THE UNIVERSITY OF CALGARY

AN ECONOMIC ANALYSIS OF NO-FAULT INSURANCE

BY

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THE UNIVERSITY OF CALGARY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "An Economic Analysis of No-Fault Insurance," submitted by Angela Tu in partial fulfillment of the requirements for the degree of Master of Arts.

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ABSTRACT

The manner in which automobile insurance is provided has become a major policy issue concerning many Canadian provinces. Although this issue has received much attention in recent years, very little research has been done to trace the effects of various insurance schemes on the social costs of accidents.

The objective of this study is to measure the relationship between various insurance premium schemes and the fatal accident rate. Particular attention is given to no-fault insurance rating schemes. An empirical model was developed to test the hypothesis that insurance pricing schemes which place emphasis on driving behavior provide a more effective deterrent to accidents than those schemes which rely more on non-behavioral factors such as risk classification groups. The automobile fatality rate per registered vehicle was regressed on the number of offenses per licensed driver, distance driven per registered vehicle, seatbelt usage and a variable depicting insurance characteristics. A time series model was applied to data for British Columbia, Manitoba and Quebec covering the years 1960-1985 and a pooled cross section time series model was applied to data for all Canadian provinces for the years 1975-1985.

The results of the study provide support for the hypothesis. The estimates strongly suggest that no-fault insurance with premium ratings schemes which are entirely independent of driving behavior are significantly associated with an increase in fatal accident rates. Conversely, the empirical evidence indicates that no-fault schemes with premiums that are dependent on the number of demerit points and past accident experience are associated with a decrease in the accident rate.

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CHAPTER ONE

INTRODUCTION

The manner in which automobile insurance is to be provided in Canadian provinces has become a major policy issue in recent years. In British Columbia, debate continues with respect to the feasibility of insurance provided through crown corporations. In Alberta, voters wait in vain for the government to fulfill its promise to remove sex discrimination in insurance premium ratings. In Ontario, several task forces over the past fifteen years have put forth arguments about the desirability of a complete no-fault automobile insurance system, and finally, in Quebec, evidence indicates that the province's no-fault automobile insurance system has been associated with an increase in the number of serious accidents. Although this issue has received much journalistic attention from various disciplines, considerable divergence remains. There appears to be some confusion of political objectives with economic goals. In provinces that do not have government insurance, there exists continual debate over the cost effectiveness of automobile insurance provided by private

companies. At the root of this debate seems to be a strong dissatisfaction with automobile liability insurance. [1]

Critics of tort law have long maintained that the traditional tort liability system is a costly and inappropriate means of providing compensation for victims of automobile accidents. One major argument is that long delays associated with the determination of damages for personal injury combined with considerable administrative costs have rendered tort law inefficient in an automobile oriented society, particularly with respect to the compensation goals of tort law. Furthermore, critics have suggested that tort law is inapplicable to automobile accidents both because they believe that most accidents are not a result of deterrable behavior, [2] and that liability insurance offsets any deterrent effect present in tort law. It is also suggested that the random nature in the application of negligence rules further mutes any deterrent effect. [3] The divergence in the awards for "pain and suffering", the difficulties in proving fault, and the ability to insure against negligence have have been said to generate inconsistencies which no longer serve as a deterrent to accident causing behavior. [4] Indeed, these characteristics have led critics to term the tort liability system a "lottery". [5]

Such criticism has resulted in the proposal and implementation of no-fault insurance systems. In a no-fault insurance scheme the injured party is compensated by his or her insurance company for accident losses regardless of fault or causation. [6] Within this labelling, there are many types of no-fault schemes which coexist. At one extreme, a complete no-fault compensation scheme essentially eliminates all tort suits which attempt to prove fault and provides all members of society with compensation for all accidents. This system has only one basic goal: to provide compensation for every injury without regard to fault of the injurer or the person injured. At the other extreme, no-fault compensation can be restricted to certain types of accidents such as automobile accidents, and it can provide full or partial compensation for accident damages.

In Canada, all provinces have limited no-fault compensation coverage in that each driver is required to carry insurance which provides that his insurance company will pay compensation to the injured driver and occupants irrespective of fault. In an effort to reduce delays and administrative costs three provinces - British Columbia, Saskatchewan and Manitoba - have implemented publicly provided no-fault insurance. The right to tort suit for damages for injuries has not been restricted in any

province, except for Quebec. Indeed, Quebec is the only jurisdiction in North America to have complete no-fault insurance for automobile injuries. [7] Insurance premiums are charged independently of driving behavior, and recourse to tort suit for damages has been completely abolished. In the event of an accident, the injured party claims compensation from the Quebec government according to a legislated schedule. Although this no-fault system has been subjected to much criticism in recent years, various task forces, particularly those in Ontario have been seriously considering a complete no-fault insurance scheme for some provinces in Canada. [8]

In these and other proposals for no-fault compensation, there has been a tendency to view the efficiency of the tort liability system solely in terms of financial considerations. Much attention is devoted to the inconsistencies of compensation in the tort liability system and the adminstrative costs and delays it entails. A major concern of these papers is to increase compensation to cover more people by decreasing administrative costs. Broader economic implications such as the effects of no-fault compensation on the incentives to avoid accidents are frequently glossed over, or simply ignored.

What are the economic implications of no-fault insurance? How have such systems affected the social costs

of accidents? While there is a general consensus among policy analysts and economists that a shift from the tort liability system to no-fault compensation could lead to a significant reduction in litigation costs and a decrease in administrative delays, major differences arise regarding the effects of no-fault compensation on the incentives to prevent accidents.

The law and economics literature which applies economic theory to basic legal doctrines suggests that the primary justification for the tort liability system is to provide incentives for careful behavior and to discourage excessive levels of risk taking activity even in the presence of liability insurance. [9] Some have argued that the removal of the tort liability threat will no longer induce drivers to undertake a level of care which is conducive to avoiding accidents. [10] On the basis of these arguments it is maintained that no-fault compensation schemes would lead to a substantial increase in accident costs.

On the other hand, no-fault proponents argue that there should be no change in the accident rate as a result of no-fault insurance. Non-tort mechanisms such as traffic regulations for driving behavior and vehicle use, and insurance premiums based on past driving experience should act as a deterrent to accident causing behavior. In

addition, some individuals argue that fear of self inflicted bodily injury may also provide some deterrence.

The empirical literature reveals conflicting results. While a number of studies have provided empirical evidence that the implementation of no-fault insurance is associated with an increase in accident occurrences, other studies have shown that accident rates have remained unchanged or have in fact declined with the introduction of no-fault compensation. [11] One major reason for the divergence in empirical results is that studies have not differentiated between premium increments based on driving behavior and no-fault insurance which is not based on driving experience. Much of the research has been applied to the United States experience. Only two studies involve Canadian data [12], and there the focus has been restricted to Quebec evidence. To date there has been no satisfactory evaluation of the impact of no-fault insurance on the social costs of accidents in Canada.

Objective of the Study

The objective of this study is to undertake an empirical investigation to measure the extent to which no-fault automobile insurance has affected the social costs of accidents. The relationship between no-fault insurance

and the cost of accidents depends on the degree to which drivers perceive the relationship between type of insurance coverage and their financial accountability for damages they cause as a result of their driving behavior. This accountability is reflected through the type of premium rating scheme existing in a particular jurisdiction. As such, this issue is primarily an empirical one. This study utilizes econometric techniques in both a time series and pooled cross sectional time series framework to test the hypothesis that there is a relationship between no-fault insurance schemes and the social cost of accidents.

Outline of the Study

Chapter Two outlines the theoretical literature pertaining to the prevention of accidents. It is shown that there is analytical support for the relationship between premium rating schemes and accidents. Chapter Three contains a review of the empirical literature relevant to the investigation of of the effects of no-fault insurance on the social costs of accidents. The studies outlined reveal ambiguous and conflicting results. Chapter Four presents the statistical models which are used to explain the observed relationship between various no-fault schemes and the social costs of accidents. The regression

analyses are conducted within a time series and pooled cross section time series framework. The results obtained from the models are presented in Chapter Five. Chapter Six concludes the study by summarizing the major findings of the study, discussing policy implications and suggesting possible areas for future research.

Notes to Chapter One

1. In the tort liability system, if it can be proved that the defendant has been negligent and the plaintiff is free from negligence, the victim is entitled to damages from the defendant. In order for an injured party to recover compensation from an offending party, the plaintiff must prove that the defendant's negligence caused his injuries and that he is free from guilt. If the victim carries first party insurance, he would claim costs from his own insurance company. The foregoing combination of common law tort liability with voluntary first party insurance and either compulsory or voluntary third party insurance is referred to as the tort liability system or the "fault" system.

2. There are two major goals concerning tort law. One is to restore the injured party to the position he was in before the negligent act, and second, to deter the injurer from committing the negligent act again.

3. United States Department of Transportation (1970), p. 54. See also Atiyah p. 565.

4. Linden (1965), United States Department of Transportation (1970), p. 35.

5. Keeton and O'Connell (1965), T. Ison (1966), and Atiyah (1980).

6. Keeton and O'Connell (1965) were the first to propose a no-fault automobile insurance program. The first complete no-fault insurance program for all accidents was implemented in New Zealand in 1973. See Woodhouse (1974) for details of the program. For more recent no-fault insurance proposals see New South Wales Law Reform Commission (1982) and Ontario Task Force on Insurance (1986).

7. This scheme was implemented by the Regie de l'assurance du Quebec in 1978. Details of the program will be discussed in Chapter Four.

8. See Ontario Task Force on Insurance (1986). This is a major report proposing that tort rights be replaced with the introduction of mandatory first party no-fault insurance which is to be delivered by the private insurance industry.

9. This school of thought is drawn from the early law and economics literature. The seminal work on tort law and accidents is Calabresi (1970). Green (1975) and Diamond (1974) is a rigorous interpretation of Calabresi. See also Posner (1977).

10. See Brown (1973) and Posner (1977).

11. See Kochanowski and Young (1985), Brown (1985), United States Department of Transportation (1985), and Zador and Lund (1986).

12. While there are a few recent studies evaluating the impact of no-fault automobile insurance on the accident rates in Quebec, no similar studies evaluating the no-fault accident relationship have been applied to government provided no-fault insurance provinces such as Manitoba, Saskatchewan, and British Columbia.

CHAPTER TWO

THEORETICAL BACKGROUND

Introduction

It is desirable to outline briefly the theoretical literature prior to the investigation concerning the relationship between premium rating schemes and accident costs. The purpose of this chapter is to establish analytical support for this linkage and to introduce several concepts which will prove to be useful in the empirical work that follows.

The theoretical foundations are drawn from two areas of research: law and economics and insurance. This chapter is divided into three sections. The first part is a presentation of a model for accident prevention and the derivation of its first best solution. A brief discussion of market failure indicates why this first best solution cannot always be reached. The second section contains a discussion of the instruments suggested to correct market failure by encouraging an adequate amount of precautions. These instruments include tort law, taxes, and penalties. Finally, the last section outlines the effects of insurance premium characteristics on the level of accident prevention.

A Model of Deterrence

There are two areas concerning economic behavior which affect the social costs of accidents: the level of activity and the amount of care taken to avoid accidents. Although the economics literature deals with both areas, most research has concentrated on the latter. The focus of the recent law and economics literature is concerned with utility maximization achieved by identifying the levels of accident precautions which minimize the social cost of accidents. This is the general approach which will be followed in this chapter.

A model for accident avoidance can be illustrated within a welfare economics framework. The model can be considered to be analogous to the neoclassical production function [1]. The production function refers to the the physical relationship between the firm's inputs of resources - capital and labour - and its output of goods or services per unit of time, ignoring prices. The model of accident prevention can be expressed by the relationship between two inputs: X, the level of precautions taken by the injurer, and Y, the level of precautions taken by the victim. These inputs are combined to produce the output, accident avoidance.

Before proceeding with the model in further detail, it is necessary to identify some underlying assumptions. The

level of care or precautions includes all activities which reduce the probability of an accident. For example, these activities can include money and time spent on defensive driving courses or on safety devices, the value of time invested in fastening a seatbelt, or the opportunity cost of driving more slowly. It will be assumed that the benefits accrued to these activities can be quantified. Also, for simplicity, it will be assumed that the cost of each unit of precaution is constant for each individual.

A further assumption is that there is an inverse relationship between safety expenditure and the frequency and severity of accidents. In addition, it is assumed that all economic agents (injurers and victims) are rational in that they are able to judge their own welfare when deciding on the amount of precautions to employ. Put differently, all agents are assumed to have perfect information concerning the distribution of injuries in relation to the level of safety they undertake. Finally, individuals' decisions are assumed to be made independently from one another.

The probability of an accident occurring is dependent on the amount of care exerted by two parties: the injurer and the victim. If the cost per unit of precaution for the potential injurer is u, and that for the potential victim

is v, then the total cost of precautions exerted by the two parties is

$$(2.1) \qquad uX + vY$$

As the amount of care taken by the parties increases, the total cost of accident prevention rises, but the probability of an accident occurring decreases. Consequently, there is a tradeoff between the cost of accidents and the cost of precautions.

It is assumed that society's goal is not to eliminate all accidents; this would require the abandonment of accident causing activity or investment in an infinite amount of resources for accident prevention. Rather, it is assumed that society's goal is to minimize the total costs of accidents and accident prevention by inducing the parties to take optimal levels of precautions. If the social costs of accidents is defined to be C, the objective function can be expressed in the following equation:

$$(2.2) \qquad \text{Min } C(X,Y) = uX + vY + A[1 - P(X,Y)]$$

where uX and vY are the total cost of precautions taken by the potential injurer and the potential victim, respectively, P(X,Y) is the probability of having no

accidents given the level of precautions taken by the parties, and A is the average cost of an accident, given that an accident has occurred. Hence, A[1 - P(X,Y)] is the expected cost of accidents.

The optimal level of precautions can be obtained by differentiating equation (2.2) with respect to X and Y. Setting the first order partial derivatives to zero, the following first order conditions are obtained:

$$(2.3) \qquad u = AP_X(X,Y)$$

$$(2.4) \qquad v = AP_Y(X,Y)$$

where $P_X = \frac{\partial P}{\partial X} \gtrless 0$ and $P_Y = \frac{\partial P}{\partial Y} \gtrless 0$

$$P_{XX} < 0 \quad , \quad P_{YY} < 0 \quad , \text{ and } P_{XY} < 0$$

These conditions state that in order for the social costs of accidents to be minimized, additional precautions should be taken so long as the marginal cost of precautions is less than or equal to the expected marginal benefits obtained from accident avoidance.

Solving equations (2.3) and (2.4) simultaneously will result in the optimal solution (X*,Y*). It can be shown that in a free market environment where each party expects to pay the full cost of an accident, A, parties can be

expected to behave in such a way as to minimize the social cost of accidents, C [2]. The reasoning behind the proof can be expressed as follows: each party's objective is to minimize the costs of accidents and accident prevention, therefore a party would increase the level of precautions until the benefit derived from the last unit of precaution equals the cost for the last unit of precaution. A party who maximizes benefits would not choose below optimal precautions because the party can gain more benefits by increasing the amount of precautions taken. Similarly, a party would never choose a level of precautions which would exceed the required minimum level of precautions. For any level of precautions above the minimum level, the cost of taking an additional unit of precaution exceeds the benefit derived from the increase in precautions. Hence, satisfying the conditions stated in equations (2.3) and (2.4) will result in an optimal amount of safety precautions which minimizes the social costs of accidents and accident prevention.

Market Failure

In practice, the optimal solution (X*,Y*) may not be reached. In the absence of external intervention, the

injurer is generally not held responsible for the accident costs imposed on the victim. In a such a situation, the injurer will take less than the optimal amount of precautions, and the victim would have to bear the entire cost of the accident. [3] This would lead to an underinvestment of precautions if parties were unable to bargain with each other.

If parties could negotiate the levels of care with each other prior to an accident without incurring transaction costs, an optimal solution could be reached. For example, the victim could "bribe" the injurer to take more precautions, or in the case where the victim has a "right" to stop the injurer from engaging in dangerous action, the injurer could pay the victim to allow him to engage in the accident causing behavior. If each party is a cost minimizer, the victim would only bribe the injurer for an amount not greater than the accident costs he would bear if no bargaining were to take place. The injurer would only accept payment if the amount was greater than the cost saving from not taking precautions. If bargaining between the relevant parties takes place, there will be an efficient allocation of resources regardless of the initial distribution of resources. In the economics literature this is known as the Coase Theorem [4].

The Coase Theorem implicitly assumes that potential parties to an accident are costlessly identifiable. However, with respect to accidents, it is either extremely costly or virtually impossible to identify potential injurers and victims prior to an accident occurrence [5]. Consequently, no such bargaining solution will be attained. In the absence of external intervention, an optimal amount of precautions will not be undertaken by injurers and victims. Hence, there is a need for external intervention.

Instruments of Deterrence

Deterrence refers to the use of penalties to induce individuals to take the cost minimizing amount of precautions when undertaking dangerous activities such as driving. The following section summarizes the types of external intervention thought to bring about deterrence of accident causing behavior. These instruments include tort liability, safety legislation and penalties, and insurance pricing characteristics. There is no general consensus as to which type of instrument provides the most effective deterrence; indeed, these instruments are frequently used in combination in an attempt to minimize the social cost of accidents.

Tort Law

The law of torts is concerned with redressing wrongful acts arising out of actions or omissions by other parties which have caused harm to the human body or property. [6] Because torts are generally unintended, the moral culpability of the tortfeasor is not always clear. It is in this area of accident compensation that tort law has come under the greatest challenge from legal scholars and policy analysts.

In the economic literature, tort law is one method of overcoming the transaction costs problem specified in the previous section. From an economic perspective, tort law can be seen as an incentive mechanism for accident prevention. This instrument is thought to minimize the cost of accidents in two ways: by defining negligence and by imposing liability rules.

The economic definition of negligence can be expressed in terms of equations (2.3) and (2.4). A party is considered to be negligent if there was another unit of precaution that could have been taken for which the benefits exceeded the costs. For example, in terms of the economic model, the injurer is deemed negligent if:

$$(2.5) \qquad u < AP_X(X,Y)$$

that is, if his marginal cost of precautions is less than the marginal benefits of precautions. By analogy, the same argument can be applied to the case of the victim. The necessary marginal condition suggests that the victim is negligent when

$$(2.6) \qquad v < AP_Y(X,Y)$$

The victim is negligent when the incremental cost of his precautions is less than the incremental benefits of avoiding accidents. Let the due care standard be defined as the value of X for which $u = AP_X(X,Y)$. In the economics literature this rule is frequently referred to as the Learned Hand standard [7].

Liability rules are defined as a set of rules concerning the allocation of accident costs among the relevant parties. In the economic model, the function of liability rules is to induce parties to select those levels of precautions which minimize the social costs of accidents and accident prevention.

There are at least 8 liability rules which could be applied to an accident situation. In general, efficient rules are those which allocate the entire accident cost to one of the parties. [8] One such liability rule that is frequently used with respect to accidents is the negligence

rule. For purposes of exposition, this rule is discussed as an example of the efficient liability rules in the next paragraphs.

According to the negligence rule the victim is liable for accident costs unless it can be proven that the injurer is negligent. If X' is the legal standard which defines negligence, Lx is the percentage of damages the injurer must pay the victim, and Ly is the percentage of damages the victim must pay, the rule can be expressed as follows:

$$(2.7) \qquad Lx(X,Y) = 0 \text{ and } Ly(X,Y) = 1 \text{ if } X>X'$$

$$(2.8) \qquad Lx(X,Y) = 1 \text{ and } Ly(X,Y) = 0 \text{ if } X<X'$$

If the injurer has taken a level of care that exceeds or equals the legal standard (i.e., X>X'), then he is not liable for the cost of the accident; the accident losses must be borne by the victim. If the injurer has been negligent at the time of the accident (i.e., X<X'), then he must compensate the victim the full costs of the accident. It follows that the injurer's cost minimizing function can be written as:

$$(2.9) \qquad \begin{aligned} Cx &= uX + A[1 - P(X,Y)] && \text{if } X<X' \\ &= uX && \text{if } X>X' \end{aligned}$$

The first order condition is:

$$(2.10) \qquad u = AP_X(X,Y)$$

If the individual is to minimize his private costs, the marginal cost of precautions must be equal to the marginal benefits of accident avoidance. This condition is efficient because it is equivalent to the optimal condition expressed in equation (2.3). By analogy, the same result can be obtained for the case of the victim.

The argument that the negligence rule is efficient forms a basic tenet of the law and economics literature. The negligence rule induces each party to engage in an efficient amount of accident prevention such that no party will be found negligent. The reasoning behind this proposition can be expressed as follows: suppose that $X<X'$ and $Y<Y'$; that is, suppose both parties fail to meet their due care standard of precautions. In the case of the injurer, his cost of taking an additional unit of precaution is less than the benefits derived from from that unit of accident avoidance. In terms of the model, $u < AP_X(X,Y)$. If the entire accident cost is imposed on the injurer, (who has not met the due care standard, X'), he will be induced to take additional precautions until the cost of the additional unit of precaution is equal to the

benefit derived from that additional unit of precaution. That is, the individual will continue to take precautions until X = X'. Once X = X' for the injurer, the negligence rule imposes accident costs on the victim (whether or not he has met the due care standard of precautions). The victim will be induced to take additional precautions until the costs and the benefits associated with the extra unit of precaution are equal. In other words, the victim will be induced to meet the due care standard.

