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A Process for Analyzing Change and Its Application to Commercial Truck Insurance

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Abstract

In business, it is important to be able to adapt to changes quickly and effectively. Government regulations are frequently changing and affect many different industries of American business. This paper outlines a process for evaluating and responding to change, with an in-depth example of its application to proposed hours of service regulations for truck drivers, and how new safety regulations will impact commercial auto insurers. Ultimately, we find the process to be effective in quantifying the impact of this legislation on expected future costs for the insurer. More broadly, the process outlined in the paper gives a structured approach to responding to change and can be used in a variety of situations.

Executive Summary

Whenever a change occurs, the natural question that arises is what effects or implications will this change have? In this paper, our team attempts to answer this question in regards to new changes in Federal Motor Carrier Safety Administration (FMCSA) regulations. Through seven changes to the current laws regarding hours of service for commercial truck drivers, the FMCSA intends to decrease driver fatigue and increase break flexibility for the drivers. Although these proposed law changes have good intentions, they have been received with mixed opinions about whether or not they can actually be successful in combating driver fatigue.

One party that is particularly interested in finding out the effects this change could have is Travelers, a property and casualty insurance company located in Hartford, Connecticut. Travelers provides multiple types of insurance coverage, such as liability, collision, and comprehensive, to commercial trucking companies through Northland Insurance. Should the proposed law changes be passed, they are likely to impact both the number and severity of accidents involving commercial trucks. This would in turn affect the amount of insurance claims Travelers would need to pay out on these policies, and Travelers would like to know how this would change if the laws were to change. This became the basis of our project.

In trying to determine how the law changes could impact Travelers, we realized that having a general process for analyzing change would be a useful tool to have, since there are bound to be more changes in the future. Our general process could be applied to any change, large or small, complicated or simple. We use a simple example to outline the general process, which has six key steps. First, a change occurs that may impact the interested parties. Second, a list must be made of the primary, secondary, and tertiary effects that the change may have. It is critical here to make note of both the intended and unintended effects of the change, as the intended effects are often significantly more apparent. Third, collect data that relates to the effects listed in the second step. Keep in mind that data should only be used if it comes from a reliable source. Fourth, analyze the data. This entails relating the data that has just been collected, as well as making assumptions when necessary. The depth of this analysis will depend heavily upon the availability of data on the topic and the time available to conduct the analysis. Fifth, compile the analysis. This could involve any number of operations and other manipulation of the data depending on the type of data, how it relates to the effects, and how much data has been collected. Finally, after the compilation is complete, the final results are evident. Although this seems like a relatively simple procedure, the complexity of its application depends entirely upon the nature of the change being analyzed.

After devising this general procedure, we applied it to the law changes proposed by the FMCSA. The potential effects that we identified are shown below in Figure 1.

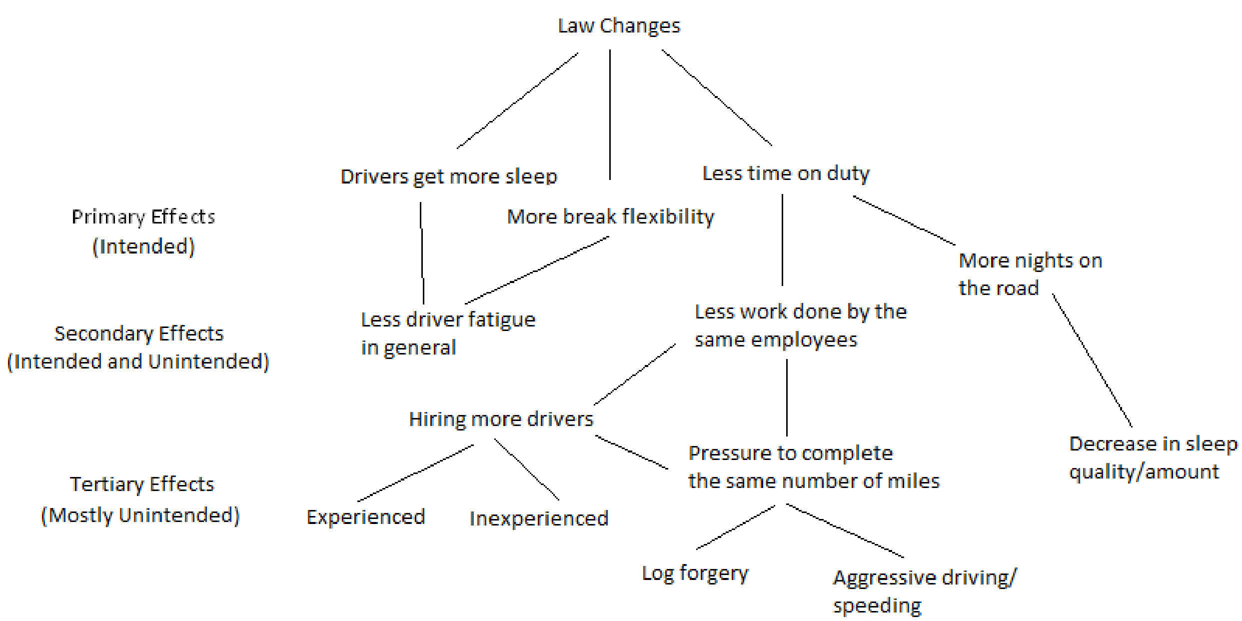

Figure 1: Effects Tree

After putting together this tree, we gathered data relating to the various effects. We looked at studies, articles, and government documentation, with a focus on finding reliable sources. Then, we were ready to analyze the data. At this point, we looked specifically at how the law change might increase or decrease accident rates based on driver compliance with the law, level of fatigue, and accident rates based on number of consecutive hours of driving.

First we looked at what percentage of drivers complies with the hours of service regulations. We assumed that drivers who were not previously compliant are unlikely to become compliant if the law changes. After determining that 77 percent of drivers comply with the law, we looked at how consecutive hours of driving affect fatigue-related accidents. We found that 9.02 percent of fatigue related accidents could be eliminated, and since fatigue related accidents are 13 percent of total accidents, there are 1.17 percent of accidents that could be eliminated based on the assumption that drivers would be less fatigued as a result of the law change. Combining this with the percentage of drivers who comply with the law, we calculated our final result: only 0.90 percent of all accidents could potentially be eliminated by the law change. This is shown graphically in Figure 2.

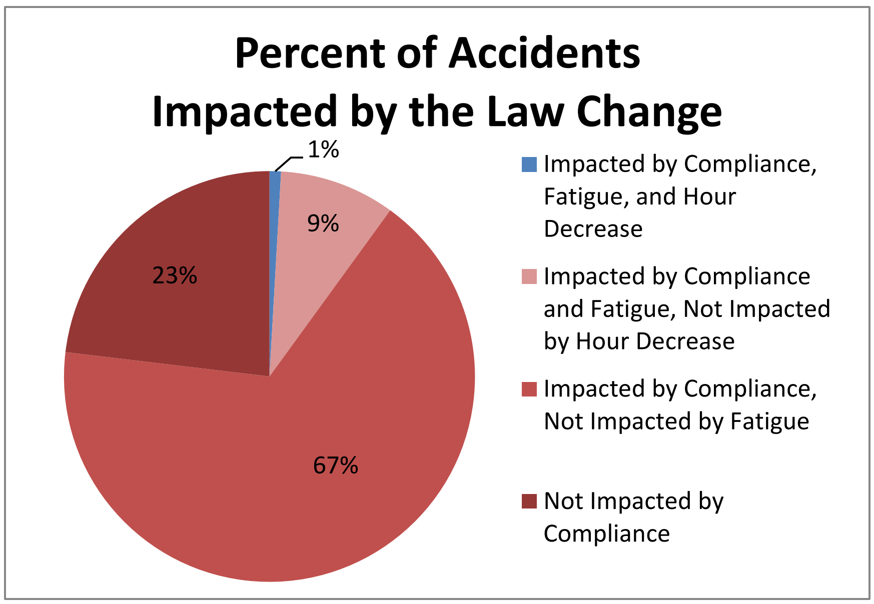

Figure 2: Percent of Accidents Impacted by Law Change

Unfortunately, we did not have a sufficient amount of adequate data to complete our analysis, but we did make recommendations for ways in which the analysis could be furthered. We also discuss the validity of our conclusion and the effectiveness of the law change in achieving the goals of the FMCSA. Lastly, in-depth explanations of the calculations done in the analysis of this paper are given in the appendix.

