0001	18.50	0.0000
Panel 8	14.64	0.0001	17.94	0.0000