The final result is that the injurer and the victim will each take an efficient amount of precautions. Although accidents will still occur, these accidents are considered to be "efficient" in the sense that the marginal costs of preventing them exceed the marginal benefits of not having those accidents. In other words, it is cheaper to pay the costs of the accident than to take the precautions necessary to prevent the accident. Consequently, those injured in accidents where neither party is negligent will not be compensated by the tort liability system.

Taxes, Fines and Safety Regulation

In the economics literature taxes are also considered to be an instrument which could reduce the costs

of accidents. This reduction in accident losses can be achieved in two ways: by imposing taxes on individuals whose level of precautions are below the efficient level, or by taxing the overall level of activity thereby reducing accident costs indirectly.

With regard to the first method, a crucial assumption is that the tax controller is able to monitor the level of precautions undertaken by individuals. Equally important is the assumption that the controller is able to ascertain the accident reducing effects derived from each type of precaution. It can be shown that taxes will bring about an optimal amount of precautions provided that these assumptions are satisfied.

Suppose a tax, t, is imposed on those individuals whose level of precautions is below the efficient level, X*. The tax structure can be denoted by $t(X^*-X)$, where X is the level of precautions chosen by the individual. Assume that this tax structure is a substitute for the tort liability system. Injurers and victims are assumed to bear their own accident costs: A' and A", respectively. The injurer's cost minimizing function may be written as follows:

$$(2.11) \qquad C = uX + t(X^* - X) + A'[1 - P(X,Y)]$$

The first order condition for costs to be at a minimum is:

$$(2.12) \qquad u = t + A'P_X(X,Y)$$

The cost minimizing conditions require that the marginal cost of precautions be equal to the marginal tax and marginal benefit of accident avoidance.

Similarly, the victim's cost minimizing function can be expressed as follows:

$$(2.13) \qquad C = uY + T(Y^*-Y) + A"[1-P(X,Y)]$$

The first order conditions is:

$$(2.14) \qquad v = t + A"P_Y(X,Y)$$

The cost of the additional unit of precaution is equal to the additional unit of tax and the benefit of accident avoidance derived from the additional unit of precaution taken.

Taxes and no compensation for the injured can be efficient if they are equal to the expected accident costs. The reasoning behind this argument can be stated as follows: from equation (2.3) it was seen that the social optimum is where $u = AP_X(X,Y)$. As was shown in equation

(2.12), the tax system induces $u = t + A'P_X(X,Y)$. Therefore an optimal solution is achieved when $t + A'P_X(X,Y) = AP_X(X,Y)$. That is, costs are at a minimum when $t = (A-A')P_X(X,Y)$ or $t = A"P_X(X,Y)$. If $A'P_X(X,Y)$ and $A"P_Y(X,Y)$ are measurable, it is possible to obtain an efficient solution with taxes based on behavior where neither party is compensated. However, in practice it is difficult and expensive to measure these costs; therefore it is not likely that an optimal solution will be obtained.

Indeed, taxes are socially optimal if and only if $t = A$ for both injurer and victim. This solution is obtained in the case where taxes imposed on a particular activity reflect the expected damages resulting from the individual's level of precautions, and that the government compensate all individuals for their accident costs. The injurer's private cost function would be:

$$(2.15) \qquad C = uX + t[1 - P(X,Y)]$$

Similarly, the victim's private cost function would be:

$$(2.16) \qquad C = vY + t[1 - P(X,Y)]$$

the first order conditions for the injurer and the victim, respectively, are:

$$(2.17) \qquad u = tP_X(X,Y)$$

$$(2.18) \qquad v = tP_Y(X,Y)$$

These first order conditions are efficient if t = A that is, when these equations are equivalent to the optimal conditions specified in equations (2.3) and (2.4).

It is also possible to impose taxes or fines on different types of accident causing behavior. For example, a fine could be imposed on driving faster than the posted speed limit. One advantage of this tax structure is that it is possible to levy varying fines for different types of accident causing behaviors. For instance, if driving above a certain speed increases the probability of an accident more than not coming to a complete stop at a "stop" sign, a more severe fine can be imposed for speeding.

It is also possible to tax the level of activity, thereby reducing the number of accidents as a possible side effect. For example, to reduce automobile accidents, taxes could be imposed on road mileage (through a gasoline tax), alcohol (indirectly affecting drunk driving), and type of car purchased (to discourage the purchase of dangerous automobiles). [9]

Suppose a controller imposes a tax on individuals who drive. If M' is the number of miles an individual would

like to drive in the absence of taxes, M is the number of miles the individual actually drives, and u is the opportunity cost to the motorist of driving one mile less than desired, the individual's cost minimizing function may be expressed as follows:

$$C = u(M' - M) + t(M) \tag{2.19}$$

By differentiating this equation with respect to the number of miles driven, the first order condition is obtained:

$$u = t \tag{2.20}$$

For costs to be at a minimum the benefit of driving an extra mile must be equal to the tax accrued to the extra mile.

In order for taxes to be effective in minimizing the costs of accidents, an optimal tax must be found for every conceivable accident causing behavior. Several problems are associated with this requirement. It is difficult to identify all accident causing behaviors. The causes of accidents involve many random factors which are often not quantifiable. Moreover, even if identification were possible, finding the optimal tax requires extensive information on the cost and benefits of the activity that

is being taxed. That is, the controller must know the marginal social cost of the activity. Furthermore, imposing a variety of taxes on many types of accident causing activities generates administration costs which may exceed the social benefits of reducing accidents.

A government agency can also influence accident rates through safety regulation. By imposing a set of fines on individuals or manufacturers whose investment in safety equipment for automobiles is below a desired standard, an optimal amount of investment in safety can be brought about. This result can be illustrated as follow. Let E^* be the desired level of investment in safety equipment, E be the level of investment which the individual chooses, and u be the cost of one unit of safety equipment. Suppose a fine, f, is imposed on those individuals whose safety equipment does not meet a certain level $(E^* - E)$. Then the individual's cost function is

$$C = u(E) + f(E^* - E) \tag{2.21}$$

The first order condition is:

$$u = f \tag{2.22}$$

The individual's costs are minimized when the cost of the unit of safety investment is equal to the increment in the fine. The same result can be obtained for fines which are imposed on all levels of precautions below the desired level of precautions, (X*-X). Note that these conditions are the same as those for taxes.

Implicit to achieving an optimal level of road safety is the assumption that the costs and the benefits of safety regulation are known. Although it is possible to measure the benefits of safety regulation, recent studies have shown that it is difficult to quantify possible side effects such as offsetting behavior [10].

Insurance and Deterrence

Insurance is a mechanism by which the burden of risks is removed from the insured and placed on the insurer in return for a premium price. By spreading the risks over time or across a large group of people, the insurer is able to pay for the costs of accidents when they arise. From an economic perspective, the purpose of insurance is to allocate the risk borne by the insured in such a way that his marginal utility of income is the same whether or not an accident takes place. [11]

It has often been said that the presence of insurance weakens the incentives for accident precautions generated by tort liability rules. It is pointed out that having a due care standard which people are expected to obey and then allowing people to insure themselves against any tort liability arising from not meeting the due care standard seems contradictory. [12] However, Shavell (1982) demonstrates that a "first best solution" can be obtained in a system with negligence rules and insurance provided that direct information is available. [13] While the availability of insurance does alter the incentives for accident prevention, the terms on which insurance is provided could be used as a substitute for the loss of incentives to reduce accident risks. Shavell suggests that the determination of premium prices and increments can be based on the definition of negligence. Indeed, Shavell shows that tort liability combined with insurance not only generates an efficient amount of care but satisfies the deterrence and compensation goals of tort law, which liability rules alone could not achieve.

In terms of the model for deterrence it can be demonstrated that attaining an optimal solution is possible with the presence of insurance. Suppose an insurance premium, I, which is an inverse function of the level of

precautions, X, is charged to the insured. The injurer's cost minimizing function can be written as follows:

$$(2.23) \qquad C = uX + I(1-X)$$

By minimizing C with respect to X, the first order conditions are obtained as follows:

$$(2.24) \qquad u = I_X$$

The individual will minimize his costs when the cost of an additional unit of precaution is equal to the reduction of insurance costs from engaging in that additional unit of precaution. The marginal cost of insurance is the premium increment given a change in the level of care taken. This solution is efficient only if the insurer can accurately monitor the level of precaution taken by the insured. In order to arrive at an efficient solution the insurer must have perfect information concerning the level of care which the insured takes and the premium must be set equal to expected accident costs. That is, $I = AP(X,Y)$.

The efficient level of care is not always attained if there is asymmetrical information between the insurer and the insured. With respect to automobile insurance, asymmetrical information occurs when the insured knows his

accident risks but the insurer cannot observe these risks. As a result, the insurer cannot price insurance according to the risks of the insured. Two problems are frequently associated with asymmetrical information: adverse selection and moral hazard. If insurance premiums are positively related to the amount of risk of the insured, adverse selection may occur because the insured has no incentive to reveal his true risk. Consequently the insured will be charged a premium lower than that which reflects his true risk. Moral hazard is also another problem associated with asymmetrical information. Once an individual has been fully insured, he will no longer be motivated to take precautions. This occurs because the insured knows his risk taking activities are unobservable to the insurer, even though these activities alter the insured's risk category.

Both moral hazard and adverse selection result in the misallocation of resources and prevent an optimal amount of precautions from being attained. Because premiums do not adequately reflect the true risks of the insured, he is not forced to face the true social costs of his actions. Consequently, insurance premiums will not motivate the individual to undertake the optimal amount of precautions. In order to address this problem, the insurer relies on indirect information which is easier and less costly to

obtain than direct information. The insurer uses the indirect information to approximate I(1-X). In the literature this information is obtained through the use of risk categories, partial insurance and past experience ratings. It is assumed that these rating techniques are utilized in conjuction with the tort liability system. Each of these schemes is examined in the following sections.

Risk Categories

Although it is difficult and costly to assess insureds' risk on an individual basis, the insurer can use past market experience to evaluate the distribution of risks among groups of individuals. The insurer can then charge premiums which are commensurate with the risk class to which the insured belongs.

The most commonly used risk classifications are those concerning age, marital status, and sex. For example, drivers belonging to the age group between 16 and 24 are known to generate the highest accident costs per capita. Because of the large losses associated with this age group, insurers tend to charge high premium prices to young drivers. The same reasoning can be applied to young, unmarried male drivers.

Premium prices which are linked to risk classifications are widely used in automobile liability insurance because this type of information is relatively easy to obtain. However, this rating technique does not provide incentives for accident avoidance. Premiums based on risk classification do not always reflect the level of care of the insured. This can be illustrated in terms of the model of accident prevention. The model is extended to include insurance. There are two elements which make up insurance prices: D, the insurance premium increment which is to be realized after an accident for which the insured was at fault, and Z, the actuarial premium which is based on factors such as age, sex, marital status and geographical place of residence. D is regarded by the insured as the accident costs he expects to pay after an accident. The insurance premium I(X) is now equal to $Z + D[1-P(X,Y)]$. Suppose that this premium is actuarially fair. That is, the premium is equal to the expected cost of an accident:

$$(2.25) \qquad Z + D[1 - P(X,Y)] = A[1 - P(X,Y)]$$

The insured's cost minimizing function can be expressed as follows:

$$(2.26) \qquad \text{Min } C = uX + Z + D[1 - P(X,Y)]$$

where C is the injurer's private cost, X is the amount of precautions he chooses to employ, u is the cost of each unit of accident prevention and P is the probability of not having an accident, given the amounts of care the injurer and the victim exert. The first order condition for an optimum is as follows:

$$(2.27) \qquad u = DP_X(X,Y)$$

The first order condition requires that the marginal cost of the insurance premium (that is, the premium increment subsequent to an accident for which the insured is at fault) is equal to the marginal benefit of avoiding an accident. Note that Z does not enter equation (2.27) because it is not a function of of the level of care taken by the insured. Therefore, for equation (2.27) to result in an efficient solution, the insurance premium must be set equal to to the expected cost of an accident, at the margin. That is,

$$(2.28) \qquad DP_X(X,Y) = AP_X(X,Y)$$

It can be shown that if the actuarial premium, Z, is not zero, D does not equal A, and therefore there is no optimal solution. Rearranging equation (2.25) gives:

$$(2.29) \qquad A = \frac{Z}{1 - P(X,Y)} + D$$

It is clear that if Z is nonzero, A is not equal to D; in fact, $D < A$. Therefore actuarial premium rating prices do not result in an efficient solution except among individuals who generate equal amounts of precautions.

This finding is intuitively appealing. For example, it is frequently cited that the high costs per capita for the drivers between the ages of 16-24 are attributed to the few that are responsible for the most serious and costly accidents. [14] Thus a particularly careful young driver will initially pay as much as a careless young driver who has not been held responsible for an accident. Furthermore, the premium does not encourage the careless driver to adopt more safety precautions. Since these premium differentials are independent of the individual's driving behavior, they do not provide any incentives for safe driving.

In recent years there has been considerable debate concerning the effectiveness of the traditional risk classification schemes. In British Columbia, Saskatchewan,

Manitoba and Quebec, it was decided that this rating technique is an ineffective deterrent to accident causing behavior and furthermore, was deemed to be unfair. As a result, the traditional risk classification system was abolished in favour of a rating scheme based primarily on past driving experience. This scheme will be discussed in a subsequent section.

Partial Insurance Coverage

Another way to reduce the misallocation of resources arising from asymmetrical information is to insure the individual for only part of his losses. This partial insurance coverage frequently takes place in the form of "deductibles". This is the amount for which the individual must self insure, with the insurer covering the remainder of the losses. For example, a $250 deductible indicates that the insured must pay for accident costs up to and including $250. Should the cost of the accident exceed this figure, the insurance company would pay for the remainder.

The purpose of a deductible is to discourage the insured from being involved in accidents. Because the individual is not fully insured, the motorist has incentive to exercise some care when driving. However, it is not

clear whether deductibles alone will bring about an adequate level of precautions.

In terms of the model, let D be the dollar value of the deductible. In order for the premium to be actuarially fair, the value of the deductible and the premium price should be equal to the social cost of accidents. That is,

$$(2.30) \qquad Z + D[1 - P(X,Y)] = A[1 - P(X,Y)]$$

As seen in equation (2.29), when Z is not zero, D is less than A, the full cost of an accident. The injurer's cost minimization function is:

$$(2.31) \qquad \text{Min } C = uX + Z + D[1 - P(X,Y)]$$

The cost minimizing condition is:

$$(2.32) \qquad u = D[P_X(X,Y)]$$

The marginal cost of taking precautions must be equal to the deductible multiplied by the probability of not having an accident given the level of precautions of the injurer and the victim. According to equation (2.30), this condition leads an optimal amount of precautions if the deductible is equal to accident costs. In other words, the

deductible must comprise the entire cost of the accident loss. Hence, "zero" insurance coverage is required to produce the social optimum. However, under this circumstance, insurance loses its function of distributing welfare evenly between two different states.

Past Experience Rating

Insurance premiums which are linked with past driving experience are another mechanism used to eliminate problems associated with asymmetrical information. Past driving experience consists of accidents for which the insured was negligent and past violations of the highway traffic code and the criminal code.

Implicit in the linking of premiums to past driving experience is the assumption that past accidents and demerit points are a good indicator of an individual's accident proneness. In an extensive empirical study, Boyer and Dionne (1987) found statistical evidence to show that past experience is indeed a good indicator of accidents. In particular, it was indicated that the number of demerit points, license suspensions and past involvement in accidents within a two year period were statistically significant in explaining the probability of an accident

for individuals. [15] Details of this study are discussed in Chapter Three.

Premiums based on past experience and number of accidents for which the insured was found negligent can be captured in the model. Let us assume that insurance prices are based on demerit points. These points are assigned when the individual has violated the highway traffic code legally enforced by a government agency. The number of assigned demerit points increases with the severity of each infraction. For example, the number of demerit points given for impaired driving is much greater than the number of demerit points assigned for driving ten kilometers above the posted highway speed limit. The probability of being assigned a demerit point $1-P^*$ is at least equal to or greater than the probability of being involved in an accident, $1-P$, and found negligent. The reasoning behind this assumption is that not all traffic violations lead to accidents, but all accidents involving negligence entail some infraction of the highway safety code. Therefore, it is assumed that $1-P^* > 1-P$.

Assume that an individual's number of demerit points can be proxied by the amount of precautions taken. The insurance premium price based on the number of demerit points is denoted by H. Then an individual's cost minimization function may be written as follows:

$$C = uX + H(1-X)[1-P^*(X,Y)] \tag{2.33}$$

The first order conditions for C to be at a minimum are:

$$u = H(1-X)P^*_X(X,Y) - H_X[1 - P^*(X,Y)] \tag{2.34}$$

The marginal cost of precautions is equal to the premium increment subject to the probability of being convicted of a traffic offense less the premium savings subsequent to a demerit free record. An efficient solution is obtained only if

$$H(1-X)P^*_X - H_X(1 - P^*) = AP_X(X,Y) \tag{2.35}$$

These results can be applied to the bonus-malus system based on past experience. This scheme consists of multi-period insurance contracting where the insurer can refer to accumulated information regarding the client's accident behavior during the negotiation process. The insurer sets the insured's premium based on past number of accidents, number of demerit points and number of licence suspensions. The key characteristic to the bonus-malus system is that in addition to penalizing the insured for careless driving behavior, the driver is rewarded for careful behavior through the reduction of premiums for

accident free periods. In this way, the insured is aware that his future premiums are dependent on both his careful driving and his careless behavior. Consequently, the insured has additional incentive to avoid accidents. Boyer and Dionne show that multi-period contracting over a sufficiently large number of periods will allow for an optimal level of accident prevention even in the presence of moral hazard and externalities. [16]

A major problem with schemes which rely heavily on past experience as reflected through accident record and demerit points is that these require substantial amounts of information. In particular, a primary issue concerns the effectiveness of imposing a penalty for accident causing behavior in a private insurance market with several competing insurers. The insurer can only obtain information on the client when he takes out an insurance policy. Therefore it would be easy for a client to obtain a more favourable rate by changing insurance companies and withholding historic information subsequent to a premium increment.

One way to reduce this adverse selection would be to permit insurers to have access to the same monopoly information. The Insurer's Advisory Organization is currently taking steps to implement a database concerning driver's claims track records classified by driver's

license rather than past insurance companies. The plan is expected to be in operation by July 1988. [17]

However, the problem may not be completely eliminated. Competition for clients may still remain and insurance companies would still be willing to insure a client even if they knew he was not telling the truth.

Companies could also form coalitions such that the client is penalized if he makes a false declaration regarding his accident history. One possibility is to charge a very high price when the client changes companies and reimburse the client a portion of the price at the end of the contract only if he has told the truth. However, there are difficulties in determining whether the client has told the truth if no historic claims record can be traced. Furthermore, in a competitive market, insurers would have incentives to reduce this price to attract new clients.

This is one reason why bonus-malus schemes have been consistently associated with monopoly insurance in Canada. Bonus-malus or claims rates scales only exist in the provinces of Manitoba, Saskatchewan and British Columbia where bodily insurance is solely provided by government agencies.

No-Fault Insurance

The economic rationale for deterrence in tort law and insurance is not widely accepted by some authorities. It is claimed that most accidents are caused by factors that are undeterrable by the threat of tort liability and insurance premium increments. Such characteristics include weather conditions, poorly designed roads, congestion, manufacturer defects in motor vehicles and human error attributed to failure of imagination and lack of judgement. This argument forms the basic philosophy behind no-fault insurance.

In the extreme form of no-fault insurance, the insured is compensated by his own insurance company for all accident costs without reference to causation or fault. The premiums are largely based on a gasoline tax, driver license fees, vehicle registrations and vehicle use; thus the intensity of driving can be extracted. This extreme version of no-fault insurance implies no premium increments subsequent to accidents or convictions of accident causing behavior. Although the value of the premiums in this scheme are unrelated to the amount care taken by the insured, it does exist in Quebec and some other parts of the world and therefore deserves some attention. Because

such a scheme places no emphasis on accident causing behavior nor accidents involving negligence, the scheme will not encourage the insured to take an optimal amount of precautions. This result can be illustrated by the model of deterrence.

Let N be the premium charge based on type of vehicle, v, the age of driver, a, a road tax, r, and geographic place of residence, g. There are no factors related to X, the number of precautions taken by the insured, included in the premium price. Since the insured is compensated for accident losses regardless of negligence, A[1 - P(X,Y)] does not enter the individual's cost minimizing function. The insured's costs can be expressed as follows:

$$C = uX + N(r, a, g, ...) \tag{2.36}$$

For the individual's private costs to be minimized, the following first order condition must be satisfied:

$$u = 0 \tag{2.37}$$

The marginal cost of precautions must be equal to zero. This condition implies that the individual will take no precautions at all if he is to minimize his costs. This result is not unexpected; the insured has no incentive to

take any precautions because they are external to his cost minimizing function.