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Chapter 1: Introduction

Over the past century, the automotive industry has developed rapidly, but one thing has remained constant: the occurrence of crashes. The frequency and cost of these accidents has changed drastically over time, but there has yet to be a method developed to completely prevent accidents. As a result of the constant threat of costly car accidents, it has become necessary for drivers to purchase insurance that will financially cover them in the event of an accident. This is especially true in the commercial trucking industry, where accidents tend to be significantly more expensive due to the larger size, power, and carrying capacity of the trucks used.

The demand for insurance coverage in the commercial auto business has brought many insurers into the market, all of them trying to offer the most cost effective product with the best coverage. In order for an insurer to provide the best product, they must be able to accurately forecast the cost of accidents in which their policyholders will be involved. Producing accurate forecasts has always been challenging, and due to the dynamic nature of the trucking industry, major changes are occurring all the time that affect the frequency and severity of accidents. Specifically, recent law changes regarding the trucking industry have had an impact on accident rates involving trucks. It is inevitable that many other changes will continue to occur in the future.

The focus of this project is to outline a general process for a commercial auto insurer to follow when adapting to any sort of change that may impact the company's loss costs. Usage of the process will be illustrated first with a simple example, then with an in-depth application of it to the proposed hours of service changes currently being considered by the Federal Motor Carrier Safety Administration. These changes are designed to limit the number of hours commercial truck drivers can spend behind the wheel in an attempt to reduce fatigue among drivers. Since the goal of this legislation is to reduce the frequency of crashes, it is clear that insurers will be affected by it and must adapt. Thus, it is an ideal example to look at when applying our general process.

Chapter 2: Background

This chapter covers background information on several topics relevant to this project. Following a short introduction of our sponsor, Travelers Insurance, we discuss different types of coverage in commercial truck insurance. Next, we move on to an overview of the Federal Motor Carrier Safety Administration and the notable current hours of service regulations for truck drivers. Finally, we describe the proposed regulation changes in detail, as well as industry reactions to the proposed changes.

2.1 Travelers & Northland

The Travelers Companies, Inc. is an American insurance company that is the result of a merge between The St. Paul and Travelers insurance companies in 2004. The Travelers Companies have been providing property and casualty insurance for over 150 years. Travelers is now one of the nation’s largest property and casualty insurers, employing over 32,000 people and offering 22 product lines. One of these lines, transportation insurance, is handled by Northland Insurance. One of the top providers of transportation insurance in the United States, Northland offers property and casualty insurance for owners and operators of commercial trucks, limousines, shuttles, and small businesses (The Travelers Indemnity Company, 2011).

2.2 Commercial Truck Insurance

Understanding the products offered by commercial auto insurers is necessary for analyzing any proposed changes in the commercial trucking industry. Each product is designed to protect the buyer of the product in the case of some sort of accident occurring. The idea behind these products is that the buyer pays for coverage in small, predictable payments, and then if something happens that requires a large, unpredictable payment, the insurance company covers a portion of the cost. Insurance prevents individuals or businesses from being caught off guard by a major, often unexpected, expense that they cannot afford.

On the insurer's side, they use their resources to build the best models they can to predict these seemingly unpredictable occurrences, such as when someone will get into a car accident. Although it is difficult to predict when one particular person will get into an accident, one can determine the average cost of the insurance policy based on historical data. Assuming that the cost of one insurance policy will equal the historical average is not necessarily accurate, but with enough policies the total costs should resemble the historical data. This process allows insurers to determine the cost of paying claims to the policyholders.

In commercial auto insurance, there are several different types of coverage that insurers commonly offer to trucking companies to protect the company from different events. Most of the types of coverage are designed to protect the companies in case of automobile collisions, but there are also others that protect them from non-crash related hazards. These different types of coverage are priced individually by the insurer using the process mentioned above, but they are frequently bundled together and sold in a package.

Liability coverage is a significant type of insurance in the commercial auto industry and in the analysis done later in this project. It covers all bodily injury and property damage claims suffered by others and only pays out when the policyholder is the driver at fault in the accident. That means if a truck driver is hit by another car and the accident is deemed to be caused by the driver of the other car, then the car driver's liability insurance would cover the costs and the truck driver's liability insurance would not pay anything.

Collision coverage is similar to liability but it covers physical damage to the policyholder's truck in the event that repairs are necessary after an accident in which the truck has collided with another vehicle. Again, collision coverage only pays out claims when the truck driver is the one who is at fault in an accident. Medical payment insurance will pay the medical bills for injuries suffered by the driver or passenger of a truck as a result of an accident. Another similar product is cargo insurance, which pays for damage done to any cargo in the truck at the time of the accident. These four types of coverage make up insurance against crashes and are the primary focus of this paper.

Collision coverage is generally grouped with another product, comprehensive coverage, and sold as physical damage insurance. The comprehensive portion of physical damage insurance will pay for any damage done to a truck in any case other than a collision involving another vehicle. The most common situations where comprehensive coverage is used are theft, fire damage, or accidents caused by hitting anything that is not another vehicle, such as an animal or guard rail. This type of coverage is also relevant to our project, as a fatigued truck driver could collide withed together a guardrail just as easily as with another vehicle.

Workers' compensation is also a frequently issued type of insurance. Any type of injury or medical payment required as a result of a worker's job will be covered by workers' compensation. An interesting feature of workers' compensation is that the insurance company is required to pay it out regardless of whether or not the worker is still employed. This makes it an extremely expensive coverage because risks that are currently unknown could require significant payments in the future. For example, when the dangers of working with Asbestos were realized, many workers' compensation policies paid for the medical bills of those who had worked in an environment where they had been exposed to Asbestos (Vaughan & Vaughan, 2003).

It is important for an insurer to properly understand and adjust each of these types of coverage as different situations come about. Due to the varying nature of the different types of coverage, there can by many different changes that could affect any or all of them. However, our general process outlines how to approach a change that affects any or every type of coverage so that the insurer can offer the best, most accurate rates to their policyholders at all times.

2.3 FMCSA Legislation

2.3.1 Federal Motor Carrier Safety Administration

The Federal Motor Carrier Safety Administration (FMCSA) is part of the United States Department of Transportation responsible for the creation and enforcement of safety regulations for commercial motor vehicles. Created January 1, 2000 as part of the Motor Carrier Safety Improvement Act of 1999, the FMCSA works with federal, state, and local law enforcement agencies, the motor carrier industry, and labor safety interest groups to accomplish its primary mission: “to prevent commercial motor vehicle-related fatalities and injuries” (Federal Motor Carrier Safety Administration, 2011).

2.3.2 Truck Driving Terms

Before detailing the current and proposed legislation, a few terms must be defined. “Driving time” is the amount of time that the truck driver spends actually driving. The “driving window” is the number of hours that the driver has in which to complete the driving time within an on-duty shift. “Duty time” is split into time spent driving and time spent on duty but not driving (time the driver spends loading or unloading the commercial motor vehicle (CMV), waiting to load or unload, doing administrative tasks, or any other activity in which the driver is in the cab, but not driving). Time spent in the “sleeper berth,” part of the cab of most trucks in which the driver can sleep, does not count as time on duty. “Off-duty” time includes time off the clock, time resting in the sleeper berth, and breaks spent outside of the CMV. For example, a driver operating under the current laws has a driving window and duty period of 14 hours as well as 11 hours of driving time. This means that of the 14 hours they spend on the job, they can spend up to 11 hours driving and three hours doing any other non-driving work. If the duty period were reduced to 13 hours within the 14-hour driving window, the driver could still drive up to 11 hours, but could only spend two hours doing non-driving work and must spend one hour on break.

Figure 3: Inside of a Sleeper Berth (Heads Carolina/Tails California, 2010)

2.3.3 Current Laws

Currently, the law states that drivers must take at least 10 hours off duty in between consecutive on-duty periods. The sleeper berth, such as the one shown in Figure 3, can be used as a substitute for the off-duty period as long as the sleeper berth time is split up into two periods, one period of at least eight hours and the other of at least two; the shorter rest period can be completed outside of the sleeper berth. Once the driver has taken 10 hours off or completed the 10 hours of sleeper berth time, their 14-hour driving window and on-duty time starts over. In addition to these regulations, there are weekly limits to how much a driver can work. If the motor carrier operates six days per week, the driver may drive up to 60 hours in seven days. If the carrier operates seven days per week, the driver may drive 70 hours in eight days. Drivers can also make use of the 34-hour restart provision – once a driver spends 34 consecutive hours off duty, their weekly driving time calculation starts over at zero.

