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Ministère de la Justice Canada

EVALUATION DOCUMENT

A STATISTICAL ANALYSIS OF THE IMPACTS OF THE 1977 FIREARMS CONTROL LEGISLATION

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EXECUTIVE SUMMARY

This evaluation report focuses on the effectiveness of the 1977 changes to the *Criminal Code* specifically designed to address the problems of firearms deaths and injuries as well as crimes involving firearms.

Evaluation:

The Treasury Board Secretariat of the Government of Canada specifies that evaluation in the federal government is the responsibility of the Deputy Minister of each Department and Agency. The federal Evaluation Policy specifies that evaluations are to be completed by officials who are independent from the programs and policies to be assessed. The Evaluation Section of the Department of Justice is a separate entity which provides independent assessments of the performance of Departmental policies, programs and operations. The unit has a direct reporting relationship to the Deputy Minister on all evaluation matters.

In undertaking this function, the Evaluation Section often engages the professional services of consultants to undertake field work which can be used for completing evaluations. For this project, we engaged Prairie Research Associates Inc. to compile and analyse data from a variety of sources, and to construct rigorous statistical models to test the impacts and effects of the 1977 and 1991 legislative amendments. This evaluation report, prepared by the Department of Justice, draws heavily from the work completed by Prairie Research.

Background:

Gun control has evolved in Canada over a long period of time, dating back to at least 1892. In 1993, the Auditor General of Canada, while noting that Canada's gun control program is both controversial and complex, recommended that the Department of Justice undertake an evaluation of the program in order to provide Members of Parliament and the Canadian public assurance that the objectives of the legislation are being met. In particular, he proposed the need for a rigorous statistical analysis of the impacts and effects of the Firearms Control Initiative on changes in rates of firearms deaths and crimes over time. This study is one of the most comprehensive statistical analyses of the impacts of any legislative initiative undertaken in Canada to date.

Methodological Approach:

The guiding questions for this study were: (i) what observed changes have occurred over time in the incidence of firearms related deaths and to what extent can these changes be attributed to firearm control legislation; and, (ii) have there been changes in the incidence of firearms offenses over time and to what extent can any changes be attributed to the firearms control legislation.

The relationship between gun controls and firearms related deaths has been studied for many decades. In the last 20 years, social scientists have used increasingly sophisticated statistical methods in an attempt to infer whether regulating access to firearms reduces the incidence of homicide, suicide and accidental deaths involving firearms. Much of this methodological research has been completed in the United States.

These studies have generally conformed to one of three approaches: exploratory analyses; time series analyses; or, structural modelling. The statistical modelling strategy for this study is comprehensive, proceeding from exploratory analysis through time series modelling and then to structural modelling. Each stage of analysis presents a successively more elaborate test of the basic proposition; namely, has gun control affected the incidence of firearms related deaths and/or criminal misuse in Canada. During the course of the study it became apparent that the 1991 legislation could not be assessed. Therefore, the findings of this evaluation report are directed to the 1977 legislative amendments.

Synopsis of Findings

As with any large scale study, it is difficult to provide a synopsis of findings. In this particular case, a summary of the findings can be somewhat misleading, because the results from the different analytical models are, at times, contradictory. As a result, we strongly recommend a full reading of the entire report in order to gain a comprehensive sense of the findings. In this regard, we note that anyone looking for a straightforward answer to the question "has gun control met its objectives?" will be disappointed. There is not a simple "yes" or "no" response.

Initially, an exploratory analysis of the data showed a number of different patterns, some of which are inconsistent. With regard to homicides, the exploratory analysis suggested that the trends in both total and firearms homicides at the national level have been declining steadily since between 1975 and 1978 depending upon the specific region examined. However, in all regions of Canada, there has been a steady decline in fiream homicides since the 1977 legislation was implemented.

With regard to suicides, the time series steadily declines after 1978 both nationally and in Western Canada and Ontario. For firearm suicides, there is a distinct change from an increasing trend prior to 1978 to a decreasing trend since 1978.

Nationally, robberies have increased steadily during the period between 1974 and 1993. However, robberies with firearms have declined over the same period. In general, the use of firearms has continued to decrease, reaching an historic low of approximately 25 per cent of all robberies in recent years.

The next stage of analysis involved more rigorous statistical analysis of these time series. The ARIMA time series modelling produced a number of different results some of which were inconsistent. For example, the models indicated that the 1977 legislation may have had a statistically significant impact on homicides involving firearms when viewed at a national level and in Ontario. But, the same patterns were not evident in other regions.

With regard to suicides, the models suggested that the legislation had a delayed impact (i.e., modelling the legislative impacts for 1979 with the introduction of the FAC system) in patterns of suicides in Ontario, Western Canada and for Canada as a whole. Firearms accidents show a similar pattern. The analysis suggests that nationally, the legislation has had a delayed impact. Similarly, the models suggest that the legislation has reduced the rate of firearms accidents in Western Canada. But, the same patterns were not evident in other regions.

Taken together, the results of the exploratory and time series analyses suggest that the 1977 legislative amendments have had some impacts. However, the results of this stage of investigation demonstrated the need to construct structural models which could assess the simultaneous impacts of gun control, social and economic factors, and other influences.

In response, structural models were constructed for this study to incorporate into the analysis social, demographic, economic and institutional variables, as well as a measure for the introduction of the gun control legislation. In constructing and testing these models, we found two primary sources of estimation error: multicollinearity and aggregation bias. Using currently available data and analytical techniques, any statistical analyses of legislative initiatives including gun control will be subject to these same phenomenon.

Having noted this, the structural models constructed for this evaluation suggest that the 1977 amendments have reduced the rate of homicides in Canada by approximately 55 per year. However, these models do not demonstrate a clear effect with regard to the incidence of suicides involving firearms. This finding is in conflict with the prevailing literature which suggests that there is a relationship between firearms availability and suicides using firearms.

The models also show a relationship between the 1977 amendments and the incidence of accidental deaths involving firearms, although the model presents a number of inconsistencies. Further, we also note that we were unable to collect data regarding firearms safety courses for inclusion in the model. In terms of criminal misuse, we were unable to obtain consistent data over a long enough period of time to undertake structural estimates of the impact of the gun control legislation on the incidence of robberies involving firearms.

One of the most significant findings was that although this study was comprehensive and very detailed, the lack of available data limited the analysis and as a result the evaluation findings. And, in this regard, it is strongly recommended that the ground work and planning for the evaluations of the 1991 and 1995 legislative amendments be done now in order to ensure, to the extent possible, that the necessary data are available.

1. INTRODUCTION

This report presents the findings from an evaluation sub-study of the impacts and effects of the Firearms Control Initiative of the Department of Justice. This initiative stems from the legislative amendments introduced into Parliament in 1977 and in 1991. This report provides a comprehensive statistical investigation of the extent to which the firearms control regime has been effective in meeting its legislative objectives as it existed at the time that the field work for this project was undertaken (i.e., 1995). This report uses statistical procedures to measure the extent to which gun control has influenced deaths by firearms in the context of many of the other social and economic factors that might also be related to those deaths.

1.1 Legislative Rationale for Gun Control

The rationale for gun control in Canada stems from the premise that many incidents of firearms misuse causing death and injury are preventable. Therefore, restricting access to firearms to responsible gun users should reduce such incidents. In addition to this public safety perspective, the Firearms Control Initiative also takes a criminal justice approach by including measures designed to deter offenders from using firearms in criminal activities.

This rationale was made clear by the government two decades ago. For example, in 1976 a publication of the Department of Justice Canada stated that "there is growing concern about the increase in crimes and tragic incidents involving the use of firearms." Furthermore, "the Government shares the public's concern regarding the use of firearms in the commission of crimes, suicide and gun-related accidents"[1]. Easy access to a firearm can mean that common everyday conflicts result in tragedy.

However, in recent years the government has enunciated another theme — gun control is intended to help maintain Canada's non-violent character, a situation in implicit contrast to the much higher rates of gun deaths and injuries in the United States.[2] In sum, both the 1977 and 1991 changes to the *Criminal Code* were designed to address public health and safety as well as the criminal misuse of firearms.

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[1] Department of Justice Canada, 1976, p. 3.

[2] For example, see the speech delivered to Parliament by the Honourable Allan Rock, Minister of Justice and Attorney General of Canada on June 13, 1995 in Hansard, 133 (217).

The Firearms Control Initiative was never oriented towards reducing the availability of all firearms in Canada, except for guns designed for military use and other high firepower firearms that have limited sporting purposes. The legislation and supporting programs are intended to focus on:

- limiting access to firearms by screening and identifying individuals whose behaviour suggests - on reasonable grounds - that they might be a danger to society or themselves; and,

- encouraging and regulating safe storage and usage practices.

The overall goal of the Initiative is to contribute to making Canada a safer society. The Intitiative is only one component of the broader government strategy to reduce crime and enhance public safety. This report examines the statistical evidence regarding the association between firearms control legislation and patterns in firearms related deaths.

1.2 Outline of the Report

Chapter Two provides background material regarding the history of firearms control in Canada, and more specifically, the 1977 and 1991 legislative amendments which are the subject of this review. This background is essential to understanding how we tested the association between the gun control regime and deaths by firearms. Contrary to widespread belief, gun control legislation/regulation and programming was not implemented at a specific point in time -- rather, it was a gradual process. This makes it difficult to find statistically significant associations between gun controls and changes in the rates of death by firearms. Chapter Three describes the methodology we used, Chapters Four through Six present the findings from our analyses of the available quantitative data.

2. LEGISLATIVE CONTEXT

As noted, this study focuses on the gun control measures developed from 1977 to 1991. It does not deal with the legislative amendments introduced into Parliament in 1995 (i.e., Bill C-68). In 1977, the *Criminal Law Amendment Act* (Bill C-51) was passed by Parliament. More recently, Bill C-17 was passed in late 1991. A brief summary of the history of the two sets of measures is provided in this chapter.[3]

2.1 The Firearms Control Initiative: Summary of Main Features

The Firearms Control Initiative is made up of two components — the legislative/regulatory component and the program component. The legislative/regulatory component includes things such a Firearms Acquisition Certificate (FAC), which is required to take possession of a firearm, while the program component includes such things as safety courses on the safe handling and use of and laws relating to firearms. This report is focused exclusively on the impacts and effects of the legislative/regulatory component.[4] This study focuses on the impacts arising from the 1977 and the 1991 changes to the *Criminal Code*, changes that represent a continuation of a long series of gun control measures that date from 1892.[5]

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[3] This chapter provides a brief informal review of the 1977 and 1991 legislation. It is recommended that readers who require specific information consult the original statutes, Orders-in-Council, and Parliamentary reports.

[4] In other words, this review focuses on the effectiveness of the Federal Government's legislative measures designed to address the problems of firearms deaths and injuries, and crimes involving firearms. A second study will focus on the program component of the initiative and examine the implementation of the firearms control program at the federal level, as well as the support to the provinces and territories by means of financial and other concrete assistance relating to specific elements of the legislation.

[5] Firearms Control Task Group, Department of Justice Canada, (n.d.) *Paper on the Registration of all Firearms, Report to the CACF.*

2.2 Background to the 1977 Legislation

In the mid seventies, federal proposals to introduce stricter gun control provisions in the *Criminal Code* were contained in the Peace and Security Program, which included other measures such as changes in murder penalties, dangerous offender legislation, changes to the early release mechanisms for federal inmates, and increased resources for crime prevention. While most of the gun control measures in Bill C-51 remained intact through the Parliamentary process, one key provision did not.

Figure 2.1 Chronology of Gun Control Legislation in Canada 1892 - 1976

1892:	The first permit system for small arms introduced.
1913:	Sale of handguns restricted to permit holders.
1920:	The *Criminal Code* amended to require every person, in order to possess a firearm, to obtain a permit from a magistrate, a chief of police, or the RCMP. British subjects already in possession of long guns did not have to obtain a permit unless they wanted to newly acquire firearms. Permits were valid for one year and records were maintained only at the local level.
1933:	The penalty for carrying a handgun outside the home or business increased to a maximum of five years.
1934:	All handguns were to be registered, wherever kept. The Commissioner of the RCMP and police departments were given the authority to issue registration certificates.
1938:	The *Criminal Code* amended to make certificates subject to renewal every five years.
1944:	Re-registration postponed because of the war. During the war, rifles and shotguns were subject to local registration.
1950:	The *Criminal Code* amended to make handgun certificates no longer subject to renewal.
1951:	A centralized registry for handguns established under the authority of the Commissioner of the RCMP.
1968:	Firearms classes — prohibited weapons, restricted weapons, and non-restricted guns — introduced.
1969:	The present system of registration of restricted weapons adopted, with one certificate for each weapon.
1976:	Bill C-83 was introduced, which included new offences for the criminal misuse of firearms, stricter penalties, the prohibition of fully automatic firearms, possession certificates with guarantors, and proposals for firearms education programs. The Bill died on the Order Paper in July 1976.

In 1976, in Bill C-83, the Federal Government had recommended that every person in possession of any firearm or ammunition be required to obtain a license, valid for five years, to be issued only if the licensing officer "is satisfied that the applicant has nothing in his or her background that would render him unfit to possess a firearms' license." The applicant would also be required to provide "the statements of two guarantors, from a selected list, who have known him or her for more than two years, to the effect that they too know of nothing that would render him or her unfit to possess a firearms' license." These proposals were not included as part of Bill C-51.

Bill C-51 received Royal Assent in August, 1977. On January 1, 1978, Bill C-51's provisions relating to new firearms offences, changes to police search and seizure powers, increases in penalties, mandatory and discretionary prohibitions from possessing firearms, and additions to the categories of prohibited and restricted weapons were proclaimed.

On January 1, 1979, the two final changes came into effect: the introduction of the Firearms Acquisition Certificate, and the Firearms and Ammunition Business Permit systems. At that time, the Federal Government entered into financial agreements with the provinces and territories to compensate them for the administration of the FAC and business permit systems.

This chronology clearly shows that the legislation emerged over a three year period of proclamation and establishment of the subsequent regulatory regime.[6] This gradual emergence of the gun control regime has important implications for measuring the association between the legislation/regulation and the outcome, namely the rate of death by firearm.

The 1977 amendments to the *Criminal Code* were developed and implemented by a Working Group on Gun Control in the Ministry of the Solicitor General. It was this unit that was responsible for the public education and police training that were necessarily associated with the changes to the *Code*; the administration of the legislative amnesty; the development of the provincial/territorial financial agreements in conjunction with the RCMP (which was responsible for ongoing administration); the development of regulations, such as those for storage of firearms by firearms business. Subsequently, in 1983, the government undertook a major safety campaign that involved pamphlets, posters, and films on the safe handling and use of firearms.

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[6] The legislation received Royal Assent in 1977 and six months later the legislation was proclaimed and implemented over the following year. The implementation period of 1978 to 1979 could be taken as the specific period when the gun control regime took effect.

Throughout the eighties, at regular meetings of the Chief Provincial/Territorial Firearms Officers (CP/TFOs), a number of amendments to the 1977 legislation were recommended, primarily of a technical or "housekeeping" nature. However, there were no changes to the firearms control provisions of the *Criminal Code* until 1991.

In 1987, the Firearms Policy Centre, which had been located in the Ministry of the Solicitor General since the mid-seventies, was transferred to the Department of Justice. In 1989, a mass shooting of school children in California prompted a proposal by the Minister of Justice to prohibit converted fully automatic firearms. The rationale for this proposal was that many converted weapons can be easily reconverted to fully automatic fire.

In 1989, government officials began working on legislation to make these and some other changes (including the housekeeping amendments referred to above) that would strengthen the enforcement of the gun control provisions in the *Criminal Code*. The shooting of the women students at the University of Montreal in December, 1989 provided additional impetus to the development of Bill C-80 which included the tightening of controls on the issuance of FACs. Before Bill C-80 died on the order paper in 1990, a committee of the House of Commons (the Reimer Committee) heard the testimony of 60 witnesses and received 350 written submissions on the Bill.

By this time, there were well organized and vociferous interest groups on both sides of the gun control debate. On one side were groups such as the Coalition for Gun Control, which was formed after the Montreal shootings. On the other side were a number of gun control interest groups, ranging from shooting and hunting organizations concerned about the effect of legislation on their sports, to organizations such as the National Firearms Association whose members generally believe that gun control excessively intrudes into the lives of law-abiding citizens.

After making both technical and substantive changes to respond to concerns raised about Bill C-80, Bill C-17 was passed by the House in November, 1991, and received Senate approval and Royal Assent on December 5, 1991.

Components of the Bill were proclaimed at different stages, between August 1, 1992 and January 1, 1994. The reasons for the phased proclamation included: to permit the development of implementation strategies and accompanying programs; to develop and receive approval for the regulations; and to allow time for gun owners and users to become familiar and comply with the legislation and regulations.

Many features of the Bill were left to be determined by regulations. Because of the extent of the regulatory powers, the Bill contained a rare provision for Parliamentary examination of new regulations prior to their enactment.[7]

In 1992, the Justice and Solicitor General Standing Committee held hearings to review the proposed regulations; their report was prepared in July 1992. In addition to the consultations with interest groups initiated by Parliament, public input on the changes was also obtained by means of the Canadian Advisory Council on Firearms, a body appointed by the Minister of Justice to make recommendations in key areas.

The implementation period began in March 1992 with the tabling in Parliament of the first set of proposed regulations. Other major dates in the phased implementation were:

- August 1, 1992 - enhancements to sentencing powers and prohibition orders, and the period for registering converted automatic firearms began;
- October 1, 1992 - the deadline for applications to register "grand-fathered" converted fully automatic firearms (i.e., the prohibition of unregistered converted automatic firearms); changes to registration and permit provisions; and, additions to *Prohibited Weapons List* and *Restricted Weapons List* took effect;
- November 1, 1992 - the National Amnesty month (later extended to December 15, 1992); and the proclamation of newly restricted and prohibited weapons in the regulations;
- January 1, 1993 - the introduction of the new FAC procedures (except the safety course) and safe storage, etc. regulations;
- July 1, 1993 - the cartridge magazine capacity limits took effect;
- January 1, 1994 - the mandatory safety course or test for FAC applicants (some jurisdictions were given extensions).

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[7] *Criminal Code* subs. 116(2) S.C. 1991, c. 40 s. 28(4).

2.3 The Objectives of the Initiative and the Legislation

The goal of both the 1977 and the 1991 Firearms Control Initiative was to afford better protection for the public against firearms mishaps and deliberate firearms misuse; that is, to make Canada a more safe society. As will be demonstrated in the next section, the 1991 amendments are largely an enhancement to those made in the late seventies.

The specific objectives of firearms control legislation are threefold:

- to control access to firearms;
- to control the availability and accessibility of specific firearms; and,
- to deter offenders from using firearms in crimes.

The legislation is therefore designed to increase the safety of the public, while maintaining a system that permits the legitimate use of firearms for sustenance and for recreational and sporting purposes.

2.4 The Main Elements of the 1977 and 1991 Legislation and Regulations

This section of the report presents a summary of main elements of the 1977 and 1991 legislation. The legislation and regulations associated with these regulations may be framed as follows:

- Measures to control access to firearms include:
  - Firearms Acquisition Certificates (FACs);
  - search and seizure powers of police;
  - prohibition orders;
  - safe handling and storage; and,
  - firearms business provisions.

- Mechanisms to control the accessibility of specific types of firearms are:
  - the prohibited and restricted weapons measures; and,
  - the prohibition of overcapacity magazines.

- Deterrence measures include the sentencing provisions.[8]

2.4.1 Measures to Control Access to Firearms

Firearms Acquisition Certificates

The 1977 legislation introduced the Firearms Acquisition Certificate (FAC), which must be obtained by persons before acquiring in any manner any type of firearm. An application to obtain an FAC is made to a firearms officer and could not be issued to persons less than 16 years of age or to persons who have been prohibited from possessing a firearm (see below). Firearms officers could refuse to issue an FAC if they had information that indicated that it would not be in the interests of the safety of the applicant or any other person. Criminal records or evidence of mental illness were typical instances where refusal was contemplated.

Few FACs were refused under this legislation, although it was apparently fairly common for informal "pre-screening" by firearms officers to occur. That is, officers would discourage inappropriate applicants. The 1977 legislation contained a subsection that stated that no persons should receive an FAC unless they had completed a course in the safe handling and use of firearms, or had completed a test in firearms handling and use. These courses, which had to be sanctioned by provincial Attorneys General, were never organized.

The 1991 legislation enhanced the FAC screening process by: increasing the amount of information required from the applicant; instituting a mandatory 28 day waiting period; requiring names of references; allowing police to conduct interviews with neighbours, family etc.; and a photograph. Other changes in the 1991 legislation include an increase in the age (from 16 to 18), seizure of the FAC if the police legally seize the firearm, and automatic revocation when a court prohibits carrying of a firearm. The legislation also made provision for a course that covered firearms law and the possession of and the safe handling and storage of firearms. Applicants for a FAC could take a test in lieu of the course to demonstrate they had the requisite knowledge needed to possess/acquire firearms.

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[8] Some aspects of the legislation apply to two objectives. In particular, prohibition orders can be viewed as deterrence/incapacitation mechanisms as well as measures to restrict access to firearms. For the purposes of this discussion we have chosen to categorize prohibition orders as measures to reduce access.

Search and Seizure Powers

The powers of the police to search for and to seize weapons were increased by the 1977 changes. Search and seizure without a warrant are possible if the police have reasonable grounds for believing that it is not desirable in the interests of safety of that person or any other person to have possession of a firearm, and that it is impractical for the officer to obtain a warrant. No major changes to these powers were made in 1991, other than to limit the availability of such powers to "exigent circumstances" to ensure compliance with section 8 of the *Charter of Rights*.

Prohibition Orders

The 1977 law introduced prohibition orders — court orders preventing a person from having access to, possessing, or having control of a firearm or ammunition or explosive substance for a specified number of years. In the 1991 legislation, the provisions were strengthened primarily to increase the power of the courts in cases of domestic violence.

Genuine Gun Collectors

In 1977, only "bona fide gun collectors" could register firearms under a "grandfather" clause and register ordinary restricted weapons as part of a collection. The term was not defined. The 1991 legislation defined "genuine gun collectors" as...

> anyone who has or seeks to acquire one or more restricted firearms that are related or distinguished by historical, etc. characteristics, has knowledge of those characteristics, has consented to periodic inspection conducted in a reasonable manner in accordance with the regulations, and has complied with regulations respecting knowledge, secure storage and the keeping of records with respect to the restricted weapons.

This definition was added to the statute in order to address concerns that applicants for restricted weapon registration certificates were able to claim gun collector status when the restricted firearm was being sought for other purposes. Therefore, the intention is to reduce the incidence of persons falsely claiming to be collectors in order to gain access to restricted weapons for other purposes.