It should be noted that this extreme form of no-fault insurance is not prevalent in all no-fault insurance schemes. It is possible to have a no-fault program combined with premium increments which are dependent on driving behavior. Indeed the issue of deterrence does not concern whether or not a no-fault insurance scheme exists, rather, it depends on the type of premium rating scheme which is in effect. This concept is addressed in greater detail in Chapter Four.

Summary and Conclusion

At the start of this chapter a model for deterrence was developed. It was shown that the "first best solution" could be obtained if potential injurers and potential victims could bargain costlessly prior to an accident. However, identification of such parties is extremely costly, if not impossible; therefore, achieving an optimal solution required the intervention of a third party. The purpose of this chapter was to examine the effects of external intervention on the optimal level of precautions. Three types of intervention were discussed: tort law,

taxes, safety regulation and fines, and insurance rating characteristics.

It was found that taxes are generally not expected to be effective in preventing automobile accidents. Although taxes can reduce the amount of driving, thereby reducing the number of automobile accidents as a possible side effect, taxes cannot directly affect the accident rate because they cannot distinguish between safe and unsafe driving, nor can they be varied with the marginal costs of accident causing activity. It was found that the tax which brought about an optimal amount of precautions was one which reflected the expected damages resulting from an individual's choice of precautions. A problem with this tax structure is that it is difficult to quantify expected accident costs on the basis of different types of accident avoidance activity.

Fines and safety regulation are just another form of taxes. Enforcement of a safety standard and imposing fines on individuals who do not meet this safety standard can influence the accident rate provided that the standard reflects the optimal level of precautions. However, it is difficult to identify the optimal standard as the effects of regulation are not always quantifiable.

It was found that negligence combined with tort liability rules produce an optimal amount of deterrence.

The injurer is held liable for the accident costs if he is found negligent. This rule induces all rational individuals to undertake the optimal amount of precautions because prevention is cheaper than paying the accident costs. Thus liability rules will lead to the optimal amount of precautions, and there will be no accidents deemed negligent by the courts.

The final section contained a discussion on insurance. The objective of this section was to trace the effects of different premium rating schemes on the optimal level of precautions. Accidents can cause a sudden large loss to victims, and therefore there is a requirement for insurance. An important function of insurance is to balance wealth between different states (i.e. an accident situation and a non-accident situation) such that the marginal utility of income is equal for all states. It was shown that an optimal amount of precautions could be achieved with the presence of insurance, provided that the insurer had perfect information on the behavior of the insured.

However, with imperfect information, there is a conflict between insurance and deterrence. As the compensation becomes more complete, the insured is less likely to exercise the "optimal" amount of care. Because insurers cannot accurately tailor insurance prices to

reflect the behavior of the insured, problems concerning moral hazard are likely to arise.

Insurers must rely on indirect information to assess premiums. Such information includes risk classifications and demerit points. In addition, insurers frequently use deductibles to encourage accident avoidance. These types of premium classifications were examined. The results from the model of deterrence suggest that the scheme which is most likely to result in the optimal solution is the one which bases its insurance premiums on the driving behavior of the insured. Such a scheme is the demerit point system; violation of the highway safety code is the closest proxy for accident causing behavior. It is also clear from the model that insurance premiums which bear no relation to accident causing activity do not encourage the optimal amount of precautions. In fact, they may lead to an increase in accidents. Insurance premiums based solely on risk classifications and no-fault insurance are schemes which fall into this category.

In subsequent chapters the results of the model for deterrence are tested empirically. Before turning to the econometric model which is used to test deterrence and no-fault automobile insurance, it is useful to examine some previous studies relating to the deterrence of automobile accidents.

Notes to Chapter Two

1. See J. P. Brown (1973), pp. 186-189.

2. Ibid., pp.340-341

3. In the economics literature this is referred to as an externality. For a discussion of externalities see Russell and Wilkinson (1980), p. 198.

4. See Coase (1960), pp. 1-44. A good discussion of the Coase Theorem and its limitations MaKaay (1980), pp.48-60.

5. Even if potential injurers were identifiable, the potential victim is essentially paying potential injurers to give up their rights to injure. This means that either all non-injurers must be paid, or there is a potential for blackmail, as those holding the rights to injure rush to identify themselves as potential injurers.

6. Dobbs (1985), p. 4.

7. See Brown (1973), pp. 340-343.

8. Ibid., pp. 331-345.

9. Taxes have also been suggested by no-fault proponents not only as a means to reduce accidents by decreasing the amount of driving, but also as a mechanism for financing no-fault insurance schemes. It is thought that taxes force drivers to bear the costs of accidents they generate and lets drivers decide under taxes whether it is worth engaging in motoring activities. In the law and economics literature this concept is frequently referred to as general deterrence. See Calabresi (1970), pp. 68-94, and Atiyah (1980), pp. 577-613 for an extensive discussion on general deterrence.

10. Peltzman (1975) argues that offsetting behavior can occur as a result of regulation. He demonstrates that people tend to substitute the marginal benefits of driving carelessly for the reduced cost of risk brought about by safety regulation. Although several studies provide evidence to contradict Peltzman's theory, (see Josch (1976), Robertson (1977), and Crandall and Graham (1984)), the extent to which this offsetting behavior is associated with safety regulation remains a significant issue of debate. If offsetting behavior exists and is not measurable, an optimal level of precautions may not be reached if regulation is used as a deterrent.

11. Shavell (1982), pp. 120-122.

12. This is a major argument put forth by no-fault proponents who support the abolishment of tort law. This argument not only applies to the automobile insurance field, it also applies to medical malpractice, products liability and worker's compensation. See Keeton and O'Connell (1965).

13. Shavell (1982), pp.120-125.

14. MacKaay (1980), p. 192.

15. Boyer and Dionne (1987), pp. 188-192.

16. See Boyer and Dionne (1985), pp.28-32.

17. Ontario Task Force on Insurance (1986), p. 97, and Insurance Bureau of Canada (1987), p. 2.

CHAPTER THREE

LITERATURE REVIEW

Introduction

In the previous chapter the theory concerning deterrence to accident causing behavior was briefly outlined. A divergence often occurs between the theoretical literature and the applied work. In some cases a theory cannot be tested due to lack of data, and in other circumstances empirical results tend to contradict the theory. It would therefore be interesting to examine the empirical results to determine whether they are consistent with the theory. Hence this chapter is focused on a review of the empirical literature concerning the investigation of the effects of no-fault insurance on the automobile accident rate. The studies which are to be examined typically estimate a regression relationship between accident data and a set of socio-economic factors which are thought to serve as explanatory variables.

This chapter begins by reviewing the empirical studies pertaining to the no-fault - accident rate relationship. A critical assessment of the literature follows, in which model specifications and econometric techniques are

highlighted. The last section contains a brief summary and conclusion.

Review of the Empirical Literature

There appears to be a divergence between theory and empirical results reflected in the literature. The economic theory does not provide clear direction for empirical research. Some studies base their empirical models on economic theory while others appear to be constructed in an ad-hoc fashion. Generally, the approach of the empirical literature has been to trace the effects of no-fault insurance on the social cost of accidents over a period of time or across geographical regions.

There are certain inherent difficulties in categorizing the various empirical studies pertaining to the no-fault - accident relationship. One reason is that relatively few studies exist which specifically deal with this issue. Furthermore, most of the studies contain similar model specifications.

The approach taken here is chronological. The review begins with a discussion of the pioneering work in the field, followed by a brief summary of Landes' model (Landes 1982) and subsequent critiques and refinements. Finally, a

series of independent studies which do not directly refer to Landes' model are outlined.

Early Models

One of the earliest investigations concerning the deterrent effects of tort law and liability insurance was conducted by Grayston (1971). The hypothesis of the study was that proponents of alternative systems to tort law of allocating accident costs, particularly those who advocate no-fault insurance are incorrect in asserting that liability insurance removes the deterrent effect provided by tort law. This hypothesis was tested by showing that the deterrence to accidents is present in those schemes which place emphasis on driving behavior.

A model was constructed to determine the effects of eliminating premium increments based on driving behavior in favour of an insurance scheme which does not hold drivers financially responsible for the accidents they cause. The regression equation took the form as follows:

(3.1) $$A_t = g(D_t, W_t, U_t, S_t, N_t, M_t)$$

where

A_t = automobile accidents per 1000 vehicle registrations in period t or state t

Dt = index of the degree to which the liability insurance rate structure is able to concentrate accident costs on those most likely to be at fault in accidents, in period t or state t.
Wt = weather index (average annual temperature in period t or state t
Ut = degree of urbanization - urban road mileage as a percent of total road mileage in period t or state t
St = percent of highway mileage surfaced in period t or state t
Nt = new motor vehicle registrations as a percent of total motor vehicle registrations in period t or state t
Mt = average annual automobile mileage (in thousands) in period t or state t

Three stage least squares regressions were run using cross section and time series data for the years 1961 to 1968. Equations were also run using automobile accident injuries per thousand vehicle registrations, and automobile accidents per thousand vehicle registrations as dependent variable. Of all equations regressed, three stage estimates using the traffic fatalities rate as the dependent variable provided the most significant results. This was to be expected; there is a greater tendency for fatalities to be reported than minor property damage or minor injuries due to automobile accidents.

The goodness of fit coefficient (R2) [1] ranged from 0.5547 to 0.7673 indicating that the independent variables explained 55 to 76 percent of the variation in the accident rates. An F test was performed [2]. The F test indicated

that the model represented a significant association between the variables at the one percent level [3].

A unique feature of this model was the variable Dt, the index measuring the degree to which premium rate structures allocate accident costs to those most likely to cause accidents. The index was based on the square root of the total number of merit classes within an insurance rating scheme. The square root was employed because it gave less weight to those schemes with a large number of class ratings. The reasoning behind this distinction was that as the number of rating classes increases, the marginal incentive to switch to an adjacent, more preferable class was relatively smaller than those incentives for less fine rating schemes. [4]

The coefficient for Dt was negative, as expected, and at least five out of eight coefficients were statistically significant at the five percent level. This result indicated that insurance schemes which tailor insurance premiums to accident behavior are associated with a decrease in the overall accident rate. In addition, the coefficients for the weather index, and the average annual automobile mileage were found to be positive, as expected, and the coefficients for the degree of urbanization, percentage of highway mileage surfaced, and new motor vehicle registrations were negative, as expected.

Grayston's results suggested that insurance schemes which attempt to concentrate automobile accident costs on those most likely to be at fault tended to reduce the accident rate. The basic conclusion of the study was that there is a strong deterrent to accident causing behavior present in liability insurance. Furthermore, accident allocation costs schemes which place less burden on those more likely to cause accidents will lead to an increased accident injury and death rate.

Landes' Study and Subsequent Models

Surprisingly, relatively little empirical research was completed concerning the no-fault - accident rate issue in the 1970's, which were the formative years of no-fault insurance legislation [5]. Major attempts to investigate the effects of no-fault insurance on automobile death rates did not continue until recently [6].

Landes (1982) developed a theoretical and empirical model to determine the effects of no-fault insurance on automobile fatality rates within no-fault jurisdictions between the years 1967 and 1975. During these years, no-fault schemes were not uniform - for example, medical coverage ranged from $200 in New Jersey to $2000 in Minnesota. To account for this variability, several

"stringency" indices were used to measure the degree of restriction on tort liability, or the tort threshold of each state [7]. The injured victim of an automobile accident is allowed to sue for damages through tort law only if his or her medical expenses exceeded this tort threshold. Landes constructed a THRESH index, which measured the dollar medical expense threshold of a state; that is, the maximum amount of no-fault personal injury coverage provided by each state. Landes also used the variable RTHRESH, which was the dollar value medical expense threshold of a state deflated by the real value of medical expenses. A third measure, PCL, the proportion of insurance claims in which the victim is denied legal action by the state's tort threshold was also used.

The annual number of fatal accidents was regressed on state population, state density, D2 - a dummy variable indicating whether or not a particular state had a no-fault plan, D1, a dummy variable indicating the state of Michigan the only state to have unlimited medical expenses covered by a no-fault plan, and one of three stringency indices: THRESH, RTHRESH or PCL. In addition, state and time dummy variables were included in the regression to capture the variability in the characteristics across the states or through time. Increasing gasoline prices, regions with

better roads, and improvements in automobile technology were some of the factors hoped to be captured.

The model was applied to a combination of cross section and time series data for fifty states and the district of Columbia, and also a sample set of data for fifteen states which adopted no-fault insurance between the years 1967 and 1976. The variables THRESH, RTHRESH, fatal accidents and population were expressed in natural logarithms. The equation containing the variable THRESH as a measure of liability restriction produced the "best" results. Except for very low thresholds of $200, the coefficients of the degree of restriction on tort liability were positive. As the tort threshold increased, the coefficients increased in value. Landes found that in those states with a medical expense threshold of $500, there was a 3.3 per cent increase in fatal accidents, and in those jurisdictions with a threshold of $2000, there was a 12.5 per cent increase in fatal accidents. These coefficients were significant at a five percent level. The coefficients for the population density were also found to be statistically significant and positive. These results indicate that the tort threshold effect on fatal accidents is stronger in those states with high population densities.

Landes concluded in her study that no-fault automobile insurance results in a substantial increase in traffic

fatalities. She noted that between 1971 and 1976, those states which enacted no-fault insurance experienced an increase of 376 to 1009 additional automobile accident deaths during the years in which no-fault insurance was in effect.

This seminal work initiated a series of subsequent studies in which refinements of Landes' model were introduced. These studies are briefly outlined in the following paragraphs.

O'Connell and Levmore (1983) questioned the validity of Landes' model. They argued that since all states retain the right to legal action for all automobile accidents resulting in death, traffic fatality rates were not a good measure for determining the effects of no-fault automobile insurance on the cost of accidents. Furthermore, the authors maintained that the tort thresholds in the no-fault states are relatively low, and such small amounts of no-fault coverage would only affect driving behavior in cases where there was little risk of injury. Although O'Connell and Levmore criticized Landes' methodology, they offered no new estimates.

Swan (1984) was also sceptical of the economic significance attached to Landes' results. A major criticism concerned the model specification. Variables which might have influenced the automobile fatality rates such as seatbelt legislation, random breath tests, number and type of vehicle, and motor fuel consumption were not included in the Landes model. In addition, with the exception of a few coefficients, he noted that most of the results were of relatively low statistical significance.

Swan respecified Landes' model to include population per vehicle, motor spirit consumption per vehicle, real price of gasoline, seatbelts, random breath tests and a no-fault dummy variable as the set of independent variables in the equation. Three ordinary least squares regressions were run with the dependent variables given by the death rate, injury rate, and the accident rate, respectively. All equations were expressed in log linear forms so that the results could be interpreted in terms of elasticities. [8]

The model was applied to pooled cross section and time series data for New Zealand and Australian States and Territories for the years 1961 to 1981. Swan's "best" equation was as follows:

$$(3.2) \qquad DR = \underset{(-2.30)}{-0.777} + \underset{(3.40)}{.0196(NF)} + \underset{(3.08)}{0.286(POP)} +$$

$$0.759(MS) - 0.202(RP) - 0.474(SB)$$
$$(6.62) \qquad (-2.04) \qquad (-8.43)$$

$$- 0.145(RB) + 8 \text{ REGIONAL DUMMIES}$$
$$(-2.26)$$

$$R\text{-squared} = 0.91 \quad DW = 1.71$$

where

DR = Death rate
NF = 1 for those states with no-fault insurance
0 otherwise
POP = population per vehicle
MS = Motor spirit consumption expressed in litres per vehicle
RP = Real price of petrol expressed in cents per litre
SB = Seatbelt effect
RB = Random breath test effect

The explanatory power of the model proved to be satisfactory: the adjusted goodness of fit coefficient ranged from 0.86 for the equation with the injury rate as the dependent variable to 0.91 for the equation with the death rate as the dependent variable. The F statistic revealed that there was little chance of multicollinearity being present. The Durbin Watson statistic was close to the value of 2, indicating that autocorrelation was not apparent [9]. The regression including fatalities as the dependent variable produced the most significant results. Less confidence was attached to the regressions containing accident rates and injuries, because the method of

reporting injuries and accidents varies over the jurisdictions and through time.

For the equation with fatalities as the dependent variable, the coefficient of 0.0196 for the no-fault variable was significant at the one percent level. This result suggested that, holding all other explanatory variables constant, no-fault legislation accounted for a 2 percent increase in the fatality rate.

The estimates of the other independent variables are also of interest. All of these variables were statistically significant at the five percent level or better, indicating that there was a 95 percent chance that these results were not obtained at random. The signs of the coefficients for population per vehicle and gasoline consumption per vehicle were positive, as expected, and the signs of the coefficients for real price of gasoline, seatbelt effect, and random breath tests were negative, as stated apriori.

The results of Swan's model supported the hypothesis that no-fault automobile insurance leads to a significant increase in automobile accidents causing deaths. Although Swan's results are statistically significant, he did not test for the robustness or stability of the model [10].

The work of Zador and Lund (1986) is essentially a critique of Landes' model. The authors pointed out that the model failed to include many variables which influenced the fatality rate. However, they did not add any new explanatory variables to Landes' model. The authors' strongest criticism was concerned with the procedure Landes employed for estimating levels of stringency. They found that the dummy variable D2, which indicated whether or not a state has no-fault insurance was highly collinear with the stringency values - THRESH, RTHRESH, and PCL [11].

To correct for multicollinearity, the authors transformed the stringency variables. Instead of estimating D2 and the stringency variables separately, these were multiplied together to form one variable called the "stringency range" [12].

Zador and Lund reestimated Landes' model utilizing "stringency range" instead of tort threshold indices. Multiple regressions on data for fifty-one states for the years 1967 to 1980 were performed. The effect of no-fault automobile insurance on fatal accidents for all regressions was found to be insignificant except for one equation, where the signs of the coefficients appeared negative. This result suggested that the number of fatal crashes was slightly lower in jurisdictions with no-fault laws compared with those states without restriction on tort liability.

However, Zador and Lund noted that "the finding should be viewed with caution, because no convincing theoretical reasons exist to expect this curvilinear effect" [13]. Furthermore, regional differences could explain this unexpected result. Geographical location was found to be a statistically significant control in the regression.

On the basis of their results, Zador and Lund concluded that no-fault automobile insurance laws which restrict the amount of tort recovery do not lead to an increase in fatal injuries in the United States. They pointed out that the low statistical significance of the results seem to indicate that very little relation exists between no-fault insurance and fatality rates. However, the low statistical significance could also be attributed to variations in insurance rating schemes among the no-fault states. Furthermore, heteroskedasticity (unequal variances in the disturbance terms), which is a common problem associated with cross section data may have accounted for some of the insignificant results. The authors did not address this econometric issue.

Independent Models

There are a number of studies which were developed independently of Landes' model. Although these studies

have employed basically the same techniques, some conflicting results are produced. In the following paragraphs these studies are briefly summarized.

Kochanowski and Young (1985) conducted an empirical study to determine the effects of no-fault insurance on fatal automobile accidents. Like Zador and Lund, they found little association between no-fault insurance and accident rates. In hope of establishing a relationship between the probability of a fatal accident occurring and specific state characteristics, the following model was posited:

(3.3) Pi = pi(PERYG, PEROL, PERMA, INCOME, POPSQ, ARESMI, DWIMI, G55MPH, SA/Vm>55, DWIPCALC, VM>55/POPSQ, I, R)

where

Pi = Fatalities per 100,000,000 vehicle miles
PERYG = percent of licensed drivers under 20 years of age
PEROL = percent of licensed drivers over 65 years of age
PERMA = percent males in licensed driving population
INCOME = per capita state income
PCALC = per capita consumption of ethanol
POPSQ = population per square mile
ARESMI = speeding arrests per 100,000,000 vehicle miles

DWIMI = arrests for driving under the influence of alcohol per 100,000,000 miles
G55MPH = percent of vehicles exceeding 55 miles per hour
SA/VM>55 = speeding arrests over vehicle miles in excess of 55 miles per hour
DWI/PCALC = arrests for driving under the influence over per capita consumption of alcohol
VM>55/POPSQ = vehicle miles in excess of 55 miles per hour over population per square mile
I = measure of the type of automobile insurance present in state i (i.e., fault or no-fault)
R = a vector of random influences and omitted factors related to fatal accidents in state i

Of particular interest is the vector I which represents insurance characteristics. The authors recognized that four basic types of automobile insurance existed in the United States for the years 1975 to 1977: no-fault insurance, no-fault insurance plus add-on insurance, liability insurance plus add-on no-fault insurance, and liability insurance. In order to capture the differences between the various types of programs, three dummy variables were used. States with liability insurance are the reference group for the dummy variables. TYPEINS1 indicated whether or not a state had no-fault insurance, TYPEINS2 referred to whether or not a state had "pure" no-fault insurance [14], and the variable ADD-ON indicated whether or not fault states had the option of

"add-on" no-fault provisions. In addition, the authors included the variable TYPEINS3 which was the percentage of tort claims made ineligible by no-fault insurance for each of the no-fault states.