2.3.4 Proposed Changes

The FMCSA lists three major goals that they hope to achieve with the new legislation. First, the new rules should reduce driver fatigue and therefore make the job and the roads safer. Shorter working hours have been linked to more sleep, which increases performance in areas like reaction time, concentration, and decision making. In addition, circadian rhythm research shows that nighttime sleep is more recuperative than daytime sleep, so regulations normalizing the driver sleep schedule could be beneficial. Second, these regulations should have a favorable effect on overall driver health. Professional drivers have been shown to have a higher frequency of high blood pressure, diabetes, cardiovascular disease, and obesity than the general population. Fewer hours working would allow drivers to not only get more sleep, but to spend more time relaxing and participating in the activities they choose. Third, the new regulations look to provide drivers with more flexibility for the scheduling of their breaks and rest. This flexibility would encourage drivers to rest when they are tired and help them adjust for unforeseen delays.

There are seven proposed changes to the current law, outlined as follows. First, the new law would change the allowable driving time from 11 hours to 10 hours following 10 or more consecutive hours off duty. The FMCSA is still considering keeping driving time at 11 hours but is favoring reducing it to only 10 in an attempt to reduce driver fatigue.

Second, the proposed changes would keep the standard driving window at 14 hours on a typical day, but the driving window could be extended to 16 hours twice per week. This extension is intended to help drivers manage unanticipated weather or traffic conditions that could cause their planned route to take longer than expected.

Third, the change would reduce the on-duty time within the driving window from 14 hours to 13 hours. During a 14- or 16-hour day, the driver must spend at least 1 or 3 hours on break, respectively. Additionally, drivers and carriers may be made liable for the maximum penalty for driving 3 hours or more over the limit. Mandating breaks attempts to improve driver performance, while the penalties are intended to reduce “egregious” time limit violations.

Fourth, drivers may only drive if it has been less than 7 hours since their last off-duty or sleeper berth period of at least 30 minutes. This means drivers cannot drive for more than 7 hours consecutively without taking a break of at least 30 minutes.

Fifth, there would be three changes to the 34-hour restart provision, which will be maintained in concept. First, the restart must include two periods between 12 a.m. and 6 a.m. For daytime drivers, the restart effectively includes two consecutive nighttime sleep periods. Drivers who drive at night would have to take a longer break in order to accommodate this change. Second, restarts can only be used if it has been 168 hours (1 week) or more since the beginning of their last restart. Finally, the driver must designate the period as a restart period. These changes will reduce the number of hours a driver can work during a seven day period from about 82 hours to 70 hours. This change intends to ensure that the restart includes a sufficient amount of recuperative sleep.

Sixth, the definition of “on duty” will be revised. Currently, any time spent in the CMV (not in the sleeper berth) counts as on duty, even if the vehicle is parked. The revision will allow some of the time spent in the CMV to be counted as off duty. This change attempts to benefit drivers who drive “day cabs” (trucks without a sleeper berth), drivers who do not want to spend all of their breaks in the sleeper berth, and those who have trouble finding a safe place to stop and take a break outside of sitting in the truck. In addition, this provision would allow team drivers to count up to two hours in the passenger seat after eight hours in the sleeper berth as off duty (Department of Transportation, 2010).

The last change is not relevant to this project, and thus has been omitted from this list. All of the pertinent changes are presented in Table 1 below.

Table 1: Current Laws and Proposed Changes

Affected	Current	Proposed
Driving window	14	14 + 16 2x/week
Duty time	14	13
Driving time	11	10
Restart	34 hours with no restrictions	- 2 periods 12 - 6 am - 168 hours apart - Must designate
On duty definition	All time in CMV or doing paid work	Some time off duty
Consecutive driving max	None	7

2.3.5 Reactions to Proposed Changes

In general, the reactions of both truck drivers and the trucking industry to the proposed changes have been very negative, but for different reasons. The trucking companies dislike the proposed law changes because they believe the changes will lead to an increase in costs, placing a significant burden on them that will be difficult to overcome during an already poor business cycle. Truck drivers, on the other hand, are worried about losing wages when they cannot work for as many hours under the new laws as they could previously. Despite the differing reasons, both parties have put forward compelling arguments against the proposed regulations.

The trucking companies have taken a simple mathematical approach to explaining their opposition to the law. They say that since their drivers will not be able to work as long, they will need to hire more drivers and buy more trucks for the new drivers to use. Further, companies argue that they have designed delivery routes based on drivers being able to work eleven-hour shifts, so the reduced hours would force them to reroute all of their deliveries. Another argument the companies have put forward is that the confusion caused by new regulations would cause more harm than the decreased driving hours would balance out with benefits. Lastly, trucking companies feel that the eleventh driving hour is rarely used, so eliminating it does not prevent many accidents but does limit drivers' ability to complete their routes in the event of traffic congestion (Natter, 2008).

Truck drivers feel as though they are the biggest victims of this legislation because it directly impacts their livelihood. One study found that 61 percent of drivers are paid based on the number of miles they drive, so limiting their hours will limit their pay by restricting the amount of time they have to drive (Braver, Preusser, Preusser, Baum, Beilock, & Ulmer, 1992). Drivers are also concerned that if companies have to pay additional costs for new trucks and drivers then overall wages will be further depressed.

Most truck drivers and trucking companies are united in opposition to the proposed changes, but a few have spoken out in favor of it. Richard Reiser of Werner, a large trucking company, wrote that “Our company's experience with these HOS regulations has shown that the rules promote driver safety, alertness and performance better than the old rules” (Natter, 2008) Similarly, some drivers have sympathized with the argument that driving in the eleventh hour is dangerous due to the increasing presence of fatigue. While there are some instances of truckers and companies siding with the new regulations, it is important to note that the industry is generally opposed to them.

Listening to the opinions of trucking companies and their drivers is important to understand the effect the proposed law changes will have. However, the power to make these changes lies solely with the legislators. Therefore, understanding the reactions is primarily useful solely for getting a different perspective on the law change than the one provided in the government’s analysis. We do draw from these reactions later when we attempt to forecast the total impact the law change will have, so it is important to have a strong understanding of the industry’s sentiments.

Chapter 3: Methodology

This chapter first details our general process for analyzing change, then describes the specific application of this process to commercial truck insurance. The general process has six steps to analyze the effects of a change and is first explained by a straightforward example. The following section explains how the team applied this process to the proposed hours of service regulation changes for commercial truck drivers.

3. 1 General Process for Analyzing Change

In this section, we will outline our general process for analyzing the effects of a change with respect to one key aspect of a business or situation, hereafter known as the "bottom line." Though this process is applied in section 3.2 of this paper, we will here make use of a simple example to introduce the process. In this example, we will look at Jon's Ice Cream Shop. Jon's shop sells five flavors of ice cream and charges extra for toppings and drinks. The shop supplies necessary utensils and supplies to its customers. Based on this setup we will discuss the general process for dealing with a change.

Step one: There is a change. Jon is considering introducing a new flavor of ice cream to the shop, which would be a change for his business. He wants to know how it will impact the shop's overall profits. The profits are the "bottom line" as mentioned above.

Step two: List the primary effects of the change. This includes the intended effects and side effects that come directly from the change. Both positive and negative effects should be considered. In the ice cream shop, introducing butterscotch will result in the sale of butterscotch ice cream, increasing it from none to some. On the other hand, if Jon decides to sell butterscotch ice cream he will have to eliminate one of his other flavors since he only has room to sell five flavors.

Next the secondary effects must be considered. In general, secondary effects are the result of a primary effect. Again, positive and negative effects should be considered. This step will involve more unintended effects than the primary effects. At the ice cream shop, the new flavor may convince people to add an extra scoop to their order to try it. It may also attract new customers or bring in current customers more frequently, both of which would increase sales of ice cream, toppings, and drinks. The elimination of an original flavor, however, may lose some customers and have the opposite effect.

This brainstorming can be extended another level to include tertiary effects, which will mostly consist of unintended consequences. This way most of the foreseeable consequences of the change are accounted for. The number and importance of tertiary effects changes with the complexity of the problem and change, and there could also be effects past the tertiary level for very complicated changes. In Jon's simple case, selling more ice cream will increase the money spent on supplies. It is possible that the addition of butterscotch ice cream will change his marginal costs; for example, butterscotch ice cream may melt more quickly and therefore require more napkins. This effect is certainly not intended, and the change in expenses will depend on the possible change in ice cream sales and popularity of the new flavor.