Firearms Businesses

Starting in 1979, firearms and ammunition businesses were required to obtain a business permit. These businesses also maintain records of transactions and inventory. Business permits must be renewed annually and renewal generally involves an inspection by either provincial inspectors or local police. The 1991 legislation included firearms museums as a form of business, invoking business regulations and requiring employees to be screened.

Safe Handling and Storage

In the 1977 legislation, firearms businesses became subject to regulations on safe handling, storage, display, etc. Individual gun owners were liable to being charged with careless use, carrying, handling, shipping, or storage. "Genuine gun collectors" of restricted weapons were also subject to safe storage regulations.

As of January 1993, individual gun owners were, for the first time, required by regulation to practice safe storage, handling, display, transportation. These provisions are intended to regulate specific day-to-day activities in which the presence of a firearm may present a safety risk if not stored and handled properly. As well, they are intended to reduce the risk of thefts of firearms and to make firearms less accessible to persons in the household who may present a risk to themselves or to others.

2.4.2 Measures to Control the Availability and Accessibility of Specific Firearms

Although the Firearms Control Initiative has not directly attempted to reduce the total number of firearms in Canada, the legislation has banned certain types of firearms and other weapons deemed to have no legitimate purposes. The accessibility of handguns and a small number of specific types of long guns is reduced by restricting their possession to persons who have registered these firearms with the national registry maintained by the Royal Canadian Mounted Police. Individuals may acquire restricted firearms for a variety of purposes (e.g., target practice, collectors, lawful professions). Registered owners of these firearms are also required to obtain permits to carry and transport.

Prohibited Weapons

Except for those weapons grandfathered by the legislation, prohibited weapons may only be possessed by the police and the military.[9] Before 1977, the *Criminal Code* specified three categories of prohibited weapons: silencers, switch blades, and any weapon not being an antique firearm or of a kind commonly used for hunting or sporting purposes in Canada declared by Order-in-Council to be prohibited. The 1977 legislation added fully automatic firearms, and sawed off shotguns and rifles to these classes. The possession or importation of a prohibited weapon carried a penalty of five years in prison.

Restricted Weapons

Restricted weapons include handguns, short barrelled semi-automatic weapons, folding or telescoping firearms, fully automatic firearms that had been registered as restricted before January 1978 and formed part of a gun collection of a genuine collector, and any other weapon not reasonably usable for hunting or sport that is declared by Order-in-Council to be a restricted weapon. The main changes to the restricted weapons provisions in Bill C-51 were the "grand-fathering" of (an estimated) several thousand fully automatics provided that the owner had registered them; and the restriction of firearms with a barrel of less than 470 mm. in length and capable of discharging centre fire ammunition in a semi-automatic manner.

All restricted weapons must be registered by the Commissioner of the RCMP. A registration certificate may be obtained upon application to a "local registrar of firearms," and possession of a restricted weapon without a certificate or permit is an offence. The certificate may be issued if the applicant is 18 years or older and the firearm is required:

- to protect life;[10]
- for a lawful profession or occupation;
- for target practice at a club approved by the Provincial Attorney General;
- because the applicant is a bona fide collector; or,

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9 There are exceptions for the police, military, and similar occupations *(Prohibited Firearms Control Regulations)*, S.C. 1991, c. 28, (ss. 92 and 98), and for designated industrial applications (ss. 90(3.1), 95(2).

10 Provincial policies have resulted in very few registration certificates and carry permits being issued for the purpose of protection of life (which would include protection from animals as well as other persons).

- because the firearm is a relic.[11]

The 1991 law made no substantial changes to the *general classes* of restricted weapons (i.e., all handguns, all short-barrelled centre fire semi-automatics rifles and shotguns). Converted automatics became restricted weapons if registered by a genuine gun collector when the prohibition took effect on October 1, 1992. In July 1992, an Order-in-Council declared as restricted a large number of firearms which had some sporting or other legitimate applications, even though they may be of military or paramilitary design.

Other changes to the restricted firearms sections of the *Code* included carry permits for persons who are not the registered owner in order to permit target shooters to share a firearm, temporary carry permits for non-resident competition shooters, and temporary storage permits to authorize safe temporary storage when storage of the restricted gun at the owner's home or place of business is unsafe or impracticable.

2.5 Evaluating the Legislation

As can be seen, the legislative context for this review is complex. However, this chapter has identified clearly the linkages between the 1977 and 1991 amendments in an attempt to show that the second set of amendments (i.e., 1991) build upon the earlier amendments (i.e., 1977) and thus represent a continuation of a long-standing government policy and commitment to public safety.

Second, this chapter has demonstrated that the legislation is quite broad. This has important consequences for an evaluation. One aspect of this has been to conceptually separate the evaluation efforts into sub-studies which will be more manageable.

Finally, this chapter has shown that both sets of legislation were implemented over a number of years. This has a number of implications for this review which are explored in greater detail in the following chapter.

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[11] Defined by regulation as a keepsake or souvenir.

3. METHODOLOGY

The 1993 Annual Report of the Auditor General of Canada noted that:

> Canada's gun control program is controversial and complex. Evaluation of the program is therefore essential to give the Canadian public and members of Parliament the assurance that its objectives are being met.[12]

To date, there has not been a comprehensive statistical analysis of the effects of the Firearms Control Initiative on changes in rates of firearms deaths and crimes over time. This study represents an attempt to accomplish this task.

This section of the report details the methodology used, but before describing the statistical procedures we used and the critical issues of data quality and consistency, it is important to discuss how statistical procedures are used to evaluate the impact of legislation and regulation.[13]

3.1 The Main Questions for the Research

A number of questions guided this research. First, there are issues relating to how the gun controls affect firearms related deaths arising from homicides, suicides, and armed robberies. Second, questions exist on the impact of gun controls on total incidents such as accidents involving children or hunters and criminal misuse such as intimidation. Finally, there is a question of displacement where controls in one area deflect problems elsewhere.

3.1.1 The Effects of Gun Control on Firearms Deaths

Firearms deaths are the primary focus of this evaluation. The general public and the media often focus on mortality statistics and individual incidents when the question of gun control arises. The following evaluation questions guide the approach to addressing the issue of the effects of the Initiative on firearms deaths:

- What are the changes over time in rates of firearm related homicides and total homicides and to what extent can we attribute any changes to firearms control?

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[12] Auditor General of Canada. (1993). *Report to the House of Commons*, Chapter 27, p. 647.

[13] This section provides non-researchers with general background on key firearms evaluation methodologies.

- What are the changes over time in the rates of firearms suicides and total suicides and to what extent can any changes observed be attributed to gun control legislation?

- What are the changes over time in the rates of accidental firearms deaths and to what extent can it be attributed to the legislation?

3.1.2 The Effects of Gun Control on Firearms Incidents

Two types of firearms incidents exist - accidental firearms mishaps (e.g., hunting accidents, children playing with guns) and criminal firearms misuse, involving offenders who deliberately use a gun to intimidate victims. Unfortunately, data on firearms accidents not resulting in death are available only from the late 1980s. Data on firearms and total robberies, and offensive weapons offences, are available from the mid-1970s to the present. This will limit our ability to investigate the impact of gun controls for these questions:

- What are the changes over time in the rates of firearms and total robberies and to what extent can any changes observed be attributed to gun control legislation?

- To what extent have there been changes in offensive weapons offences, especially offences relating to restricted weapons, and can any changes be attributed to gun control?

3.1.3 Displacement

For some firearms incidents, it is necessary to address the question of displacement: substitution of method may occur if firearms are less accessible than other weapons. If displacement occurs, then there may be no net saving in lives (for example) because the perpetrator has substituted another method of killing. The issue of displacement applies primarily to analysis of changes in homicides, suicides, and robberies. The implication for evaluation is simple. Statistical analyses of changes in the death rates must include both those resulting from homicides, suicides, and robberies involving all weapons as well as deaths resulting from firearms. If the overall rate has not changed or has increased, while the rate due to firearms has decreased, then displacement may have occurred.

3.2 Detecting the Impact of Legislation and Regulation

In a statistical evaluation of legislation, the researcher must perform a specific set of tasks:

- The outcome indicator must be specified and obviously related to the objectives of the legislation. In the case of gun control, death rates by firearms are an obvious outcome indicator. This rate will vary from month to month, year to year, and among different jurisdictions. Some influences or causes of this fluctuation may be social or economic such as poverty, percentage of persons below a certain age or unemployment. Other influences on the rate of death are differences in administration and enforcement from jurisdiction to jurisdiction and over time.

- For some evaluation methods the legislation itself needs to be summarized in the form of a numerical indicator. Two methods are common. First, the legislation may be represented by a "O" or a "1" that merely denotes whether it is in effect or not. As a simple example, one can use a graph of monthly homicide rates and see whether the level changes after the legislation is in effect. Alternatively, one can examine homicide rates in two jurisdictions, one with and the other without legislation. A second approach is to select an indicator that is a result of the legislation or closely approximates it. In this case, Firearm Acquisition Certificates (FACs) are a central feature of the legislation and their numbers should be a good outcome indicator of the legislation.

- The researcher needs to identify other influences or causes that may affect the outcome indicator. These social, economic and institutional influences may have an impact on the death rate from guns and needs to be included in any consideration of the impact of the legislation.

- Finally, the researcher must present a model that connects the outcome indicator (usually termed the *dependent variable)* to the influences (termed the causes or *independent variables)*. This model can be simple, such as a graph that shows the death rate before and after the legislation. The model may be complex and attempt to account for many influences on death rates simultaneously. Both approaches are used in this evaluation.

3.3 Evaluating Impacts and Effects

The relationship between gun controls and deaths by homicide, suicide and accident has been studied for many decades. In the last 20 years, social scientists have used increasingly sophisticated statistical methods in an attempt to infer whether regulating access to firearms reduces the incidence of homicide, suicide, accidental death, and armed robbery using guns. Much of this research has been completed in the United States. In the last few years, these studies have taken on a new urgency with the perceived increases in homicides and criminal violence involving firearms.

These studies have generally conformed to one of three approaches: exploratory analyses; ARIMA analyses; or structural models. This evaluation study employs all three approaches.

3.3.1 Exploratory Analyses

Exploratory analysis is the most common approach. These methods examine the relationship between two variables such as gun density rates (the number of guns per 100,000 of population) and suicide rates using such techniques as correlations or plotting data trends.

As an initial step in a research process, exploratory approaches are useful for exploring correlations between variables as well as identifying factors peculiar to the data.[14] These techniques have little explanatory power in that, while they may identify relationships, they cannot clarify the direction of any relationships between variables and thus whether or not there is causality in identified relationships.

A number of studies utilize exploratory analyses of available data to examine factors that might affect suicides and homicides. With regard to suicides, several studies have shown a positive relationship between firearms prevalence and rates of suicide.[15] Typically these studies show there is a correlation between gun density and suicide deaths. Other studies suggest a relationship between availability of firearms and the incidence of firearms suicides by comparing different jurisdictions internationally[16] while other research examines the relationship between availability of firearms and the incidence of homicides.[17]

In another exploratory approach, an American study found that increases in suicides by firearms accounted for the majority of the rise in the suicide rate, especially for men under 40 years of

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[14] For example, some data shift seasonally. This is important to know when developing more advanced statistical models.

[15] For examples see: Boyd and Moscicki, 1986, "Firearms and Youth Suicide" in *American Journal of Public Health,* 76:1240-42; Clarke and Jones, 1989, "Suicide and Increased Availability of Handguns in the United States" in *Social Science and Medicine,* 28:905-9; and, Lester, 1988, "Gun Control, Gun Ownership and Suicide Prevention" in *Suicide and Life Threatening Behaviour, 18:176-80.*

[16] For examples see: Lester, 1990, "The Availabiity of Firearms and the Use of Firearms for Suicide - A Study of 20 Countries" in *Acta Psychiatrics Scandinavia,* 81:146-7; and, Killias, 1993, "International Correlation Between Gun Ownership and Rates of Homicide and Suicide" in *Canadian Medical Association Journal of Medicine,* 148:1721-25.

[17] For examples see: Killias, 1993; and, Lester, 1988, "Firearm Availability and the Incidence of Suicide and Homicide" in *Acta Psychiatrics Belgium,* 88:387-93.

age.[18] Using a similar approach, another study concludes that firearms suicides have risen more than suicides by other means in the United States.[19]

In Canada, studies using an exploratory analysis have attempted to show a relationship between firearms control laws and changes in firearms suicide rates.[20] Other exploratory studies examine the relationship between gun control measures and rates of firearms suicides by comparing across international jurisdictions.[21] Another series of exploratory analysis examine the correlation between firearms control measures and changes in the incidence of violent crimes, including homicides.[22]

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18 See: Boyd, 1983, "The Increasing Rate of Suicide by Firearms" in *New England Journal of Medicine,* 308:872-74. In this article, Boyd plots the suicide rates for 1953 and 1978, separating these rates by gender, to illustrate what appeared to be a change in the population characteristics of those people committing suicide. As well, he uses graphs to show that during the period (i.e., 1953 and 1978) there was an overall increase in firearms suicides while the non-firearms suicide rate fell or remained stable.

19 See: Boyd and Moscicki, 1986. After inspecting plots of the suicide rates between 1930 and 1985, the authors argue that increases are most dramatic after 1970, and that the greatest increases are among males aged 15 to 24. The authors conclude **that** the lethality of firearms makes this method more successful than other forms of suicide.

20 For examples see: Moyer and Carrington, 1992, *Gun Availability and Suicide* Ottawa: Justice Canada; and Lester, 1994, "Gun Control and Rates of Firearms Violence in Canada and the United States - A Comment" in *Canadian Journal of Criminology Oct:463-4.*

21 For examples see: Sloan et. al., 1990, "Firearm Regulation and Rates of Suicide - A Comparison of Two Metropolitan Areas" in *New England Journal of Medicine* 322:369-373; and Mundt, 1990 "Gun Control and Rates of Firearms Violence in Canada and the United States" in *Canadian Journal of Criminology, 32:137-54.*

22 For examples see: Beaver et al., 1993, "Does Handgun Legislation Change Firearm Fatalities" in *Journal of Pediatric Surgery,* 28:306-9; Fife and Abrams, 1989, "Firearms' Decreased Role in New Jersey Homicides after a Mandatory Sentencing Law" in *The Journal of Trauma,* 29:1548-51; Sloan et. al., 1988, "Handgun Regulations, Crime, Assaults and Homicide - A Tale of Two Cities" in *New England Journal of Medicine,* 319:1256-62; and, Thomsen and Albrecktsen, 1991, "An Investigation of the Pattern of Firearms Fatalities Before and After the Introduction of New Legislation in Denmark" in *Medical Science and Law,* 31:162-66.

Figure 3.1 Rates Per 100,000 of Firearm Suicides and Total Suicides

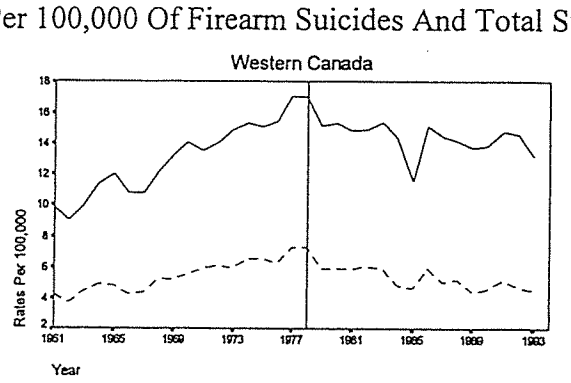

Figure 3.1 shows a time series of total suicides (top line) and of firearm suicides (bottom line). Clearly, there has been a change in the pattern over time. If one imposes a date for the start of the gun control regime, one might be tempted to infer that it was the causative factor, however, as previously noted, exploratory analysis cannot determine whether the observed changes are different from a random shift in the pattern. Furthermore, exploratory analyses do not account for other simultaneous influences that may contribute to the change in observed patterns. Individual studies using exploratory analysis support speculation on causal relationships and may also be useful in the inspection of data quality. However, these techniques do not allow one to firmly support or reject any conclusion about the causal relationship between gun control legislation and changes in the death rates involved in homicides, suicides, robberies, and accidents.

3.3.2 Time Series Analyses

ARIMA analyses[23] examine patterns of a single outcome variable such as the rate of homicides using a firearm. If the statistical pattern changes after the introduction of a policy such as gun control legislation, then the case strengthens for concluding that the legislation has had an impact on death rates. A statistical analysis of the data is undertaken to discover the mathematical model that replicates the patterns in the outcome variable. The introduction of the policy is modelled using an *impact or transfer function* to statistically evaluate the effects of the policy.

The strength of ARIMA methods is that they provide a method for determining whether a new policy has had a statistically significant impact on the pattern of the time series.[24]

In this context, this method allows us to determine whether the introduction of the gun control legislation in 1977 had a statistically significant impact on the monthly patterns of death by guns.[25] This approach is based on a methodology originally developed by Box and Jenkins in 1976.[26] The methodology requires the analyst to use their judgement within a guiding framework. As a result, there are several acceptable pattern specifications that may exist for a

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[23] Auto Regressive-Integrated Moving Average (ARIMA) techniques are also termed Time Series Analyses and are estimated by a broad range of techniques under the rubric of Box-Jenkins methodologies. This should be distinguished from structural models that use time series data.

[24] Throughout this report we use the term statistically significant. Briefly this term refers to a standard that research accepts for results being important. Many phenomenon are affected by a range of influences, some of which we understand and others we do not. Often these unknown influences are ascribed to random chance. When a time series such as monthly deaths from guns shifts in a way that only has a small chance of being due to random chance, we say the change has been statistically significant. The degree of risk one runs in accepting that the observed change is not due to chance depends on the costs of being wrong and the degree of control we have over extraneous influences. In testing aircraft parts we are willing to accept a much smaller chance of being wrong than in social research where 5 per cent (or 19 times out of 20) is the usual standard and the one we accept in this report.

[25] The patterns are based on two specific mathematical models known as an autoregressive process and a moving average process. An autoregressive process simply states that the outcome variable can be predicted solely based on its past values, while the moving average process states that the outcome variable is the result of a weight average of random values. These mathematical processes are combined with seasonal factors to produce the full ARIMA model.

[26] Box and Jenkins, 1976, *A Time Series Analysis, Forecasting and Control*, Revised edition, San Francisco, Holden Day.

given data series.[27] Several studies have used ARIMA analyses to assess the effectiveness of firearms control measures.[28]

ARIMA modelling has a number of important requirements. First, this technique needs large data sets both before and after the policy interventions in order to avoid obtaining misleading results. The essence of ARIMA is that patterns are compared before and after the legislation; for this to be successful, there must be sufficient data both before and after the legislation to identify the model that generated the data.

Second, the correct identification of the data patterns is open to debate. Several equally valid variations may be used to represent the data patterns. The choice may alter the statistics somewhat, but small variations should not change overall conclusions. The general rule used by statisticians is that one uses the simplest model possible.

Third, and very important for this research, allowing for varying implementation schedules is fundamental to the model. As is clear from the discussion in Section 2, it would be overly simplistic to assume that all of the impacts of legislative changes occur the day that a specific law or provision is proclaimed. Allowances must be made for behavioural changes which are anticipatory of an impending legislative change as well as those behavioural changes which occur in response to the actual passage of the law.

In summary, ARIMA models support a test of a time series to determine whether legislation and regulation are associated with a statistically significant change in the pattern of death rates. Like all statistical tests, ARIMA does not prove a causal relationship. Where one might have a graph

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[27] As shown in Chapter 2 the Canadian gun control legislation and subsequent regulation have been implemented in phases. This obscures the relationship between policy implementation and outcomes.

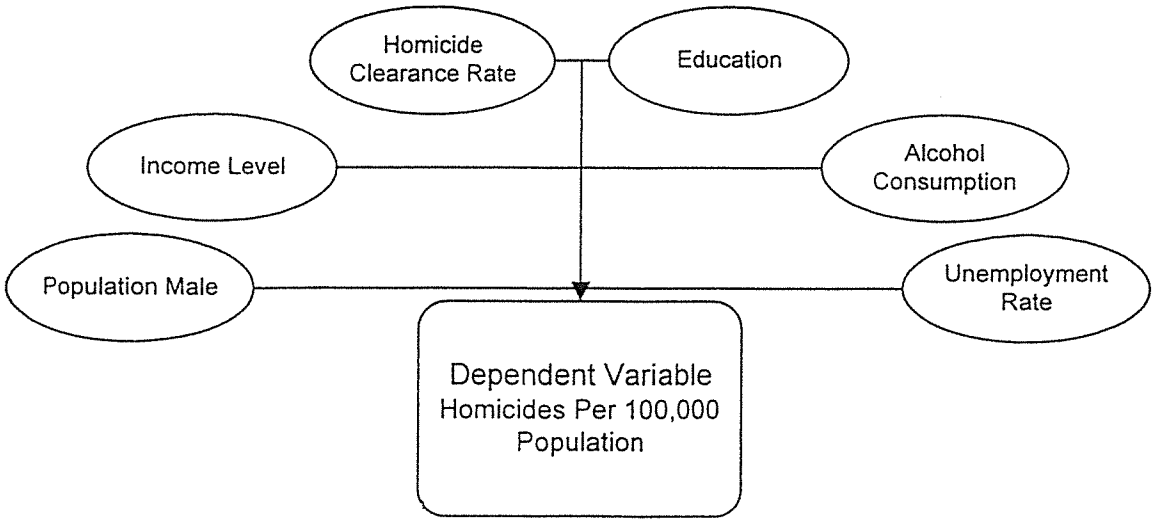
[28] For examples see: Deutsch and Alt, 1977,"The Effect of Massachusetts's Gun Control Law on Gun-Related Crimes in the City of Boston" *Evaluation Quarterly*, 1:543-568; Hay and McCleary, 1979, "Box-Tiao Time Series Models for Impact Assessment: A Comment on the Recent Work of Deutsch and Alt" *Evaluation Quarterly,* 3:277-314; Loftin et al., 1991, "Effects of Restrictive Licensing of Handguns on Homicide and Suicide in the District of Columbia" *The New England Journal of Medicine*, 325(23):1615-1620; Jung and Jason, 1988, "Firearm Violence and the Effects of Gun Control Legislation" *American Journal of Community Psychology*, 16: 515-523; McDowall et. al., 1989, "Did Mandatory Firearm Ownership in Kennesaw Really Prevent Burglaries?" *Sociology and Social Research,* 74(l):48-51; and McDowall et. al., 1991,"General Deterrence through Civilian Gun Ownership: An Evaluation of the Quasi-Experimental Evidence" *Criminology, 29:541-559.*

of death rates over time and question whether gun control legislation had or had not made an impact, ARIMA methods provide a rigorous test for this question.[29]

3.3.3 Structural Models

A structural model articulates a causal theory about the relation between death rates and other social, economic, demographic and legal changes. An equation specifies this theory and is estimated statistically, usually using multivariate regression procedures. Figure 3.2 shows a structural model where a number of independent variables (causes) are hypothesized to influence the dependent variable (death rates). Another equivalent way of saying this is that the independent variables are selected to explain the movements or variation in the dependent variable.