Regressions were performed using cross section data and quarterly time series data for fifty-one states and the years 1975, 1976 and 1977. Although the authors were unable to perform regressions for two quarter due to lack of data, they found that the model was reasonably successful in linking state characteristics with fatal accidents. The F statistics were significant at the one percent value, indicating a high linear association between the set of explanatory variables and the explained variable. The model was significant in explaining approximately sixty percent of the cross state variations in fatal injuries.

Of the sixteen regressions run, most of the coefficients of Ii, that is, the type of insurance for state i, were statistically insignificant at the conventional five percent level. The four coefficients which displayed statistical significance had a negative sign, contrary to apriori expectations, indicating that the rate of fatal accidents was sightly reduced in those jurisdictions with no-fault insurance [15]. The authors hypothesized that TYPEINS3 - the variable which measured

the percentage of claims made inelegible by the state tort threshold is expected to have more statistical significance than TYPEINS2 and TYPEINS1, which specified no-fault and true no-fault jurisdictions. On the contrary, this measure turned out to be the weakest variable of the three.

Low statistical significance among the explanatory variables is often an indication of multicollinearity. A zero order correlation matrix was calculated for interactive variables such as alcohol consumption and drunk driving arrests, vehicles travelling in excess of 55 miles per hour and speeding arrests, and vehicles in excess of 55 miles per hour and population density. The extremely low values indicated that there was little chance of multicollinearity being present among these variables.

The coefficients of the variables PERYG, PERMA and POPSQ were found to be positive in sign and statistically significant at the five percent level. INCOME was negative in sign, and statistically insignificant. The link between the number of speeding arrests, SA/VM>55, and fatal accident rate was positive and significant at the five percent level indicating that more fatalities were found in states with a greater number of speeding arrests. While this result seems paradoxical at first, the authors concluded that such a result is plausible. They noted that a high number of speeding arrest would indicate a more

dangerous driving environment, and a higher chance of fatal accident occurrences [16].

Another interesting result is that the authors found virtually no relationship between speeding and fatal injuries. The coefficients for the G55MPH were very close to zero, and statistically insignificant. Inspection of a covariance matrix revealed little multicollinearity among these variables. This result implied that the variability of speed across the states has no bearing on fatal injuries.

Kochanowski and Young's results supported the hypothesis that no-fault automobile insurance does not result in a higher traffic fatality rate. In fact, the authors concluded that there exists no relationship between no-fault insurance and fatality rates, and that fears of a dramatic increase in deaths as a result of no-fault insurance appear to have no empirical foundation.

Medoff and Magaddino (1982) conducted a study to test the hypothesis that no-fault insurance reduces the deterrence of accident causing behavior. Instead of using the highway fatality rate as the independent variable, accident loss ratios experienced by state insurance companies were used. The loss ratio (LR) was measured by

the ratio of accident claims costs to the average premium per insured vehicle multiplied by the ratio of number of accidents over the number of insured vehicles.

Four dummy variables were used to distinguish the different types of no-fault statutes enacted throughout each state. MNF indicated mandatory no-fault insurance where the right to sue for liability has been restricted, CNF indicated all states which have compulsory no-fault insurance, but either have some or no restrictions on tort liability, ALLNF indicated states which have optional no-fault insurance, where the right to legal action may or may not be restricted, and finally the variable PNF represented those states which have a "pure" no-fault system, which was a scheme closest to the plan proposed by Keeton and O'Connell [17]. The authors hypothesized that the PNF states should have the greatest impact on state loss ratios, followed by MNF, CNF and ALLNF.

Two stage least squares regressions were run using cross section data for fifty one states in the year 1977. The results of these regressions were reported as follows:

$$(3.4) \quad LR = \underset{(-.26)}{-10.65} - \underset{(1.69)}{.118}COST - \underset{(-.72)}{.044}TEMP - \underset{(-1.74)}{.079}RAIN$$

$$+ \underset{(.69)}{.057}SMSA + \underset{(.74)}{.413}AGE + \underset{(2.05)}{1.37}MALE + \underset{(1.27)}{.001}INC$$

$$- .476SPDLMT + 3\ REGIONAL\ DUMMIES + \underset{(-2.07)}{}$$

$$\underset{(.78)}{1.609NF}$$

R-squared value: 0.31

where

LR = Loss Ratio
C = intercept
COST = Average cost of insurance premiums
TEMP = the number of days of the year that the temperature was 32 degrees farenheit or less
RAIN = average number of days where precipitation was 0.1 inches or more
SMSA = the percentage of population residing in metropolitan areas
AGE = percentage of drivers under 25 years of age
MALE = percentage of drivers who are male
INC = median income earnings of individuals 16 years of age or older
SPDLMT = percentage of vehicles traveling over 55 miles per hour
NF = No-Fault insurance

The goodness of fit coefficients ranged from 0.31 to 0.45 indicating that the independent variables were only 40 percent successful in explaining the state variances among the loss ratios.

The signs of PNF, and CNF were positive and significant at the ten percent level. The coefficient for MNF was 6.308, and was statistically significant at the one percent level. ALLNF was positive in sign but not significant in explaining the variance of state loss ratios

among the states. This result was not unexpected, since these states experienced little or no change in their tort liability system with the introduction of no-fault insurance.

Other explanatory variables which were significant at the five percent level were the coefficients for the percentage of male drivers, which was positive, as expected. The coefficient for the percentage of vehicles exceeding the 55 miles per hour was negative in sign, which was unexpected. This result implied that low speed drivers incur a greater risk of being involved in an accident than those who exceeded the 55 miles per hour speed limit. The authors suggest that traffic conditions govern driving speed more than the posted speed limit. Therefore, accident occurrences may depend less on speed and more on the deviation of a vehicle's speed from the general flow of traffic [18].

Medoff and Magaddino's overall result suggest that the states with no-fault legislation experience a greater accident loss ratio that those without no-fault insurance. They concluded that those states with PNF experienced the greatest an increase of 7.449 percent in loss ratios, those states with MNF and CNF experienced on increase of 6.308 percent and 3.995 percent in loss ratios, respectively, in the year 1977 as a result of the adoption of no-fault

insurance. However, these results do not necessarily imply an increase in the accident rate as the authors claim. Loss ratios are a poor measure of the accident rate as they are subjected to distortions of underreporting and are sensitive to variations of insurance requirements (i.e. minimum damage levels) across states and through time. Furthermore, an increase in loss ratio cannot always be associated with an increase in accident rates; it may well be that there is a tendency to file greater insurance cost claims in no-fault jurisdictions because of the relatively easy access to compensation. In light of these factors, Medoff and Magaddino's results cannot be considered conclusive.

Gaudry (1985) constructed a model, entitled DRAG, to explain the demand for road use (DR), accidents (AC), and their severity (GR) and the number of highway injury victims (VI) for the province of Quebec. The basic structure of the model is described as follows:

Demand equation:

(3.5) $DR = DR(gas, dei)$

Performance equations:

(3.6) AC = AC(DR, mat, n.f., fa, cor, acc)
(3.7) GR = GR(DR, inj, fat, vic)
(3.8) VI = AC X GR

where

gas = gasoline sales
dei = sales of deisel
mat = accidents with material damages only
n.f. = nonfatal accidents
fa = fatal accidents
cor = accidents with bodily damages for n.f. and fa
acc = accident total (mat + n.f. + f)
mbc = "morbidity" of accidents with corporal damages
mtc = mortality of accidents with corporal damages
inj = injuries
fat = fatalities
vic = victims (inj + fat)

By examining the equations simultaneously effects of no-fault Quebec automobile insurance on the number of road victims can be traced in two ways: directly through the type of accident and its severity, and indirectly through the demand for road use. The authors hypothesized that the Quebec Automobile Insurance Act should lead to a simultaneous increase in accident property damage, injuries and fatalities.

The model was applied to Quebec monthly time series data for the years 1956 to 1982. The equations of the model were estimated using Box-Cox transformations on both the independent and dependent variables [19]. Problems of autocorrelation and heteroskedasticity were recognized and

corrected accordingly, so that truly random variances in the regression errors were obtained.

The effects of no-fault legislation in Quebec can be traced in three ways: the direct effect, which measures the change in accidents as a result of the introduction of no-fault insurance, holding road use constant; the indirect effect, which depicts the change in accidents associated with no-fault insurance, allowing road use to vary; and finally, the total effect, which combines the indirect and direct effects. Gaudry's results are listed as follows:

Table 3.1

Effect of Insurance (%change)

Dependent Variable	Direct	Indirect	Total
(1) Accidents with only property damage	8.5 (1.04)	2.5	11.0
(2) Accidents with at least one injury but no deaths	26.3 (5.94)	1.4	27.7
(3) Fatal Accidents	3.3 (.58)	1.7	5.0
Deaths	3.6	3.2	6.8
(2) + (3)	23.8	1.4	25.2
(1) + (2) + (3)	14.7	2.3	17.0

The results supported the author's apriori expectations. There was a 17 percent increase in the overall number of accidents as a result of the Quebec Automobile Insurance Act. Accidents involving personal injuries but no deaths

increased by 27.7 percent. This result was statistically significant at the five percent level, indicating a 95 percent probability that this estimate was not obtained by chance. Fatal accidents increased by 5 percent as a result of no-fault insurance, but this estimate was not statistically significant. There was a 1.7 percent increase in the demand for road use, leading to a 1.4 percent increase in the number of injuries and a 2.5 increase in material damages, as a direct result of the increase in road use.

Structural stability was tested by examining the order of magnitude of the results after changing the functional form of the variables in the model. It was found that the magnitude of the results were not changed, indicating that the model was numerically robust.

On the basis of the DRAG model, Gaudry concluded that there was a sizable increase in accidents involving material damages, injuries and fatalities as a result of the enactment of the 1978 Quebec Automobile Insurance Act. However, only the estimate of the increase of 27.7 percent in non fatal injuries was statistically significant. Although this estimate seems to be larger than most estimates in other studies, Gaudry claims that these results are "conservative" when compared to the results

obtained by visual analysis and loss rating experience of Quebec insurance companies [20] .

Rea (1986) questioned the economic significance of the DRAG model, particularly the 27.7 percent increase in injuries as a result of the Quebec Automobile Insurance Act. He suggested that the dramatic increase in injuries may not be entirely attributed to the no-fault insurance legislation. He pointed out the possibility of an increase in the reporting of accidents due to the accessibility to compensation without the determination of fault. If this is true, Rea suspected that there will be an incentive to exaggerate losses when fewer resources are devoted to the determination of fault. At any rate, reported injuries is not an accurate proxy for the social costs of accidents, as they are subjected to biases of reporting standards, which change over time.

Boyer and Dionne (1987) used Gaudry's results to criticize the Quebec No-fault Automobile Insurance system. They pointed out that the increase in accidents can be attributed to the no-fault premium price which is based neither on risk classifications nor driving experience. They suggest that accidents in Quebec would be reduced substantially if premium prices were based on driving

behavior and accident experience. To support this recommendation the authors estimated a statistical relationship between past driving experience and the probability of accidents using data obtained from a sample of 19013 drivers for the years 1982-83.

The model employed 53 variables including population characteristics, demographics, class of license and behavioral variables. Of particular importance were the variables X, the individual's number of demerit points accumulated in the 1982-83, Y, the individual's number of license suspensions for criminal offenses effective in the past year, and Z, the individual's number of accidents in the past two years. For the first model the dependent variable consisted of a dummy variable equal to zero for individuals with perfect driving records and one otherwise. A second model was also developed to reflect accident experience. The dependent variable was equal to zero if the individual had no serious accidents during the years 1982-83, and equal to zero otherwise. The purpose of this model is to provide evidence suggesting that premiums tailored to driving behavior are sufficient incentives to reduce accident occurrences even in the presence of no-fault insurance. The results for the models are reported as follows:

Table 3.2

Model I

Dependent variable: 0 no accident
1 otherwise
Adjusted R-squared value: 0.0407
F Statistic: 1.52

Variable	Coefficient	t stat
X	0.011	(12.37)
Y	0.057	(2.77)
Z	0.040	(10.05)

Model II

Dependent Variable: O no serious accident
1 otherwise
Adjusted R-squared Value: .0124
F Statistic: 6.5378

Variable	Coefficient	t stat
X	0.0013	(3.39)
Y	0.0267	(2.94)
Z	0.0120	(6.92)

It was found that the coefficients for X, Y, and Z in both models were positive and significant indicating that driving experience is a good predictor of accident probabilities. Boyer and Dionne also found that it takes 5 demerit points to double the average probability of an accident while it takes 9 demerit points to double the probability of a serious accident. Similarly, one accident on the driving record indicated a 60 percent higher than average chance of incurring another accident. Indeed, these results suggest that premiums which are commensurate with driving behavior and accident experience are good predictors of accident risks. On the basis of these

results the authors conclude that premium rating schemes which are based on driving record act as deterrents to accident causing behavior. However, the low adjusted R-squared value indicated that the models were not successful in explaining the variation in accident records. Therefore the results should be interpreted with some caution.

Graham and Garber (1984) investigated the effects of safety legislation on the motor vehicle occupant death rate. Although they did not specifically examine the effects of no-fault automobile insurance on the fatality rate, they did include a no-fault insurance variable and a cost of accident index in their estimation equation, which yielded some interesting results.

The model was estimated for the United States using time series data for the years 1966 to 1980. The equation utilizing occupant death rates as a dependent variable was as follows:

$$(3.9) \quad VODR = \underset{(-0.85)}{-2.84} - \underset{(-2.36)}{1.31(REG)} - \underset{(0.43)}{0.02(SPEE)} +$$

$$\underset{(1.51)}{1.38(PCALC)} + \underset{(.0.99)}{12.2(PCDRV)} - \underset{(-1.09)}{2.78(URB)}$$

$$+ 12.93(PCVMT) + 0.74(PCSMALL) -$$

$$(3.50) \qquad (0.36)$$

$$- 0.93(NF) + 0.14(COA) + 0.59(PCREI)$$
$$(-0.73) \qquad (0.86) \qquad (2.14)$$

$$- 0.16T + e$$
$$(-6.14)$$

where

c = intercept
REG = proportion of miles driven by trucks subject to safety standards
SPEE = average off-peak hour speed of vehicles on main rural highways
PCALC = consumption of alcohol per working adult
PCDRV = proportion of licensed drivers under the age of 25
PCKVMT = proportion of miles driven by trucks
PCSMALL = proportion of miles driven by compact and subcompact cars
NOFAULT = proportion of vehicles registered in states with no-fault laws
COA = cost of accident index [21]
PCREI = real earned income per working adult
T = a linear time trend
e = a stochastic disturbance term

The goodness of fit coefficient indicated that the model was successful in explaining 98 percent of the variation in the United States car, truck and bus fatality rate. The coefficients of the explanatory variables contained the same signs as the authors hypothesized, with the exception of the no-fault and cost of accident variable. The authors expected that a higher accident rate would be associated

with no-fault insurance because it was thought that no-fault laws tend to reduce the monetary incentives to drive carefully. The unexpected negative sign attached to the coefficients of the no-fault variable and the cost of accident variable seemed to imply one of three things: either that the model was misspecified, or that monetary incentives to drive cautiously have no influence on the motor vehicle death rate. A third possible explanation for the weak results is that most states with no-fault insurance have varying "merit" rating schemes where premiums are commensurate with driving records. Both coefficients were found to be statistically weak, indicating a strong possibility that these results were obtained by chance. The low t ratios can be attributed to the small sample size estimated, resulting in the restrictions of the degrees of freedom (number of observations minus the number of variables), hence, a statistically weak analysis. On the other hand, the low t ratios could also be an indication that no-fault insurance has very little effect of the accident rate. This explanation is not convincing in light of the low Durbin-Watson value indicating autocorrelation and the low statistical significance attached to the estimates of most of the variables in the model.

Overall Assessment of the Literature

To date, relatively few studies have been undertaken to investigate the effects of no-fault insurance on the accident rate. The important econometric studies which have examined the no-fault - accident rate relationship were reviewed in this chapter. In these studies it was found that the independent variables were successful in explaining a significant portion of the variation in the accident rates among regions or through time. This finding demonstrates that the factors which contribute to the causes of accidents can be identified and are statistically well-determined, contrary to the beliefs of those no-fault proponents who claim that accidents are attributed to random or "chance" happenings.

However, these studies do not reach a general agreement with regard to the effect of no-fault insurance on the automobile accident rate. Of the nine studies reviewed, five (Grayston, Landes, Medoff and Magaddino, and Gaudry) suggested that there exists a positive relationship between the removal of liability for motor vehicle accidents and the automobile accident rate. These studies repeatedly found a higher accident rate to be associated with no-fault jurisdictions, as compared to those regions without no-fault legislation. With the exception of the

Medoff and Magaddino study, all these findings were statistically significant.

In the remainder of the nine studies, it was found that little or no relationship exists between no-fault insurance and the accident rate. These results were indicated by coefficients that were close to zero and were of weak statistical significance. In addition, Zador and Lund, and Graham and Garber found a negative relationship between no-fault insurance and the accident rate, implying that no-fault jurisdictions were associated with a lower accident rate. These results were statistically significant for Zador and Lund, but not for Graham and Garber. However, neither authors provided a convincing explanation for their findings. Nonetheless, the four studies concluded that there exists little or no relationship between no-fault and accidents, and the authors suggested that fears of increases in accident rates as a result of no-fault legislation seem to be unfounded.

It appears that these empirical results are far from consistent. The divergence of the results can be attributed to misrepresentation of the no-fault - accident relationship and inappropriate testing procedures. Some of these issues are discussed in the following paragraphs.

Several studies employed property damage accident data, non-fatal and fatal accident statistics as the

dependent variables. It was found that those models which estimated traffic fatality rates produced the most significant results. For example, Medoff and Magaddino employed loss ratios as a proxy for the accident rate. The study showed a weak positive no-fault - accident rate relationship. A plausible explanation for this lack of statistical significance lies in the type of data utilized. Loss ratios, along with property damage claims are subjected to biases due to underreporting and the variation in definition from region to region.

There were several different methods of incorporating the effects of no-fault insurance into the models reviewed. Swan, Graham and Garber, and Gaudry employed the most basic type of dummy variable which was equal to one for no-fault jurisdictions, and zero for all others. This type of dummy variable was adequate for those jurisdictions with uniform no-fault schemes, but was less accurate when applied to regions with varying types of no-fault laws. For example, Graham and Garber employed a dummy variable to represent the five different no-fault schemes existing in the United States. Because this variable does not capture the differences between the five no-fault schemes, it is not surprising that the coefficent for the no-fault variable was of an unexpected sign and was statistically insignificant.

Kochanowski and Young, and Medoff and Magaddino utilized several dummy variables to reflect the differences among state no-fault laws. Three variables were used in the Kochanowski and Young study and five types of dummy variables were used in the Medoff and Magaddino study. A danger in using too many dummy variables is that the degrees of freedom are sacrificed resulting in a less powerful statistical analysis [22].

The different types of no-fault insurance schemes were also represented by indices such as the "tort threshold" and those measuring the percentage of insurance claims barred from tort recovery. In Landes, and Zador and Lund, these indices were combined to form a "stringency" index to measure the degree of no-fault restrictions on tort suits in each state.

Although some studies employed a considerable degree of sophistication in representing the no-fault insurance variable, most studies reviewed in this chapter have overlooked the significance of premium rating schemes on the costs of accidents. This is an important issue because a particular insurance rating scheme can alter the effects of a no-fault insurance scheme on the accident rate. For example, a partial no-fault scheme with premium prices which are commensurate with driving behavior, (reflected through the number of demerit points accumulated), may lead

to a reduction in the accident rate. On the other hand, the same no-fault insurance scheme with premium rates which are entirely independent of driver behavior may lead to an increase in the accident rate.

With regards to minimizing the social costs of accidents, the issue here not only concerns whether or not a jurisdiction has a particular type of no-fault insurance; it also involves the type of premium rating scheme in effect. The only study to address the issue was Grayston. In his study, the effects of insurance premium increments on accident rates were tested by employing a cost of insurance index and an index reflecting the number of merit rating classes within each state insurance scheme. It was found that merit rating classes did have a significant effect on accident rates. This issue will be addressed in more detail in Chapter Four.

Several econometric issues come into play when estimating the regression relationship between accident data and a set of explanatory variables. Some of these problems were not adequately addressed by the studies reviewed in this chapter. These issues include multicollinearity, heteroskedasticity, and structural

stability. These topics are briefly discussed in the following paragraphs.

The modelling of accident rates is prone to problems of multicollinearity because of the interactive nature of the factors used as explanatory variables. Of particular concern is the positive relationship between no-fault states and tort thresholds, the number of drunk drivers arrested and the per capita alcohol consumption, the percentage of vehicles speeding and the number of drivers arrested for exceeding a speed limit, and so forth. If multicollinearity is not detected among the independent variables and corrected accordingly, large standard errors and confidence intervals will occur, resulting in statistically low estimates. In addition, difficulties exist in distinguishing the effects of the correlated independent variables on the dependent variable [23].

Few studies addressed this issue. Landes included highly collinear independent variables in her regressions without performing any tests for multicollinearity. The results are insignificant and inconclusive. Although some studies used the logarithmic functional form to avoid problems of multicollinearity, only 2 studies (Graham and Garber, and Kochanowski and Young) provided a discussion of the nature of the interdependencies of the explanatory variables in the modelling of accident data.