Step three: Collect data. After extensive brainstorming, the next step is data collection. This is the research phase of the process. Collect data relating each of the effects to the "bottom line" and to each other. Data relating the effects to each other will help determine how the analysis is combined later on, as well as help make necessary assumptions. It is critical that the data is objective and comes from reputable sources. It is also a good idea to look at past changes similar to the current one for useful information. For the ice cream shop, past sales data can tell Jon how many supplies are used per sale, as well as how many toppings and drinks are sold per scoop of ice cream. He also needs to know the profit margin for drinks, toppings, and various ice cream flavors. If he has made any flavor changes in the past, he can use this to help him estimate by how much replacing an old flavor with butterscotch will affect overall sales.

Step four: Analyze the data. After collecting data relating the effects to each other and to the bottom line, consider the data with those relationships in mind. The depth of the analysis will depend on the time and resources available as well as the number of effects and amount of data that has been collected. More assumptions may be necessary to complete the analysis. In this step the data becomes useable in preparation for combining the available information and determining the final answer.

For Jon's ice cream shop, the analysis would include several things. Depending on the data he has, Jon would have to make a few assumptions and estimates to start. He would make an educated guess of how much butterscotch ice cream he will sell and how much the sale of butterscotch ice cream would change the sale of the four remaining ice cream flavors. This new flavor distribution could be combined with each flavor's profit margin to find the new expected revenue per scoop, which is a primary effect in that it indicates butterscotch's impact on revenue as a function of flavor alone. For secondary effects, he would use the same data to determine the amount of business the addition of butterscotch and elimination of another flavor will bring in or lose and whether it is additional scoops, new customers, or repeat customers. This information can be combined with current information regarding toppings and drinks per ice cream sale to find a change in sales of all ice cream, toppings, and drinks. These secondary effects lead to tertiary effect of increased expenses for utensils and supplies which can be calculated from current expense reports.

Step five: Compile the analysis. After collecting and analyzing data, compile the information as it relates to the bottom line. This may require any number of calculations to add, subtract, multiply, divide, or otherwise combine the numbers produced by step four. The outcome of this step is the final result.

At the ice cream shop, Jon is now ready to compute his overall profit change. Since profit is revenue minus losses, Jon will use a relatively simple formula to compute the effect of butterscotch ice cream on his profits. The numbers produced by the analysis were: expected revenue per scoop (converted to a percentage of original revenue per scoop), change in ice cream sales, topping sales, and drink sales, and change in supply expenses (all changes expressed as percentages). For ease of computation, he could first take the percent change in ice cream sales, topping sales, drink sales, and supply expenses and multiply them by current sales and expenses to get the dollar change in sales and expenses. He would then multiply the new expected revenue per scoop (percentage) times the expected ice cream sales, add the expected change in topping sales and drink sales, and subtract the expected change in expenses. This will result in the expected profit change.

Step six: Obtain final results. Upon completing step five, there will be an answer for the bottom line. It is good to think about the result and make sure that it is reasonable. In addition, a sensitivity analysis may be useful to see what would change if a few numbers in the analysis changed. This is especially important if conflicting sources were used or several assumptions had to be made to complete the analysis.

In Jon's case, he may want to conduct a sensitivity analysis on different flavor distributions or with a few different reasonable numbers for the changes in sales. This depends on the specific information he had before conducting his analysis. More detailed and reliable numbers do not require as much of a sensitivity analysis as assumption-based analysis.

This general process provides a guideline for dealing with change. First, consider the change and the problem's bottom line. Second, brainstorm primary, secondary, and tertiary effects, including intended and unintended outcomes. Third, collect data relating the effects to each other and to the bottom line. Fourth, analyze the data as needed to prepare it for compilation and make necessary assumptions. Fifth, compile the analysis to arrive at an answer. Sixth, consider the result and conduct sensitivity analyses if needed. As this is a very general process, it can be applied to changes of varying difficulty, detail, and magnitude.

3. 2 Process Application for Commercial Truck Insurance

Now that the general process has been explained and its use has been demonstrated by a simple example, we will describe how the team applied the process to a more complicated change: the potential impacts of the law changes outlined in section 2.3.4 of this paper.

3.2.1 Effects

We first examined the primary, secondary, and tertiary effects of the proposed law change. It was important to take into consideration that just because these law changes have been proposed, that does not necessarily mean that they will have a positive impact. Therefore, we looked both at outcomes that could be positive and outcomes that could be negative. Based on our intuition, we came up with the following ideas for impacts that the law change could have, and then organized them into a tree diagram, shown in Figure 4, to make the chain reactions more clear:

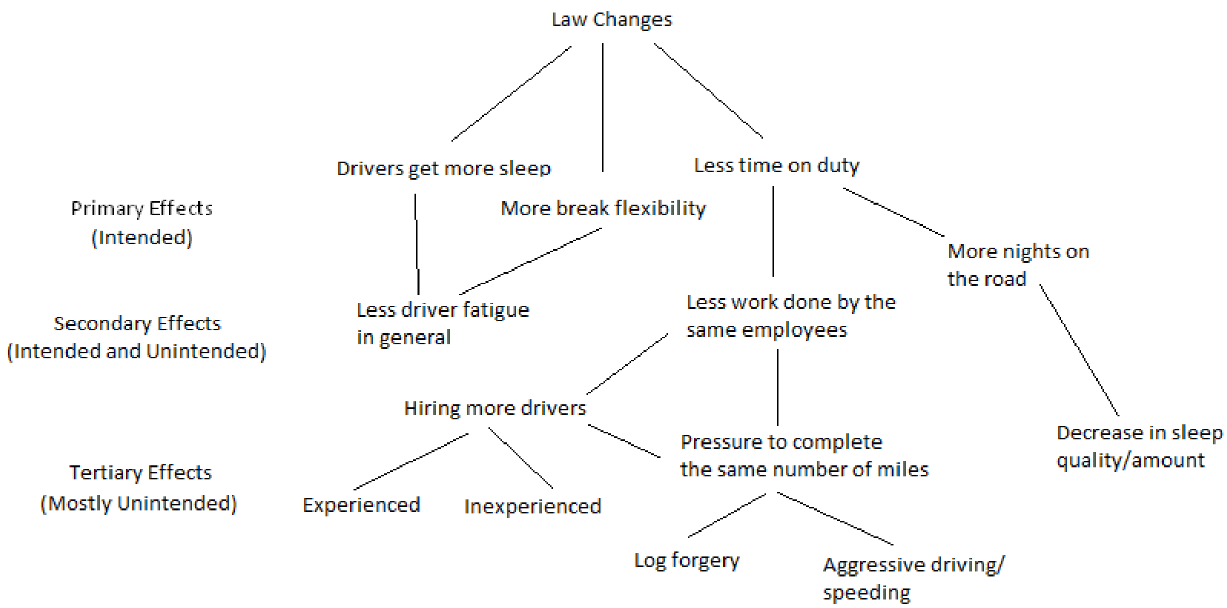

Figure 4: Potential Impacts of the Law Changes

The primary effects of the law change are generally intended effects. As noted in the motivation for the law change, the intended effects are that drivers will get more sleep, have more break flexibility, and spend less time on duty. These are all, of course, positive impacts because law changes rarely intend to cause negative impacts.

The potential negative effects start to become apparent in the secondary level of effects. While more sleep and better break flexibility will likely lead to reduced driver fatigue in general, less time on duty could mean that less work will be done by the same employees, or that the drivers may need to spend more nights on the road.

The tertiary and further levels of effects show even more potential for unintended negatives. More nights on the road could lead to a decrease in the quality or amount of sleep, as drivers sleeping in a sleeper berth generally do not get as good sleep as they would at home in their bed (Carroll, 1999) This is the opposite of the intended effect of drivers being less fatigued. Employees' inability to complete the same amount of work under the new laws could put pressure on both the current drivers and the trucking companies to complete the same number of miles that were being accomplished under the previous set of laws. The current drivers might be more likely to drive more aggressively (making the roads less safe, the opposite of the intention of the law change) or to drive over the allowable time, thus breaking the law, and simply forging their log books, such as the one shown in Figure 5, and lying about the amount of time they are driving. Trucking companies will likely need to hire more drivers to get the same amount of work done once each driver is driving less. They might need to hire new, inexperienced drivers who might not be safe truck drivers yet, or they might be able to hire experienced drivers who are currently unemployed because of the state of the economy.