Figure 3.2 Structural Model of Homicides



[29] In an ideal setting, the best ARIMA modelling is conducted in relation to legislation which is passed in one specific period and, additionally that compliance with the legislative changes are instantaneous. As has been shown above, the Canadian gun control legislation and regulations have been implemented gradually.

A structural model allows a researcher to examine several influences on an outcome indicator (dependent variable) simultaneously. It also discriminates between those variables that have a positive or negative influence as well as measuring the degree to which that influence is exerted. Finally, it allows one to assess whether that influence is statistically significant.

If an independent variable moves in step with the dependent variable it will be positively correlated and this will emerge from the statistical modelling procedure. It will have a positive regression coefficient. Likewise, an independent variable that moves in an opposite direction will have a negative regression coefficient. Tests of statistical significance on each independent variable are used to establish whether the influence of that variable on the dependent variable is more than chance.

Structural models require the researcher to itemize all the influences believed to affect the dependent variable. In the case of homicide deaths one might hypothesize that poverty, the rate at which murders are solved (homicide clearance rate), and incidence of alcoholism would have an impact on the death rate.

A methodological problem is how to express legislation mathematically. One popular approach is to create a special variable (termed a dummy variable) that takes on the value of "O" prior to the legislation and "l" after.[30] This variable is then used along with other social and economic indicators in the model where its statistical significance may be determined.

As with any statistical procedure, there are methodological issues. First, the form of the data is an important aspect of structural models. *Cross-sectional data* expresses the variation in death rates at a point in time. An example of cross-sectional data is a table showing the death rates for January 1991 as a result of suicide in the member countries of the United Nations. A cross-sectional structural model that used income, measures of poverty, ethnic diversity, and an indicator for the existence of gun control would be one approach for testing for the effectiveness of the legislation. This indicator on gun control would vary depending on the level of control

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[30] This formulation is termed an intercept dummy. It models the legislation as having a permanent effect on the outcome variable, by shifting the entire time series up or down. Other formulations model the policy as changing the relationships between the dependent variable and the independent variables. These slope dummy variables are infrequently used in policy research.

in each country. A regression model could be used to test whether variations in death rates among the countries were associated with variations in gun control.[31] Since the gun control regime in Canada is national in scope, cross-sectional models using provincial data alone are not applicable to Canada since there is no variation in the legislation across the provinces.

Time-series data are the second type of data used in a structural model where variability in death rates is expressed over time. A table showing death rates, income levels, measures of poverty and an indicator for gun control for Canada from 1961 to 1993 is a time series data base.[32] Typically the time series data represent measurements taken on a monthly, quarterly or annual basis. Outcome variables such as firearms deaths are "regressed" against potential explanatory variables such as age, gender, and income as well as measures of the policy intervention (e.g., date at which firearms legislation implemented). Time-series models seek to explain variations in, for example, firearms deaths over time, by attributing observed changes to variations in explanatory variables such as socioeconomic indicators and the policy intervention.[33]

A third type of structural model uses pooled cross-sectional time-series data. Although, this approach has not been used widely in statistical analysis of judicial legislation/regulation, it is a widely used method in applied econometrics. The data are aggregated across multiple sites

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31 For examples of this type of approach, see: Geisel et. al., 1969, "The Effectiveness of State and Local Regulation of Handguns: A Statistical Analysis" *Duke Law Journal,* 647-676; and Boor and Bair, 1990, "Suicide Rates, Handgun Control Laws, and Sociodemographic Variables" Psychological Reports, 66:923-930.

32 Again, note the distinction between time series analysis (ARIMA) models where only a single outcome variable, death rates, is used and a structural model that estimates the relationship between that outcome variable and a number of independent variables hypothesized to cause its variability.

33 For examples see: Carrington and Moyer, 1994, "Gun Control and Suicide in Ontario" *American Journal of Psychiatry,* 151:606-608; and, Cantor and Lewin, 1990, "Firearms and Suicide in Australia" *Australian and New Zealand Journal of Psychiatry, 24:500-509.*

through time.[34] The strength of this type of model is that the technique allows for an increased number of observations and thus enhances the power of statistical tests of significance.[35]

A review of articles using structural models to test the effectiveness of firearms control initiatives in reducing firearms deaths, accidents and incidents reveals a lack of consensus as to what factors need to be included in the models. There have been numerous debates about the inclusion or exclusion of candidate variables.[36] This issue is central to the use of structural models under the general term specification.

3.3.4 Specification of Variables and Models

The term specification refers to the form of the equation that expresses the structural model and the variables that are hypothesized to be associated with variations in the outcome. For the most part, there is no theory that supports anything but a linear relationship between the dependent and independent variables. The literature on gun control has used this approach exclusively.[37] Therefore, the form of the regression models has universally been assumed to be linear.

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[34] To visualize this data structure, imagine that we had social, economic and legislation information on all UN countries from 1960 to 1993. We have pooled the cross-sections across time. A range of specialized methods are needed to estimate structural models using these data but estimates are generally more reliable because more information is available.

[35] A subtle, and not often made, distinction exists between regression coefficients from cross-section and time series models. Cross-section data provides a snap-shot of different countries at various stages in the development of a criminal justice policy. The coefficients from these models are interpreted as measuring long-term outcomes of policy change. Time series data track the monthly or annual variations and associations between outcome variable and independent variables. Such data produce regression coefficients that measure the short-term reaction to policy change. If the data are monthly, then time-series data produce estimates of the month-to-month reaction to gun control. By implication, pooled cross-section/time-series data provides mid-term estimates.

[36] For examples see: Berk et. al., 1979, "Estimation Procedures for Pooled Cross-Sectional and Time Series Data" *Evaluation Quarterly*, 385-410; Mauser and Holmes, 1992, "An Evaluation of the 1977 Canadian Firearms Legislation" *Evaluation Review,* 16:603-617.

[37] This is not a minor issue. What researchers are implicitly assuming with a linear model is that the relationship between a independent variable, such as a measure of poverty (per capita income for example), and the dependent variable (gun deaths) is constant. In other words, as per capita income falls, social unrest and general crime rates may increase. Gun deaths may be hypothesized to also increase. A linear relationship states that the rate of increase is constant and that there are no threshold effects. As income falls, the death rate is hypothesized to increase at a constant rate.

Much more complex is the selection of independent variables. One can hypothesize a range of possible influences on gun deaths, but all too frequently, there is no information to create the needed variables, or one accepts a proxy that imperfectly measures the phenomenon in question. This problem confronts all structural modelling.[38]

A number of data definition issues must be surmounted in the specification of all structural models.

- Most often, information is collected for general administrative reasons and not to test hypotheses about policy matters such as the efficacy of gun controls. In a sense, then, researchers are opportunistic in their use of information, having to bend the analytic technique to suit the data available. It is usually the case that statistical modelling is performed with incomplete information.

- The way data are reported and compiled has a tremendous influence on the types of analysis that are possible. This issue is known as deciding on the appropriate *unit of analysis.* Aggregate data, such as death rate for a province or country, allows one to know how many times an event occurs within a specific time period. Incident level data may allow the research to identify key characteristics associated with specific events such as the relationship between victim and perpetrator, and the ages of victims and perpetrators. The wealth of information available from incident level data can enhance the power of statistical tests designed to assess the significance of any impacts of legislative changes. However, often key information is missing at the incident level such as income and other aspects of the social circumstances of victim and perpetrator. Obviously, if a murder is unsolved, there will be no information on the perpetrator.

- Just as the unit of analysis (aggregate versus incident) affects the accuracy of data, so *the frequency of data* alters the accuracy of statistical models. Ideally, all the data would be reported on at least a monthly basis. This would allow the construction of models based upon monthly data, with a large number of observations which would in turn allow very

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[38] A profound bias can occur in structural modelling. If one includes an irrelevant variable in the set of independent variables, no harm results. There is a slight loss in the power of testing statistical significance, but the remaining regression coefficients are usually unaffected (except in the case of multicollinearity discussed below). However, if one omits a variable that is an important cause of variability on the dependent variable, then all the remaining regression coefficients are biased. This is known as omitted variable bias and is critical in the research on gun control. Because one can specify theoretically the variables that should be included in the regression, does not mean that they are available. If key variables are omitted, then the coefficients on all the other variables are biased.

accurate statistical inferences. Unfortunately, while the dependent variables are generally reported on a monthly basis (e.g., homicide incidents), the independent variables (e.g., socioeconomic factors) are not.[39] This means that some of the models to be presented in this study will be limited to using data at an annual reporting frequency, reducing usable observations by a factor of 12.

The quality of the data is a serious issue.[40] In addition to being collected for purposes other than testing legislative changes, data are always subject to collection and coding errors. For this reason, empirical research needs to commit substantial resources to reviewing the data and deciding when data observations are in error and when legitimate information has been recorded. This evaluation used information that has been collected for the past several decades, much of which has never been accessed for research.

Structural models based on regression methods encounter a number of technical problems that affect inference and estimation. *Heteroscedasticity and auto-correlation*[41] are violations to the assumptions underlying the regression model. Data that exhibit these features still provide unbiased (valid) estimates of the regression coefficients, but tests of significance are weakened. In other words, a researcher risks concluding that coefficients are not statistically significant when they are. A number of tests and procedures are available to cope with these problems. Cross-sectional data often exhibits heteroscedasticity while time series data often produces auto-correlation.

A more important problem is *multicollinearity.* This is not a statistical problem or a violation of the assumptions underlying regression, but simply a feature of a particular data set used by the researcher. When two or more of the independent variables are correlated, then the resulting regression estimates will be unstable. More specifically, multicollinearity makes it very difficult to determine the true relationship between independent variables and the dependent variables.

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[39] Section 3.4 identifies the dependent and independent variables to be used in the statistical models presented in this study.

[40] Often, data are collected for administrative purposes and are not checked for accuracy. As is shown below, very significant errors can be included in these data requiring the researcher to clean the information prior to use. Regressions using this information with errors, even a single extreme value, can produce completely misleading results. One of the important roles of exploratory analysis is to allow the researcher to examine information prior to its use in the statistical model.

[41] Heteroscedasticity exists where the errors from a regression model are related to one or more independent variables. Auto-correlation exists where the errors from a regression model are systematically related to themselves.

The greater the number of independent variables, the greater the likelihood of multicollinearity between variables thus making it difficult, if not impossible, to determine the relative impacts of a variable of interest (e.g., gun control legislation).

Figure 3.3 Comparison of Structural Models Using Cross-sectional and Time Series Data

	Advantages	Disadvantages
Cross-Sectional Data	Can reflect different levels of legislation or enforcement among jurisdictions.	Requires detailed descriptions of legislation and its enforcement in many jurisdictions.
	Social, economic and demographic data can isolate the impact of the legislation.	Often data are missing if jurisdictions do not collect information in similar ways.
Time Series Data	Data collection differences among jurisdictions is not relevant.	Information may not be collected with consistency over time. Data gaps and changes in definition over time are common.
	Intuitively easier to communicate results because pre-post designs are clearer.	Strong interrelationships between explanatory variables (multicollinearity) lessens the ability to isolate relative effects.

In general the research on gun controls has not tested regression models for problems such as heteroscedasticity, autocorrelation and multicollinearity. In this research we do perform these tests.

There are many potential problems associated with structural modelling, so many that one might ask why these models are used at all. It is important to stress that this class of statistical model represents the most powerful methodology for exploring causal relationships. Figure 3.3 summarizes the advantages and disadvantages of time-series and cross-sectional data.

3.4 Dependent and Independent Variables

We have already explained that dependent variables are the outcome variables that are associated with the legislation. In the case of gun control, death rates are the logical dependent variable and this is used for exploratory, ARIMA, and structural models. Independent variables used in structural models are the hypothesized causes of movements in the dependent variable. This section of the report reviews the available data and introduces the problems we encountered in constructing viable data bases for statistical analysis.

3.4.1 Dependent Variables - Overview of the Information Sources

To assess the impacts of the firearms control initiative, this study sought data that accurately measures incidents involving firearms over a sufficiently long period of time. A broad categorization of this data includes information on homicides, robbery, assault, suicides and accidents involving firearms.

Two Statistics Canada data bases track incidents of homicides, robbery and assault in Canada. The Uniform Crime Reporting Survey (UCR1) commenced in 1961 through the joint efforts of Statistics Canada and the Canadian Association of Chiefs of Police (CACP). The UCR1 database provides statistics at the aggregate level (provinces) and on a monthly basis.

The second data base, the Revised Uniform Crime Reporting Survey (UCR2) was developed to improve upon the UCR1. Data collection for UCR2 commenced in 1988. The process of data collection is administered by Statistics Canada in conjunction with actual police departments which report statistics at the *individual incident level.* This data base has a wide variety of details concerning specific incidents. However, this is a new survey and data are collected in only selected jurisdictions.[42]

Homicides

The best source of data on homicides is the Statistics Canada Homicide Survey. Collection of information for this data base started in 1961. Since its inception, a number of changes have been made to the survey, the most important of which were undertaken in 1990 in an effort to increase the volume and detail of data collected. This change caused a number of problems because the two formats (old and new) are not completely compatible. Specifically, the most

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[42] With each year, additional jurisdictions contribute reports and the potential for UCR2 grows with each passing year. Unfortunately, for this study UCR2 is of limited value.

serious problem stems from the elimination in 1990 of a data field entitled "unknown firearm".[43] Because this field no longer exists, when the pre-1990 data were converted (by Statistics Canada) into the current format all of the crimes committed with "unknown firearms" were coded as non-firearms offences.[44] This tends to understate the true level of pre-1990 firearms offences.

Suicides

Data regarding suicides are compiled by the Health Statistics Division of Statistics Canada.[45] Aggregate monthly data by province are compiled and include the method of suicide. In particular, this evaluation will rely on a field representing the number of suicides by firearms and explosives. Another field classifying the type of firearm used was added in 1979; however, for the purposes of this research there are insufficient observations to include it in the statistical analysis.

Fatal Accidents with Firearms

The Health Statistics Division also records the number of fatal accidents with firearms. These data are also aggregated at the provincial level and are available on a monthly basis. As with the data on suicides, a detailed breakdown by the type of firearm was only begun in 1979.

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[43] Data base administrators have assured us that these cases amount to less than ten per cent of the data. This programming error was remedied after 1991 and these incidents are now included as "other firearms-like weapons". However, this produces a discontinuity in the data on homicides and may obscure the impacts of legislative changes.

[44] There are other problems as well. For example, in 1974 **the** data base began including manslaughter and infanticide. In order to maintain consistency over the entire period covered by the data base, we had to filter these types of cases out of the post-1974 data.

[45] Numerous studies have shown that suicides tend to be under-reported both in Canada and in other countries. For examples, see: Aldridge and St. John, 1991, "Adolescent and Pre-Adolescent Suicide in Newfoundland and Labrador"; Malla and Hoenig, 1983, "Differences in Suicide Rates: An Examination of under Reporting", *Canadian Journal of Psychiatry,* 28 (4), 291-293; and, Speechley and Stravaky, 1991, "The Adequacy of Suicide Statistics for Use in Epidemiology and Public Health", *Canadian Journal of Public Health, 82* (1), 38-42. In question is whether or not the tendency towards under-reporting can be assumed to remain relatively constant across both time and space.

Robbery and Assault

The UCR1 data base provides aggregate statistics on the frequency of various incidents on a monthly basis. Data on robberies and robberies with a firearm are available for the period from 1974 through 1994. There are also data available after 1983 regarding the total number of assaults and those assaults involving the discharge of a firearm with intent. The difficulty is that assaults involving discharge with intent represent less than one per cent of the total number of assaults. Given this fact, an analysis of these data for comparative purposes would be of little utility.

3.4.2 Independent Variables - Overview of Sources

This section presents the candidate independent variables for the models. An important part of the analysis presented in this study requires the use of structural models to try to explain violent crimes, and in particular, those incidents perpetrated with firearms. The choice of independent variables in the structural model is a critical part of the analysis. This study is intended to test the effectiveness of Canadian firearms legislation, and therefore, only relevant variables that can be linked to violent crimes and accidents should be considered. *Ad hoc* variable selection and stepwise practices are frequently used variable selection techniques, employed for the purposes of empirical analysis because of their relative simplicity. However, they represent questionable methodology and can affect the results of the study.[46]

Demographics

Demographic variables provide information on the characteristics of a given population. Population is an important variable for two reasons. First, most of the variables used in this study are expressed as rates per 100,000 population (e.g., rates of suicide or homicide). Secondly, a variable representing population density can capture differences that inherently exist between rural areas, small towns and urban areas.[47]

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[46] *Ad hoc* variables are those chosen without theoretical justification. A properly constructed model should only contain those variables that are expected to have an effect on the dependent variable. Adding irrelevant variables can reduce the precision of the statistical calculations.

[47] For example, residents in rural areas tend to own more firearms per capita than those in urban areas. On the other hand, certain crime rates are higher in urban areas. Population density allows us to capture these facts in our models.

Most of the academic research around firearms control identifies young adults as an important explanatory variable. Similarly, gender (proportion of the population as male) is another important explanatory variable identified in the literature.[48] Detailed information on the population by age and gender is available from Statistics Canada. The available data cover the entire time period which we are modelling (i.e., 1961-1993).

Socio-economic Status

Socio-economic status is often an integral part of structural models. There are a number of variables that can be used to reflect socioeconomic status. On the economic side, in our research we are including education, income and levels of unemployment as independent variables.

For example, we note that the literature suggests that as economic conditions worsen, crime increases. For example, if the income gap in an area becomes large and there are few opportunities to be gainfully employed, crime may be perceived as a viable alternative.[49] We expect that incidents of robbery, homicide and suicide will be inversely related to the income level of the area under study. The best indicator that we could find to account for income was average personal income per person per province for the period 1961 to 1993. These data are available from Statistics Canada.

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[48] Researchers have argued that young adults are more inclined to engage in criminal activities that older individuals. Similarly, the majority of crimes are committed by males. Some studies combine the age distribution and proportion male population into a single data series in order to avoid the multicollinearity that often exists between these two variables.

[49] For examples see: Geisel et. al., 1969, "The Effectiveness of State and Local Regulation of Handguns: A Statistical Analysis" *Duke Law Journal,* 647-676; Murray, 1975, "Handguns, Gun Control Laws and Firearm Violence" *Social Problems,* 23:81-92; Magaddino and Medoff, 1982, "A Reanalysis of Deterrence and Gun Control" *Atlantic Economic Journal,* 10:50-53; Magaddino and Medoff, 1984, "An Empirical Analysis of Federal And State Firearm Control Laws" *Firearms and Violence: Issues of Public Policy,* (Don Kaates Ed.). Harper & Row, 225-258; and Kleck and Patterson, 1993, "The Impact of Gun Control and Gun Ownership Levels on Violence Rates" *Journal of Quantitative Criminology,* 9, s. 249-287.

The unemployment rate is generally considered to be an important socioeconomic variable in crime related studies.[50] We expect that there will be a positive relationship between the unemployment and crime rate. We were able to obtain data on unemployment by province for the period 1966 to 1993. These data are available from Statistics Canada.

On the social side, there is a wealth of literature which indicates that a significant number of homicides occur in dysfunctional domestic situations.[51] The divorce rate may function as a proxy for marital breakdown. This variable has been frequently used to model violence against women and female homicides. As both these violent crimes are covered by our homicide and violent assault dependent variables, the divorce rate may be an important part of the analysis. The best data available is the number of divorced people by province for the period 1971 to 1993. These data are available from Statistics Canada.

Numerous studies have also used educational levels to model violent crime.[52] We expect that

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50 For examples see: Murray, 1975, "Handguns, Gun Control Laws and Firearm Violence" *Social Problems,* 23, 81-92; Sommers, 1980, "Deterrence and Gun Control: An Empirical Analysis" *Atlantic Economic Journal,* 8, 89-94; Magaddino and Medoff, 1982, "A Reanalysis of Deterrence and Gun Control" *Atlantic Economic Journal,* 10, 50-53; Sommers, 1982, "Deterrence and Gun Control: A Reply" *Atlantic Economic Journal,* 10(2), 54-57; Sommers, 1984, "The Effect of Gun Control Laws on Suicide Rates" *Atlantic Economic Journal,* 12(l), 67-69; Magaddino and Medoff, 1984, "An Empirical Analysis of Federal and State Firearm Control Laws" *Firearms and Violence: Issues of Public Policy* , (Don Kaates Ed.). Harper & Row, 225-258; Boor and Bair, 1990, "Suicide Rates, Handgun Control Laws, and Sociodemographic Variables" *Psychological Reports,* 66, 923-930; McDowall, 1991, "Firearm Availability and Homicide Rates in Detroit, 1951-1986." *Social Forces, 69:1085-1* 101; Mauser and Holmes, 1992, "An Evaluation of the 1977 Canadian Firearms Legislation" *Evaluation Review,* 16, 603-617; and Kleck and Patterson, 1993, "The Impact of Gun Control and Gun Ownership Levels On Violence Rates" *Journal of Quantitative Criminology,* 9, 249-287.

51 For examples see: Sommers, 1980, "Deterrence and Gun Control: An Empirical Analysis" *Atlantic Economic Journal,* 8, 89-94; Magaddino and Medoff, 1982, "A Reanalysis of Deterrence and Gun Control" *Atlantic Economic Journal,* 10, 50-53; Sommers, 1982, "Deterrence and Gun Control: A Reply" *Atlantic Economic Journal,* 10(2), 54-57; Sommers, 1984, "The Effect of Gun Control Laws on Suicide Rates" *Atlantic Economic Journal,* 12(l), 67-69; Boor and Bair, 1990, "Suicide Rates, Handgun Control Laws, and Sociodemographic Variables" *Psychological Reports,* 66, 923-930; and Kleck and Patterson, 1993, "The Impact of Gun Control and Gun Ownership Levels on Violence Rates" *Journal of Quantitative Criminology,* 9, 249-287.

52 For examples see: Geisel et. al., 1969, "The Effectiveness of State and Local Regulation of Handguns: A Statistical Analysis" *Duke Law Journal,* 647-676; Murray, 1975, "Handguns, Gun Control Laws and Firearm Violence" *Social Problems,* 23, 81-92; Sommers, 1980, "Deterrence and Gun Control: An Empirical Analysis" *Atlantic Economic Journal,* 8, 89-94; Magaddino and Medoff, 1982, "A Reanalysis of Deterrence and Gun Control" *Atlantic Economic Journal,* 10, 50-53; Sommers, 1982, "Deterrence and

as educational levels increase, crime rates will decrease. For this study, we were able to obtain data on the number of individuals graduating from undergraduate and graduate degree programs by province for the years 1970 to 1993. These data are available from Statistics Canada.