Heteroskedasticity is another inherent problem in accident modelling, particularly when applied to cross section data which are prone to biases in the variances of the disturbance terms. Some consequences of heteroskedasticity include exaggerated t and F test results, as confidence intervals appear narrower when they are in fact wider [24]. Again, few studies tested for this issue. It is important that models be subjected to such empirical testing to avoid misleading results.

Structural stability of parameters was another econometric issue overlooked by many studies. The strong statistical results of some models could be due to characteristics of a particular data set. There may well be other specifications which are equally as plausible where the results of interest are statistically weak. Such an example would be the case where results are sensitive to parametric changes in the functional form [25]. Gaudry tested and accounted for this issue, and Swan was aware of the structural stability problem, but did not perform tests. Other studies ignored this issue altogether. It is particularly important to test for structural stability, especially when using time series data to ensure the reliability of results.

Finally, an important point to note is that the bulk of the empirical literature has been applied to data for

the United States. Only two studies were conducted utilizing Canadian data, and these models were restricted to accident statistics for the province of Quebec. While it is tempting to draw inferences for Canada from results of the United States studies, one must keep in mind that no-fault statutes in Canada are markedly different from those in the United States. Furthermore, one cannot apply the results of the Quebec study to the investigation of the effects of no-fault in British Columbia, Saskatchewan and Manitoba. Quebec has a "pure" no-fault scheme and no premium increments, whereas British Columbia and Saskatchewan have limited no-fault coverage as well as premium increments for the number of accidents a driver incurs. The differences between these schemes will be discussed in detail in the next chapter.

Summary and Conclusion

It appears that the positive effects of no-fault automobile insurance on the accident rate are statistically well-determined although the studies reviewed here do not come to any conclusive agreement on their results. Perhaps the divergence of estimates can be attributed to shortcomings in the modelling techniques and the

econometric testing. Finally, even if the results of these studies were similar, no inferences can be drawn for Canada because the Canadian no-fault schemes are inherently different from their counterparts in the United States. For these reasons, there is a need to develop a model for Canadian data.

In the following chapter, a model investigating the relationship between no-fault insurance and automobile accident rates for Canada is specified. The model specifically addresses some of the issues mentioned in this chapter in hope of attaining a better explanation for of the effects of no-fault insurance and premium rating schemes on the accident rate.

Notes to Chapter Three

1. The goodness of fit coefficient measures the degree of linear association between the explanatory variables and the explained variable.

2. For the F statistic the hypothesis that the regression coefficients are equal was tested. This hypothesis was rejected at the one percent level. See Pindyk and Rubinfeld pp. 65 - 66 for an explanation of the F statistic.

3. If a linear relationship exists between two or more explanatory variables, multicollinearity is said to exist. Some consequences of multicollinearity are wide confidence intervals hence weak statistical estimates, and difficulty in distinguishing the effects of the correlated explanatory variables. See Ibid., pp. 87 - 90.

4. See Grayston (1971), P. 29.

5. Between 1971 and 1976 sixteen states in the United States adopted no-fault insurance. Between 1970 and 1978 five provinces in Canada - British Columbia, Saskatchewan, Manitoba, Ontario and Quebec required compulsory no-fault insurance. In 1974, New Zealand and two Australian states inacted no-fault insurance.

6. Surveys and estimates of increases for insurance payout ratios and raw statistics were compared, see Widdiss et al. (1977) and Pearson (1978). However, to my knowledge, no econometric studies have been carried out between the years 1972 and 1982.

7. See Landes (1982), p. 59.

8. Elasticities measure the percentage change in the dependent variable given a percentage change in a particular independent variable.

9. See Gujarati (1978) for an explanation of the Durbin Watson statistic.

10. A model is considered stable or robust if its results are not sensitive to defensible changes in statistical methods or changes in the structural form of the variables. See Pindyk and Rubinfeld p. 8

11. Zador and Lund obtained Landes' data tapes for analysis. They found that the D2 and stringency variables were highly collinear with goodness of fit values (r2) ranging from 0.80 to 0.99. See Zador and Lund (1986), p. 238.

12. Ibid., pp. 235 - 236.

13. Ibid., p. 234.

14. This "pure" no-fault scheme exists in the state of Michigan. This no-fault statute provides unlimited medical expense coverage for personal injuries due to automobile accidents.

15. The stastistically significant coefficients were -0.1925, -0.1825 for the variable TYPEINS1 for the years 1976:1 and 1976:3 respectively, and -0.1899 and -0.1832 for the variable ADD-ON in the year 1977:4 and 1977:5 respectively. See Kochanowski and Young (1985), p. 285.

16. Ibid., p. 283.

17. This is the no-fault scheme for Michigan. See note 12.

18. See Medoff and Magaddino (1982), pp. 381 - 383.

19. Box-Cox transformations enable the investigator to decide what mathematical form best accounts for the relationship between the explanatory and the explained variables. See Gaudry (1985) p. 23. Gaudry employed an

algorithm for Box-Cox transformations applied to regression models with heteroskedasticity and autoregressive residuals.

20. See Gaudry (1985) pp. 17 - 24.

21. This cost of accident index was also employed by Peltzman (1975). It is an index of medical and car repair costs of each state.

22. The degrees of freedom are measured by the number of observations minus the number of independent variables. A greater number of degrees of freedom in a model allows for estimates containing greater levels of significance, hence a more powerful statistical analysis. See Pindyk and Rubinfeld (1981), p. 25.

23. See Gujarati (1978), pp. 200 -206.

24. See Graham and Garber (1984) for a discussion of the importance of structural stability in accident modelling.

CHAPTER FOUR

SPECIFICATION OF THE MODEL

Introduction

To date, studies which have investigated the empirical relationship between no-fault automobile insurance and accident rates have yielded conflicting results. While some studies provide strong evidence that there exists a positive relationship between no-fault insurance and the accident rate, other studies conclude that very little association, if any, exists.

As seen in Chapter Three, much of the divergence among these results can be attributed to model mis-specification or overlooked empirical issues. This chapter sets out a theoretical framework in which some of these overlooked factors are addressed. Two models are specified. The first model deals with time series data to ascertain whether or not there are any deterrent effects associated with no-fault insurance, and whether the implementation of a no-fault insurance scheme consistently leads to a higher accident rate. A second model combines cross section and time series data to determine whether there is deterrence of accident causing behavior present in liability

insurance. This will enable us to tell how much deterrence is lost when switching from a liability insurance system based on driver behavior and demographic factors to a no-fault insurance scheme which places little emphasis on accident causing behavior.

Thus Chapter Four proceeds as follows. Some basic issues concerning model development are addressed in the first section. This is followed by a description of the models, a discussion of the explanatory variables, and a justification for their inclusion. The presentation of the results for these models is left to the next chapter.

Issues to be Addressed in the Models

A major reason for developing a model for Canada is that very few studies investigating the relationship between no-fault insurance and automobile accidents have been applied to Canadian data. To date, research in this area has been dominated by studies conducted for the United States. As seen in the previous chapter, the results obtained from these studies do not come to any specific agreement on the relationship between no-fault insurance and the incentives to avoid accidents. Even if these studies were conclusive, one cannot draw inferences for

Canada by merely extrapolating results from United States studies and applying them to Canada. Perhaps the most significant reason is that no-fault insurance schemes in Canadian jurisdictions differ markedly from their American counterparts. Some major differences are discussed in the next two paragraphs.

Three types of no-fault insurance are present in Canada. The first type is a complete or "pure" no-fault system where unlimited medical and rehabilitation expenses due to personal injury are provided in addition to lump-sum compensation for personal injury. Recourse to tort suit for injury damages has been completely removed. [1] This "pure" no-fault insurance scheme is present in the province of Quebec and is the only one of its kind in North America. The second type of no-fault scheme present in Canada is the partial no-fault system, where first party (no-fault) insurance is mandatory but the right to sue for personal injury damages has not been eliminated. In these schemes, no-fault compensation for injuries and death is provided up to a designated limit. [2] These first party benefits are subtracted from any tort award in attempt to avoid double compensation and discourage those cases without permanent disability or substantial pain and suffering claims from going to court. Partial no-fault schemes are provided by the governments of British Columbia, Saskatchewan, and

Manitoba. A third type of no-fault scheme is associated with provinces with privately provided insurance. In these provinces, limited no-fault coverage is required on a mandatory basis, and is included in "Section B" of the Standard Automobile Policy. Medical and funeral expenses, disability income and death benefits up to a certain dollar limit are paid to the insured regardless of fault. Generally, the no-fault payments do not differ substantially in coverage and value from province to province. As with government provided insurance, the right to tort suit for personal injury has not been limited.

By comparison, three types of no-fault insurance exist in the United States, of which two are substantially different from those schemes in Canada. The first type of automobile insurance is the "add-on" no-fault scheme which is very similar to the partial no-fault insurance in Canada. No-fault coverage is available on a compulsory or optional basis, and the right to sue for tort damages has not been limited. The second type of no-fault insurance scheme attempts to eliminate most tort claims based on fault by substituting generous no-fault compensation for medical expenses, lost wages and survivor benefits. However, the right to tort suit has not been removed. The state of Michigan fits into this type no-fault scheme: unlimited medical coverage is provided for automobile

accident injuries. The third type of scheme is called "modified" no-fault where provisions of benefits are relatively low, and only those fault based claims which are adequately compensated by no-fault provisions are barred from tort suit. In these states the variations in the limitation for tort suit damages are significant. The tort thresholds range from $200 in New Jersey to $4000 in Minnesota. [3]. Some states have a verbal threshold requiring injuries such as "loss of body member" or "permanent and serious disfigurement" before tort suit is allowed [4].

Another important distinction between the American and Canadian no-fault systems is that those in the United States were primarily designed to finance medical expenses otherwise not available to accident victims. In Canada, public health care covers a major portion of medical expenses arising from automobile injuries. The philosophy behind designing a no-fault system in Canada is one of reducing administrative and litigation costs in addition to extending compensation [5]. In light of these differences between no-fault insurance schemes in Canada and the United States, it would be desirable to trace the effects of no-fault schemes on the fatal accident rate in Canada.

All provinces in Canada have opted for some type of no-fault provision. Yet within the past decade, the

central policy issue concerning legislators and the insurance industry has focused on no-fault insurance and the manner in which it is to be provided. The issue is not whether no-fault insurance should be provided in Canadian provinces - there seems to be a clear agreement among policy analysts that no-fault insurance would provide quicker, and in some cases, more adequate compensation for automobile related injuries while significantly reducing litigation costs. Rather, the central issue underlying the fault-no-fault debate concerns the ability of the no-fault insurance scheme to hold individuals financially responsible for their accident causing behavior.

Of great importance to the investigation of the no-fault insurance fatal accident relationship is the distinction between the different premium rating schemes. This factor ultimately determines the results and conclusions drawn from the empirical evidence. In Chapter Two it was shown through conventional economic theory that premium prices and increments have an effect on driving behavior. Yet many studies reviewed gave little or no attention to the effects of premium rating classifications on the fatal accident rate. Instead, these studies employed a dummy variable to distinguish between no-fault and liability insurance jurisdictions, ignoring the subtle differences between the pricing schemes within the no-fault

jurisdictions themselves. It is important to account for the differences between no-fault schemes without premium increments and those with premium increments based on the number of accidents and demerit points. A partial no-fault insurance scheme with premium increments based on past driving behavior could lead to a reduction in accidents as was implied but not explained by some studies.

In the construction of the models, attention is given to the different types of premium rating schemes present in the provinces with no-fault insurance. In particular, a traditional premium rating scheme in which insurance prices are based on age, sex, marital status, and geographical place of residence will be contrasted with a scale containing premium rating entirely based on past driving experience without discrimination on the basis of age, sex or marital status. The effects of these schemes on the traffic fatality rate are differentiated from the effects of a complete no-fault scheme in which the premium rate structure is entirely independent of driver behavior.

By appropriately specifying a model which attempts to explain the automobile fatality rate, and by fitting it to the accident experiences of provinces with publicly provided no-fault insurance, some indication of the effects of no-fault insurance on the accident rate can be obtained. More specifically, we will be able to ascertain whether

there is any deterrence concerning accident causing behavior within these no-fault insurance schemes.

A conceptual model which explains accident behavior must be developed carefully to be consistent with theory as well as data and information constraints. One issue to be addressed in the development of the model is the choice of dependent and independent variables. A number of studies reviewed in the previous chapter included variables which appeared to be chosen on an ad hoc basis, especially those variables which served as proxies for unavailable data. While some proxies seem plausible, the reliability of the data used for these proxies is questionable. The representation of accidents as a dependent variable is of concern as these data are frequently susceptible to reporting biases. Many previous studies employed data on injuries and property damage for the independent variables in the statistical models. The results for these models often appeared to be inconclusive. A major reason is that these data are subjected to reporting standards which vary through time and across jurisdictions. Another possible explanation is that accident data may be exaggerated because there is a tendency for an increase in <u>reported</u> accidents, as the implementation of no-fault insurance makes obtaining compensation easier.

Many proponents of no-fault insurance claim that even if there is no deterrence in no-fault insurance, there is no deterrence of accident causing behavior in liability insurance either. Although it is believed that premium increments as a result of being at fault in an accident provide some deterrence to accident causing behaviors, the much greater deterrent effect of a large adverse tort award is lost. These proponents assert that the little deterrence remaining to the tort liability system is not worth the cost of operating and administering the system. Pooling cross section and time series data provides the opportunity to determine whether there is a significant amount of deterrence to accident causing behavior present in liability insurance.

Finally, by constructing a model which involves legal factors and socio-economic characteristics, it is hoped that the effects of public policy countermeasures (e.g. compulsory seatbelt legislation and enforced speed limits) used to reduce the occurrences of accidents can be evaluated.

The Nature of Accident Modelling

Modelling accident data to determine the causal relationships between accidents and a set of socio-economic and legal variables represents a difficult challenge from both a theoretical and empirical standpoint. Accidents are sometimes considered to be random events involving a vast number of stochastic factors which obscure any systematic pattern. However, the problem becomes less apparent when a working theoretical definition of an accident which takes a probabilistic approach is considered:

> Accidents are random events, unpredicted by those involved, which have been caused by potentially identifiable factors that may be traceable to the acts of victims or others, or which may be more likely because of environment in which the individual is placed just prior to the event. [6]

Essentially this definition implies that there are two sides to accident modelling. First, accidents can be attributed to factors concerning driver weaknesses and carelessness. Second, accidents can be anticipated as a consequence of the environment: road design, weather conditions, congestion, and mechanical flaws in vehicles contribute to the occurrences of accidents.

The explanatory variables of the model to be developed can be divided into factors influencing driving behavior and those influences involving driving environment. The emphasis of the model is not so much on establishing fault of an individual in an accident situation, but is concerned with the behavioral and environmental aspects contributing to the probabilistic causes of accidents which can be discerned through a long period of time or through a large number of geographic regions.

Model Specification

Two models are developed to test the effects of no-fault automobile insurance rating schemes on the motor vehicle fatality rate. A time series model is constructed to examine the change in fatal accidents associated with the introduction of government provided no-fault insurance. A second model combines data from all the provinces in Canada to investigate whether there exists a significant difference in fatality rates between those provinces with government provided no-fault insurance and those provinces with privately provided insurance.

Ideally, we would like to develop a model to determine the relationship between no-fault insurance and the social

costs of accidents. Unfortunately, there is no figure which captures the overall social costs of accidents. Medical and rehabilitation expenses, loss of lives and limbs, pain and suffering, and property damage are difficult to quantify on a consistent basis over a long period of time. Perhaps the best approximation for accident costs is the number of accidents themselves.

The general models to be developed and tested will focus on the number of road fatalities per 100,000 vehicles. This ratio allows comparison of fatality rates among provinces. Although a number of studies reviewed estimated an accident model in which the total number of accidents or the total number of injuries were included as the dependent variable, in the previous chapter it was argued that these data were subject to biases in reporting standards, making the data unreliable. For this reason the number of accidents resulting in injuries will not be used. The measure of traffic fatalities is more reliable although not entirely unambiguous over time and across geographical regions [7].

Model I

The first model is applied to annual time series data covering the period 1960-1985 for the provinces which implemented partial and complete mandatory no-fault automobile insurance. All independent variables except for the no-fault, seatbelt and time trend variables are expressed in logarithms so that the results can be measured in terms of elasticities [8]. The general model is specified as follows:

$$(4.1) \quad \ln FR = bo + b1 \ln OF + b2 \ln KM + b3 SB + b4 NF + b5 T + e$$

where

FR = motor vehicle traffic fatalities per 100,000 registered vehicles
KM = number of kilometers driven
OF = number of traffic violations
SB = mandatory seatbelt legislation
NF = mandatory no-fault automobile insurance
T = Time trend capturing highway and vehicle design improvement

In the following section the explanatory variables are described in detail and the rationale for the inclusion of each of these variables is noted.

Explanatory Variables

Traffic Offenses

The behavior of individual drivers is directly related to the incidence of traffic accidents. Studies have shown that the greater the number of driving errors which an individual makes, the more susceptible he or she is to being involved in an accident. It would be ideal to have information on the number and type of errors drivers commit while driving. However, no such information is available.

One proxy for driver behavior is the number of traffic offenses committed. Although this information is somewhat ambiguous in that only detected drivers who violate traffic laws are recorded, the number of offenses does give some indication of the degree of negligence and carelessness within a driver population. Boyer and Dionne (1987) have found empirical evidence to indicate that behavior related variables such as demerit points and license suspensions for criminal code traffic offences are significant in explaining the probability of an accident for an individual driver [9].

However, for a population of drivers, the expected sign of this variable is indeterminate. According to economic theory, the degree of care a driver exerts in his activity is inversely related to the probability of an

accident occurring. If the number of traffic violations represents the degree of negligence and carelessness in the behavior of a driver population, then this variable is expected to be positively correlated with the fatality rate. On the other hand, the number of traffic offences may indicate the ability of law enforcement to deter or prevent accidents. The relationship between number of offences and accidents is expected to be negative if drivers who are caught and penalized become less likely to be involved in an accident. If the degree of law enforcement is actually a measure of deterrence of accidents, then the sign of this variable is expected to be negative. That is, the degree of law enforcement is expected to be negatively correlated with the fatal accident rate.

Distance Travelled

The number of vehicle kilometers travelled is expected to be postively correlated with the dependent variable. The amount of distance travelled can be considered as an approximation for the amount of risk exposure to accidents faced by drivers and occupants. Increases in distance travelled can therefore be expected to be linked with a rise in fatality rates as drivers and their passengers

become more exposed to the probability of being involved in an accident.

Seatbelt Legislation The introduction of compulsory seatbelt usage can be anticipated to reduce the death and injury rates. Numerous studies have documented a negative relationship between seatbelt usage and the number of traffic fatalities. [10] Although Peltzman (1975) argues that additional safety to vehicles through the usage of seatbelts encourages more dangerous driving which may lead to an increase in motorcycle and pedestrian deaths, a number of studies [11] provide evidence which contradicts Peltzman's theory. It is therefore anticipated that compulsory seatbelt legislation will lead to a decrease in the traffic death rate.

Speed Limits There exists convincing evidence that speed influences the likelihood of a fatal accident. The United States Highway Safety Council estimates that the chances of survival in an automobile crash are 31 to 1 when travelling at 60 miles per hour, but drop drastically to 7 to 1 when travelling between 70 and 80 miles per hour. [12]. Moreover, several studies have concluded that the drop in speed limit from 65 miles per hour to 55 miles per hour has saved a significant number of lives. [13] Therefore, it is hypothesized that the introduction of

lower speed limits will have a negative influence on the fatal accident rate.

Time Trend

Highway design is an important factor which influences the number of traffic fatalities. Several studies conducted by the United States Department of Transportation show that improvement in highway markings, signals and road surface have significantly reduced the number of accidents. In particular, a large number of divided limited access highways have substantially reduced the risk of collisions involving cross-traffic and head on collisions. In Canada both provincial and Federal Governments have worked steadily over the years to improve highway design. In the past 25 years, increasing amounts of funding have been devoted to highway improvement [14]. It is therefore anticipated that highway improvement will lead to a decrease in fatal accidents over time.

Vehicle design technology is also thought to influence the driver's ability to avoid accidents and survive crashes should they occur. Vehicle safety has been continously improving each year. The safety standards passed by both United States and Canadian governments have encouraged manufacturers to improve vehicle design. In addition, adverse publicity concerning alleged design defects and the

threat of costly tort suits have had a substantial effect on manufacturer's efforts to ensure vehicle safety quality.

Although it is difficult to obtain a proxy for road and vehicle design due to lack of data, it is postulated that highway and vehicle safety improvement is a function of time. A linear time trend is used to capture highway and vehicle improvements. The sign of the time trend is anticipated to be negative; as time progresses vehicle and highway safety are expected to improve, contributing to the reduction of fatal accidents.

The No-Fault Variable

Because the focus of this study is on no-fault automobile insurance, attention will be given to the theoretical relationship between no-fault insurance and the fatality rate.