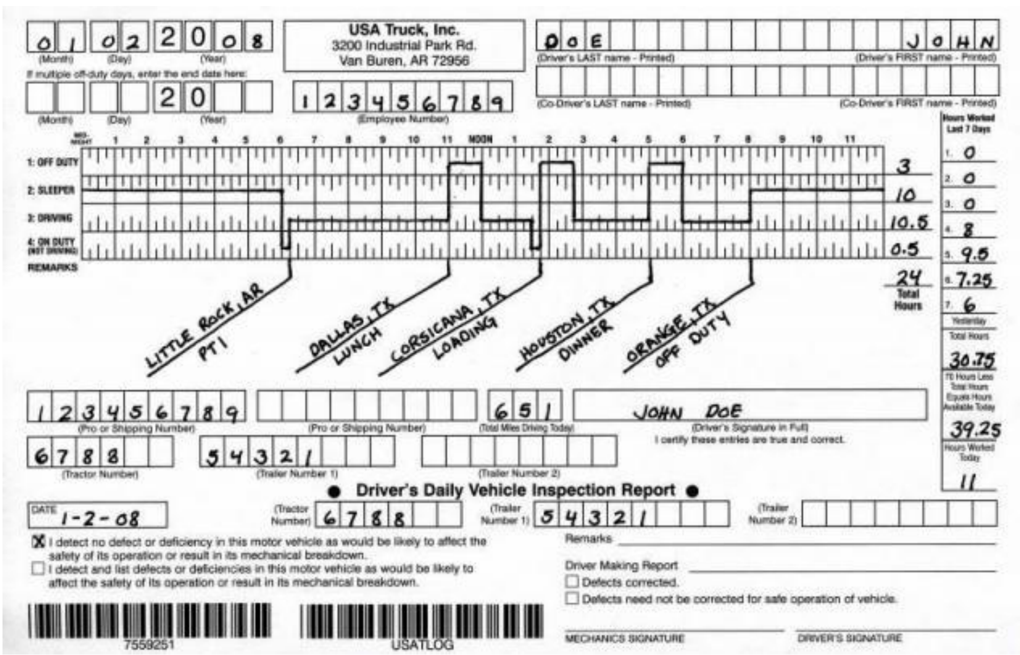
01 02 2008
(Month) (Day) (Year)
If multiple off-duty days, enter the end date here:
20
(Month) (Day) (Year)
USA Truck, Inc.
3200 Industrial Park Rd.
Van Buren, AR 72956
123456789
(Employee Number)
DOE JOHN
(Driver's LAST name - Printed) (Driver's FIRST name - Printed)
(Co-Driver's LAST name - Printed) (Co-Driver's FIRST name - Printed)
MID-NIGHT 1 2 3 4 5 6 7 8 9 10 11 NOON 1 2 3 4 5 6 7 8 9 10 11
1: OFF DUTY 3
2: SLEEPER 10
3: DRIVING 10.5
4: ON DUTY (NOT DRIVING) 0.5
REMARKS
24 Total Hours
LITTLE ROCK, AR PTI
DALLAS, TX LUNCH
CORSICANA, TX LOADING
HOUSTON, TX DINNER
ORANGE, TX OFF DUTY
Hours Worked Last 7 Days
1. 0
2. 0
3. 0
4. 8
5. 9.5
6. 7.25
7. 6
Yesterday
Total Hours
30.75
70 Hours Less Total Hours Equals Hours Available Today
39.25
Hours Worked Today
11
123456789
(Pro or Shipping Number)
(Pro or Shipping Number)
651
(Total Miles Driving Today)
JOHN DOE
(Driver's Signature in Full)
I certify these entries are true and correct.
6788
(Tractor Number)
54321
(Trailer Number 1)
(Trailer Number 2)
● Driver's Daily Vehicle Inspection Report ●
DATE 1-2-08
(Tractor Number) 6788
(Trailer Number 1) 54321
(Trailer Number 2)
☒ I detect no defect or deficiency in this motor vehicle as would be likely to affect the safety of its operation or result in its mechanical breakdown.
☐ I detect and list defects or deficiencies in this motor vehicle as would be likely to affect the safety of its operation or result in its mechanical breakdown.
Remarks
Driver Making Report
☐ Defects corrected.
☐ Defects need not be corrected for safe operation of vehicle.
7559251
USATLOG
MECHANICS SIGNATURE
DRIVER'S SIGNATURE

Figure 5: A Truck Driver's Daily Log (Micklin, 2009)

3.2.1.1 Assumptions

There were initially a few more ideas of potential effects that were not included in the tree because they were decided to be either negligible or having little to no impact on Travelers.

The ideas which were not included, and assumptions about why they were not used, are outlined as follows.

There might be more traffic or congestion from more trucks doing the same amount of work. Although this was an initial thought, we decided that trucking companies were probably more likely to hire more drivers, rather than increasing the number of trucks in their fleet, in order to achieve the same amount of work as before. Thus this idea was not looked at.

With trucks being forced to stop more frequently on the road for breaks, the risk of robbery would increase. This includes both robbery of the cargo inside the trucks and stealing the entire truck itself. However, it is unlikely that many trucks are being stolen since most of them are standard transmission with 12-18 gears, making them difficult for the average person to steal. We also assumed that cargo being stolen from trucks when they are stopped does not currently happen very often, so it was not likely that the potential increase would be a large factor in our analysis. However, the amount of time that would have been necessary to complete sufficient research on this topic was beyond the scope of this project, so it may be an inaccurate assumption.

Greater demand for drivers may increase driver wages and thus improve the quality of driving (Saltzman & Belzer, 2002). While this may be true and interesting to examine from an economic standpoint, this would not have much (if any) direct impact on Travelers. The team also determined that since many drivers are paid per mile (Braver, 1992, p. 351), the incentive to drive more miles (and perhaps drive a bit more recklessly) may negate the potential increase in driving quality caused by a potential increase in wages.

Trucking companies may need to buy more trucks, in which case they could purchase safer trucks. If the trucking companies are currently financially capable of purchasing newer, safer trucks, than this should have already been done. If they are not financially capable of such purchases, then they will certainly not be able to purchase them when they need to get more work done (and probably hire more drivers).

The new restart policy might cause nighttime drivers to switch to a daytime shift, since the restart must now include two nighttime periods of 12 a.m. to 6 a.m. While this might be true, this would require significantly more research about what it would take to make a nighttime driver switch to a daytime shift, and there would be no accurate way to predict what percentage of drivers would make this shift simply as a result of the new restart policy. This would also probably not have a significant impact on the end result, so the amount of research this would require would not justify the small gain of having this information. Therefore this topic was not looked at in depth.

Since forgery may become more of a problem, would it be worth installing electronic mile recorders in the trucks? This would definitely help combat log forgery, but might not necessarily change the driving habits of the drivers. Since this is merely a suggestion for fixing a current problem and could not realistically be implemented before the law change, it would not play a role in our analysis.

More sleep could potentially lead to better long-term health for the drivers. While this is true, we suspect that Travelers does not pay out a significant number of claims for long-term health issues of truck drivers. Although there are long-term health issues associated with truck driving, there is almost always a different underlying cause that is not profession-dependent. For instance, truck drivers tend to have a higher risk of heart disease, but there is also a high percentage of truck drivers who smoke. One could easily argue that the smoking, not the driving, caused the heart disease.

Trucking routes may need to be adjusted for shorter shifts. This would definitely be a concern and a major expense for the trucking industry. However, this would really not have a direct impact on Travelers because all of the same roads would still be traveled to deliver the same products; it would just be a different route.

While these were all logical and interesting ideas, we decided to focus on as many of the primary, secondary and tertiary effects shown in Figure 4 as available time and resources allowed for. Including all of the topics listed here would have made our project too broad, which is why some of them had to be omitted. However, we felt that it was important to mention the topics that were overlooked. From this point onward, only effects shown in the tree are considered.

3.2.2 Data Collection and Analysis

After the team discussed all of our ideas and decided which to include and which to omit, the next step was to find unbiased and objective data to either support or disprove our suppositions. For example, it would be better to look at a general study on the number of hours of sleep truck drivers get per night, rather than a study that used hours of sleep to either promote or demote the law change. Studies that already have an “opinion” or “intention” may have skewed the data to achieve their goals, and this is not the kind of data we wanted to use if it could be avoided. If we did use a study that was in favor of the law change, we made every attempt to find a comparable study that was against the law change. Aside from studies, data was also gathered from news articles and government documentation.