Behavioural Variables

Several studies have included a variable representing alcohol consumption in their analysis.[53] We expect that the number of criminal incidents are positively related to the levels of alcohol consumption. Data on alcohol consumption is available from the Addiction Research Foundation and from Statistics Canada. We constructed a continuous time series on the total litres of beer, wine and spirits consumed by province and converted this into a per capita proxy for the period from 1971 to 1993. One other factor used to model violent crime is use of illicit drugs. As a proxy for illicit drug use, we have collected information on the number of arrests for illicit drugs. Unfortunately, this variable is only available between 1977 and 1993. This proxy variable is a weak and indirect measure of drug use since arrests reflect police activity and this may not be directly related to actual drug use.

Ethnicity/Race

Finally, most U.S. studies into gun control include ethnicity and/or race as independent variables. In our research, we include proportion born in a foreign country (available from Statistics Canada) as well as a measure of the proportion of the population that are registered Aboriginals (available from the Department of Indian and Northern Affairs).

Most social and economic research in the United States routinely includes race as a factor in policy analysis. Because many see racism in the United States as having become woven into the

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Gun Control: A *Reply" Atlantic Economic Journal,* 10(2), 54-57; Magaddino and Medoff, 1984, "An Empirical Analysis of Federal and State Firearm Control Laws" *Firearms and Violence: Issues of Public Policy*, (Don Kaates Ed.). Harper & Row, 225-258; and Kleck and Patterson, 1993, "The Impact of Gun Control and Gun Ownership Levels on Violence Rates" *Journal of Quantitative Criminology,* 9, 249-287.

[53] For examples see: Sommers, 1980, "Deterrence and Gun Control: An Empirical Analysis" *Atlantic Economic Journal,* 8:89-94; Magaddino and Medoff, 1982, "A Reanalysis of Deterrence and Gun Control" *Atlantic Economic Journal,* 10, 50-53; Sommers, 1982, "Deterrence and Gun Control: A Reply" *Atlantic Economic Journal*, 10(2), 54-57; and Kleck and Patterson, 1993, "The Impact of Gun Control and Gun Ownership Levels on Violence Rates" *Journal of Quantitative Criminology,* 9, 249-287.

social, economic and institutional fabric, the fact that Blacks might be relatively more involved in crime deaths from guns is not seen as the result of race, but the outcome of a population that has systematically been subject to social and economic barriers. Although Blacks have lower than average incomes and economic status, race adds an important explanatory power to statistical models that attempt to explain the variation in the rate of death from guns by including a proxy for systemic racism.

Similarly, in Canada the Aboriginal death rate from homicide, suicide and accidents is much higher than for the general population[54], however, Aboriginals are under-represented in firearm deaths.[55] Again this is not the outcome of being Aboriginal *per se* but the result of a specific social and institutional context.[56]

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[54] Silverman and Kennedy, *Deadly Deeds: Murder in Canada, 1995,* report that the murder rate for Aboriginal offenders is ten times that of the general population. A number of authors have offered explanations for why Aboriginal persons might be involved in crime more frequently than the general population. For example, La Prairie (1987) argues that the deprived social and economic condition of native people in Canada has been produced by a colonization process that eliminates the traditional male role, resulting in frustration and increased levels of family violence. Havemann (1985) first advanced the colonization thesis arguing that this has produced an underclass in Canada. US research into Indian involvement in violence (Kupferer and Humphrey, 1975) identified factors such as "acculturative pressures, impoverishment, alcohol usage, and blocked assimilation."

[55] Doob, Grossman and Auger, "Aboriginal Homicides in Ontario", *Canadian Journal of Criminology,* January 1994, pp. 29-62, note that "Aboriginal victims tended to be more likely beaten to death and were less likely to have been shot to death than were non-aboriginal victims."

[56] An important methodological point is that we only have aggregate data on the percentage of the population that are Status Aboriginal persons. We do not have data on homicides committed by Aboriginal persons. This is a weakness to the data that can bias the statistical estimation process.

Other Factors

Three other factors have been included in our models. First, as a proxy for the perceived effectiveness of the legal system, we have included a variable on the homicide clearance rates. Numerous studies have suggested that perceptions of the probability of apprehension and the nature of punishments have some degree of influence on criminal activity.[57]

We have also gathered data on the number of Firearms Acquisition Certificates (FACs) issued annually by province. These data are available since 1979. In consultation with the staff at the office of the Chief Provincial Firearms Officer, in Saskatchewan and Manitoba, we also devised a strategy that allows a calculation of the total number of valid FACs in circulation on an annual basis. This figure is significantly different from the number issued each year.

A third factor that is sometimes included in structural models tries to capture long-term trends on the dependent variables not fully accounted for by available independent variables. In order to improve the models, researchers sometimes use a trend variable. These variables are not to be interpreted as causal and the correlation will not really mean anything as time in and of itself does not cause an event to happen. Unless the theory suggests a reason for drift in the outcome variable, there is no basis to include this variable.[58] Such a variable is included to pick up all the unknown linear influences that may affect the dependent variable.

3.4.3 Aggregation

One can develop a list of theoretically sound independent variables, but the information may not be collected. Equally important, the available data may not be collected on the same time base. Finally, some jurisdictions may not collect the required data, or information may not be available in the format needed. Structural modelling involves compromises in terms of what variables can be included in the analysis -- invariably, most models are forced to exclude variables for which there are no measures.

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[57] For examples see: McDowall, 1991, "Firearm Availability and Homicide Rates in Detroit, 1951-1986" *Social Forces,* 69, 1085-1101; and Mauser and Holmes, 1992, "An Evaluation of the 1977 Canadian Firearms Legislation" *Evaluation Review,* 16, 603-617.

[58] Time trends have been used in modelling technical change where the pace of inventions is seen as outside the system -- a trend line serves as an approximation (proxy) for that influence.

Although most of the data we collected were available on a province by province basis, there were a number of factors that prompted us to aggregate data into four groups: Atlantic Canada, Quebec, Ontario and Western Canada.[59] One factor that motivated this aggregation was the large population differences by jurisdiction. Population base became a problem with some jurisdictions such as Saskatchewan, Manitoba, Prince Edward Island, and Newfoundland because they did not have sufficient incidence of some dependent variables (e.g., fatal accidents with firearms) to support accurate statistical analysis. Aggregation of these provinces remedied this problem, but at the expense of modelling provincial differences.

Part of the problem with aggregation is that details and differences between the aggregated regions are lost. This may obscure some of the regional differences that account for differing rates of suicides, homicides, robberies, etc. However, we attempted to aggregate areas with similar characteristics, and the detail lost through aggregation was less than the accuracy gained by acquiring better dependent variables.

Regrettably, we had to omit the data on the territories from our structural analysis. Frequently, as in the case of unemployment and personal income per person, these data were not collected or were collected much later in the data series (e.g., personal income data was not collected until 1987 in the territories). We therefore determined that the analysis would be too restricted if we only used data from 1987 until 1993.

3.4.4 Factors Affecting the Structural Modelling of the Legislation

The introduction of a law and its subsequent impact on behaviour are rarely instantaneous. One of the primary factors affecting our ability to model the legislation concerns the phasing-in of the legislation. All provisions of the 1977 legislation were implemented in January, 1978 with the exception of the FAC and business permit provisions, both of which were implemented in January, 1979. The 1991 legislation, however, was phased in a much more gradual manner

[59] We experimented with models that separated British Columbia from the Prairie provinces and found no difference in the results. To improve the overall model results, we then elected to use the four western provinces as a group to ensure sufficient information for certain outcomes such as accidental deaths.

between June, 1992 and January, 1994.[60] It is therefore impossible to obtain definite results regarding the 1991 legislation given that current data sources only extend to 1993.

A new law goes through Parliamentary processes (e.g, readings and committee hearings) all of which take time. Throughout these proceedings, the public becomes aware of what the proposed legislation entails and may gradually change behaviours in advance of the actual introduction of the new law. This type of compliance can be termed anticipatory". Another possibility is that many people may not expect a particular law to be enforced and only alter their behaviour after witnessing evidence to the contrary. In this second case, behaviour will only change gradually after the introduction of a law as people adapt their behaviour in accordance with the level of enforcement.[61] Another possibility is that people may initially alter their behaviour either in advance of, or at the implementation stage of a new law. However, if people perceive that there is a lack of rigorous enforcement, they may well revert to their past behaviours.

Structural modelling techniques using a "dummy variable" to represent the legislation require that the impacts of a new law be instantaneous. As noted above, this assumption is not valid in the case of the firearms legislation, especially with the 1991 provisions. We adapted our methodology to allow for gradual changes in public behaviour. This adaptation was accomplished in one of two ways. First, we varied the point at which the discrete dummy variable takes effect and tested a series of intervention points. We moved the dummy variable so that the change occurred a year before or after the law was actually implemented, thus allowing for anticipatory or adaptive responses respectively.

Our second approach was to use the number of FACs issued as a proxy for the implementation of the firearms legislation. Although this second method has some advantages, we could not use it with the time series models (ARIMA) as they required monthly data while the issuance of FACs was only available on an annual basis for the years modelled. In this case, we used three discrete dummy variables to allow for changes in behaviour concurrent with the 1977 legislation, as well as a year before and one year after. The continuous dummy variable that measured the

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60 For analytical purposes, we have specified January, 1993 as the "implementation date" for the 1991 legislation as this marks the month in which the enhanced FAC screening process and the secure storage provisions came into effect. However, prior to this date, restricted provisions had been implemented as well as new sentencing procedures and regulations for museums and businesses. The final portion of the legislation, the firearms safety education program requirements were implemented over the course of 1994.

61 See for example: Hay and McCleary, 1979, "Box-Tiao Time Series Models for Impact Assessment: A Comment on the Recent Work of Deutsch and Alt" *Evaluation Quarterly*, 3, 277-314.

number of FACs issued in accordance with the legislation was only used in conjunction with the structural models.

3.5 Summary

The ability of this study to evaluate the impact of the 1977 and 1991 legislation is directly related to the availability and quality of the data. Irrespective of the data limitations discussed in this Chapter, the currently available data support a range of statistical tests.

The choice of statistical models is based on both a review of the international criminological literature as well as the data availability in Canada. Because we had access to previously unreleased information, and by special arrangement with Statistics Canada, we were able to examine micro level information. Overall, the statistical models presented in the next three chapters represent the most sophisticated analysis of gun control attempted in Canada to date.

4. EXPLORATORY ANALYSIS

As an initial exercise, we undertook an extensive exploratory analysis of all the dependent variables to be used in our analysis. Several other studies using Canadian data have conducted studies based on graphical analysis. As mentioned previously, this approach provides insight into the dependent variables that we are analysing. Trends, outliers, and visible shifts in the series that may have an impact in the time-series and structural analysis may be identified, and potential problem spots located. Exploratory analysis highlights changes in the pattern of data, but will provide only limited insight into the *causes* of these changes. Unfortunately, at the time that we collected data for this study, the data were only available until 1993. Thus, the exploratory analysis does not provide any insights into the 1991 legislation.

4.1 Analysis Results

The graphs presented in this section show the annual change in homicide[62], suicide[63], robbery, assault and fatal accident rates per 100,000 population, as well as the proportion of each incident category that involved a firearm. These figures have been generated both nationally for each regional group that we used in our analysis, specifically: Canada, Atlantic Canada, Quebec, Ontario, and Western Canada.

4.1.1 Homicides

The firearm related and total homicide rates (Figure 4.1) for Canada increased steadily until 1975, at which point they started a steady decline, continuing to 1993. This trend persists in two of the four homicide series, with the exception of Atlantic Canada, which rises until 1975 (1973 for homicides with firearms), remains fairly constant until 1978, and then subsequently falls after 1978. Ontario also shows a series that is relatively stable after reaching a peak in 1975. The preliminary analysis indicates that the peak for firearm homicide was reached between 1975 and 1978. After the 1977 legislation, there is evident a long-term downward trend in homicide.

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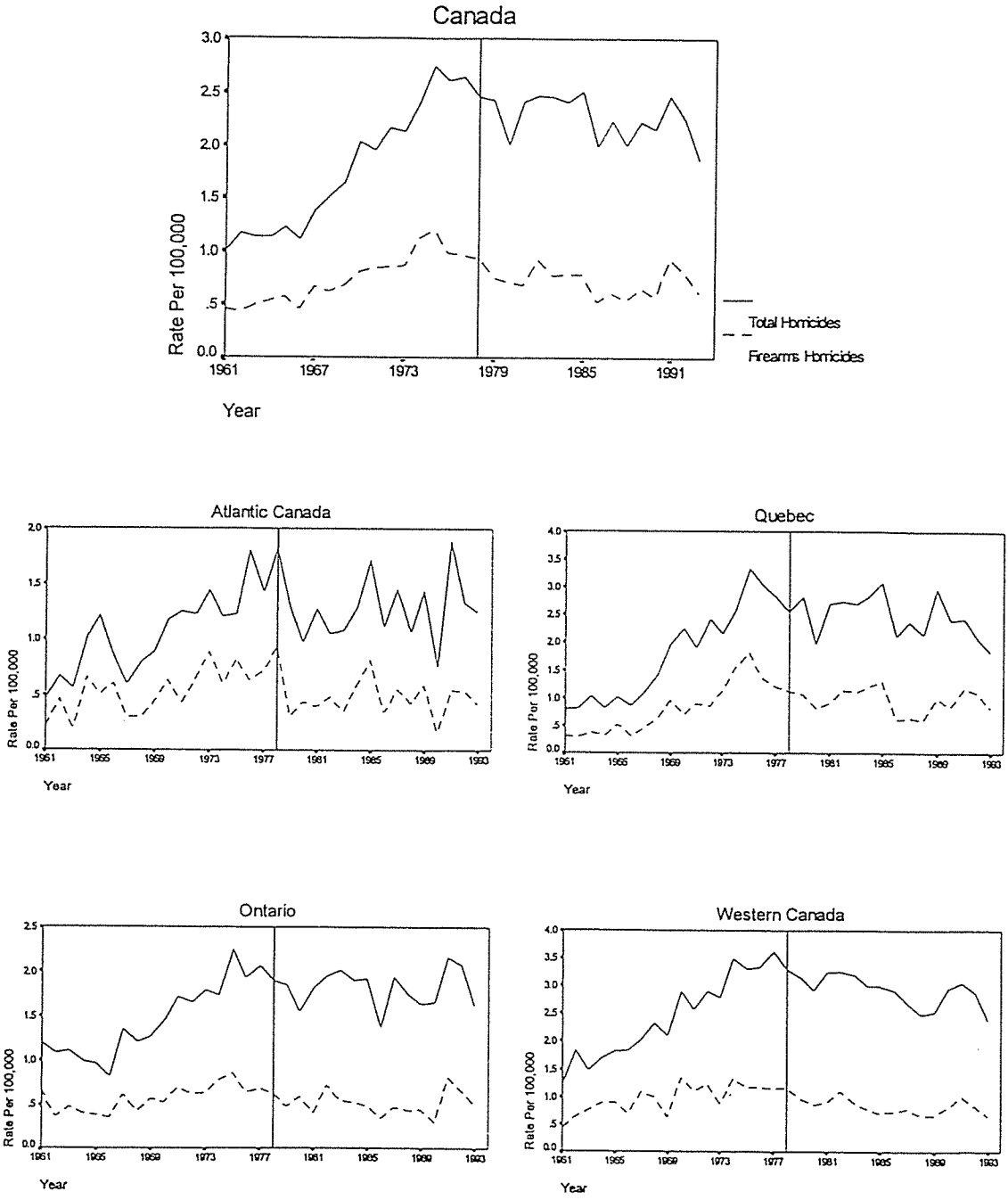
62 Excluding infanticide and manslaughter.

63 The data on suicides with firearms contains incidents for all suicides committed with firearms and explosives. The current Causes of Death Database does not distinguish between these two types of suicides; however the vast majority of all suicides in this category were undertaken with firearms (for 1993, 99.8% of all firearms/explosives suicides were undertaken using firearms).

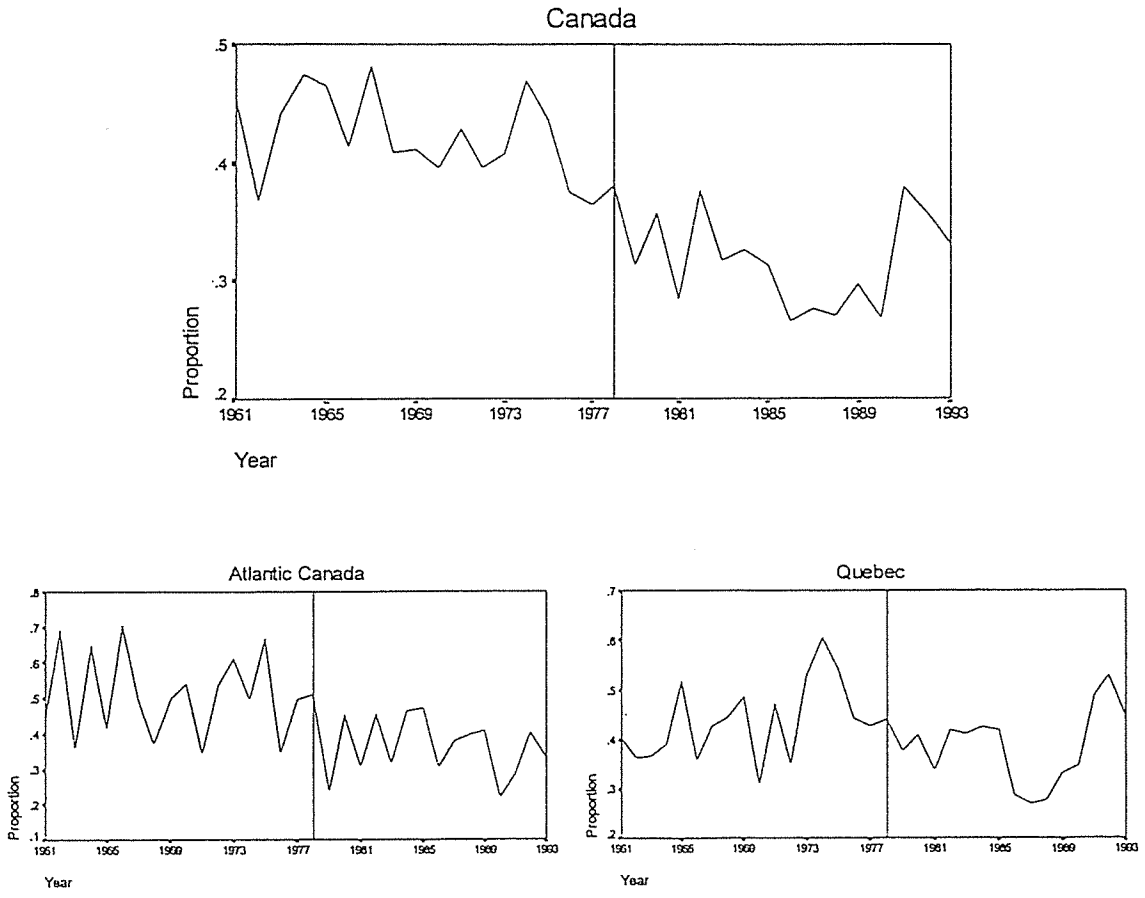
Figure 4.1 Rate Per 100,000 Of Firearm Homicides And Total Homicides



Source: Statistics Canada Homicide Database

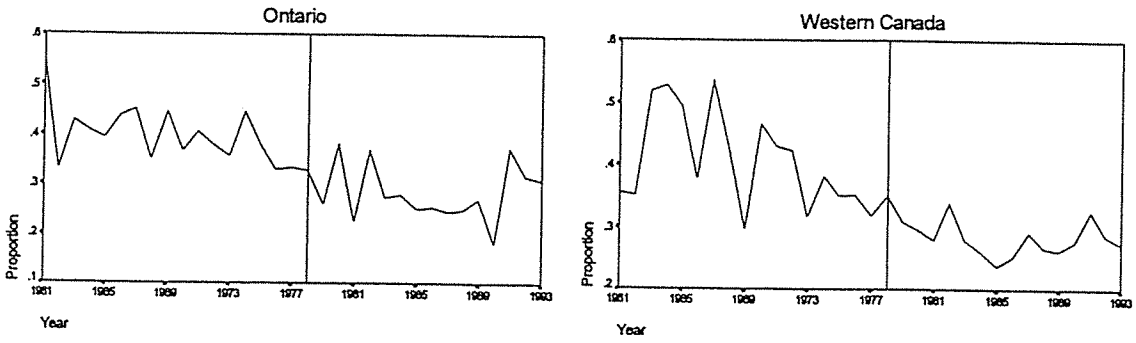
The proportion of homicides committed with firearms in Canada (see Figure 4.2) shows variations on a year by year basis, however, it remained relatively constant until 1974 (i.e., between 40% and 48%). Beginning in 1974, there is a clear downward trend until 1981 (from about 45% to less than 30%). There is a sharp spike upward in 1982 (to more than 35%) and then a continuation of the downward trend until 1989. The only significantly different data from a visual standpoint are the Atlantic Canada data as a shift took place in the proportion of homicides committed with firearms in 1978. Prior to 1978, the ratio was relatively constant ranging from 40 to 65 per cent, while after 1978 it established a new range from 25 to 40 per cent.