The a priori sign of the "No-fault" variable depends on two factors: whether no-fault insurance exists, and what type of premium rating scheme is in effect. These two factors are discussed in the following sections. The first part contains a summary of the expected effects of no-fault insurance on the accident rate, and the second section concerns a discussion of the a priori effects of premium rating schemes and no-fault insurance on the cost of accidents.

According to economic theory, there is a positive relationship between no-fault insurance and fatality rates. As shown in Chapter Two, the major argument of the law and economics literature is that liability systems based on negligence induce an optimal amount of care. It is assumed that the probability of an individual being involved in an accident is inversely related to the level of care he takes when driving, as well as the level of care taken by all others on the road. Under negligence rules, the injurer is made liable for all costs of accidents if he has been found negligent. By shifting the burden of accident costs to those who do not meet a particular standard of care, individuals are forced to take the "optimal" amount of precautions if they wish to minimize costs. By encouraging individuals to take the optimal amount of precautions, the law and economics literature suggests that negligence based systems act as a deterrent to accidents.

If no-fault automobile insurance eliminates or restricts liability for damages the individual is no longer financially responsible for the accidents that he or she causes. Consequently, individuals are not encouraged to take an optimal amount of precautions. It is argued that no-fault insurance would "permit potential injurers to shift some or all of the costs of their activity to

potential victims and may result in higher losses from accidents" [15].

On the other hand, proponents of no-fault insurance claim that there is no significant relationship between no-fault compensation and fatality rates. They contend that the conventional economic theory which is based on the assumptions of "perfect and costless information" and rational behavior on the part of all economic actors is unrealistic. [16] They stress that drivers do not have access to perfect and costless information, and that there is evidence that drivers do not always behave rationally. [17]. In addition, they point out that most no-fault legislation restricts tort recovery for minor injuries only; death and serious injuries are still subject to tort liability. On the basis of these arguments, it is claimed that no-fault insurance does not necessarily reduce the level of driving care, leading to an increase in fatality rates. In fact, it is argued that little or no relationship exists between no-fault insurance and fatality rates.

The above discussion suggests that the relationship between no-fault insurance and traffic fatality rates depends on the degree to which drivers perceive the relationship between type of insurance coverage and their financial accountability for damages caused as a result of

their driving behavior. This accountability is reflected through the type of insurance premium increment scheme present in the provincial jurisdictions. The two types of government insurance pricing schemes are discussed in the following paragraphs.

In Quebec, the pricing for bodily injury insurance is charged through a gasoline tax, driver license fees, vehicle registration fees and weight and type of vehicle for those automobiles driven for purposes other than pleasure. There are no risk classifications based on age, marital status, or geographical territory. Moreover, the price of insurance has no relation to past driving experience. There are no insurance premium increments subsequent to an accident in which the driver is at fault, nor is the premium price a function of traffic violations. The premium price is essentially a flat surtax which all drivers must pay regardless of their risk classifications and driving record. Such a scheme is not expected to induce accident avoidance since insurance premiums are independent of driving behavior. Therefore, no-fault insurance is expected to have a positive influence on the accident rate.

On the other hand, British Columbia, Saskatchewan and Manitoba have a partial no-fault scheme combined with a bonus malus system or a claims rate scale. The traditional

actuarial rating scheme where individual premiums are based on the expected claims costs of a particular driver determined by the driver's age, sex, marital status and geographical place of residence has been removed. Instead, premium rates are charged according to type of automobile, distance driven, driver record based on demerit points and traffic offenses and on the number of claims in which the insured was more than 50 percent at fault. Safety demerit points are assessed whenever a driver is convicted of certain offenses under the Highway Traffic Act or the Criminal Code of Canada. The number of demerit points is based on the severity of the offense committed. For example, two demerit points are assessed for a speeding conviction, six points for a careless driving conviction and ten points for driving while impaired. In addition, demerit points are assessed for every accident for which the driver is partially or fully responsible.

Premium surcharges are also based on the number of accidents a driver incurs for which he or she is 50 percent at fault. For example, In Manitoba, the surcharge for two or more accidents within two years for which the person is responsible is $100 and $200 for each additional accident. A similar premium charge of $150 per accident is levied in British Columbia.

In addition, a driver can improve his subclassification by not acquiring any demerit points or incurring accidents for which he or she is responsible. The claims rate scale rewards good driving behavior in periods of free demerit points and penalizes accident causing behavior reflected through periods of accumulated demerit points. Because insurance premiums are geared toward driver behavior, a deterrent effect is expected to be present. On the basis of this discussion, one would expect a negative relationship to exist between no-fault insurance and the fatality rate for the provinces of British Columbia, Saskatchewan and Manitoba. The a priori sign for the relationship between insurance and accident rates in non no-fault insurance provinces (e.g. Alberta, Ontario and the Maritime provinces) is discussed in Model II.

Other Variables

Several modifications could be made to the model specified in equation (4.1) by incorporating additional explanatory variables which have been included in previous studies. These include income per capita, alcohol consumption per capita, and demographic factors.

A number of studies reviewed have used income per capita to reflect the level of driving intensity. Since driving intensity is already captured by distance driven in equation (4.1), there is no need to employ an income variable in the model. However, other previous studies used income per capita to reflect the level of risk taking within a population of drivers. Higher levels of income increase the value of time and therefore may contribute to speeding and risk taking. On the other hand, if injuries mean giving up time (e.g. because the person is incapacitated), the individual may consider time gained by speeding a tradeoff against time lost by being injured. In addition, high levels of income could be associated with more investment in safety equipment and driver education, resulting in a lower incidence of fatal accidents. Although there is no empirical evidence to show that these relationships exist between income and risk, it would be interesting to determine the effect. Therefore a variable depicting real income is included in equation (4.1).

The results have been mixed for previous studies which have included income as an explanatory variable. While Kochanowski and Young (1985), and Peltzman (1975) have found the coefficient of income per capita to be negative and insignificant, and Medoff and Magaddino (1983) found it to be positive and insignificant, Graham and Garber (1984)

found it to be positive and statistically significant. These studies used nominal income per capita to capture the income effects. It would seem plausible to use real income per capita rather than nominal income per capita; therefore equation 4.1 will be modified to incorporate real income per capita.

A number of studies reviewed in the previous chapter have hypothesized a positive relationship between alcohol intoxicated drivers and fatal accidents. According to the United States Department of Transportation, "half of the traffic fatalities in the United States each year are caused by alcohol related crashes in which 70 persons are killed per day". [18] One study has also suggested that the sharp rise in alcohol consumption between the early 1950's and the late 1970's have had a significant effect on the highway fatality rate. [19] Kochanowski and Young (1985), Graham and Garber (1984), and Peltzman (1975) have included alcohol consumption per capita or alcohol sales per capita to capture the effects of alcohol intoxication on fatal accidents. All these studies found this variable to be insignificantly related to traffic deaths. However, it is possible that these results are attributed to a characteristic specific to a population sample. For this reason alcohol consumption per capita is included in the model to reflect driver sobriety.

Several studies previously reviewed hypothesized that demographic factors influence the fatal accident rate. In particular, it is postulated that an increase in the proportion of drivers in the age 16 to 24 category and an increase in the proportion of male drivers is expected to be associated with an increase in fatal accidents. The rationale behind this expectation is that these drivers as a group tend to cause more accidents than any other group, largely because they are inexperienced, or because they have a tendency to be reckless. A variable depicting the proportion of licensed drivers between the ages 16-24 is included in equation (4.1).

The studies which included demographic factors as explanatory variables yielded mixed results. Kochanowski and Young (1985) found the coefficient for proportion of drivers to be positive and significant, and Medoff and Magaddino (1982) found the coefficient for the proportion of male drivers to be positive and significant. On the other hand, Grayston (1971) found the coefficients of these variables to be insignificantly different from zero. All these studies were applied to cross section data. The only time series study to use demographic factors was Graham and Garber (1984), in which the variables were found to be statistically insignificant. This is to be expected as the proportion of drivers belonging to the age group of 16 to

24 is expected to change slowly over time, especially with respect to annual data.

Several studies also included variables capturing the effects of the 1973-1981 oil embargo. It is thought that during this period characterized by high fuel prices and an emphasis on conservation, there would be a reduction in speeding and driving intensity which ultimately affect the fatal accident rate. The variable depicting distance driven has captured this effect, therefore there is no logical reason for the inclusion of this variable in the model.

Some studies included the percentage of automobiles older than five years as a control variable for accidents. Two reasons for the inclusion of this variable can be ascertained: as technology progresses with time cars become better equipped with safety features. Second, older vehicles are more susceptible to accidents because of deterioration and mechanical failure. As noted in the section discussing the time trend variable, technological improvements in vehicle design have been accounted for in the model. Therefore there is no reason for the inclusion of this variable.

Finally, as in most statistical analyses of this nature, random influences are omitted either because they are unpredictable or because such data is unavailable. For

example, it is impossible for the model to take into account freak snow storms which cause severe fatal accidents or a multi-fatality occurrence caused by a driver who has a heart attack.

Model II

One major argument no-fault proponents put forth is that the imposition of compulsory liability insurance has made the tort-liability system an inappropriate deterrent mechanism. Pooled cross-section time series data provides the opportunity to test the extent to which the deterrent effect of accident causing behavior is present in the liability insurance system, the claims-rate systems and the "pure" no-fault insurance scheme in Quebec. By appropriately specifying a model which explains automobile accidents, and fitting it to cross-province experience, some indication of the deterrent effects of various insurance schemes can be discerned.

The model is applied to pooled cross-section time series data for the ten provinces during the period of 1960-1985. While cross section analysis alone may have been desirable, it was not possible to apply this technique to per province Canadian data as the number of degrees of

freedom are too restrictive. Combining cross section and time series data allows for a substantial increase in the degrees of freedom, hence a more powerful statistical analysis.

The model focuses on the fatal accident rate as the dependent variable as in the time series model, because these data are more reliable than injuries or the total number of injuries and property damage accidents combined. Since the nature of cross section data is inherently different from time series data, it is useful to summarize these differences and how they affect the variables used for the pooled cross section time series model.

Model II is specified as follows:

$$(4.2) \qquad DR = B1Xij + B2Xij + B3Iij + uij$$

where DR is the fatal accident rate per 100,000 vehicles, B1Xij is a matrix of population characteristics influencing the death rate for each province i for the years j, B2Xij is a matrix of institutional factors such as seatbelt legislation and speed limits which are thought to influence the death rate, and B3Xij represents a set of insurance characteristics believed to affect the traffic fatality rate. B1, B2, and B3 are vectors of coefficients, and ut

represents the disturbance terms. A discussion of the variables included in these matrices is provided in the following section.

Explanatory Variables

Offenses The number of offenses committed per licensed driver is included as an independent variable in Model II. As mentioned in the previous section, offenses can reflect the degree of carelessness within a driver population, hence this variable would have a positive relationship with the death rate. On the other hand, the number of offenses can be thought to represent the detection rate of accident causing behavior, in which the number of offense recorded is expected to have a negative impact on the death rate. For these reasons, the anticipated sign for offenses cannot be ascertained.

Distance Travelled

As in the time series model, distance travelled is considered to be a proxy for the degree of risk exposure to accidents. As seen in the previous model, several studies have indicated that the probability of having a fatal accident increases with distance travelled. Hence it is

anticipated that there is a positive relationship between distance travelled and the traffic fatality rate.

Seatbelt Usage The percentage of population wearing seatbelts is included as an explanatory variable in the cross section model. As mentioned previously, various studies have found that a decrease in fatality rates is associated with an increased usage of seatbelts by both occupants and drivers. [20] Therefore the sign of the variable depicting seatbelt usage is expected to be negative.

The availability of data permits examination of the effects of seatbelt legislation depicted through the percentage of population using seatbelts. This information is taken from National Seatbelt Surveys conducted by Transportation Canada for the years 1975 to 1985 [21].

Speed As explained in Model I, the enforcement of lower speed limits is expected to have an inverse relationship with fatal accidents. However, this variable would not have much effect on the accident rate in a pooled cross sectional time series analysis since speed limits were reduced in all provinces at the same time. Therefore the variable depicting lower speed limits will not be included in the model.

Insurance Characteristics

Cross section analysis permits the investigation of the effects of various insurance factors on the fatal accident rate which were precluded in the time series model because of data restrictions and the nature of time series. In particular, cross section analysis allows us to test the extent to which the deterrence of accident causing behavior is present in the various types of premium rating schemes in Canada.

Three variables depicting insurance premium rating schemes are incorporated into the model: a variable indicating the provinces with claims rate premium prices (e.g. Manitoba, Saskatchewan and British Columbia), another representing those provinces with liability insurance (e.g. Alberta, Ontario and the Maritime provinces), and finally, a variable depicting complete no-fault insurance ratings in Quebec.

Before examining the effects of these insurance schemes on the incentives to prevent accidents it is necessary to examine the nature of the different no-fault schemes present in Canada. As mentioned at the beginning of this chapter, three types of insurance rating schemes can be found in the Canadian provinces. Insurance for

bodily injury in which premiums have little relation to driver behavior, partial no-fault insurance where premium costs are determined on the basis of demerit points and accidents for which the person involved is 50 percent or more at fault, and finally, add-on no-fault insurance where premiums are based on the number of accidents for which the driver is at fault as well as his or her geographic place of residence. The first two insurance schemes were discussed in some detail in Model I; therefore it is not necessary to elaborate on these here. However, the third type of insurance has not been discussed at any great length, and therefore shall be described in the following paragraphs.

In provinces where insurance is privately provided, there are six categories which determine the insurance premium rate that an individual pays. These include the area where a policyholder resides; the age, sex, and marital status of the individual; the use to which the vehicle is put; the limit of third party liability coverage purchased; the deductible on which own-vehicle coverage is purchased; and the value of the insured's car. Although these determinants of insurance rates are clearly defined, the practice followed by individual insurance companies in implementing the category of rate structures varies widely, particularly with respect to the the accident record

category. [22] Some insurance companies raise premium rates subsequent to an accident; others "forgive" or disregard the first accident. Nor is there consistency in the premium rates charged. A premium charge for two persons belonging to the same categories used for rate determination can differ as much as 30 percent from one insurance company to another. In spite of these inconsistencies, all insurance companies are able to rationalize the particular practices with the standard definition and keep within the requirements of the Insurance Bureau of Canada Statistical Plan.

While there is expected to be some deterrent effect in liability insurance, the deterrent effect is anticipated to be weaker than that in the claims rate scale. The reason behind the expectation can be expressed as follows: in liability insurance the only category based on driver behavior is the accident record category. Yet even within this category there are inconsistencies in the application of premium determination, as discussed above. The potential accident causer does not know whether his or her premium charge will be increased as a result of an accident and if the premium is raised, the increment is not always consistent. Indeed, the value of the premium increment is not always known with certainty in provinces with liability insurance, whereas in B.C., Saskatchewan and Manitoba, the

premium increment value is made clear by government legislation.

The apriori signs of the claims rate pricing and liability insurance premiums are negative as both insurance schemes are tailored to driving behavior. However, the coefficient for the claims rate scale is expected to be more negative than that for liability insurance. Finally, the sign for Quebec no-fault insurance is expected to be positive, since this premium scheme has no relation to driving experience.

Other Variables

Average Cost of Insurance The average cost of insurance can be considered to be a simplistic indication of the concentration of accident costs on automobile owners, where high average premiums are thought to be associated with a high concentration of costs on drivers. Relatively lower insurance rates might be expected to be related to more accidents, as it makes driving possible for a relatively larger proportion of people, particularly those belonging to high risk groups. In addition, lower insurance premiums may induce some individuals to shift to sportier, presumably dangerous vehicles. It is expected that a greater cost deterrent to a driver causing an

accident is associated with a greater incentive to drive carefully. Therefore, one might expect a postive linkage to exist between average price and fatality rates.

On the other hand, a low insurance price may be a reflection of lower accident rates. In such a case, insurance companies may experience a lower payout of benefits, and are therefore able to lower the premium price. If this effect is dominant, one might expect the relationship between prices and accidents to be positive. Because it is not known what effect dominates, one cannot state the a priori relationship between the cost of insurance and the accident rate.

Premiums Written to Assigned Risk Insurers A more precise measure of the degree to which accidents are concentrated on those who are at fault is a measure of the deterrence that is lost when moving from a premium rating scheme which places emphasis on driver experience to one which relies less on driver behavior. One way to capture this effect is to use the ratio of assigned risk premiums written to the total amount of automobile insurance premiums written for the whole industry. The reason for the inclusion of the variable can be explained as follows: insurance companies will only issue insurance if they expect to recover their losses. If a potential client is

of a high risk category, and the expected claim from this client is greater than the premium collected, then the insurer will refuse to insure that particular individual. Provincial regulations require that the cost of insurance be kept within prescibed limits such that insurance is available to most people. Rather than insure high risk drivers at low premium rates, therefore incurring a loss, insurance companies refuse to insure these drivers. Therefore it is not surprising that many insurance companies refuse to insure those belonging to extremely high risk categories for profit reasons. These individuals must then be assigned to a special insurer. In Canada, this assigned risk insurer is known as the Facility Association. The percentage of premiums written falling into this assigned risk category can be used as a measure of the inability of the insurers to collect premiums based on driver characteristics. As this ratio increases, the ability of the insurer to concentrate accident costs on those at fault diminishes. On the basis of these arguments, it is anticipated that this ratio is positively related to the number of fatal accidents. Unfortunately, insufficient data prevented the testing of this relationship. [23]

Summary

Two models for fatal accident behavior were developed in this chapter. A time series model was specified to capture the effects of the introduction of a change in premium rating schemes on the fatal accident rate. A second model was applied to pooled cross section time series data to determine whether there exists a significant degree of difference in fatality rates between the various types of insurance schemes in Canada.

The following chapter presents the results obtained for the estimation of equations (4.1) and (4.2). The results obtained from modifications to the models are also reported.

Notes to Chapter Four

1. The removal of recourse to tort suit has been completely removed for Quebec residents only. Non residents injured in an automobile accident in Quebec still retain the right to sue for damages.

2. As of May 1986 the limits for British Columbia, Saskatchewan and Manitoba are $200,000, and $50,000 for the province of Quebec. See Insurance Bureau of Canada Publication (1986).

3. For a description of the various no-fault automobile insurance plans which exist in the United States, see Rolph, et al. (1985), vol IV.

4. Ibid, p. 12.

5. See Ontario Task Force on Insurance (1986), pp. 98-102.

6. Votey (1986), p. 85.

7. Such data do not distinguish between multiple deaths due to catastrophes such as bus crashes and other motor vehicle fatal accidents.

8. The slope coefficent measures the percentage change in the fatal accident rate for a given percentage change in a particular independent variable, holding all other factors constant. In the economics literature, this concept is referred to as "elasticity". See Gujarati (1978) p. 54.

9. See Boyer and Dionne (1987).

10. See Jonah and Lawson (1984) for a review of the studies which have found a negative relationship between seatbelt usage and severity of accidents.

11. See Crandall and Graham (1984), Robertson (1977) and Joksch (1976).

12. Insurance Information Institute (1982), p. 52

13. United States Highway Safety Council (1977), p. 51.

14. Transport Canada, 1975-1986.

15. Kochanowski and Young (1985), p. 273.

16. Landes (1982), p.

17. Zador and Lund (1986) p. 229, Kochanowski and Young (1985) p. 322, Calabresi (1970), p.45.

18. See American Enterprises for Public Policy Research (1978) p. 32.

19. United States Highway Safety Council (1977) p. 51.

20. Crandall et al (1986) p. 165.

21. Transport Canada, Annual Report, various issues, 1975-1985.

22. See Insurance Bureau of Canada Newsletter March 1987, p. 4

23. Data for assigned risks were only available from the Facility Association. No data were available for

public automobile insurance provinces as they do not underwrite assigned risks to the Facility Association. Although data for Ontario and Alberta were available as early as 1977, data for other privately provided insurance provinces were severely limited. A major reason is that some of these provinces only joined the Facility Association within the past few years.

CHAPTER FIVE

RESULTS

Introduction

The results for the models used to investigate the relationship between no-fault insurance and the fatality rate are presented in this chapter. The first section contains a discussion of the types of data employed in the models and the methodology used to obtain the regression results. This is followed by a presentation of the estimates. A summary of the results is provided in the last section.

Model I

Data

The fatality rate model specified in the previous chapter was estimated using annual data for the years 1960-1985. While quarterly or monthly data would have been more desirable as it allows for an increase in the degrees of freedom, this data was not employed due to availability restrictions. Although monthly figures for traffic fatalities were available for some provinces much of the

data for the explanatory variables were only available on an annual basis.

The time period 1960-1985 was chosen for a number of reasons. Much of the data prior to 1960 was unavailable. Moreover, 1960-1985 was the time period in which various provinces implemented government-run no-fault insurance. Since the objective of this study is to investigate the empirical linkage between no-fault insurance and the fatal accident rate, the time period chosen appears to be appropriate.