In the process of gathering data, it quickly became apparent that there was a plethora of information on some topics, such as the effects of sleep deprivation, while there was minimal information available on other topics, such as quality of sleep in a sleeper berth. For the topics on which we found abundant information, we had to determine which studies were most reliable and most relevant. For example, a study with 16 subjects would not be as reliable as a study with 100 subjects. There was also the problem of having a study with a lot of information, but some of it was too specific. For instance, one study showed the impact of seven consecutive nights of having only five hours of sleep. While this showed the general impact of getting less sleep than needed, it was not directly helpful as there was no evidence that most truck drivers are getting five hours of sleep for seven consecutive nights on a regular basis.

In the case where information either was not available or was inadequate, assumptions had to be made. If information was not available, we had to either assume it did not have an impact, which might not be true, or manipulate inadequate data to make it more useful. For instance, we supposed that if drivers were spending more nights on the road sleeping in a sleeper berth, the quality of sleep in the sleeper berth would be less than if the driver slept at home. However, there was very little data on this subject, possibly because quality of sleep is difficult to quantify. In any case, this was an instance where, had we needed to use this information in our analysis, assumptions would need to be made.

Keeping in mind the primary, secondary, and tertiary effects as well as what kinds of data would be useful for the analysis, we found studies and collected data on a few main topics. Circadian rhythm (the "biological clock") could provide insight into how time of day affects alertness and driving habits. The negative implications of limited amounts of sleep, such as slower reaction time, less alertness, and feeling fatigued would be important in determining the significance of fatigue's role in accidents. Along similar lines, driving with a lack of sleep has been compared to driving under the influence of alcohol, but this was not used because it was not directly relevant. The number of consecutive hours behind the wheel also plays a role in accident rates and has been well studied and documented. Cost of accident data could provide information to build a distribution of accident severity. The number of drivers who actually comply with the hours of service regulations was also critical because gives insight into how many drivers the law changes would actually impact. Once data was gathered on all of these topics, we felt we had a strong base of data to use in the analysis.

For the analysis, we decided to focus on trying to determine how accident rates would change if the law changes. We assumed throughout the analysis that all drivers were using the full allotted driving time every shift. We looked at current driver compliance with the laws, accidents caused by fatigue, and the impact of consecutive hours of driving on accident rates. The law change would only affect drivers who will actually comply with the law, so only accidents caused by compliant drivers could change as a result of the law change. As for accidents caused by fatigue, these would be the accidents that should decrease as a result of the law change, since less driver fatigue is one of the main goals of the law change. However, we found that some secondary and tertiary effects may actually cause the number of accidents to increase. Since the number of hours of driving per shift would decrease from eleven to ten, we looked at how the length of time behind the wheel affects accident rates. For each of these three topics, we calculated the percentage of drivers or accidents to which it pertained. Then, to compile the factors of our analysis, we multiplied them together to find the percentage of accidents that the law change could impact. This is discussed further in the analysis and discussion section of this paper.

Chapter 4: Analysis and Discussion

The ultimate goal of our analysis was to determine how the law change would impact Travelers. Since the amount of claims paid out by Travelers is dependent upon the number and severity of accidents, we set out to find what percentage of total accidents could be affected by the law change. We began with an initial assumption that all accidents could be affected by the law change, and then gradually decreased this percentage. In order to have a complete analysis we also needed to look at how the severity of accidents would change, but unfortunately the data on this topic was insufficient, and conducting the necessary research to complete this would have been beyond the scope of the project.

To start, we had to determine how many truck drivers would actually comply with the law change. In a study entitled “Long Hours and Fatigue: A Survey of Tractor-Trailer Drivers,” the researchers interviewed truck drivers at various truck stops on major highways throughout four different states. The questions used strategic wording in an attempt to get an honest answer from the drivers. For example, rather than simply asking “Do you ever go over the driving limit of 10 hours per shift?” (where the preferred answered would be “no”), the study asked “Some truck drivers have told us that they often have to work longer than the hours of service rules, either to meet tight schedules or to make ends meet. During the past month, did you ever work longer than permitted?” (Braver, 1992, p. 345) This way of phrasing the question implies that the researchers understand that there may be a reason to go over the limit sometimes, and thus they are more likely to receive an honest answer. We felt that this method of surveying provided reliable data. It is also worth mentioning that even though this survey was conducted in 1992, we concluded that it would be more accurate than a study conducted after 2003 because in 1992 the driving limit was 10 hours, and that is what the law proposes. Thus although the survey was not very recent, the data is more relevant than a more recent study in which the limit was 11 hours.

From this study, we extracted data regarding what percentage of drivers fell into the following four categories of weekly driving hours: less than 50, 51 to 63, 64 to 70, and greater than 71. We assumed that all shifts use the full allotted 10 hours. We then converted weekly driving hours to weekly driving shifts under this assumption. We also assumed, for simplicity, that drivers in the less than 50 category were driving for exactly 50 hours per week and drivers in the greater than 71 category were driving exactly 71 hours per week. For the categories with ranges, we used the midpoint. Then we converted weekly driving shifts to monthly driving shifts, using four weeks per month. Finally, using the monthly driving shifts and the percentage of drivers in each category, we found a weighted average number of shifts per month. This information is summarized in Table 2.

Table 2: Calculation of Average Shifts per Month per Driver

Weekly driving hours	Percentage of drivers	Weekly Driving Shifts	Monthly Driving Shifts
<50	25.92%	5	20
51-63	24.53%	5.7	22.8
64-70	25.10%	6.7	26.8
71+	24.45%	7.1	28.4
		Weighted average:	**24.45**

After finding the average number of driving shifts per month per driver, we set out to determine what percentage of drivers regularly complies with the hours of service regulations. The same survey that provided information on weekly driving hours also provided information on how many times in the past month drivers drove for more than 10 hours in a day. The responses were again sorted into four categories: never (zero times), once or twice, three to ten times, and over eleven times. We decided to assign a level of compliance to each of these four categories. Those who did not violate the law comply 100 percent of the time. We also gave the benefit of the doubt to those who only drove over 10 hours once or twice in the past month, and assigned 100 percent compliance to this group as well. We made this assumption because these drivers are generally complying and may have encountered a circumstance that might force them to be on the road longer, such as bad weather. For those in the three to ten times category, we found the midpoint and divided by the average shifts per month that we previously calculated. This gave us the percentage of shifts, per month, that the drivers in this category were violating the regulation. Since we were looking for level of compliance, we then subtracted this number from one. The compliance for the final category, over 11 times, was computed the same way as the three to ten category, using the midpoint of 11 and 24.45 (the average shifts per month). After a percentage of compliance was determined for each category, a weighted average was again used to determine the overall percentage of drivers complying with the law. This information is summarized in Table 3, shown below.

Table 3: Calculation of Average Compliance with HOS Regulations

Number of times drove more than 10 hrs in a day	Percentage of drivers	Compliance
0	37.61%	100%
1-2	14.37%	100%
3-10	25.50%	73%
11+	22.52%	28%
	Average compliance:	**77%**

Thus we determined that truck drivers are complying with the law 77 percent of the time. This can be extended to say that 77 percent of truck drivers are compliant with the law. It is only these drivers, and

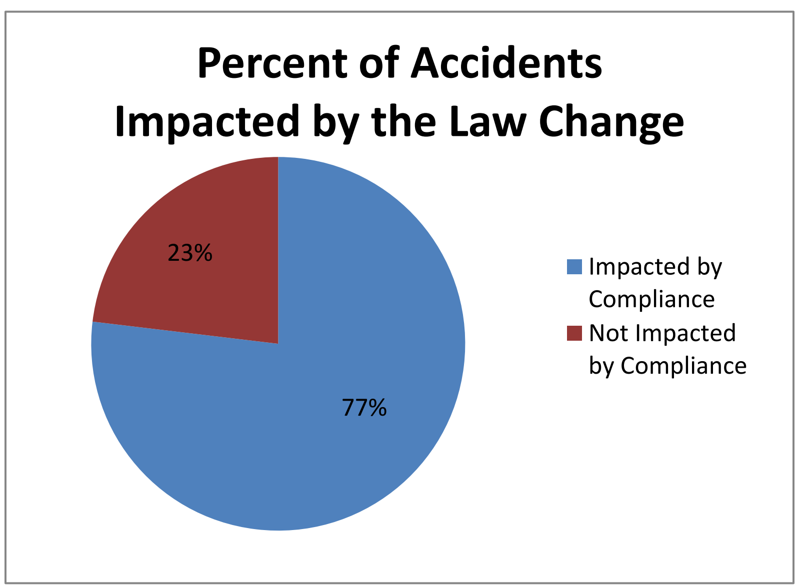

Figure 6: Percent of Accidents Impacted by the Law Change, 1

thus the accidents caused by these drivers, that could be impacted by the law change. We have assumed that the distribution of drivers who would comply with the law change would be the same as it was when this survey was conducted. We have now reduced the percentage of total accidents that could be affected by the law from 100 percent to 77 percent. This is shown graphically in Figure 6: Percent of Accidents Impacted by the Law Change, 1.