Figure 4.2 Ratio Of Homicides With Firearms To Total Homicides



Source: Statistics Canada Homicide Database

Figure 4.2 (Cont'd)



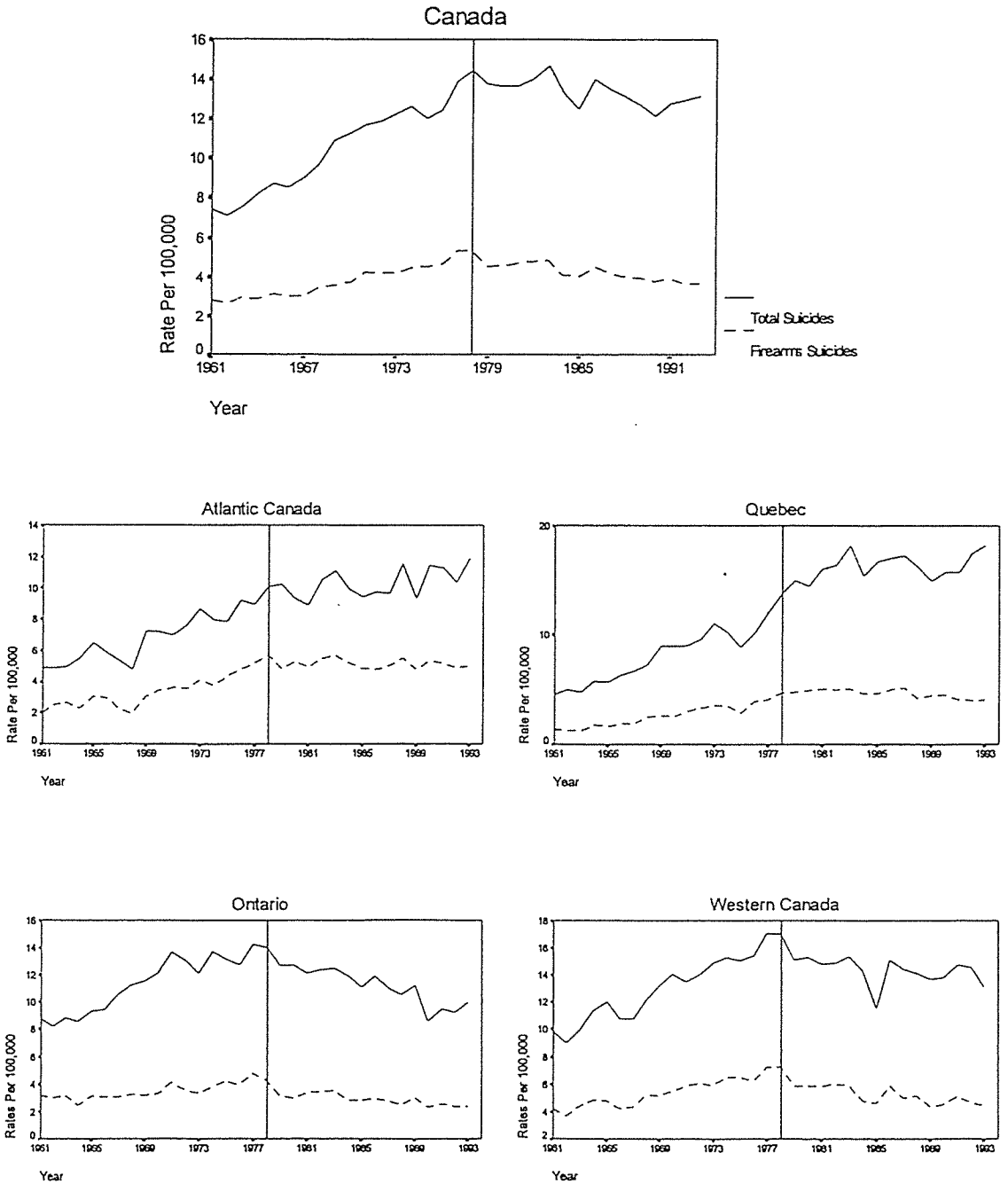
Source: Statistics Canada Homicide Database

4.1.2 Suicides

The firearm and total suicide rates for Canada (Figure 4.3) rose consistently until 1978, when there was a distinct change into a trend of slow decrease between 1978 and 1992. There were regional variations to this pattern.

For Ontario and Western Canada, it was a change from an increasing trend to one of slow decrease after 1978, both for the firearm and overall suicide rates. For Quebec and Atlantic Canada, it was a change from an increasing trend to a levelling trend for firearm suicides after 1978. For overall suicide rates in Atlantic Canada, it was a change from a fast increasing trend before 1978 to a slow increasing trend afterwards. In Quebec, the overall suicide rate increased to a peak in 1983 before changing into a levelling trend.

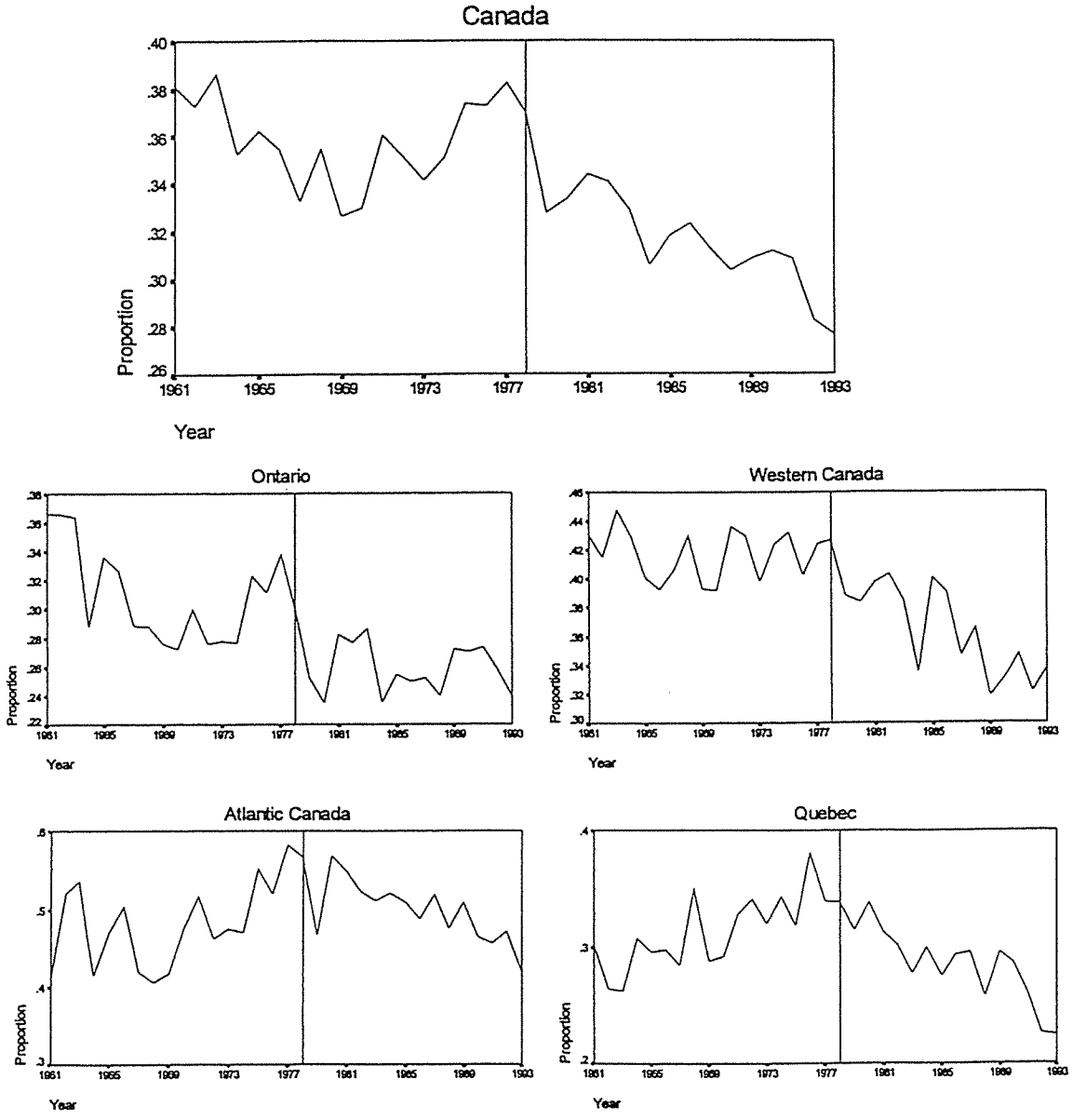
Figure 4.3 Rates Per 100,000 of Firearm Suicides and Total Suicides



Source: Statistics Canada Causes of Death Database

If we look at patterns in the ratio of firearms suicides to total suicides (Figure 4.4), we can see that there was a general downward trend between 1961 and 1969 in Canada (from 38% to 33%). After 1969, there was a reversal in this trend with the proportion of suicides peaking in 1977 (again at about 38%). Thereafter, there has been a steady decline to approximately 28 per cent in 1993.

Figure 4.4 Ratio Suicides with Firearms to Total Suicides



Source: Statistics Canada Causes Of Death Database

Looking at the regional patterns, one can see a number of differences, although in all four regions there are evident declines in the proportion of firearm suicides at about the time of the 1977 legislation. In general, the proportion of suicides using firearms appears to have fallen and this exploratory analysis suggests that changes in the series may be associated with the 1977 firearms legislation.

4.1.3 Fatal Firearm Accidents

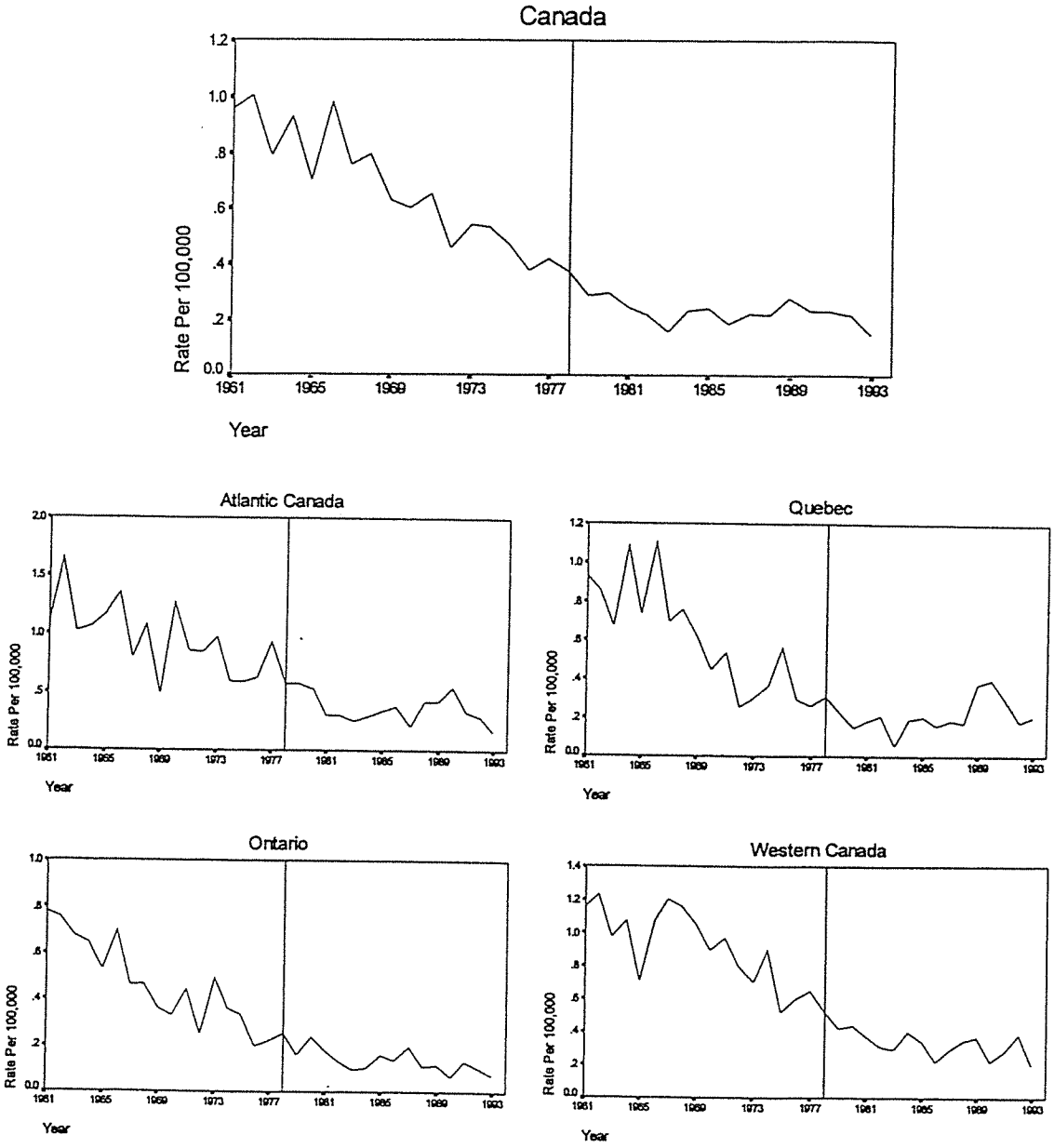
The series on fatal firearm accidents (Figure 4.5) all show similar patterns. They fall consistently from 1961 until 1983, and then seem to either level off (Ontario and Quebec) or decline at a slower rate (Atlantic and Western Canada). No real shift in any of the trends in fatal firearms accidents is evident at, or around the time of the 1977 firearms legislation.

4.1.4 Robberies

The rate of firearms and total robberies for Canada (Figure 4.6) appears to be fairly constant from 1974 to 1993, with marked increases appearing in 1982 and 1992. In Atlantic Canada the rate of robberies with firearms is almost constant, but this same rate falls in Quebec over the same time period. For Ontario and Western Canada however, the rate of both robberies and robberies with firearms begins to climb slightly around 1989, with total robberies rising faster than robberies with firearms. None of these series give any real evidence of a shift occurring in or around 1978.

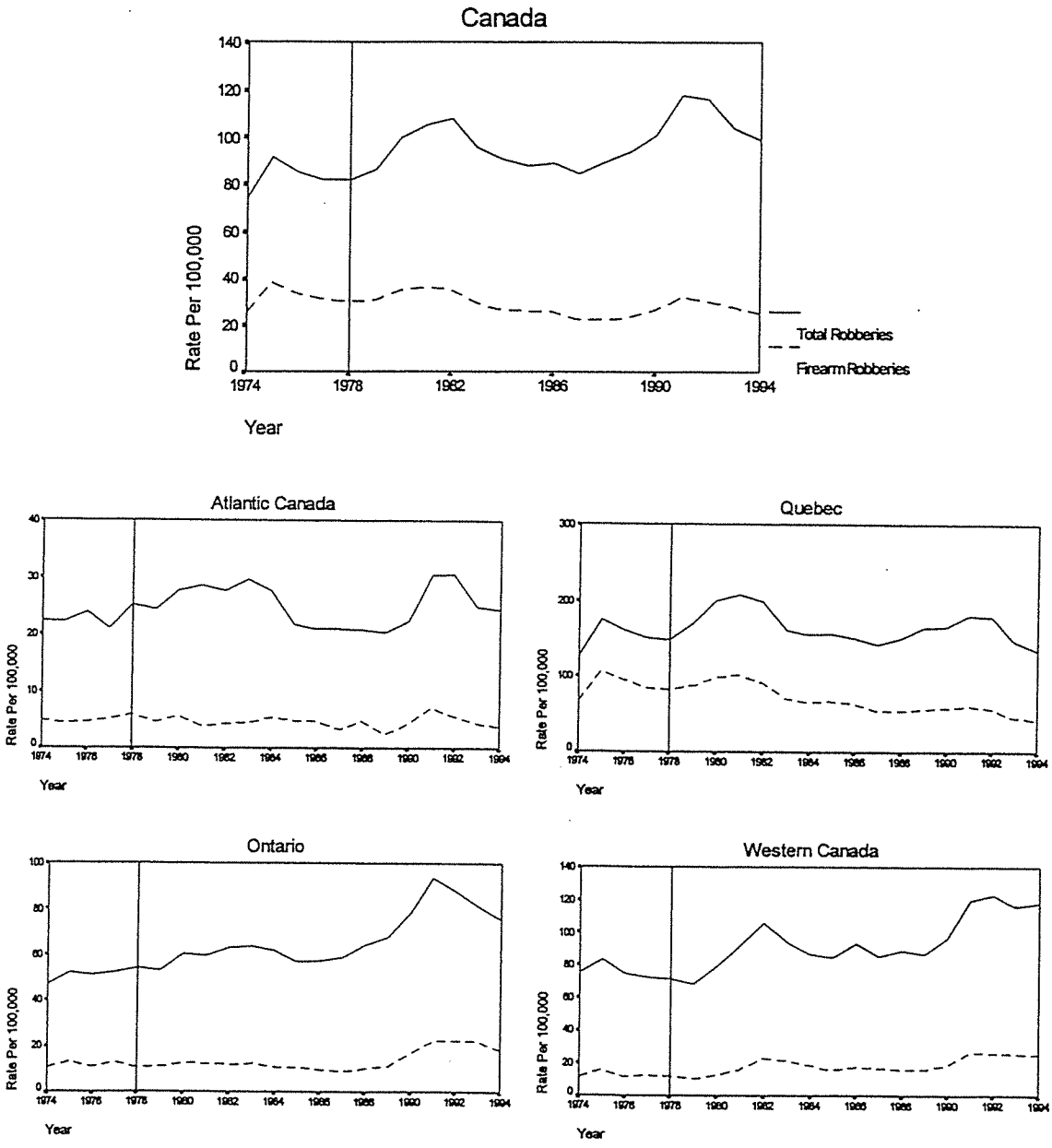
If we look at the ratio of robberies with firearms to total robberies (Figure 4.7), we can see that since 1975, nationally, there has been a steady decline from more than 40 per cent to about 25 per cent in 1994. There is a great deal of regional variation in this series, except in Quebec which follows the same trend as the national statistics. The remaining three regional series show marked differences at the time of the 1977 legislation, however, thereafter the trends are very different in each of the three regions.

Figure 4.5 Rates Per 100,000 of Fatal Firearm Accidents



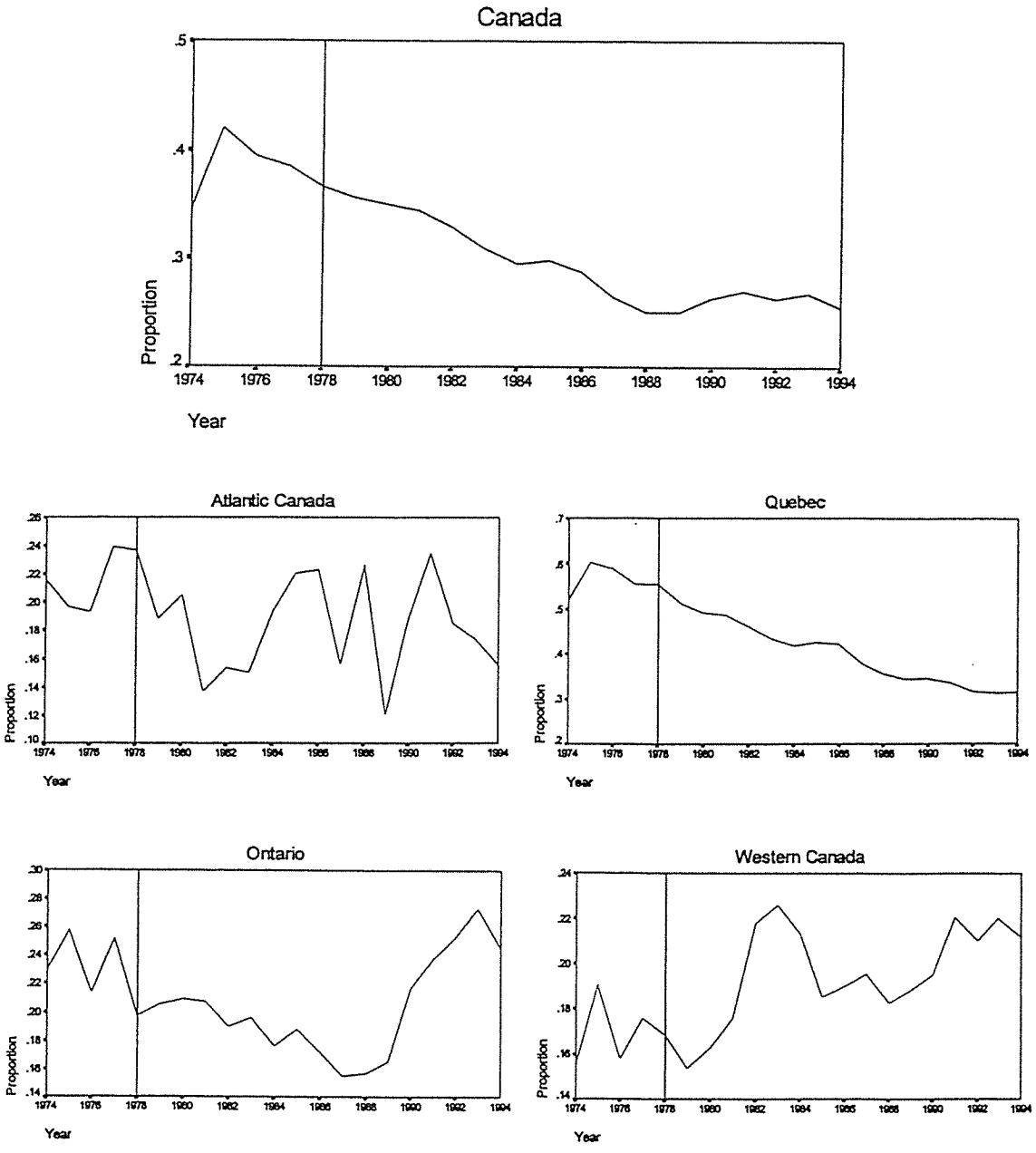
Source: Statistics Canada Causes Of Death Database

Figure 4.6 Rates Per 100,000 of Firearm Robberies and Total Robberies



Source: Statistics Canada Centre For Justice Statistics

Figure 4.7 Ratio of Robberies with Firearms to Total Robberies



Source: Statistics Canada Centre For Justice Statistics

4.2 Preliminary Conclusions

Exploratory analysis shows a number of inconsistent patterns in death rates and in the proportion of deaths involving firearms.

- The trends in death rates for total and firearm homicides at the national level have been declining steadily since 1978. The peak for firearm homicide rates was reached between 1975 and 1978, depending upon which region. However, in all regions of Canada, there has been a steady decline in firearm homicides since 1978.

- At a national level, the time series on suicides decline steadily after 1978. This pattern is also evident in Western Canada and Ontario. For firearm suicides, there is a distinct change from an increasing trend prior to 1978 to a decreasing trend since 1978.

- Fatal firearm accidents have trended downward continuously in all regions since 1961, however, there does not appear to be a relationship between this trend and the 1977 legislation.

- Nationally, robberies have increased over the 1974 through 1993 period, but robberies involving firearms have declined over the same period. In general, the use of firearms has continued to decrease reaching an historic low of approximately 25 per cent of all robberies in recent years. Quebec has shown a general decline in total robberies and robberies involving guns.

In general, exploratory analysis suggests that the turning point in the time series relating to homicides and robberies occured prior to the 1977 legislation. However, after the legislation, this change became a long-term trend. For suicides, it is clear that 1978 marks a turning point where the rates turn downward.

As stressed in Chapter 3, exploratory analysis is useful as a description of the dynamics of the dependent variable, however, it does not represent a strong explanatory tool. In other words, the times series portrayed in this chapter provide suggestions of impacts but they do not demonstrate anything conclusively about the impact of the legislation and on shifts in the time series on firearm deaths.

5. ARIMA ANALYSIS

Time-series analysis is a statistical process based on a procedure developed by Box and Jenkins, that examines the patterns in the dependent variables. This process essentially models future values of a data series based solely on the patterns established in the past.[64] Thinking about the time series presented in Section 4, what ARIMA modelling tests is whether the pattern of the data is different before and after the date of the change. Unlike exploratory analysis where we visually inspect the data to identify patterns, ARIMA provides a rigorous statistical basis for assessing whether there are changes in the observed patterns.