The data used were extracted from various sources. The number of fatal accidents, the number of traffic offenses, the number of litres of motor fuel consumption, and the number of registered vehicles were taken from Statistics Canada [1]. Included in the data for traffic offenses are the total number of offenses committed under the criminal code, federal and provincial statutes, and municipal bylaws. While it was found that over 50 percent of the offenses accounted for infractions such as driving while impaired, driving without a license, speeding, and negligence, no disaggregated data were available to separate the effects of the different types of offenses on the accident rate.

The number of fatal accidents per province per year was chosen over total number of accidents as fatal

accidents are less susceptible to reporting biases. Fatal accidents were expressed in rate form to allow interprovincial comparison. The rate was obtained for each province by dividing the number of fatal accidents per year by the annual total motor vehicle registrations per year.

No statistics for the total kilometers travelled by motor vehicles are available for Canada. However, an approximation of the distance travelled can be obtained from the ratio of motor vehicle fuel sales to the total number of motor vehicle registrations. Visual inspection of this ratio reveals that the figures have declined recently. It may well be that the emergence of smaller and more fuel efficient vehicles has contributed to the overall decrease in the ratio. Therefore, this ratio is adjusted by multiplying it by an index for the average fuel efficiency of the province's vehicle fleet. This index was taken from various issues of Transport Canada's Annual Report.

It would have been desirable to obtain figures on the proportion of drivers and occupants wearing seatbelts. Unfortunately this data is only available for the years following 1971, which does not permit its application to the time series model due to the limited degrees of freedom. [2] A dummy variable is used to represent compulsory seatbelt laws in the time series model. It is

noted that the use of this dummy variable is only a simplistic representation of the effects of seatbelt laws since the full impact of such laws does not necessarily occur in the first years of legislation, nor does it remain constant thereafter. However, it is assumed that there must be some increase in seatbelt usage subsequent to the implementation of compulsory seatbelt legislation. The years in which lower speed limits were enforced were taken from the Canada Yearbook for various years.

The statistics for drivers belonging to the 16 to 24 age group for each year in British Columbia and Manitoba were provided by the Transportation departments of British Columbia and Manitoba, respectively. Data for Quebec regarding the age breakdown of the licensed drivers were unavailable. In addition, income per capita for each province was obtained from CANSIM. [3]

Finally, the years in which a particular province has no-fault insurance legislation is represented by a dummy variable. This variable is set equal to one for the years with no-fault insurance, and is equal to zero otherwise.

Methodology

The regression equations were initially run using ordinary least squares (OLS). All variables in the model except for the dummy variables were expressed in natural logarithms so that parameters could be estimated in the form of elasticities.

The Durbin-Watson statistic was utilized to indicate first-order serial correlation. Since there were no lagged dependent variables used in the model equations, the Durbin-Watson statistic is considered to be a reliable and unbiased indicator of autocorrelation. When such correlation was revealed, the maximum likelihood iterative technique was used to transform the data to obtain estimators of minimum variance. [4] As time series data is frequently prone to problems of autocorrelation, it was not surprising that some equations contained this problem.

Given the interactive nature of the explanatory variables, there is a strong possibility of multicollinearity among these variables. The presence of multicollinearity was tested by utilizing partial correlation matrices as well as regressing a suspect collinear variable on another. When multicollinearity

appeared to plague the results, the "problem variables" were combined to form an index variable. [5]

Tests concerning levels of significance were performed to identify good estimators. These tests involved one tailed tests for all variables with the exception of the variable depicting offenses and the intercept term. A one tailed test is desirable for cases where there are strong a priori reasons to believe that a particular variable will take on a specific sign. As discussed in the previous chapter, the sign for the offense variable is indeterminate, hence a two tailed t test is appropriate for this variable.

Results for Model I

Equations (5.1) through (5.11) present the basic results of the fatal accident estimates for the model specified in equation (4.1) applied to time series data for the provinces of Quebec, British Columbia and Manitoba. The model was not applied to data for Saskatchewan. Although Saskatchewan has a government provided no-fault automobile insurance scheme introduced in 1946, some data for this province before the year 1960 is unavailable. Since the objective of the model is to test the effects effects of the implementation of government run no-fault

insurance on the fatal accident rates, the model is inapplicable to 1960-1985 Saskatchewan data.

The equations were estimated over the time period 1960-1985 using OLS. The constant or intercept term is reported, followed by the estimated coefficients for the explanatory variables. Below each of the coefficient values is the corresponding t statistic. As noted in the previous section, one tailed levels of significance tests were employed except for those variables whose a priori signs were uncertain. The coefficient of determination - the adjusted R-squared value, which measures the proportion of variation in the fatal accident rate that is explained by the independent variables in the regression - and the Durbin-Watson statistic are also reported.

Quebec

The results for Quebec are presented in equation (5.1) below. The Durbin-Watson statistic indicated that autocorrelation was a problem. Therefore, the model was adjusted accordingly by running the regression using the maximum likelihood iterative procedure. The regression results for Quebec are presented as follows:

$$(5.1) \qquad FR = \underset{(-.36)}{-3.88(C)} + \underset{(-1.74)*}{.2612(DIST)} + \underset{(2.34)*}{.2832(OFF)}$$

$$- .3181(SB) + .0330(NF) - .0301(T)$$
$$(-3.24)^{**} \quad (1.73)^{*} \quad (-2.23)^{*}$$

$$\bar{R}^2 = .9452 \quad DW = 1.92 \quad Rho = .1807$$

where

FR	= Fatality rate per 100,000 vehicles
C	= intercept
DIST	= number of vehicle kilometers travelled
OFF	= number of traffic offenses per licensed driver
SB	= compulsory seatbelt legislation
NF	= No-fault legislation
T	= time trend
*	= significant at the five percent level
**	= significant at the one percent level

The adjusted R-squared value of 0.9452 allows one to conclude that the model is significant in explaining nearly 95 percent of the variation in the fatal accident rate. This result is particularly encouraging given the inherently unpredictable nature of accident behavior and the interactive nature of the factors which influence it.

Of primary interest is the estimated coefficient of the no-fault variable. As mentioned in the previous chapter, a no-fault automobile insurance scheme which does not hold an individual financially responsible for the injuries he or she causes through an automobile accident is expected to lead to an increase in fatal accidents. The coefficient of .0330 attached to the no-fault variable is positive and significant at the 5 percent level, as anticipated. This result suggests, holding all other variables constant, that the implementation of the Quebec

Automobile Insurance Act in 1978 was associated with an increase in the fatal accident rate.

The coefficient for fuel consumption per motor vehicle which serves as a proxy for distance travelled was found to be positive and significant at the 5 percent level. It is implied by this estimate that increased fuel consumption per motor vehicle will result in an increase in the fatal accident rate. This is consistent with the theory that increased distance travelled increases exposure to the risk of an accident.

The coefficient for the number of offenses per driver was found to be positive and significant at the one percent level. This result indicates that an increase in the number of offenses per licensed driver is associated with an increase in the fatal accident rate, holding all other variables constant.

The coefficient for compulsory seatbelt legislation is negative and significant as expected. This suggests that the implementation of compulsory seatbelt use reduces the fatal accident rate, which is consistent with the theory.

Finally, the coefficient for the time trend was negative and statistically significant, implying that the improvements in road quality and automobile design technology have contributed to the decrease in accident fatalities over time.

British Columbia

Several regressions containing data for British Columbia were run using OLS. The results for the model applied to British Columbia data are listed below:

$$(5.2) \quad FR = \underset{(-6.99)**}{-42.38(C)} + \underset{(8.09)**}{1.585(DIST)} - \underset{(-2.82)**}{.2146(OFF)}$$

$$- \underset{(-2.82)**}{.2359(SB)} - \underset{(-2.17)*}{.2132(NF)} - \underset{(-2.64)**}{.0239(T)}$$

$$\bar{R}^2 = .9061 \qquad DW = 2.09$$

As mentioned in the previous chapter, the a priori sign for the coefficient of the no-fault variable is expected to be negative. The reasoning behind this expectation is that no-fault insurance premiums in British Columbia are based on a bonus-malus system, in which premium prices are tailored to driver records. Since premiums rise as the number of accidents, demerit points, and traffic offenses increase, the bonus-malus system is expected on have some deterrent effect on accidents. The coefficient of the no-fault variable is negative, as anticipated, and is significant at the 5 percent level. This result implies that no-fault insurance combined with a bonus malus system has contributed to the decrease in fatal accidents. The negative relationship between no-fault

insurance and traffic fatalities also suggests that insurance premiums in a claims rate scale which are partially tailored to an individual's driving behavior does act as a deterrent to fatal accident causing behavior.

Also of interest is the coefficient for the variable capturing the number of offenses per licensed driver. The sign of this coefficient is positive and statistically significant, indicating that traffic offenses per licensed driver has some positive effect on the fatal accident rate, and that perhaps the number of offenses is a good proxy for the degree of careless driving behavior within the British Columbia driver population.

The coefficient for fuel consumption per registered vehicle is positive and highly significant, confirming the hypothesis that distance travelled is directly related to increased risks of fatal accidents. The coefficient for seatbelts is negative and highly significant, indicating that the introduction of compulsory seatbelt legislation has led to a decrease in fatal accidents. Finally, the negative and statistically significant coefficient attached to the time trend variable suggests that technological progress in highway and vehicle design has contributed to the overall decrease in motor vehicle fatality rates.

Manitoba

The results for Manitoba listed below are very similar to those for British Columbia. Low correlation between the years in which speed limits were reduced (SPDLMT) and (STBELT) allowed for the inclusion of a separate variable (SPDLMT) in the regression equation.

$$(5.3) \quad FR = \underset{}{7.73(C)} + \underset{(.90)}{.1742(DIST)} + \underset{(1.62)}{.2675OFF} \quad \underset{(2.52)**}{}$$

$$- \underset{(2.25)*}{.2422(SB)} - \underset{(-3.31)**}{.2655(SPDLMT)} - \underset{(2.62)**}{.3229(NF)} - \underset{(-2.23)*}{.0267(T)}$$

$$\bar{R}^2 = .9328 \qquad DW = 1.81$$

The coefficient for the no-fault variable indicating the bonus-malus premium rate classification system is negative and highly significant as stated apriori. This result implies that fatalities have decreased with the implementation of the bonus-malus system, holding all other variables constant. This confirms the hypothesis that tailoring insurance premium to driver behavior reduces the overall fatal accident rate.

The coefficient for seatbelt legislation is negative and highly significant, as expected. The coefficients attached to adjusted motor fuel consumption per vehicle is

positive and statistically significant at the 10 percent level indicating that distance travelled is an approximation for exposure to the risk of fatal accidents. The coefficient for offenses is positive suggesting that an increase in offenses leads to an increase in fatal accidents. Finally, the coefficient for the time trend is statistically significant and negative in sign. This estimate provides evidence that improvements in highway design and vehicle technology are related to a decrease in fatal accidents over time.

Modifications to Model I

There are several modifications which could be made to the model specified in equation (4.1). Only those changes based on theory will be made. The variables which are to be added to the model are real income per capita, proportion of licensed drivers between the ages of 16-24, and alcohol consumption per capita.

Adding income per capita, (REALINC), to equation (4.1) altered the explanatory power of the regressions. The results for British Columbia, Manitoba and Quebec are listed below:

British Columbia:

$$(5.4)\quad FR = \underset{(-4.10)**}{-37.78(C)} + \underset{(8.00)**}{1.59(DIST)} - \underset{(-1.80)*}{.2088(OFF)} - \underset{(-2.57)**}{.2230(SB)}$$

$$- \underset{(-1.92)*}{.1969(NF)} - \underset{(-0.67)}{.5810(REALINC)} - \underset{(-1.52)}{.0407(T)}$$

$$R = .8793 \quad DW = 2.13$$

Manitoba:

$$(5.5)\quad FR = \underset{(1.64)}{12.15(C)} + \underset{(.116)}{.0321(DIST)} + \underset{(3.55)**}{.3284(OFF)} - \underset{(-1.24)}{.1388(SB)}$$

$$+ \underset{(.19)}{.4849(REALINC)} - \underset{(1.87)*}{.2473(SPDLMT)} - \underset{(-1.80)*}{.2268(NF)} + \underset{(.455)}{.0089(T)}$$

$$\bar{R}^2 = .9563 \quad DW = 2.07$$

Quebec:

$$(5.6)\quad FR = \underset{(-.809)}{-1283(C)} + \underset{(1.65)}{1916(DIST)} + \underset{(.708)}{.0746(OFF)} - \underset{(2.23)**}{.2826(SB)}$$

$$- \underset{(-.706)}{.6020(REALINC)} + \underset{(1.55)}{.0912(NF)} - \underset{(-.381)}{.01355(T)}$$

$$\bar{R}^2 = .9385 \quad DW = 2.04 \quad RHO = .7137$$

In all models for British Columbia, Manitoba and Quebec, the coefficient for real income per capita was negative and insignificant. Furthermore, adding this variable to the models altered the statistical significance of some variables. In the Quebec model, the variable capturing offenses per licensed driver became insignificant and in

the Manitoba regression the distance travelled variable became statistically insignificant. Multicollinearity was likely to be a problem in these models since it was found that real income per capita was highly collinear with offenses and distance travelled. This would explain why these variables became insignificant when real income per capita was added to the model.

Low multicollinearity between the speed limit variable and other explanatory variables allowed for the inclusion of the speed limit effect in the Manitoba model. While adding the variable did not alter the statistical significance of other independent variables, the overall explanatory power of the regression decreased slightly from 0.97 to 0.94. The coefficient for the dummy variable depicting the years in which Manitoba enforced lower speed limits was found to be negative and highly significant at the one percent level. This result provides evidence to support the hypothesis that the imposition of lower highway speed limits contributes to a significant decrease in the fatal accident rate.

The variable capturing the proportion of young drivers to total drivers was added to equation (4.1) for British Columbia and Manitoba data. The model was not applied to Quebec as data regarding age breakdown of the Quebec driver

population was unavailable. The results for British Columbia and Manitoba are listed below:

British Columbia:

$$(5.7)\quad FR = \underset{(-5.67)**}{-39.82(C)} + \underset{(5.85)**}{1.453(DIST)} - \underset{(-1.85)}{.1662(OFF)} - \underset{(-2.01)*}{.1973(SB)}$$

$$- \underset{(-1.58)}{.1829(NF)} + \underset{(.86)}{.3090(TEEN)} - \underset{(-.91)}{.0148(T)}$$

$$\bar{R}^2 = .8802 \quad DW = 1.94$$

Manitoba:

$$(5.8)\quad FR = \underset{(.162)}{1.44(C)} + \underset{(1.61)}{.1614(DIST)} + \underset{(1.78)*}{.2109(OFF)} - \underset{(1.23)}{.1233(SB)}$$

$$- \underset{(-1.04)}{.1024(SPDLMT)} - \underset{(-1.74)*}{.2212(NF)} - \underset{(-.85)}{.3565(TEEN)} - \underset{(2.78)**}{.0505(T)}$$

$$\bar{R}^2 = .9091 \quad DW = 2.02$$

Adding the variable for young drivers to the regression equations lowered the adjusted R-squared values for both the British Columbia and Manitoba estimates. The coefficients for the ratio of young drivers to total drivers were positive for British Columbia and negative for Manitoba. Neither estimate was statistically significant at the 5 percent level. These results suggest that there

is no evidence to suggest a significant correlation between young drivers and fatal accidents. Furthermore, adding this variable to equation (4.1) did not alter the signs or the statistical significance of the other estimates in the regressions for both British Columbia and Manitoba.

A variable depicting sobriety in a driver population was added to equation (4.1). As mentioned in Chapter 4 several authors have postulated a positive relationship between alcohol consumption and fatal accidents. Alcohol consumption per capita was added to equation (4.1). The results for British Columbia, Manitoba and Quebec are listed below:

British Columbia:

$$(5.9)\quad FR = \underset{(-6.63)^{**}}{-41.69(C)} + \underset{(7.79)^{**}}{1.56(DIST)} - \underset{(-1.90)}{.2380(OFF)} - \underset{(-2.23)^{**}}{.2149(SB)}$$

$$+ \underset{(.567)}{.0002(ALC)} - \underset{(-2.19)^{*}}{.2373(NF)} - \underset{(-1.82)^{*}}{.0203(T)}$$

$$\bar{R}^2 = .8785 \quad DW = 2.10$$

Manitoba:

$$(5.10)\quad FR = \underset{(-.486)}{-5.66(C)} + \underset{(.387)}{.1011(DIST)} + \underset{(.653)}{.001(OFF)} - \underset{(-1.72)^{*}}{.1925(SB)}$$

$$+ \underset{(.954)}{.5492(ALC)} - \underset{(-2.06)^{*}}{.2473(SPD)} - \underset{(-1.81)^{*}}{.2362(NF)} - \underset{(-1.52)}{.257(T)}$$

$$\bar{R}^2 = .9095 \quad DW = 1.87 \quad RHO = .3893$$

Quebec:

(5.11) FR = -12.97(C) + .8642(DIST) + .0949(OFF) - .287(SB)
(-1.07) (1.93)* (1.08) (-3.71)**

+ .0084(ALC) + .0464(NF) - .0022(T)
(0.98) (1.44) (-0.12)

$\bar{R}^2$ = .9518 DW 1.92 RHO = .2881

The coefficients for alcohol consumption per capita were positive but insignificant for all three provinces. This result is not unexpected. An increase in alcohol consumption does not necessarily lead to an increase in drunk driving.

Results for Model II

It would be desirable to compare the effects of different premium rating schemes on the accident rate across various provinces. A model applied to cross-section and pooled time series cross section data allows for these effects to be tested. In addition, it would be interesting to determine whether the estimates from the cross section analysis corroborate the time series results obtained from Model I. Although the time series results suggest that the exogenous forces are well represented in a formulation consistent with the underlying model specification, it is

possible that the trend related variables could lead to spurious influences.

Data

The sample data are represented by ten Canadian provincial cross sections over the period of 1975-1985. The Yukon and the Northwest Territories were not included as data were not available for some particular years. Moreover, accident statistics reported for those territories are often too small to have any significant influence on the overall estimates of the model.

The period 1975 to 1985 was chosen because it encompassed a time in which all government provided insurance schemes were in full operation, with the exception of the Quebec Automobile Insurance plan, which was implemented in 1978. This eleven year time period provides the opportunity to examine the relationship between the cost of accidents and no-fault insurance schemes with or without premium increments based on driver behavior. In addition, this relationship can be compared with the effects of privately provided insurance which uses the traditional premium rating scale, on the accident rate.

The data used for the pooled cross sectional time series model were extracted from the same sources as those for the time series models. The number of automobile

related fatal accidents, offenses, licensed drivers, car registrations, and total amount of fuel consumption per province were taken from various Statistics Canada catalogues. [6] The percentage of driver population wearing seatbelts for each province for the years 1975-1985 as well as the estimated fuel efficiency per vehicle fleet were taken from various annual reports provided by Transport Canada.

Data for the proxies concerning insurance characteristics were obtained from various sources. Average insurance premiums for various provinces were taken from Statistics Canada for the years 1975 to 1985. [7] Finally, details of the premium rate structures for the provinces with government automobile insurance were provided by the British Columbia Insurance Corporation, Saskatchewan Government Insurance Office, Manitoba Public Insurance Corporation, and the Regie l'assurance automobile du Quebec.

Methodology

The model was first applied to cross sectional data covering the years 1975-1985. Despite the limited degrees of freedom, all the coefficients were of the correct sign. However, few coefficients were statistically significant at the conventional 5 percent level. Furthermore, the adjusted R-squared values ranging from 0.14 to 0.53 suggested a relatively poor fit. In addition, none of the F statistics were significant at the 5 or 1 percent level, indicating a poor linear association between the dependent and independent variables. The overall estimates are indicative but not conclusive; therefore it is desirable to apply the model to pooled time series cross sectional data.

Implicit to the pooling of time series cross sectional data is the assumption that the parameter estimates are stable throughout time and across provinces. Stability of parameters was tested by using the analysis of covariance test. Equations for each year were estimated, and it was found that the null hypothesis of constant parameters over time could not be rejected. Separate equations were also estimated for each region. Again, the null hypothesis of stable parameters was accepted.

There are two major problems frequently associated with pooling data. First, cross sectional data are prone to problems of heteroskedasticity, in that individual cross

sections have a tendency not to be mutually independent. Second, time series data are susceptible to problems of autoregressive disturbance terms, as apparent in the time series models in the previous section.

To address these statistical problems, the sample was was applied to a cross-sectionally heteroskedastic and timewise autoregressive model [8]. Essentially the model allows for the presence of heteroskedasticity of the disturbance terms in the cross section units and autocorrelation of the error terms through time. The sample data are subjected to a double transformation. The autoregressive error terms are removed by forcing the parameter p to be the same for all time series units, and a second transformation takes place to remove heteroskedasticity so that the variance in error terms is equal for each cross sectional unit. The transformed data are then estimated by applying the Ordinary Least Squares method.

The pooled cross section time series model employs the same explanatory variables as the time series models - with the exception of insurance characteristics, which are represented by a set of alternative proxies. Before reporting the results of the pooled cross sectional time series model, it is necessary to discuss the proxies used

to represent insurance characteristics and the reasons for their inclusions.