The team next decided to determine how the number of consecutive hours of driving impacted accident rates. A study entitled “Effect of Driver Fatigue on Truck Accident Rates” provided the necessary data for our analysis. In this study, data was gathered from police reports about the cause of accidents. They classified accidents as “fatigue-suspected” if the following two conditions were met: the truck driver was deemed to be “at fault” in single vehicle accidents and the police reported the primary cause of the accident to be truck driver fatigue. After analyzing their data, they found that the increase in number of “fatigue-suspected” truck accidents is not uniform at all hours of driving. The data showed that below the 9.5 hour mark, there were no significant changes in “fatigue-suspected” accident rates. However, there was a sharp increase in “fatigue-suspected” accident rates after 9.5 consecutive hours of driving. After fitting a one-way model to the data and conducting an F-test, this sharp increase was found to be significant at the one percent level (Saccomanno, 1995, p.444-445). For these reasons we felt that this was reliable data to use in our analysis.

The accident rates in the study for less than or equal to 9.5 consecutive driving hours and greater than 9.5 consecutive driving hours (hereafter known as the “lower rate” and the “higher rate,” respectively) were given in accidents in per million kilometers. Since the law change would decrease the number of hours drivers could drive per shift from 11 to 10, an accident rate with units of accidents per hour would be more useful to us, so we converted the given rates. We made two important assumptions here. First, we assumed that the half-hour breaks that drivers would be required to take every seven hours should the law change would not disrupt their continuity of driving. For example, if a driver has driven for seven hours, takes a half-hour break, and then drives for three more hours, we have considered this as 10 consecutive hours of driving. Second, in order to make the conversion from accidents per million kilometers to accidents per thousand hours, we assumed an average speed of 50 miles (or 80.4672 kilometers) per hour. We used accidents per thousand hours because the conversion to accidents per hour resulted in a very small number. These rates are summarized in Table 4.

Table 4: Calculation of Accidents per Thousand Hours

Consecutive driving hours	Accidents per million KM	Accidents per Thousand Hours
≤ 9.5 Hours	0.1093	0.00880
> 9.5 Hours	0.2347	0.01889

Under the current law, drivers may drive 11 hours per shift. This would be 9.5 hours at the lower rate followed by 1.5 hours at the higher rate. This would result in 0.0001119 accidents per 11 hours of driving. Under the new law, drivers would only be permitted to drive 10 hours per shift. This would be 9.5 hours at the lower rate, and 0.5 hours at the higher rate. The 11th hour would then be completed by either a different driver starting their shift or the same driver after a full rest period. Either way, the 11th hour would be completed at the lower rate, so there would be a total of 10.5 hours at the lower rate and 0.5 hours at the higher rate. This would result in 0.0001018 accidents per 11 hours of driving. This implies that 90.98 percent of “fatigue-suspected” accidents as a result of consecutive hours of driving will still occur if the law changes. In other words, this is a decrease of 9.02 percent.

Since this decrease would only pertain to accidents caused by fatigue, as a last step for this part of the analysis we needed the percentage of accidents cause by fatigue. According to

"The Large Truck Crash Causation Study" conducted by the FMCSA, 13 percent of accidents involving large trucks are caused by fatigue (Craft, n.d.). Since we determined that these accidents could decrease by 9.02 percent, by multiplying these two percentages we obtain the percentage of overall accidents that could decrease as a result of fatigue and the decrease from 11 to 10 hours of driving per shift, which would be 1.17 percent of all accidents. In order to then apply these results to our overall analysis, we made the assumption that fatigue related accidents are evenly distributed among drivers who comply with the law and drivers who do not comply with the law. We have already determined that only 77 percent of accident could be impacted by the law change based on compliance, and based on the assumption just mentioned, only 1.17 percent of these will be eliminated based on fatigue and the decrease from 11 to 10 hours of driving per shift. Thus, only 0.90 percent of total accidents could be prevented as a result of the law change. This is presented graphically in Figure 7.

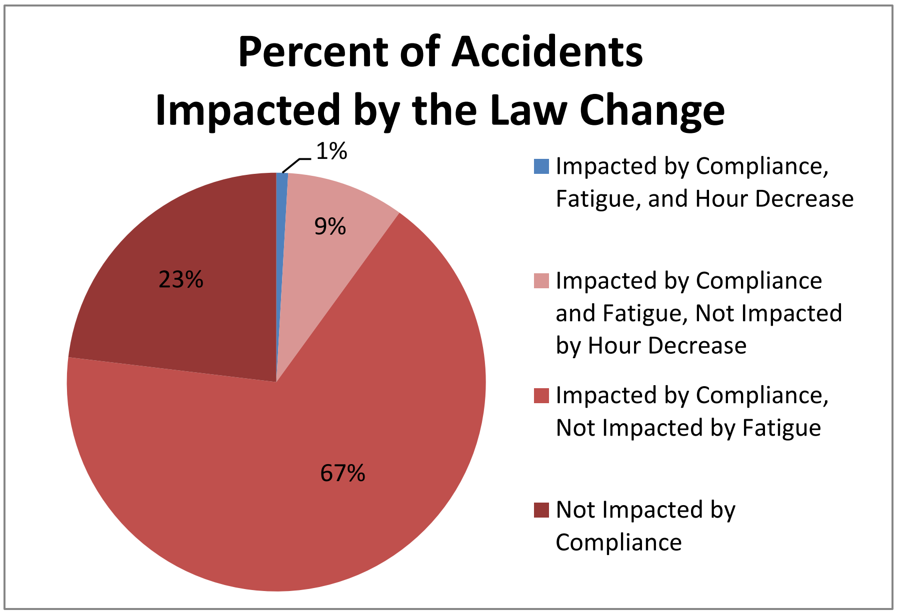

Figure 7: Percent of Accidents Impacted by the Law Change, 2

This result answers the initial question of how the law change will affect accident rates among truck drivers. Using this information, insurers will be able to adjust their models to accurately represent the current situation. Achieving this result was the goal of applying the general process, so the method was successful. In the following section we validate the result and discuss further work that could be done to improve the process and analysis of the legislation.

Chapter 5: Conclusions and Recommendations

Having concluded the analysis, it is important to both understand the results obtained and see where further work could be done. We want to verify that the value for projected reduction in accidents derived in the previous section is accurate and reasonable. Further, we can provide insight into areas that are worthy of further research that could improve the accuracy of the projection. First, it is essential to have a complete understanding of the derived result.

In our analysis, we concluded that only 0.90 percent of accidents could decrease as a result of the law change. This is a quite small and seemingly insignificant number, but we feel as though it is accurate. Although our analysis is incomplete, it is unlikely that we could find a way for this percentage to increase significantly.

The three main motivations for the law change were to decrease driver fatigue to make the roads safer, increase break flexibility so that drivers can rest when they feel it is necessary, and improve overall driver health. We have not considered the third motivation in our analysis. The second motivation appears to be indirectly related to the first, in that they both aim to decrease driver fatigue. The first motivation was the main focus or our analysis because it seems to be the one that the law changes attempt most to achieve. However, it seems as though the ends do not justify the means; the impact that these law changes may have is so small that it may not be worth the effort to have the law changed. Perhaps the FMCSA should focus its efforts instead on devising a more effective way to arrange the cargo in the trucks so it doesn't shift and cause an accident, or improve the brake systems on trucks so they do not fail as frequently. In "The Large Truck Crash Causation Study" conducted by the FMCSA, cargo shift has a high relative risk (56.3) of causing an accident, and brake failure has a high rate of being a factor in the cause of accidents (29 percent of accidents). Fatigue, on the other hand, has a relative risk of only 8.0 and is a factor in only 13 percent of truck accidents. It seems as though the time and money of the FMCSA could be better spent on accident causes that are more prevalent than fatigue.