These techniques have not been commonly used in the legislative evaluation literature for two reasons. First, many are uncomfortable with the notion that impacts can be inferred merely by examining the "dependent" variable (e.g., suicides using guns). Second, the techniques are recent and complicated. Nevertheless, there are numerous examples where ARIMA methods have been used to assess legislative changes. For example, ARIMA methods have been used in evaluating seat belts legislation, and firearms controls in other jurisdictions.[65]

Inherent to time-series analysis is the idea that data such as stock prices, retail sales, or armed robbery follow a specific pattern over time. If this pattern can be detected, then the future can be predicted by modelling and extending the existing pattern. The patterns underlying the time series can be complex. Often seasonal factors can emerge in the series; retail sales increasing in December and falling off in January is an example of seasonality. Other factors can alter the pattern over time. Policy changes often cause a noticeable shift or jump in a time-series. For example an increase in the tax rate may cause consumption to fall either temporarily or permanently. In the case of gun control, time-series analysis tests whether the legislation has produced a shift in the regular pattern of incidents, and if so whether the shift has been in the direction intended.

To start this process, consider the monthly pattern of homicides in Canada. This is a much more detailed representation of the time series shown in Chapter 4.

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[64] For a detailed mathematical treatment of ARIMA modelling, please refer to the detailed technical appendices (under separate cover).

[65] See for example: Deutsch, and Alt "The Effect of Massachusetts' Gun Control Law on Gun-Related Crimes in the City of Boston". Evaluation Quarterly, 1, 543-568., and Hay and McCleary "Box-Tiao Time Series Models for Impact Assessment; A Comment on the Recent Work of Deutsch and Alt". Evaluation Quarterly, 3, 277-314.

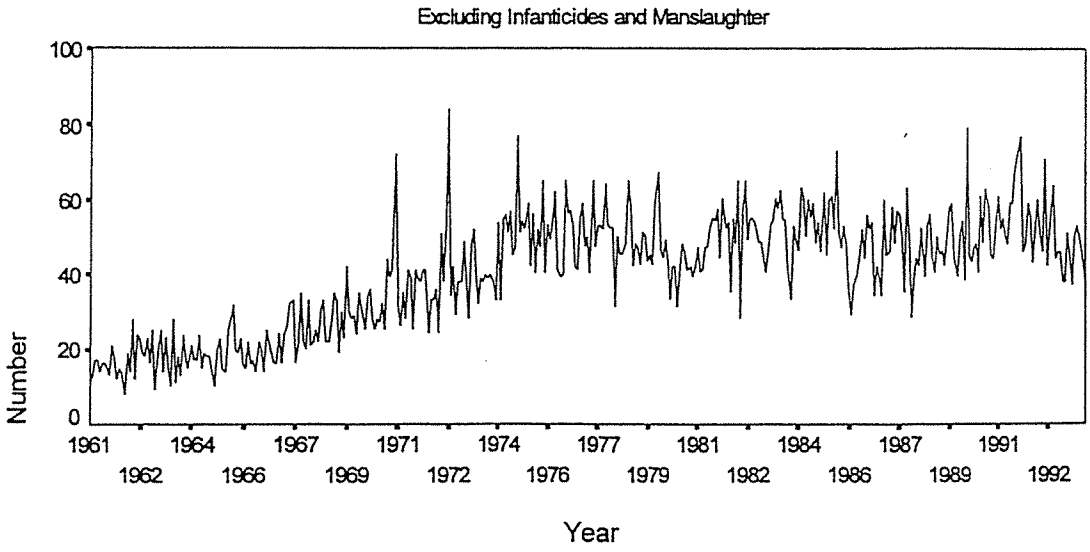
As seen in Figure 5.1, the pattern of homicides followed an upward trend from 1961 until the 1974-1978 period. At this point there appears to be a shift in the trend. The questions that we pose in this section are:

a) What is the model that generates the variations in the time series?

b) Is the shift that we observe in the 1974-78 period (if a shift does in fact occur at this point) a permanent statistically significant change?

c) To what extent can we associate the 1977 legislation with this change?

Figure 5.1 Total Homicides in Canada by Month



Statistics Canada Homicide Database

5.1 Methodology

5.1.1 The 1977 Legislation

To assess the effectiveness and the impact of the 1977 legislation using time-series analysis techniques, a number of processes must be followed.

- We restricted the data used for the model identification to data between 1961 and 1977. By specifying a model entirely with pre-legislation data, we are able to generate post-legislation forecasts that can be compared with the actual data series. This procedure can be revealing, as a dramatic difference between the actual and forecasted values may be indicative of some sort of structural change.

- We then examine whether the 1977 legislation is statistically associated with the change in the series by using a dummy variable or transfer function.[66]

- The transfer function used in this study takes on values of either 0 (before the date) or 1 (after the date), depending on whether or not the legislation is in effect.

- We also vary the date of the transformation to find the most likely position for such a change.

We used data on homicides, suicides, and fatal firearm accidents to examine the impact of the 1977 legislation.[67] These data were well suited to this analysis, as each series commences in 1961, providing enough pre-legislation data for the models to be identified. Further, the series all continue through to 1993, leaving a large post-legislation period for impact evaluation. The data that we collected on assaults and robberies was not used for a study of the 1977 legislation. The data on assaults was not available prior to 1983, and therefore could not be used in this portion of the analysis.

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[66] A transfer function is another name for the dummy variable used to represent the introduction of the legislation.

[67] The data on robberies was insufficient prior to 1977 to support time series analysis. The robbery models were also highly seasonal, and, after standard adjustments seasonal differencing to achieve stationarity, we were left with only three years worth of data for pre-legislation specification--an insufficient number of observations for accurate identification of seasonal models.

It was impractical to do an individual analysis for every province. A successful analysis requires a minimum amount of data (usually over 100 observations) that is not available in individual provinces outside of Ontario and Quebec. We therefore grouped the provinces in the following fashion.

i) Canada, including data from all ten provinces and two territories;
ii) Quebec, including data from the province of Quebec only;
iii) Ontario, including data from the province of Ontario only;
iv) Atlantic Canada, including data from Newfoundland, Prince Edward Island, Nova Scotia, and New Brunswick; and,
v) Western Canada, including data from Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, and the Northwest Territories.[68]

5.1.2 The 1991 Legislation

The form of the intervention tests used for evaluating the impact of the 1991 legislation is essentially identical to that used for the 1977 models. We used pre-legislation data to specify a model that we then fitted with a transfer function. We subsequently estimated this new specification over the entire range of the data. As before, we used a dummy variable that was equal to 0 before the assumed date of the policy and 1 after as the transfer function, and ran the model three times per series; once with the date set in January 1992, once in January, 1993, and once in January 1994.[69]

Data on homicides, suicides, and fatal firearm accidents terminates in 1993. This does not provide enough post intervention data for an analysis of the impact of the 1991 legislation on these series. However, data on assaults and robberies are available until 1994 at the time of our study, and this supports a preliminary analysis of the 1991 legislation in these areas. As before, we evaluated five different groups of provinces; Canada, Atlantic Canada, Western Canada, Quebec, and Ontario.

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[68] Data from the Yukon and Northwest Territories were included in the ARIMA analysis, but were not used in the structural analysis reported in Chapter 6 due to limitations in the independent variables.

[69] Again to remind the reader, we experimented with several dates to replicate the phase in of the legislation and its full implementation.

5.2 Results

We have summarized the results of the analysis in Figures 5.2 through 5.10. The significance of the transfer function variable refers to the t-statistic calculated for this variable. We generally acknowledge that variables with a t-statistic in excess of the absolute value of 2 are significant. The sign of the coefficient indicates the effect that the intervention variable had on the series in question; a negative coefficient on a homicide series indicates that the intervention depressed homicides, while a positive one indicates the opposite.

Some of the cells in the tables are blank, and these represent series that did not have a definite and consistent pattern over the analysis period. In other words, we were unable to establish a pattern in the pre-legislation period. Other cells have only dashes and these indicate that the series is entirely random, i.e. cannot be expressed as an equation. A recurring problem with the ARIMA model is that the pattern must be expressed as a specific mathematical equation. In some cases, the series is no different from a random process. Such data series cannot be used in testing for impact and can only be set aside, as we have done.

The tables display a wide variety of results. It is not uncommon to find intervention coefficients with opposite signs in the same table. However, it is the significance test in each table upon which we will base our conclusions.[70]

We modelled the legislation by testing three points across the time period January, 1977 to January, 1979. In this way, we hoped to ensure that we could detect a delayed impact, if any, to the legislation.

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[70] Entries in the tables that are followed by a * represent dummy variables with a high standard error (greater than 0.35). These standard errors are a consequence of specifying the best possible ARIMA model before adding the dummy variable; as a result the dummy adds little to the model, and is likely related to one of the other variables (resulting in multicollinearity, a problem that causes high standard errors). Most published studies do not reveal the standard errors on the dummy variables, which is unfortunate since this statistic is key to correctly interpreting the study results. The nature of the ARIMA model is described by the number of autoregressive, moving average and differencing terms. This is usually noted by showing a model as an ARIMA (0,1,4) (0,0,0) model. The interested reader can explore this in more detail in the technical appendices (under separate cover).

Figure 5.2 Results of ARIMA Intervention Analysis on Total Homicides

Test Area	ARIMA Model	Significance of Intervention Variable		
		Jan., 1977	Jan., 1978	Jan., 1979
Canada	(0,1,4) (0,0,0)	Insignificant*	Insignificant*	Insignificant*
Atlantic Canada	(0,1,2) (0,0,0)	Insignificant*	Insignificant*	Insignificant
Quebec	(0,1,4) (0,0,0)	Insignificant*	Insignificant*	Insignificant*
Ontario	(0,1,4) (0,0,0)	Insignificant*	Insignificant*	Insignificant*
Western Canada	(0,1,2) (0,0,0)	Insignificant*	Insignificant*	Insignificant*
* See Footnote 70				

Figure 5.3 Results of ARIMA Intervention Analysis on Homicides with Firearms

Test Area	ARIMA Model	Significance of Intervention Variable (Sign of Variable Coefficient)		
		Jan., 1977	Jan., 1978	Jan., 1979
Canada	(0,1,3) (0,0,0)	Insignificant* (+)	Significant* (-)	Insignificant* (-)
Atlantic Canada	(0,0,0) (0,0,0) Random Process	-	-	-
Quebec	Unidentifiable			
Ontario	(0,1,3) (0,0,0)	Insignificant* (-)	Significant* (-)	Significant* (-)
Western Canada	(0,1,3) (0,0,0)	Insignificant* (-)	Insignificant* (-)	Insignificant* (-)
* See Footnote 70				

Homicides

The ARIMA analysis presents mixed results with regard to whether or not the 1977 legislation is associated with the reduction in the overall homicide rate (Figure 5.2) and the reduction of homicides with firearms (see Figure 5.3). For example, Figure 5.2 suggests that the legislation

has not had any impact on the overall homicide rates. On the other hand three dummy variables in Figure 5.3 are statistically significant and negative implying that the 1977 legislation has had some effect on the firearm homicide rates in Ontario and for Canada as a whole. In the exploratory analysis, we also noted that there is some indication of change in the homicide series (see Figure 4.1). The rising trend that starts in 1961 levels out around 1975; this explains the negative coefficient assigned to the intervention variables. However, since the series effectively stopped increasing in 1975, it appears that although the legislation may have had some impact on the incidence of homicides, other factor(s) may also be responsible for reversing the trend in the data series.

Suicides

Figures 5.4 and 5.5 detail our findings from the ARIMA analyses of suicides. The positive coefficient assigned to all intervention functions (dummy variables) in January, 1977 reflects the fact that the suicide rate has continued to rise from the beginning of the series in 1961 to the intervention point. The fact that this intervention variable is insignificant in the majority of the models tested for 1977 and 1978 suggests that there are other factors driving the series. The increase in the suicide rate is clearly not motivated by anticipation of a change in the firearm legislation. The negative intervention functions observed in the January, 1979 models suggest that the legislation had some delayed effect on this series. This parallels the exploratory analysis, which indicated for some regions that there is a shift in suicides at this point. However, we stress that the models demonstrate high standard errors.

Figure 5.4 Results of ARIMA Intervention Analysis on Total Suicides

Test Area	ARIMA Model	Significance of Intervention Variable (Sign of Variable Coefficient)		
		Jan., 1977	Jan., 1978	Jan., 1979
Canada	(1,1,1) (0,0,0)	Insignificant* (+)	Insignificant* (+)	Insignificant* (-)
Atlantic Canada	(0,1,4) (0,0,0)	Insignificant* (+)	Insignificant* (+)	Insignificant* (-)
Quebec	(0,1,1) (0,0,0)	Insignificant* (+)	Insignificant* (+)	Insignificant* (+)
Ontario	(0,1,1) (0,0,0)	Insignificant* (+)	Insignificant* (-)	Significant* (-)
Western Canada	(0,1,1) (0,0,0)	Insignificant* (+)	Insignificant* (+)	Significant* (-)
* See Footnote 70				

Figure 5.5 Results of ARIMA Intervention Analysis on Suicides with Firearms and Explosives

Test Area	ARIMA Model	Significance of Intervention Variable (Sign of Variable Coefficient)		
		Jan., 1977	Jan., 1978	Jan., 1979
Canada	(1,1,6) (0,0,0)	Significant* (+)	Insignificant* (+)	Significant* (-)
Atlantic Canada	(0,1,3) (0,0,0)	Insignificant* (+)	Insignificant* (+)	Insignificant* (-)
Quebec	(0,1,2) (0,0,0)	Significant* (+)	Significant* (+)	Insignificant* (+)
Ontario	(0,1,6) (0,0,0)	Insignificant* (+)	Significant* (-)	Significant* (-)
Western Canada	(0,1,5) (0,0,0)	Insignificant* (+)	Insignificant* (+)	Significant* (-)
* See Footnote 70				

Figure 5.6 Results of ARIMA Intervention Analysis on Fatal Accidents with Firearms

Test Area	ARIMA Model	Significance of Intervention Variable (Sign of Variable Coefficient)		
		Jan., 1977	Jan., 1978	Jan., 1979
Canada	(0,0,0) (1,1,1)	Insignificant* (-)	Insignificant* (-)	Significant* (-)
Atlantic Canada	(0,0,0) (1,1,1)	Insignificant (-)	Insignificant (-)	Insignificant (-)
Quebec	(1,0,1) (1,1,1)	Insignificant* (-)	Insignificant* (-)	Insignificant* (-)
Ontario	(0,0,0) (1,1,1)	Insignificant (-)	Insignificant (-)	Insignificant (-)
Western Canada	(0,0,0) (1,1,1)	**Significant*** (-)	**Significant*** (-)	**Significant*** (-)
* See Footnote 70				

Fatal Accidents

There is slightly more support for the effectiveness of the 1977 legislation in the ARIMA models on fatal accidents (Figure 5.6), but again we are left with mixed results. All the intervention functions for Western Canada are negative and significant. However of the remaining 12 intervention functions only one is negative and significant. This results in 4 of 12 dummy variables indicating that the legislation was effective.

Figure 5.7 Results of ARIMA Intervention Analysis on Total Robberies

Test Area	ARIMA Model	Significance of Intervention Variable (Sign of Variable Coefficient)		
		Jan., 1992	Jan., 1993	Jan., 1994
Canada	(0,1,1) (1,1,2)	Insignificant* (-)	Insignificant* (-)	Insignificant* (-)
Atlantic Canada	(0,1,1) (1,1,2)	Insignificant* (-)	**Significant*** (-)	Insignificant* (-)
Quebec	(0,1,3) (1,1,2)	Insignificant* (-)	Insignificant* (-)	Insignificant* (-)
Ontario	(0,1,1) (2,1,2)	Insignificant* (-)	Insignificant* (+)	Insignificant* (-)
Western Canada	(0,1,2) (1,1,2)	Insignificant* (+)	Insignificant* (-)	Insignificant* (+)
* See Footnote 70				

Figure 5.8 Results of ARIMA Intervention Analysis on Robberies with Firearms

Test Area	ARIMA Model	Significance of Intervention Variable (Sign of Variable Coefficient)		
		Jan., 1992	Jan., 1993	Jan., 1994
Canada	(1,0,1) (1,1,1)	Insignificant* (-)	Insignificant* (-)	Insignificant* (-)
Atlantic Canada	(1,0,0) (0,0,0)	Insignificant* (+)	Insignificant* (+)	Insignificant* (+)
Quebec	(1,0,1) (1,1,1)	Insignificant* (-)	Insignificant* (-)	Insignificant* (-)
Ontario	(0,1,1) (0,1,1)	Insignificant* (-)	Insignificant* (-)	Insignificant* (-)
Western Canada	(1,0,2) (1,1,2)	Insignificant* (-)	Insignificant* (-)	Insignificant* (-)
* See Footnote 70				

Total Robberies and Robberies with Firearms

Due to data availability, the series on robberies and assaults were used to undertake a preliminary test of the 1991 legislation. The results of this preliminary analysis do not suggest that the 1991 legislation reduced robberies or robberies with firearms. However, we note that there is insufficient post-legislation data available to support the analysis.

5.3 Preliminary Conclusions

The ARIMA tests on the time series (homicides, suicides and fatal accidents) show inconsistent patterns with regard to the relationship between the 1977 legislation and changing patterns of death rates. Recall that ARIMA provides a rigorous statistical test whether the pattern of a time series shifts at the time of a policy change. We shifted the date of this intervention across three years to assess anticipatory and lagged effects from the legislation but found no consistent patterns linking the legislation to changes in firearms deaths.

- For homicides, the ARIMA tests suggest that the 1977 legislation had some effect on the firearm homicide rate in Ontario and for Canada as a whole.

- For suicides involving firearms, the intervention is statistically significant for Ontario and Western Canada as well as for Canada as a whole for an intervention modelled in 1979.

- Firearm accidents show a similar type of pattern. Nationally, the intervention is statistically significant in 1979 for Canada as a whole. For Western Canada, the intervention is significant for all three models (i.e., 1977, 1978 and 1979). No consistent patterns emerge for other regions.

For the 1991 legislation, preliminary analyses could only be conducted with regard to robberies with firearms because the data on homicides, suicides and accidents end in 1993. In general, there is little evidence that the pattern of robberies with firearms was affected by the legislation, however, we note that the post-legislation period is represented by two or less years of data. This places a major constraint on the analysis.

Overall, the ARIMA analyses do not demonstrate consistent patterns across the various time series. This does not necessarily lead to a conclusion about the effectiveness of the firearms control legislation. Rather, it suggests that any effect that does exist is complex and not easily determined by just examining the outcome variable (i.e., death rates).

The ARIMA tests parallel the exploratory analysis that showed suggestions of an impact for some regions in some years. As well, we note that ARIMA tests demonstrate the need for structural models to simultaneously examine the impacts of gun control, social, economic and other influences.

6. STRUCTURAL ANALYSIS

Structural analysis is different from time-series and exploratory analysis because it evaluates the impact of the legislation once all other factors have been accounted for. When simple visual inspection of the dependent variables is undertaken in the exploratory stage, any change in the death rate around the time of the legislation can only be attributed to the new law. ARIMA series improves upon this assumption by attributing deviations from the historical patterns to the firearm restrictions using a statistical test. Structural analysis further improves upon both of these methods in terms of causal explanatory power by attempting to measure the effects of all related socio-economic phenomena before assigning significance to the legislative changes.

Essentially then, by using structural models we will attempt to evaluate the net effect that the firearm legislation had on crime rates after all other relevant factors have been accounted for. The "other factors" that we consider in our study are the determinants of violent crime identified in sociological and criminological literature and for which we were able to procure satisfactory measures (see Chapter 3 on data collection).

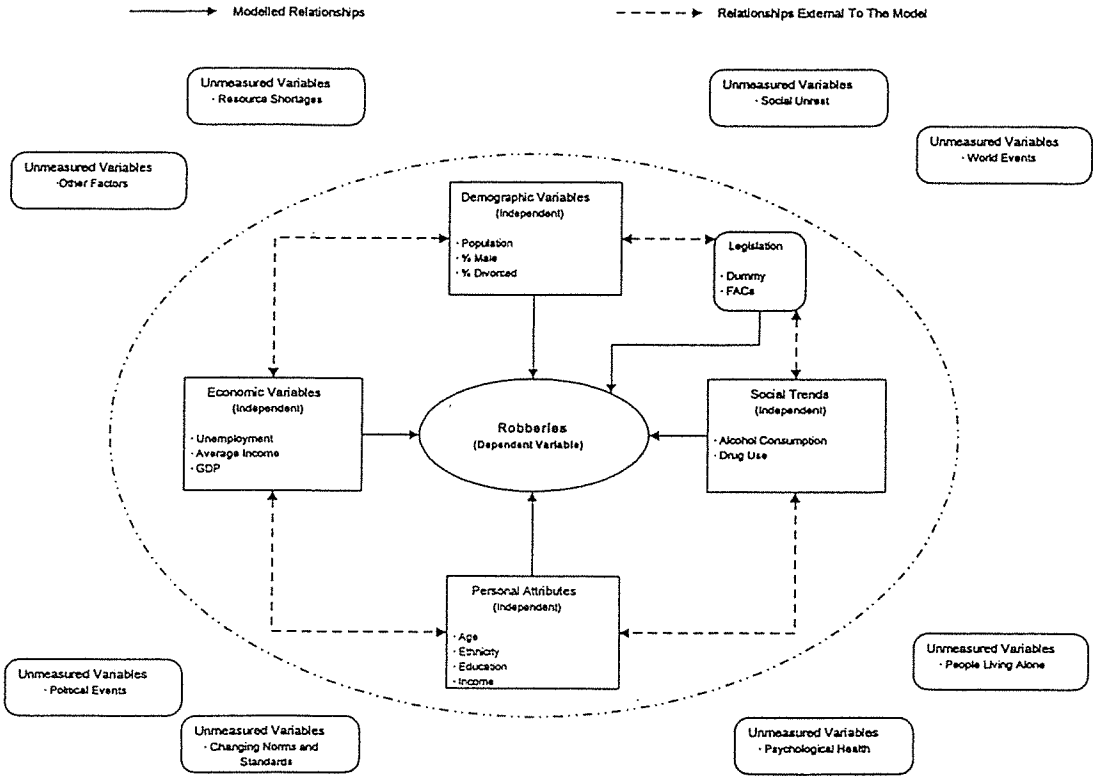
As mentioned in Chapter 3, a critical problem is that structural models may omit statistically significant influences on the dependent variable. When theory provides no guidance on the correct independent variable, or data are missing, the structural models are incomplete.

6.1 Modelling The Motivating Factors

Our knowledge is expanding, although clearly we cannot expect to model all forces that lead to criminal behaviour. The structural specification used in criminological research is a simplified version of reality, in which a limited number of external factors (the independent variables) are hypothesized to influence the crime in question (the dependent variable), while everything else is assumed to be either irrelevant, indirectly accounted for in the chosen independent variables, or constant.

Figure 6.1 illustrates how a structural model might simplify reality by limiting the number of relationships that exist between the dependent variable (in this case robbery) and the multitude of potential independent variables. Within the dashed oval are those variables that are available for inclusion. Outside, are the influences that may have important roles to play in the variation of the dependent variables (in this case robberies), but for which suitable data do not exist. The independent variables are shown in the rectangles, and the solid lines show the direct relationships captured by a single equation regression model. There are also a range of relationships among the independent variables that are not measured. The legislation is simply one of a set of potential explanations for variation in the dependent variable.