Dummy Variables

The simplest approach to representing insurance characteristics among the provinces is to employ dummy variables. A naive method would be to use a zero - one dummy variable to represent fault and no-fault insurance. However, there are limitations to this approach as it does not allow one to distinguish between provinces with partial no-fault insurance where premium ratings are based on driver behavior, and Quebec which has no-fault insurance where premiums costs have little association with driver behavior.

Instead, two dummy variables are used to disaggregate the different types of automobile insurance in Canada. Quebec, which has complete no-fault automobile insurance is the base category to which the other no-fault jurisdictions will be compared. A dummy variable D1 is set equal to one for those provinces with partial no-fault insurance, and zero otherwise. A dummy variable D2 is set equal to one for those provinces with privately provided insurance, and zero otherwise. The equation to be estimated can be written as follows:

$$(5.12)\quad FR = C + B1(OFF) + B2(DIST) + B3(STBELT) + B4(D1) + B5(D2)$$

where

C = intercept
OFF = number of offenses per licensed driver, expressed in natural logarithms
DIST = distance driven (total fuel consumption/total vehicle registration) multiplied by a fuel efficiency factor, expressed in natural logarithms
SB = percentage of driver population wearing seatbelts
D1 = 1 for BC, Manitoba and Saskatchewan ("claims rate" no-fault insurance)
= 0 otherwise
D2 = 1 for Alberta, Ontario, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland (private liability insurance)
= 0 otherwise
(Quebec Automobile No-Fault insurance)

The results for the model specified in Equation (5.1) are presented in below.

$$(5.13)\quad FR = \underset{(1.93)*}{.7225(C)} + \underset{(1.31)}{.5292(DIST)} + \underset{(1.78)*}{.5550(OFF)} - \underset{(-1.66)*}{.0588(SB)} - \underset{(-3.98)**}{.6310(D1)} - \underset{(-1.86)*}{.5692(D2)}$$

$$\bar{R}^2 = .8627 \qquad F = 21513$$

The high adjusted R-squared value indicates that the model explains 86 percent of the variation in the accident rate.

This is a very good fit considering that the data from various geographical regions were pooled.

Of primary interest are the comparisons among provinces with "traditional", bonus-malus and no-fault premium rating schemes. The statistical results lend support to the hypothesized outcomes. All the coefficients representing insurance characteristics were found to be statistically significant and of the expected sign. The estimates provide evidence that while no-fault premium ratings are positively associated with an increase in fatal accidents, the bonus malus premium rating scheme is associated with a significant reduction in the fatal accident rate. The negative coefficient for traditional premium rating schemes also suggests that there exists a negative relationship between privately provided insurance and fatal accidents, although the magnitude of the relationship is not as great as that number for bonus malus schemes and fatal accidents.

The coefficient reflecting the impact of arrests on the fatal accident rate is negative and highly significant at the 5 percent level. This result implies, holding all other factors constant, that the degree in which drivers are arrested for deviant driving behavior is negatively related to fatal accidents. This result lends support to

the hypothesis that the magnitude of arrests for driving offenses acts as a deterrent to fatal accidents.

The coefficient for distance driven is positive but only significant at the 10 percent level. This result implies that distance driven is not a good approximation for the level of risk exposure to a fatal accident when explaining the variation of fatal accidents across the various no-fault jurisdictions. This was somewhat expected from cross sectional analyses, as the population and environmental characteristics would play a larger role in determining the fatality rates from one no-fault jurisdiction to another.

The estimates for seatbelts imply, holding other factors constant, that fatality rates are consistently lower in those provinces with compulsory seatbelt legislation, as was hypothesized. In addition, the negative and highly significant coefficient confirms the results of the time series models.

It is entirely possible that the highly significant coefficients associated with the dummy variables capturing insurance characteristics are not significantly different from one another. Such a situation could lead to biased and meaningless results. It is therefore desirable to perform a covariance F test. The value of the F covariance statistic clearly exceeds the critical value of the F

distribution at both the 5 and 1 percent levels. On the basis of this result it can be concluded that there exists a significant amount of difference between the the effects of the insurance rating schemes on accident rates. In addition, the highly significant F test also indicated that the model represents a significant degree of association between fatal accidents and the explanatory variables.

Average Cost of Insurance

A variable depicting average cost of insurance, (AP), was added to equation (4.2) as a proxy for the degree of accident cost concentration on automobile owners. The results are listed as follows:

$$(5.13) \quad FR = \underset{}{.5273(C)} + \underset{(1.32)*}{.4376(DIST)} - \underset{(-1.51)*}{.6523(OFF)}$$
$$\underset{(1.96)**}{} \qquad\qquad$$

$$- \underset{(-3.16)**}{.0290(SB)} - \underset{(-2.13)**}{1.10(D1)} - \underset{(0.98)}{.4713(D2)} - \underset{(-0.35)}{.0045(AP)}$$

$$\bar{R}^2 = .4735 \qquad F = 20145$$

The adjusted R-squared value decreased considerably, and the coefficient attached to the average cost of insurance variable was not significantly different from zero. This result suggests that the price of insurance is not related

to the accident rate. In addition, the other independent variables were of the correct sign. However, the statistical significance for the variables capturing distance travelled and compulsory seatbelt legislation was lost.

These results were not unexpected. The average cost of insurance represents a very crude measure of financial accountability on the part of individual drivers. In particular, insurance prices differ widely among private insurance companies, and only a small portion of liability insurance rates is based on driving behavior. Furthermore, a high insurance price does not necessarily indicate a high premium increment based on the driver's record. Finally, the result indicates that there is no evidence that lower insurance prices are associated with a higher accident rate, contrary to the beliefs of some analysts. The evidence suggests that lower insurance prices will not encourage a switch to more dangerous cars, nor does it indicate that more young people will be induced to drive. If lower insurance rates do encourage more young people to drive, or induces a switch to faster, more dangerous vehicles, then the results show that these factors do not lead to higher accident rates. This evidence supports the finding in the time series models that there is little

relationship between the proportion of young drivers and fatal accidents.

A better proxy would be an index measuring insurance premium increments that are geared toward driving behavior. A higher premium increment is expected to be associated with a decrease in accidents as it would encourage drivers to be more cautious. Unfortunately, lack of sufficient data, particularly for the provinces with privately provided insurance, prevents the inclusion of this variable in equation (4.2).

Summary

Proponents of no-fault automobile insurance argue that the elimination of the possibility of increased insurance premiums, policy cancellations and liability costs in excess of policy coverage would no longer have an impact on the deterrent to accident causing behavior. The results from the time series and pooled cross sectional time series models imply that there is no empirical basis for these beliefs.

The estimates from the time series regressions for the provinces of British Columbia, Manitoba, and Quebec support the hypothesis that there exists a strong relationship between rate classification schemes and fatal accidents.

The claims rate scales in British Columbia and Manitoba which are partially tailored to driver behavior were contrasted with the Quebec no-fault insurance scheme where premium ratings have little association with accident causing behavior. The regression results for Quebec provide strong evidence that those premium rating classifications which do not concentrate costs on those at fault result in an increase in fatal accidents. On the other hand, those premium rating schemes which are based on driver behavior indicated by demerit points and number of offenses committed by drivers is associated with a significant decrease in fatal accidents.

Furthermore, the pooled cross sectional time series model provides additional empirical evidence to support the hypothesis that there is a relationship between the type of premium rating scheme and fatal accidents. The estimates for those provinces with claims rate scales and traditional liability premium rating schemes were both negative and both highly significant at the one percent level. However, the coefficient for the claims rate scale was greater than the coefficient for liability insurance, implying that the claims rate scale has a greater deterrent effect on fatal accidents than does traditional liability insurance. This finding makes intuitive sense because the claims rate scale is more tailored to driving behavior than is the

traditional premium rating scale. In addition, there is a larger degree of uncertainty for the driver under the traditional premium rating system and the standards for which the premium is raised as well as its dollar value vary among the private insurers. Finally, the highly significant and positive coefficient for the complete no-fault insurance program in Quebec reinforces the finding from the time series model that complete no-fault insurance is significantly and positively associated with an increase in the traffic fatality rate. This result is consistent with the earlier inference from the Quebec model that complete no-fault insurance is associated with an increase in fatal accidents.

The results also strongly suggest that compulsory seatbelt legislation is effective in reducing the severity of accidents. This is indicated by a consistently negative and statistically significant coefficient for the seatbelt legislation variable for all time series estimates and the pooled cross sectional time series model. In addition, distance travelled is positively related to fatal accidents and is highly significant in all three models. This result indicates that distance travelled is a good proxy for risk exposure to accidents.

The variable representing the number of driving offenses within a driver population was negative and

significant for the Quebec model, and negative and significant for British Columbia, Manitoba and the pooled cross section time series model. The divergence of these results suggest a limitation inherent to the time series model. As made clear by Votey (1984), statistical models such as this one cannot always distinguish between deterrence and deviant behavior. The sign of the coefficient for offenses only indicates which of the two effects is more dominant. While the negative sign for offenses in the Quebec and the pooled cross sectional time series models suggests that the number of recorded offenses per driver represents the deterrent effect of policing, the positive signs for the offense variable in the British Columbia and Manitoba models suggest that offenses represent the degree of deviant driving behavior.

Such conflicting results could be an indication of severe multicollinearity. However, relatively low values for the partial correlation matrices for offenses and other independent variables in the model indicated that multicollinearity was not a problem.

Although the relationship between no-fault insurance schemes and the fatal accident rate appears to be solid, as indicated by the high adjusted R-squared values and the significant individual t statistics, there is a possibility that the strong results obtained from Model I are

statistical artifacts of a particular data set. Applying equation (4.1) to data for three provinces provides the opportunity to evaluate the performance of the explanatory variables chosen for the model and guard against errors caused by fitting a particular sample set too closely. As seen in equations (5.1) to (5.13), the high adjusted R-squared values and the statistically significant coefficients indicate that the model performs equally well for data from all three provinces. In addition, the results from the pooled cross sectional time series model further reinforce the statistical evidence found in the time series models.

Although the results indicate that traffic fatalities can be explained, it would be desirable to have more reliable and detailed data. The majority of the data employed for these models are extracted from police statistics. It is recognized that some categories of accidents - particularly those involving property damage and injuries are subjected to reporting biases which are volatile through time and across geographic regions. Hospital statistics for injuries would have been more accurate; unfortunately, the unavailability of such data precluded such model applications.

The following chapter summarizes the findings of this study. It also discusses policy implications and areas of further research.

Notes to Chapter Five

1. The following information was taken from Statistics Canada Catalogues. Number of fatal accidents: Motor Vehicle Traffic Accidents 53-206, Motor vehicle fuel consumption: Motive Fuel Consumption 53-207, Number of automobiles: Automobile Registrations 53-219, Number of offenses: Traffic Enforcement Statistics 85-205, and Juristat 85-002.

2. Regressions containing the variable depicting percentage of drivers wearing seatbelts were tried. Although all coefficients contained the expected signs, few were statistically significant. These low t statistics are attributed to the lack of degrees of freedom.

3. "CANSIM" is an official mark of Statistics Canada. Real income per capita was obtained from the CANSIM identifier 001014.8.1.

4. The Maximum Likelihood iterative technique, also known as AR(1) is automatically invoked in TSP unless otherwise specified. This process takes the form of

$$e = e + u$$

This technique is asymptotically equivalent to the commonly used Cochrane-Orcutt technique, differing for only very small samples.

5. See Kennedy (1979) for a description of this technique.

6. See note 1.

7. Statistics Canada Family Income Expenditure, various years, and Insurance Bureau of Canada Facts various issues 1975-85.

8. See Kmenta (1971) pp. 508 - 517

CHAPTER 6

CONCLUSION

Summary

This study was devoted to the analysis of the relationship between no-fault insurance and the social cost of automobile accidents. It has often been suggested by policy analysts that the manner in which automobile insurance is to be provided can be explicitly linked with the level of care an individual exerts when driving, which in turn influences the accident rate within a particular region. This linkage, often referred to as the deterrent effect, is frequently overlooked when designing a system of automobile insurance. If such a relationship exists, and is ignored, an insurance system could lead to needless increase in the social costs of accidents. The purpose of this study was to determine whether the deterrent effect does exist in various types of no-fault insurance schemes, and if so, to what extent it affects the social costs of accidents.

Chapter Two examined the theoretical foundations of accident behavior to determine whether a deterrent effect exists. The effects of tort law, safety regulation, taxes

and types of insurance schemes on the level of care individuals take to avoid accidents were discussed. It was established that there is some theoretical support for the no-fault insurance - accident linkage. Indeed, it was argued that negligence rules, driver behavior, regulation of vehicle use, and insurance with ex-post premium rates based on driving experience affect the level of care a driver takes.

Chapter Three contained a survey of the literature. This chapter not only served as an introduction to the methodology of accident modelling, but also identified the factors traditionally thought to influence accident prevention behavior. The chapter indicated that the results of previous studies which tested the relationship between accidents and no-fault insurance were mixed. Several studies suggested that there is no relationship between no-fault insurance and accidents, while others concluded that the implementation of a no-fault insurance program was associated with significant increases in accident losses. A major reason for the divergence in the results is that the majority of studies surveyed failed to distinguish between a no-fault system with premium increments based on driver behavior and one with no premium increments.

Chapter Four set out a theoretical and empirical model which was used to investigate the relationship between various types of insurance premium systems and the accident rate. It was found that no single variable could adequately explain the variation in fatal accident rates. The determination concerning causes of accidents is a complex issue encompassing psychological and environmental factors as well as economic characteristics. The empirical model developed in this study incorporates some of these factors. The fatal accident rate per 100,000 vehicles was regressed on the number of offences per licensed driver, the distance driven per motor vehicle, a variable indicating safety measures including compulsory seatbelt legislation and where possible, lower speed limits, and a variable depicting insurance premium characteristics.

The model was applied to two types of data: time series data for the years 1960-1985 and pooled cross sectional time series data for the ten Canadian provinces over the years 1975 to 1985. In the time series model a no-fault insurance system with no premium increments based on driver behavior was contrasted with a partial no-fault insurance system where premiums were related to driving experience. The model was applied to Quebec, British Columbia, and Manitoba time series data. In all model applications it was found that the regression results

explained between 91 and 95 percent of the variation in the fatal accident rate, with standard errors in the 0.100 range. In addition, all coefficients in all regressions were statistically significant at the 5 percent level. The sign for no-fault insurance was found to be positive and significant for Quebec, and negative and significant for both Manitoba and British Columbia. The results for Quebec imply that the implementation the Quebec Automobile Insurance Act in which premiums are not linked to driving experience was associated with a significant increase in the fatal accidents rate. Conversely, the empirical evidence for Manitoba and British Columbia indicate that the introduction of a claims rate scale in which premium increments were determined by driving record and linked with a significant decrease in fatal accidents.

The hypothesis that premium increments are related to accidents was tested in a pooled cross section-time series model. Data from Canadian provinces for the years 1975-1985 were combined to perform statistical analysis. The deterrent effects of three types of insurance systems in Canada were tested: the complete no-fault scheme where premium charges are independent of driver behavior, the partial no-fault system where premiums charged are based on ex-post driving behavior, and the privately provided insurance schemes where premium charges are based on

ex-ante demographic characteristics and expected driver behavior. The R-squared value of .86 indicated that the model explained more than half of the variation in the accident rate in Canada. This is a particularly good result, given the nature of pooled data. Again, all coefficients were found to be statistically significant at the five percent level or better, and all were of the expected sign. The covariance F test indicated that the intercepts for insurance premium characteristics were significantly different from one another. The results of the model indicated that provinces with premium ratings based on ex-post driving behavior were associated with the most significant decrease in accident rates. Privately insured provinces experienced a decrease in accident rates to a lesser degree. Finally, it was found that the province of Quebec containing complete no-fault insurance experienced a significant increase in fatal accidents.

Contributions Made by this Study

Previous studies have focused on the no-fault accident rate relationship without distinguishing between no-fault insurance with premium increments based on past driving experience and those without. In Chapter Two and Three the

importance of these factors were recognized. This study has incorporated these factors into the empirical models.

From the theory and the literature reviewed, it was pointed out that there seems to be little linkage between the theoretical developments of deterrence and the empirical testing of deterrence. While several authors have developed a theory to support the existence of the no-fault accident rate relationship, they do not test their theories empirically. Conversely, several empirical models have been developed on an ad-hoc basis without any specific reference to theoretical foundations. This study has attempted to bridge the gap between the two extremes by constructing an empirical model based on economic theory.

This study differs from previous studies concerning deterrence in several ways. One difference is that it compared the effects of various insurance premium rating schemes on the accident experience of Canadian provinces. While previous studies focused on the relationship between no-fault insurance and accidents, very few took into account the structural difference between no-fault schemes depicted by the premium rating scales.

A second difference is that this study not only examined the change in the fatal accident rate before and after the introduction of new premium rating schemes in various provinces, it also evaluated the performance of

these insurance schemes in a pooled cross sectional time series framework. In addition, the pooled data was used to confirm the results obtained from the time series models. The majority of previous studies used either time series or cross-sectional model but not both techniques to test their hypotheses.

Policy Implications

A key policy issue formulated at the beginning of the study was whether there is a significant relationship between the manner in which automobile insurance is provided and the social costs of accidents. The motivation for this question came from the argument advanced by no-fault proponents that there is no relationship between financial accountability and the social costs of accidents. This argument is of great significance as it forms the central justification for abolishing fault.

The results obtained from this study cast serious doubts on the validity of this argument. Indeed, the statistical inferences provide strong evidence that the degree of financial accountability for careless behavior can affect the accident rate, contrary to what no-fault proponents assert. In particular, the results indicate that those schemes in which insurance premiums are priced

according to the individual's behavior as depicted through demerit points and his or her accident record are significantly associated with a reduction in accidents. Premium pricing that is based primarily on actuarial considerations were found to be less effective in reducing the social costs of accidents. Finally, the positive association of no-fault insurance with accident rates in Quebec indicates that there is little deterrence to accident causing behaviors present in complete no-fault schemes.

The results for Quebec do not imply that people will have a greater tendency to kill themselves in accidents simply because they are no longer held financially responsible for the accidents they cause. Obviously the instinct of self protection will motivate people to avoid accidents. Nevertheless, the results do indicate that self preservation instincts are not sufficient to produce a socially desirable level of accident avoidance. The evidence suggests that people tend to be less careful when financial responsibility for accidents is removed.

The results of this study imply that there is a deterrent to accident causing behavior present in liability and claims rate insurance. On the basis of these results, the adoption of a complete no-fault insurance scheme, in which premium prices have little relation to driving

experience, would result in a substantial increase in the number of accidents. In the long run these costs are likely to offset any immediate saving incurred by the reduction in litigation and administrative costs.

Having determined that there is little deterrence to accident causing behavior present in complete no-fault insurance does not imply that no-fault insurance is socially undesirable. It is possible to design a no-fault insurance system which encourages safe driving while keeping with the objective of compensating all victims regardless of fault.

Finally, the results of this study indicate that the deterrence of accident causing behavior is not a question of distinguishing between no-fault and fault systems, nor is it a question of whether private or public industry provides the insurance. Rather, the key element to the deterrence controversy lies in the ability of the insurance scheme to hold individuals financially responsible for accident causing behavior. As long as it can be shown that financial accountability is directly related to the incentives to avoid accidents, there is no economic rationale for eliminating such a system.

Shortcomings and Areas for Further Research

The causes of accidents are difficult to quantify given the interactive nature of the independent variables. Modelling accidents is an extremely complicated task because it involves complex human decisions, psychological and demographic factors as well as economic factors. The psychological and behavioral factors can only be proxied. For instance, offense committed only serves as a very simplistic representation of the degree of carelessness within a driver population. It remains unknown to what extent offenses influencing fatal accidents are captured by the proxy.

The results of equation 4.1 and 4.2 are indicative but not conclusive. A shortcoming of the model concerns the incorporation of institutional factors (i.e. the type of no-fault insurance scheme) which influence fatal accidents. Although slope dummy variables were included to represent various types of no-fault insurance schemes, it is possible that the subtle differences between no-fault schemes were not captured by this variable.

Lack of data resulted in some assumptions about the parameters. For example, it would have been much more desirable to include data regarding the average speed of cars and a more detailed breakdown of demerit points,

suspended licenses and the number of accidents per driver. In addition, it would have been desirable to measure the effects of a premium increase which a driver must bear if deemed at fault in an accident. While limited information was available for some government provided insurance schemes, no information of this nature was available for provinces with privately provided liability insurance. The Insurance Bureau of Canada (IBC) is currently making efforts to improve its database by integrating insurance pricing information from all provinces. The IBC will also require all insurance companies to report track claims records of all drivers. This statistical plan is expected to commence in July 1988. [1]

Improvements to the model would be made by a closer examination of the interactive factors which influence accident rates. In the discussion of the literature review and the model results the possible existence of simulteneity among variables was implied. Further research may include attention to this issue and the development of a model to include structural equations. Unfortunately, the problem of incorporating these factors into a statistical model has no easy solution. Until a more detailed and more accurate data base regarding accidents and their causes is developed, the problem is likely to remain.

Notes to Chapter Six

1. Ontario Task Force on Insurance (1986), p. 97, and Insurance Bureau of Canada (1987), p. 2.

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