5.1 Recommendations for Further Analysis

There are a number of steps that could be taken if one wanted to enhance the analysis that we began in this paper. For instance, in referring back to the potential effects of the law change shown in Figure 1, we have only touched upon some of these topics in our analysis. Although we found data regarding unemployment in the trucking industry, we did not use this anywhere in the analysis. We could have made a distribution to model what percentage of newly hired drivers would be experienced and what percentage would be inexperienced, then looked at the varying accident rates between these two groups. We also did not look at how speeding or aggressive driving may increase as drivers attempt to complete the same amount of work in less time, or the difference in quality of sleep in a sleeper berth versus at the driver's home. There is also no guarantee that drivers would use their extra hour off duty for sleep, in which case fatigue would not decrease as a result of the law change.

Another component we could have added to our analysis to make it more accurate is sensitivity analyses. For example, we found in an article about causes of accidents that 13 percent are caused by fatigue, but what if this number is incorrect? We could look at a reasonable range of values, for instance 10 percent to 16 percent and determine how the final result would change within this range of possible values. If we did a similar range analysis for each variable used, our final result would have been a range of possible numbers rather than a specific one.

The benefit of this would be that we can say with far more certainty that the true value is in the range than we can say that the true value is the single number we have computed here.

We also could have looked at how our calculations would change if some of our assumptions had been different. If we had not assumed that all drivers use all 11 available driving hours during every shift that they drive, we would see that this law change may apply to an even smaller segment of drivers, as critics of the proposed law change have implied. We also made some smaller scale assumptions throughout the analysis, such as deriving our accidents rates under the assumption that truck drivers drive at an average speed of 50 miles per hour. How would this change if they decide to speed to get more miles done in less time? What if it rose? What if this was not a valid assumption? In this case we would again conduct a sensitivity analysis.

Lastly, it is more than just the number of accidents that impacts the amount of claims paid out by Travelers. The severity of accidents is also critical; a severe accident will result in a much higher claim than a slight accident. With more accurate resources or more time to conduct a study of our own, we could have explored which types of accidents (severe versus not severe) that would be more likely to be eliminated by less fatigued drivers. If the number of less severe accidents were to decrease, this could result in the average claim size actually increasing, which may offset the impact of fewer total accidents on the amount of claims paid out by Travelers.

Chapter 6: Bibliography

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Chapter 7: Appendix

Calculation of Average Shifts per Month per Driver

We used the data from Table 4 on page 354 of Braver's study (1992) for this calculation. The data was presented in the following form:

	State							
	CT		FL		OK		OR	
Weekly Driving Hours	Number	%	Number	%	Number	%	Number	%
<50	83	31%	125	26%	65	27%	45	19%
51-63	72	27%	127	26%	53	22%	49	21%
64-70	46	17%	141	29%	60	24%	61	26%
71+	67	25%	90	19%	67	27%	76	33%

The study was conducted in multiple states, but we needed an overall percentage of drivers in each category, so we summed the number of drivers in each driving category and divided each by the total number of drivers surveyed to find the percentage of drivers in each category. For example, in the 51-63 category, there are 72 + 127 + 53 + 49 = 301 drivers. When this number is divided by the total number of drivers in the survey (1227), the percentage is 24.53, as seen in Table 2. This table is replicated below:

Weekly driving hours	Percentage of drivers	Weekly Driving Shifts	Monthly Driving Shifts
<50	25.92%	5	20
51-63	24.53%	5.7	22.8
64-70	25.10%	6.7	26.8
71+	24.45%	7.1	28.4
		Weighted average:	**24.45**

The other percentages in the "percentage of drivers" column were calculated in the same manner. In order to convert weekly driving hours to weekly driving shifts, we used the assumption that each shift was 10 hours. For the first and last row, we used the given number, so 50/10 = 5 shifts per week, and 71/10 = 7.1 shifts per week. For the other two, we used a midpoint, so for the 51-63 category, we used ((63 - 51)/2) + 51 = 57, then did 57/10 = 5.7 shifts per week. This same method was used for the 64-70 category. The monthly driving shifts are simply the weekly driving shifts multiplied by four. The weighted average is then computed as the percentage of drivers in each category multiplied by the monthly driving shifts in that category, and then summed, as follows:

Weighted average = (.2592)*(20) + (.2453)*(22.8) + (.2510)*(26.8) + (.2445)*(28.4) = 24.45

Calculation of Average Driver Compliance

We used the data from Table 4 on page 354 of Braver's study (1992) for this calculation. The data was presented in the following form:

Number of times drove more than 10 hrs in a day	State							
	CT		FL		OK		OR	
	Number	%	Number	%	Number	%	Number	%
0	96	36%	226	46%	87	35%	57	25%
1-2	34	13%	78	16%	36	14%	30	13%
3-10	69	26%	103	21%	66	27%	78	34%
11+	69	26%	83	17%	60	24%	67	29%

This data came from the same study used for the calculation of average shifts per month per driver, and we calculated the percentage of drivers in each category in the same manner as the previous calculation. These percentages are seen in Table 3, replicated below:

Number of times drove more than 10 hrs in a day	Percentage of drivers	Compliance
0	37.61%	100%
1-2	14.37%	100%
3-10	25.50%	73%
11+	22.52%	28%
	Average compliance:	**77%**

For the first two categories, overall compliance was assumed to be 100 percent. For the other two categories, this number was calculated in the following way. For the 3-10 category, we used an average number, so in this case it was (3 + 10)/2 = 6.5. Then, we took this number and divided by the average number of shifts per month as calculated previously to obtain the percentage of times per month that the law was being violated: 6.5/24.45 = 0.2659. Since this is the percentage of times that the law has been violated, we subtracted this number from 1 to obtain percentage of times complying with the law: 1 - 0.2659 = 0.7341. This same method was used for the 11+ category, using 24.45 as the "upper bound," so the average was (11 + 24.45)/2 = 17.72. Once all of the numbers in the compliance column were computed, we found the weighted average by multiplying the percentage in each category by its respective compliance and summing the results:

Weighted average = (.3761)*(100) + (.1437)*(100) + (.2550)*(73) + (.2252)*(28) = 77 percent

Calculation of Change in Fatigue Related Accidents

We used data taken directly from Table 2 on page 446 of Saccomanno's study (1995) for this calculation. The data in the accidents per million KM column of our Table 4, replicated below, came directly from the study:

Consecutive driving hours	Accidents per million KM	Accidents per Thousand Hours
≤ 9.5 Hours	0.1093	0.00880
> 9.5 Hours	0.2347	0.01889

To calculate the number of accidents per thousand hours, we made the assumption that truck drivers had an average speed of 50 miles per hour. We first converted this to kilometers per hour:

(50 miles/1 hour)*(1.609344 kilometers/1 mile) = 80.4672 kilometers per hour

Then, we were able to convert from accidents per million kilometers to accidents per thousand hours. We did not convert directly to accidents per hour because this would have produced a very small number:

(.1093 accidents/1,000,000 kilometers)*(80.4672 kilometers/1 hour)*1000 = 0.00880 accidents per 1000 hours

This calculation was, of course, for the lower rate; the same calculation was made for the higher rate.

The next step was to calculate current number of accidents per shift, so that it could be compared to accidents per shift if the law changes. Currently, shifts may be 11 hours long. This is 9.5 hours at the lower rate followed by 11 - 9.5 = 1.5 hours at the higher rate. This means that in one shift under the current law there would be

[(0.00880 accidents/1000 hours)*9.5 hours] + [(0.01889 accidents/1000 hours)*1.5 hours] = 0.0001119 accidents.

If the law changes, drivers would only be permitted to drive for 10 hours per shift, so there would be 9.5 hours at the lower rate, followed by 0.5 hours at the higher rate. Then either the same driver would drive again after resting, or a new driver would finish the 11^{th} hour. Either way, the 11^{th} hour would be driven at the lower rate. Therefore, after the law change, 11 hours of driving would consist of 10.5 hours at the lower rate and 0.5 hours at the higher rate:

[(0.00880 accidents/1000 hours)*10.5 hours] + [(0.01889 accidents/1000 hours)*0.5 hours] = 0.0001018 accidents

This means that 1 – (0.0001018/0.0001119) = 9.02 percent of “fatigue-suspected” accidents could decrease as a result of the law change. Since 13 percent of overall accidents are caused by fatigue, (0.13)*(0.902) = 1.17 percent of overall accidents could be eliminated by fatigue.