Figure 6.1 Structural Model of Robberies



The choice of independent variables in the structural model is a critical part of this analysis. This statistical study tests the effectiveness of Canadian firearms legislation, and therefore only relevant variables that can be linked to violent crimes and accidents should be considered. Ad hoc variable selection and stepwise[71] practices are frequently used variable selection techniques employed for the purposes of empirical analysis because of their relative simplicity. However these approaches can include as significant, factors that have no logical bearing on the outcome variable.

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71 A step-wise regression is a model building technique that advocates simply adding independent variables to the model as long as the adjusted R^2 statistic keeps increasing. Our goal in this study is not to maximize our adjusted R^2 statistic, but to evaluate the effectiveness of certain legislation; these two goals are not the same.

The variables that we can use in this study are limited to data that have been collected by Statistics Canada, Health Canada and other departments and agencies over the relevant time frame, and at an appropriate intertemporal and geographical level. Although there are several socio-economic variables that we would like to have included in the analysis they were not available in a form needed for the analysis.

6.1.1 Available Data

Data availability had an effect on our choice of both independent and dependent variables. Due to the data restrictions that we encountered, we have limited our dependent variables to suicides, homicides, robbery, and assault, all with and without firearms, in addition to fatal firearm accidents. These are the dependent variables whose variation we are seeking to model using structural analysis.

Based upon previous empirical studies of gun control legislation, we have constructed a number of candidate structural models for each of our dependent variables. All of the variables included in these equations have been frequently used in other statistical analysis.[72] However, not all the variables were available at an annual and provincial level for the years 1961 to 1993. This section presents the variables that we planned to include, and outlines how these were limited to those for which data were available.

Most of the dependent variables under consideration are available on a monthly basis, and we therefore hoped to collect these independent variables at the same frequency. Unfortunately, we were only able to find many independent variables at an annual frequency, and have therefore been forced to limit our structural analysis to annual data.

The independent variables used in this analysis can be classified into three general categories: economic factors, demographic variables, and social trends. Not all the independent variables will be relevant to every dependent variable. A detailed outline on the specific data series that we collected is found in Chapter 3 of this report.

6.2 Data Transformations

The majority of the data we are using for this analysis cannot be put directly into a statistical model. Since most of the data series are a direct function of the population, it is necessary to

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[72] We have not explored new theories that require micro data sets (such as UCR2). Restrictions on data availability has confined the analysis to aggregate data.

use proportions or ratios in the models.[73] This section outlines the transformations that we made to the variables prior to using them in our structural analysis.

6.2.1 Dependent Variables

In empirical studies, the crime rate is generally expressed as a rate per 100,000 population. This measure adjusts for the differences in population that occur among geographical areas, and across points in time. We therefore transformed the data on homicides, robberies, assaults, suicides, and accidents with firearms as a rate per 100,000 population.

6.2.2 Independent Variables

As with the dependent variables, we transformed the independent variables so they were not population dependent.

- We re-scaled the series on population: male aged 15-24, Registered Aboriginal persons, divorced, and immigrants to percentage of the total population for the purpose of this analysis. This was done by dividing the specific population subgroup by the total population of the same area and multiplying by 100. We calculated these statistics for Atlantic Canada, Quebec, Ontario, and Western Canada. We used this same transformation strategy on alcohol consumption. The number of litres consumed in each area was divided by the corresponding population.

- The data series on valid Firearms Acquisition Certificates were transformed to a rate per 100,000 population by dividing the total population in the appropriate area by 100,000, and the dividing the number of valid FACs in the same region by this new number. We changed the data on students graduating from university so that it would be a rate per 100,000 population. The method we used for this transformation is the same as that used for the FACs.

- We did not need to modify the series on personal income per capita. Data on unemployment were left as a percentage of the total population, as this is an acceptable format for use in our analysis. Finally, we simply left the data on clearance rates as a proportion, defined by the number of incidents cleared by arrest over the total number of incidents.

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[73] Such as murders per 100,000 population, and the proportion of the total population that is divorced.

6.3 Estimation Methodology

The data that we have collected for this analysis can be divided into two structural groups: the data that vary longitudinally over time (from 1961 to 1993), and the data that vary cross-sectionally across the country (from Newfoundland to BC). To get the best results possible, we want to maximize the number of data points in our analysis, and this implies that the two structural data sets should be combined. However, both of these data groups have distinct characteristics that must be accounted for when using them for statistical analysis; therefore, joining the two requires the use of a specialized technique. We have chosen to use the Kmenta generalized least squares (GLS) estimation methodology for pooled cross-sectional and time series data, in conjunction with Ordinary Least Squares (OLS) pooling with dummy variables

Time series data often introduce autocorrelation and multicollinearity into models. Autocorrelation occurs when there is a correlation between the error terms associated with different observations. When autocorrelation is a problem the estimates of the regression coefficients will be inefficient (although unbiased) and the estimates of the coefficient's standard errors will be biased and inconsistent. When multicollinearity is present, coefficients may have implausible magnitudes, incorrect signs, and high standard errors.

Cross-sectional data will often exhibit problems with heteroscedasticity. Heteroscedasticity occurs when the variance of the error term is not constant. Its presence results in inefficient (although unbiased) parameter estimations, and biased estimated variances for these parameters. Therefore, if a pooled data set is estimated without any corrections for autocorrelation and heteroscedasticity, in all likelihood the estimated parameters will experience inefficiency from two sources: the time series and cross-section components of the data.

The Kmenta GLS estimation method alters the estimation procedure by estimating the degree of heteroscedasticity and autocorrelation present in the model and then adjusts the estimates to correct for these problems. We used the statistical package SHAZAM 7.0 to run the GLS pooled models.

The pooled OLS model with dummy variables is simply estimated by stacking all the cross-sectional data, and estimating the model using OLS and cross-sectional dummy variables. This model often has significantly more problems with serial correlation than the Kmenta technique and subsequently we only had limited success with this model.

6.4 Model Specification

This section outlines the model specifications that we used in the structural model section of our analysis. Although most of the data that we have acquired is available by province, we have chosen to use the following provincial breakdown: Atlantic Region (Newfoundland, PEI, New Brunswick, and Nova Scotia), Quebec, Ontario, and Western Canada (Manitoba, Saskatchewan, Alberta, and BC). We chose to aggregate the Atlantic and Western provinces because it significantly reduces the number of dummy variables that we have to employ. We chose to exclude the territories for much the same reason: they supplied very little data for the degrees of freedom that they would consume in the analysis.[74]

6.4.1 Homicides

We obtained detailed monthly data at the provincial level on homicide from the Homicide Survey of the Canadian Centre for Justice Statistics. The data on homicides dates back to 1961, with statistics on infanticides and manslaughters commencing in 1974. Further, we were provided with monthly statistics by province on the number of homicides perpetrated with a firearm over the same period. We will use data on total homicides, and homicides by firearms, as dependent variables in our analysis, with infanticides and manslaughters removed entirely from the data (see Figure 6.2 for specification of variables).

Based on the review of the literature, independent variables that may be included in a model of homicides include: percentage graduating from a university program, percentage male youth, unemployment, personal income, percentage population divorced, percentage male population, percentage Registered Aboriginal persons, percentage recent immigrants, alcohol consumption, FACs, homicide clearance rate, and dummies for the gun control legislation. Initially, we endeavoured to have one variable represent proportion male, and another youth population (ages 15-24). However in our preliminary structural analysis, we discovered that these two variables were highly collinear, and therefore combined them into the variable male youth.[75]

We ran two sets of models on homicides. The first set included all the data we had from 1968 onwards, while the second used the additional data that became available for the years 1971-

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[74] Adding a new region to pooled cross-sections, time series data is not without some problems. The model needs to add dummy variables to account for the new region and this reduces the power of the statistical test. In the case of the territories, we judged that any gain by including these data was outweighed by a loss in statistical power.

[75] Multicollinearity among sets of independent variables reduces or even eliminates the contributions to the regression model of any member of that set.

1993; these extra variables include the divorce rate, per capita alcohol consumption, and education (per cent graduating from university).

Figure 6.2 Coverage of Candidate Variables - Homicides

Variables	1961	1965	1966	1968	1970	1971	1993
Dependent							
Homicides Per 100,000							
Firearm Homicides Per 100,000							
Independent							
Homicide Clearance Rate							
Percentage Male Youth							
Personal Income							
FACs Per 100,000							
Percentage Registered Aboriginals							
Unemployment Rate							
Percentage Immigrated							
Percentage Graduating University Students							
Percentage Divorced							
Alcohol Consumption Per Capita							
Dummy Variable (0 for 1961-1976 1 for 1977-1993)							
	Shows data availability						

6.4.2 Suicides

We acquired information on suicides in Canada between the years of 1961 and 1993 from the Statistics Canada Health Statistics Division. This information included statistics on suicides by several methods: poisoning, suffocation, submersion, firearms and explosives, cutting, jumping, and other unspecified means. The data are available by month and province. Detailed statistics on suicides with specific firearms are also available, but only for dates after 1979. Therefore, for our structural models we will use total suicides, and suicides by firearms as our dependent variables.

Independent variables that we considered using for estimation include: percentage graduating from university, educational attainment, unemployment, personal income, population divorced, percent male youth, number of Registered Aboriginal persons, immigrants, FACs, alcohol consumption, and dummies for the gun control legislation. Unfortunately, it is not feasible to use all of these independent variables in our estimation, as some of the series do not start early enough. Figure 6.3 shows the year data become available for each of the candidate independent variables.

Since the legislation that we are testing was implemented in 1978, we want to retain a large sample of observations prior to this date. However, if we omit an important socio-economic variable in our attempt to maintain a high sample size, we may get inaccurate results. Ideally, we would include a data series on education, drug arrests, and alcohol consumption in our model. However if we reduce our data set to allow estimation with all these variables, our sample size shrinks to 1977-1993. Eliminating the drug related arrests[76] variable increases the sample size to 1971, giving seven years of data prior to the change. If we eliminate the data on population, immigration, and alcohol consumption, we can increase our sample size to 1965-1993, enlarging our pre-legislative period to 13 years. With this sample size we retain variables on demographics (male population and age groups), economic conditions (unemployment and personal income), and minority groups (Registered Aboriginals). However, the loss of the education, alcohol, and immigration variables may result in biased and inconsistent parameter estimations.

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[76] Exclusion of the 'drug related arrest' variable is not a real issue as this variable measures the behaviour of law enforcement agencies as much as it does drug use; it is therefore not an accurate measure.

Figure 6.3 Candidate Variables - Suicides

Variable	1961	1965	1966	1968	1970	1971	1977	1993
Dependent								
Suicides Per 100,000								
Firearm Suicides Per 100,000								
Independent								
Percentage Male Youth								
Personal Income								
FACs Per 100,000								
Percentage Registered Aboriginals								
Unemployment Rate								
Percentage Immigrated								
Percentage Graduating from University								
Percentage Divorced								
Alcohol Consumption Per Capita								
Drug Related Arrests Per 100,000								
Dummy Variable (0 for 1961-1976 1 for 1977-1993)								
	Shows data availability							

Alterations that may be made to this model include estimating it with firearm suicides, and non-firearm suicides as the dependent variables. Further, we have considered that there may be a high degree of correlation between personal income and unemployment rate, and have therefore also estimated the model excluding each of these variables in turn.

6.4.3 Fatal Accidents with Firearms

Statistics on fatal accidents with firearms are available from the Statistics Canada Health Statistics Division. We acquired these statistics on a monthly provincial level from 1961 to 1993. A further breakdown of fatal accidents by type of firearm is also available from the same source, but these data only date back to 1979. Our dependent variable will therefore be the rate of fatal firearm accidents per 100,000 population.

Independent variables that may be included in a model of fatal accidents with firearms include percent male youth, alcohol consumption, FACs, dummies for the gun control legislation, and percentage Registered Aboriginals. As well, we have decided to include a time trend because of the results from the exploratory analysis. Unlike almost every other dependent variable series, the fatal accident data exhibited a long-term tendency to decline as a function of time. This pattern is not easily explained by any of the independent variables we are considering.[77] We therefore hypothesized that this may be a secular trend in the data series and have included 'time' as an independent variable in some of the models.

Because we expect that the alcohol consumption variable will be very important in this portion of the analysis, we decided to limit our data to the years 1971-1993. Figure 6.4 represents the availability of data for the fatal accident structural analysis.

We varied this model by including and excluding the time trend, and the proportion Registered Aboriginals variables.

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[77] We were unable to obtain information on the participation rate in firearms safety programs.

Figure 6.4 Candidate Variables - Fatal Accidents with Firearms

Variable	1961	1965	1966	1970	1971	1976	1993
Dependent							
Fatal Accidents Per 100,000							
Independent							
Percentage Male Youth							
FACs Per 100,000							
Percentage Registered Aboriginals							
Alcohol Consumption Per Capital							
Dummy Variable (0 for 1961-1976 1 for 1977-1993)							
	Shows data availability						

6.4.4 Violent Crimes - Robbery

We obtained the data series containing monthly statistics on robbery, and robbery with firearms by province from the Centre for Canadian Justice Statistics at Statistics Canada. Statistics on robbery with firearms were first collected in 1974, and continue to 1993.

Independent variables that seem reasonable to be included in a model of robbery with firearms include: percentage graduating from university, unemployment, personal income, population divorced, percentage male youth, percentage Registered Aboriginals, percentage immigrants, FACs, probability of arrest, and dummies for the gun control legislation (see Figure 6.5). In this part of the analysis, there is no need to exclude any series from the model, with the exception of percentage graduating from university, as the series with the dependent variable does not start until 1974.

Figure 6.5 Candidate Variables - Robbery

Variable	1974	1976	1993
Dependent			
Robbery Per 100,000			
Robbery With Firearms Per 100,000			
Independent			
Probability of Arrest			
Percentage Male Youth			
Personal Income			
FACs Per 100,000			
Percentage Registered Aboriginals			
Unemployment Rate			
Percentage Students Graduating from University			
Percentage Divorced			
Percentage Immigrated			
Dummy Variable			
	Shows data availability		

A second model on robbery that we will estimate is with the variable 'robbery with firearm' replacing 'robbery' as the dependent variable.

6.5 Results

The following section presents a summary of the structural analysis results. Although we ran Kmenta and OLS pooled models for each model specification, there were several instances in which autocorrelation seriously qualified the results for the OLS models. We have therefore limited our results in this section to statistically valid models.

6.5.1 Total Homicides

The total homicide models are presented in two distinct sections: first we present models with data from 1968 to 1993, and second we present models using data from 1971 to 1993 which include a larger set of independent variables.

Our first results were for a simple model, using the variables: percentage male youth, unemployment rate, homicide clearance rate, percentage immigrants, proportion Registered Aboriginals, personal income, and the dummy variable for the years 1968-1993. Figure 6.6 presents the results obtained by this model. In a recent article, it was argued that a time-trend may be needed in a structural analysis because homicides have shown a tendency to fall over time. However, in our exploratory analysis, we concluded that the only series that exhibited strong secular patterns was fatal accidents with firearms. We have therefore refrained from using a time variable in the homicide analysis.[78]

The sign of the coefficient indicates whether the variable has a negative or positive effect on the homicide rate. The correct sign here for the Gun Law Dummy Variable is negative. A t-statistic greater than or equal to the absolute value of 2 means that the variable's effect on the homicide rate was statistically significant (at the 5% level).[79] Therefore, according to this model, the gun law, male youth, the homicide clearance rate, personal income and Registered Aboriginals are all significant variables.

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[78] A time trend makes a specific assumption about the influence of an unknown variable on a series. Economists often use such a variable to explain changes in tastes or technology. A similar rationale does not seem plausible here. Mauser and Holmes (1992) used a time trend in their model, however as noted, the results of our exploratory analysis do not support the use of a time trend.

[79] This is a rule of thumb. The actual level of a significant t value is determined by the total number of observations, the number of variables in the regression and the covariance of the dependent variable and the specific independent variable.

Figure 6.6 Results from Pooled (Kmenta) Regression Model for Canadian Actual Homicide Rate with the Variable 'Personal Income' (1968-1993)

Variables	Coefficient	t-Statistic
Gun Law Dummy	**-0.43962**	**-3.31**
Homicide Clearance Rate	**-0.02624**	**-6.82**
Unemployment Rate	0.01518	1.02
Percentage Youth Male	**0.29532**	**5.93**
Percentage Immigrants	0.01790	0.11
Percentage Registered Aboriginals	**0.50729**	**8.63**
Personal Income	**0.01189**	**5.82**
Constant	-0.94584	-1.75
	R^2 = .672 df = 96	

When we restrict the analysis to 1971-1993, a number of additional independent variables become available for our analysis. These variables include: percentage of population divorced, percentage graduating from university, and per-capita alcohol consumption (see Figure 6.7).

Figure 6.7 Results from Pooled (Kmenta) Regression Model for Canadian Actual Homicide Rate Adding Population Divorced, Population Graduating from University, and Per-Capita Alcohol Consumption (1971-1993)

Variables	Coefficient	t-Statistic
Gun Law Dummy	**-0.54794**	**-3.51**
Homicide Clearance Rate	**-0.02348**	**-5.06**
Unemployment Rate	-0.02610	-1.29
Percentage Male Youth	**0.40050**	**3.74**
Percentage Immigrants	0.05333	0.27
Percentage Registered Aboriginals	**0.38893**	**3.74**
Personal Income	-0.00262	-0.59
Population Divorced	**0.56744**	**2.88**
Population Graduating	0.34659	0.38
Alcohol Consumption	**0.01884**	**2.28**
Constant	**-2.4502**	**-2.24**
	R^2 = .807 df = 81	

Of the newly incorporated variables, population divorced and per-capita alcohol consumption are significant and positively related to the homicide rate, while the education proxy (percentage graduating from a university program) is statistically insignificant. The gun law dummy remains significant. What this regression model suggests is that the 1977 legislation reduced the homicide rate by .5 per 100,000. This seems a small number, but the total rate is about 2.5 per 100,000, suggesting that the gun control legislation may have reduced the death rate by 20 per cent. Again, there are important problems (multicollinearity) with this model and any firm conclusion should wait until all aspects of the analysis are presented.

Our next step in evaluating the impact of the 1977 legislation on homicides was to use the number of FACs per 100,000 population as a measure for the implementation of the legislation in place of the dummy variable. Using this new variable, we re-estimated all of the previously mentioned models. The results are tabulated in Figures 6.8 and 6.9.

Figure 6.8 Results from Pooled (Kmenta) Regression Model for Canadian Actual Homicide Rate (1968-1993)

Variables	Coefficient	t-Statistic
FACs	**-0.00019**	**-4.74**
Homicide Clearance Rate	**-0.02486**	**-6.87**
Unemployment Rate	**0.05033**	**3.01**
Percentage Male Youth	**0.18726**	**3.53**
Percentage Immigrants	0.02540	0.18
Percentage Registered Aboriginals	**0.55873**	**9.48**
Personal Income	**0.01002**	**7.12**
Constant	-0.11596	-0.20
	R^2 = 0.7057 df = 96	

Using FACs per 100,000 population as a proxy variable for the 1977 legislation does not change many results. In the two models that use data from 1968-1993, the only significant change is that unemployment becomes a significant independent variable with a positive coefficient instead of an insignificant one. For the model from 1971-1993, population male youth and population divorced lose their significance when FACs replace the dummy variable. This suggests interaction between FACs and these variables--again signalling multicollinearity.

Figure 6.9 Results from Pooled (Kmenta) Regression Model for Canadian Actual Homicide Rate Adding Population Divorced, Population Graduating from University, and Per-Capita Alcohol Consumption (1971-1993)

Variables	Coefficient	t-Statistic
FACs	**-0.00016**	**-3.07**
Homicide Clearance Rate	**-0.02121**	**-4.25**
Unemployment Rate	0.02894	1.06
Percentage Male Youth	0.16994	1.45
Percentage Immigrants	0.17647	0.95
Percentage Registered Aboriginals	**0.42299**	**3.92**
Personal Income	-0.00239	-0.49
Population Divorced	0.35994	1.84
Population Graduating	-0.66965	-0.64
Alcohol Consumption	**0.01967**	**2.13**
Constant	-0.27641	-0.26
	R^2 = .807 df = 81	

Based upon these models, we constructed Figure 6.10 which summarizes the results of the significance tests we conducted on the legislation. We have included the results of the pooled OLS models in these tables even though detailed regression results are not provided in this section of the report.

Figure 6.10 Results of Structural Significance Testing of the Legislation Variables for Models with Total Homicides as the Dependent Variable

Model		Variable Used for Legislative Intervention	
Kmenta Models		**Dummy**	**FACs**
Model 1:	Including Personal Income 1968-1993	**Significant**	**Significant**
Model 2:	Divorce, Alcohol, and Education 1971-1993	**Significant**	**Significant***
OLS Models		**Dummy**	**FACs**
Model 1:	Including Personal Income 1968-1993	**Significant**	**Significant**
Model 2:	Divorce, Alcohol, and Education 1971-1993	Insignificant*	**Significant***
*Models may suffer from serial-correlation as the DW statistic was indeterminate. Estimates will still be unbiased and consistent.			

A provisional conclusion is that the gun control regime has had a statistically significant impact on the homicide rate in Canada. However, as is discussed in Section 6.6 below, there is a multicollinearity issue that qualifies the results.

6.5.2 Firearm Homicides

The next stage of our analysis of homicides was to repeat the analysis for all the models, replacing the dependent variable of homicides per 100,000 population with firearm homicides per 100,000. As mentioned in Chapter 3, a programming oversight by Statistics Canada classified the incidents involving an unknown firearm prior to 1991 as homicides without firearms. After 1991, this classification error was remedied, and these incidents are now included with the others involving firearms (they are placed in a field labelled other firearm-like weapons). This problem produces a 'discontinuity' in the data on homicides with firearms that may obscure the impact of the later legislative change.

Figure 6.11 Results from Pooled (Kmenta) Regression Model for Canadian Firearm Homicide Rate (1968-1993)

Variables	Coefficient	t-Statistic
Gun Law Dummy	**-0.23736**	**-3.20**
Homicide Clearance Rate	**-0.01381**	**-6.28**
Unemployment Rate	**0.02329**	**2.70**
Percentage Male Youth	**0.15086**	**5.49**
Percentage Immigrants	**0.18665**	**2.04**
Percentage Registered Aboriginals	**0.16101**	**6.56**
Personal Income	0.00145	1.23
Constant	-0.20164	-0.56
	R^2 = 0.5337 df = 96	

As with the models with total homicides as the dependent variable, these structural models tend to show that the legislation had a statistically significant impact, reducing the rate of firearms deaths per 100,000 population. The impact appears small, but it is not. According to the model presented in Figure 6.11, gun control has reduced the rate of firearms related deaths by .24 per 100,000, while the model presented in figure 6.12 suggests a reduction of .19 per 100,000. Both of these figures are statistically significant at the .05 level. The fact that all the models concur makes a good case for the effectiveness of the 1977 legislation on firearms homicides. To further verify this point, we ran the same models with FACs replacing the dummy variable as a proxy for the firearm legislation (see Figures 6.13 and 6.14).

Figure 6.12 Results from Pooled (Kmenta) Regression Model for Canadian Firearm Homicide Rate Adding Population Divorced, Population Graduating from University, and Per-Capita Alcohol Consumption (1971-1993)

Variables	Coefficient	t-Statistic
Gun Law Dummy	**-0.19450**	**-2.42**
Homicide Clearance Rate	**-0.01442**	**-5.69**
Unemployment Rate	0.00234	0.22
Percentage Male Youth	**0.14607**	**2.76**
Percentage Immigrants	**0.27364**	**2.90**
Percentage Registered Aboriginals	**0.13224**	**2.50**
Personal Income	**-0.00633**	**-2.58**
Population Divorced	0.16740	1.56
Population Graduating	0.36797	0.76
Alcohol Consumption	0.00723	1.69
Constant	-0.00244	-0.01
	R^2 = .807 df = 81	

Figure 6.13 Results from Pooled (Kmenta) Regression Model for Canadian Firearm Homicide Rate (1968-1993)

Variables	Coefficient	t-Statistic
FACs	**-0.00010**	**-4.53**
Homicide Clearance Rate	**-0.01257**	**-5.81**
Unemployment Rate	**0.04618**	**4.40**
Percentage Male Youth	**0.10744**	**3.66**
Percentage Immigrants	**0.19793**	**2.39**
Percentage Registered Aboriginals	**0.19482**	**8.77**
Personal Income	0.00069	0.75
Constant	0.00592	0.02
	R^2 = 0.5879 df = 96	

When FACs replace the dummy variable as a proxy for the 1977 legislation. The significance of all the variables in both models using data from 1968-1993 remains unaltered when the dummy variable is replaced by FAC (Figure 6.13). Perhaps more important is the fact that while alcohol consumption was apparently a statistically significant factor for total homicides, it is insignificant in explaining firearm homicides.

Figure 6.14 Results from Pooled (Kmenta) Regression Model for Canadian Firearm Homicide Rate Adding Population Divorced, Population Graduating from University, and Per-Capita Alcohol Consumption (1971-1993)

Variables	Coefficient	t-Statistic
FACs	**-0.00010**	**-3.42**
Homicide Clearance Rate	**-0.01196**	**-4.49**
Unemployment Rate	**0.03370**	**2.39**
Percentage Male Youth	0.08008	1.56
Percentage Immigrants	**0.28774**	**3.51**
Percentage Registered Aboriginals	**0.10528**	**2.14**
Personal Income	-0.00502	-1.99
Population Divorced	0.17277	1.75
Population Graduating	-0.64157	-1.22
Alcohol Consumption	0.00667	1.50
Constant	0.55845	1.10
	R^2 = .664 df = 81	

Figure 6.14 portrays a model restricted to the period 1971 - 1993. The substitution of FACs for the dummy variable has an impact on the variables unemployment rate and percentage male youth.

These data also show that the legislation has had a statistically significant impact when measured using FACs. These results suggest that an additional 10,000 FACs reduced the rate of firearms related deaths by about 1 per 100,000 of population.

Based upon all the models for firearm homicides, we constructed Figure 6.15 which displays the results of the significance tests conducted on the legislation. We have included the results of the pooled OLS models in these tables even though detailed regression results are not provided in this section of the report (see technical appendices under separate cover for detailed results).

Figure 6.15 Results of Structural Significance Testing of the Legislation Variables for Models with Firearm Homicides as the Dependent Variable

Model		Instrumental Variable Used for Legislative Intervention	
Kmenta Models		**Dummy**	**FACs**
Model 1:	Simple Model 1968-1993	**Significant**	**Significant**
Model 2:	Including Divorce, Alcohol, and Education 1971-1993	**Significant**	**Significant**
OLS Models		**Dummy**	**FACs**
Model 1:	Simple Model 1968-1993	**Significant**	**Significant***
Model 2:	Divorce, Alcohol, and Education 1971-1993	Insignificant*	**Significant***

*Models may suffer from serial-correlation as the DW statistic was indeterminate. Estimates will still be unbiased and consistent.

6.5.3 Suicides

As with the analysis of homicides, and homicides by firearms, we ran a series of Kmenta models and pooled OLS models for suicides. The OLS models suffered from severe serial-correlation problems, and the results need to be viewed with caution (see technical appendices under separate cover). What follows is an exclusive discussion of the Kmenta type model results.

Figure 6.16 (next page) displays the results of our structural analysis for suicides.

Figure 6.16 Results from Pooled (Kmenta) Regression Model for Canadian Total Suicide Rate (1971-1993)

	Model 1 Using Dummy Variable		Model 2* Using Number of FACs	
Variables	Coefficient	t-Statistic	Coefficient	t-Statistic
FACs			-0.0003	-0.93
Gun Law Dummy	-0.1663	-0.27		
Unemployment	-0.0747	-0.76	-0.0164	-0.14
Personal Income	**-0.0737**	**-3.38**	**-0.0677**	**-3.02**
Percentage Male Youth	0.7829	0.51	0.6236	0.41
Percentage Registered Aboriginals	**1.4400**	**2.17**	**1.3981**	**2.15**
Percentage Divorced	**2.1301**	**2.53**	**2.2511**	**2.68**
Alcohol Consumption	**0.2202**	**6.76**	**0.2089**	**5.98**
Percentage Graduating	**13.416**	**2.91**	**11.326**	**2.19**
Constant	-48.268	-0.61	-39.525	-0.50
	R^2 = .5827 df = 83		R^2 = .596 df = 83	

*Models may suffer from autocorrelation as the DW statistic was indeterminate. Estimates will still be unbiased and consistent.

In both models, significant independent variables for the suicide rate include personal income, percentage Registered Aboriginals, percentage divorced, alcohol consumption, and percentage graduating from university. Neither model suggests that the 1977 legislation significantly reduced suicide rates. With homicides, we found that both the total homicide rate and the firearm homicides rates were significantly reduced by the introduction of the legislation.

Figure 6.17 Results from Pooled (Kmenta) Regression Model for Canadian Firearm Suicide Rate (1971-1993)

	Model 1 Using Dummy Variable		Model 2 Using Number of FACs	
Variables	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
FACs			0.0001	0.97
Gun Law Dummy	0.3156	1.22		
Unemployment	**0.1144**	**2.55**	**0.1144**	**2.29**
Personal Income	-0.0178	-1.93	**-0.0197**	**-2.01**
Percentage Male	**2.0742**	**2.64**	**1.9806**	**2.59**
Percentage Registered Aboriginals	0.3484	1.07	0.4205	1.31
Percentage Divorced	0.3302	0.97	0.2634	0.77
Alcohol Consumption	**0.0533**	**3.77**	**0.0588**	**4.01**
Percentage Graduating	3.1044	1.55	4.0103	1.85
Constant	**-105.26**	**-2.64**	**-101.22**	**-2.59**
	R^2 = .376 df = 83		R^2 = .393 df = 83	

Figure 6.17 portrays the findings with regard to suicides with firearms. Neither of the models suggest that the 1977 firearms legislation has had a significant impact on the incidence of suicides with firearms. This finding is inconsistent with the prevailing literature which is based primarily on exploratory analyses.

Another interesting result we can take from this analysis is the fact that proportion male youth was an insignificant dependent variable for total suicides, but both this variable and alcohol consumption are highly significant for firearm suicides. This accords with most analyses on suicide that suggest men use guns in suicides and that alcohol is an important factor. Also, percentage Aboriginal persons tends to be an important explanation for overall suicides, but not for firearm suicide.

6.5.4 Fatal Firearm Accidents

Using the rate of fatal firearm accidents per 100,000 as the dependent variable, we ran two sets of models: one set using the Kmenta pooling technique, and the other with OLS and dummy variables. Results from the Kmenta models are displayed in the following figures. The results in Figure 6.18 tabulate the models that were estimated without the time trend variable, while Figure 6.19 (next page) presents the same models with the addition of the time trend variable.

Figure 6.18 Results from Pooled (Kmenta) Regression Model for Canadian Fatal Firearm Accident Rate (1971-1993)

	Model 1 Using Dummy Variable		Model 2 Using Number of FACs	
Variables	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
FACs			**-0.00004**	**-4.08**
Gun Law Dummy	**-0.09642**	**-2.53**		
Percentage Male Youth	**0.42347**	**7.73**	**0.37791**	**7.88**
Percentage Registered Aboriginals	**-0.05399**	**-3.27**	**-0.03881**	**-2.56**
Alcohol Consumption	**-0.00454**	**-2.73**	**-0.00748**	**-4.37**
Constant	**-20.217**	**-7.29**	**-17.675**	**-7.18**
	R^2 = .683 df = 87		R^2 = .727 df = 87	

Figure 6.19 Results from Pooled (Kmenta) Regression Model for Canadian Fatal Firearm Accident Rate (1971-1993)

	Model 1 Using Dummy Variable		Model 2 Using Number of FACs	
Variables	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
FACs			**-0.00004**	**-2.91**
Gun Law Dummy	-0.07525	-1.55		
Percentage Male Youth	**0.35200**	**3.68**	**0.37134**	**4.09**
Percentage Registered Indian	-0.03742	-1.54	-0.03796	-1.74
Alcohol Consumption	**-0.00624**	**-2.52**	**-0.00753**	**-3.42**
Time Trend	-0.00541	-0.87	-0.00047	-0.08
Constant	**-16.469**	**-3.32**	**-17.339**	**-3.69**
	R^2 = .688 df = 86		R^2 = .726 df = 86	

Three of four structural models on fatal accidents suggest that the 1977 legislation has a small, but statistically significant impact on the rate of fatal accidents involving firearms. Other important independent variables include percentage male youth, the time trend, and alcohol consumption. The high value of the constant suggests that there are important omitted variables.[80]

In all four structural models, per-capita alcohol consumption is significant, and has a negative coefficient implying that people who drink more will be less likely to be killed in a firearm accident. This result is counter intuitive; we would expect the coefficient to be positive, indicating that the more an individual drinks the greater the probability of a fatal accident. This counter intuitive result occurs due to the fact that we are relying on aggregated data for this study, and this situation provides an excellent opportunity to outline a limitation of the analysis.

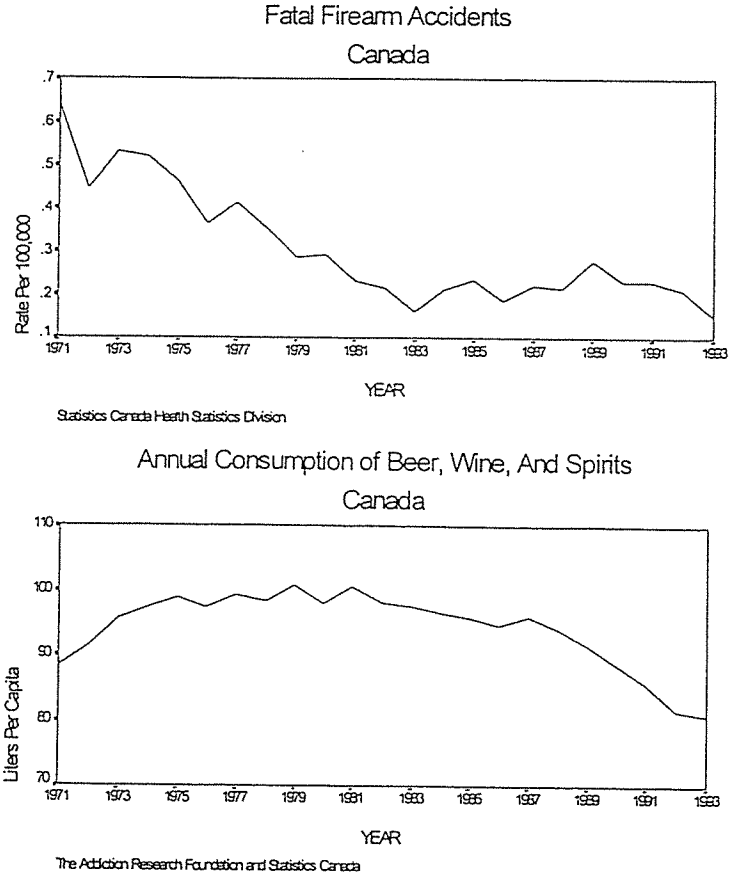
As seen in Figure 6.20, when fatal firearm accidents are falling (from 1971 to 1983), alcohol consumption rises, and when the accident series levels off after 1983, the alcohol consumption

[80] For example, participation rates in gun handling safety courses and the prosecution of weapons offences (e.g. violation of prohibition orders) are just two variables that could improve these regressions.

series falls. Therefore, based on the aggregate data, our regression analysis (which fundamentally is simply a complex correlation model) has concluded that the relationship is reciprocal; more alcohol results in fewer accidents. Fundamentally, this problem occurs because our data is aggregated. We cannot identify the people killed in firearm accidents who were also drinking, all we have is data on national rates of alcohol consumption. There is no guarantee that the two are the same.

This problem with data aggregation is not restricted to this model. As long as we work with aggregated data, there will be instances where these problems occur to varying degrees. The only way to completely eliminate this inaccuracy is to improve the actual data used for the statistical analysis. Clearly then this is not an analysis problem, but a data collection problem that is beyond the scope of this research.

Figure 6.20



Based upon all the models for fatal firearm accidents, we constructed Figure 6.20 which displays the results of the significance tests conducted on the legislation. We have included the results of the pooled OLS models in these tables even though detailed regression results are not

provided in this section of the report (see technical appendices under separate cover for detailed results). These results suggest that the legislation has reduced fatal firearm accidents.[81]

Figure 6.21 Results of Structural Significance Testing of the Legislation Variables for Models with Fatal Firearm Accidents as the Dependent Variable

Model		Variable Used for Legislative Intervention	
Kmenta Models		**Dummy**	**FACs**
Model 1:	Excluding Time Trend 1971-1993	**Significant**	**Significant**
Model 2:	Including Time Trend 1971-1993	Insignificant	**Significant**
OLS Models		**Dummy**	**FACs**
Model 1:	Excluding Time Trend 1971-1993	**Significant**	**Significant**
Model 2:	Including Time Trend 1971-1993	Insignificant	**Significant**

6.6 Regression Fragility - Analysis of Multicollinearity

The results presented thus far suggest that for homicides (total and firearms related) and fatal accidents involving firearms, the firearms legislation has had a statistically significant impact. Further, this impact may reduce the incidence of homicides by about 20 per cent. Before making final conclusions, however, we examined these models for reliability and validity. Specifically, we removed and added variables to the regression and changed time series spans in order to determine the degree to which such changes affected the models.

To test the extent of the instability in the models, we performed a series of tests on all the models that have data available from 1971 onwards; specifically homicides, and suicides. The fatal accident model had too few independent variables for this exercise, and the robbery model

[81] There is clearly a weakness with these models due to the reliance on aggregated data. This suggests the need for caution in interpreting the results. Furthermore, the model includes an independent variable with a counter-intuitive coefficient sign.

suffered from excessive autocorrelation and there is little point in working with this specification any further.

Overall, we found that there is evidence of multicollinearity between some of the variables. Multicollinearity is a problem that frequently occurs in aggregate time series data. Our use of pooled cross section, time series data mitigates, but does not eliminate the problem. One metaphor for the effect of multicollinearity is passing a picket fence in front of a school. The pickets obscure the full view of what is happening in the school yard. Similarly, multicollinearity obscures the view of how each independent variable influences the dependent variable.

Although this is a troublesome issue, and it does qualify the results, after the analysis of the structural models we conclude that they are sufficiently robust to allow us to make some preliminary conclusions on the impacts of the firearms legislation to death rates.

6.7 Preliminary Conclusions

6.7.1 Homicides

Some preliminary conclusions from the structural analysis can now be presented for the main types of firearms deaths. Arguably homicides involving guns have the highest profile and Figure 6.22 presents a summary of the structural analysis using the information from 1971 to 1993 for the 1977 legislation. By using the more restricted time span, a larger range of independent variables are eligible for inclusion. A number of points emerge from Figure 6.22.

- The Gun Law Dummy is significant for both total and firearms homicides. The fact that the impact appears to be greater for total as compared to firearms homicides is misleading. A coefficient of -.55 in total homicide rates and -.19 in firearm homicide rates does not suggest that substantial displacement has occurred.[82]

- It is important to note that there are other important explanatory variables necessary to understand patterns in the homicide rate. Percentage Male Youth, Registered Aboriginals, and Population Divorced all have impacts on the total homicide rate.

- The Percentage Registered Aboriginals variable has a large impact on the total homicide rate, but the impact is much less on firearms homicides (.38 versus .13). This conforms

[82] If one assumes a total homicide rate of 2.5 per 100,000, then a -.55 reduction is about 20 per cent. The firearm homicide rate is about .5 per 100,000 and a -.19 reduction is a decrease of about 40 per cent.

to the analysis by Silverman and Kennedy which suggests that Aboriginal persons are more prone to use weapons other than guns in homicides. It is also important to understand this relationship. Canadian aboriginal people have high rates of involvement in violence and have high rates of incarceration. This involvement has been seen by researchers and policy analysts as a symptom of the social, economic and institutional setting Aboriginal persons tend to encounter.

Figure 6.22 Results from Pooled (Kmenta) Regression Model for Canadian Actual Homicide Rate (1971-1993)

Variables	Total Homicides Using Dummy Variables		Firearm Homicides Using Dummy Variable	
	Coefficient	t-Statistic	Coefficient	t-Statistic
Gun Law Dummy	**-0.54794**	**-3.51**	**-0.19450**	**-2.42**
Homicide Clearance Rate	**-0.02348**	**-5.06**	**-0.01442**	**-5.69**
Unemployment Rate	-0.02610	-1.29	0.00234	0.22
Percentage Male Youth	**0.40050**	**3.74**	**0.14607**	**2.76**
Percentage Immigrants	0.05333	0.27	**0.27364**	**2.90**
Percentage Registered Aboriginals	**0.38893**	**3.74**	**0.13224**	**2.50**
Personal Income	-0.00262	-0.59	**-0.00633**	**-2.58**
Population Divorced	**0.56744**	**2.88**	0.16740	1.56
Population Graduating	0.34659	0.38	0.36797	0.76
Alcohol Consumption	**0.01884**	**2.28**	0.00723	1.69
Constant	**-2.4502**	**-2.24**	-0.00244	-0.01
	R^2 = .807 df = 81		R^2 = .664 df = 81	

- It is useful to note that, based on these structural models, economic variables, such as unemployment and personal income per capita have no role in explaining the homicide rate.

6.7.2 Suicides

Based on Figure 6.23, the Gun Law Dummy does not appear to have a statistically significant impact on total suicides or suicides involving guns. As noted previously, these findings conflict with the prevailing literature on this topic which shows that there is a relationship between firearms availability and firearms suicides. This study did not examine firearms availability, rather it examined patterns in the incidence of suicides and examined the relationship between identified patterns and the timing of the implementation of the firearms legislation. The results of this analysis indicate that other factors have been important explanators of the incidence of suicides and firearms suicides in Canada.

Figure 6.23 Results from Pooled (Kmenta) Regression Model for Canadian Total Suicide Rate (1971-1993)

Variables	Total Suicides Using Dummy Variable		Firearm Suicides Using Dummy Variable	
	Coefficient	t-Statistic	Coefficient	t-Statistic
Gun Law Dummy	-0.1663	-0.27	0.3156	1.22
Unemployment	-0.0747	-0.76	**0.1144**	**2.55**
Personal Income	**-0.0737**	**-3.38**	-0.0178	-1.93
Percentage Male Youth	0.7829	0.51	**2.0742**	**2.64**
Percentage Registered Aboriginals	**1.4400**	**2.17**	0.3484	1.07
Percentage Divorced	**2.1301**	**2.53**	0.3302	0.97
Alcohol Consumption	**0.2202**	**6.76**	**0.0533**	**3.77**
Percentage Graduating	**13.416**	**2.91**	3.1044	1.55
Constant	-48.268	-0.61	**-105.26**	**-2.64**
	R^2 = .5827 df = 83		R^2 = .376 df = 83	

*Models may suffer from serial-correlation as the DW statistic was indeterminate. Estimates will still be unbiased and consistent.

- An increase in per capita income is associated with a decline in total suicides and has a weak role in explaining suicides by firearms.[83]

- Unemployment is associated with suicides using guns, as is the variable Percentage Male Youth. This accords with the conventional wisdom that job loss is traumatic and that men tend to use guns in committing suicide.

- There are other important differences between the total and firearms suicides. The Percentage Graduating from University is related to total suicides but not a factor in firearms suicides. Similarly, percentage Registered Aboriginals is significantly related to total suicides but not firearms suicides.

6.8 Additional Comments

The relatively robust results obtained for homicides and suicides need to viewed with caution. A number of important biases and statistical problems confound any definitive conclusions on the efficacy of fireams control.

- **Multicollinearity** exists within the independent variable set. The experiments in varying the regression specification illustrates the nature of the problem and the profound influence this has on the coefficients.

- **Aggregation bias** exists because we cannot measure at the incident level. The independent variables are measured at the provincial level. For example, this means that we are inferring the relatively higher involvement of men in firearms suicides by correlating the percentage of men in a province with variations in the provincial suicide rates.[84] If we had incident level data, where gender were identified, the estimation of this relationship would be much more reliable. We have seen earlier in this chapter, how aggregated data can produce unanticipated results -- alcohol consumption is negatively correlated with fatal accidents with firearms.

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[83] A t-statistic of 1.93 is close to significance at the 5 per cent level.

[84] For another example, from the models presented, one can infer that percentage male youth and Registered Aboriginals are important explanatory variables with regard to homicide rates. What these models do is correlate the percentage of the population in a Province that fit into each of these groups with variations in the Provincial homicide rates. What is needed is incident level data to verify or disconfirm these correlations.

In addition to counterintuitive results, aggregated data can produce plausible results, which are wrong in magnitude. This causes an overestimate or underestimate of the impact of any variable. For policy evaluation such as this research, this can be a serious source of error.

- **Data limitations** are manifest in several ways. First, we are unable to obtain the data needed, usually because it has not been collected. Second, the series may not extend as far back or be as current as needed. Finally, data may contain anomalies that are hard to reconcile.

Finally, one of the most disappointing aspects of this study is that we have been largely unable to examine the 1991 legislative changes. Independent variables often did not extend to the present or the observations on dependent variables were unavailable for a sufficient period after the legislation had been proclaimed and implemented.

7. CONCLUSIONS

The Firearms Control Initiatives of 1977 and 1991 are the result of a long evolution of legislation and regulation dating from 1892 that Canada has introduced to manage the ownership and handling of firearms. This evaluation is the most comprehensive statistical evaluation of gun control legislation and regulation attempted in Canada to date.

7.1 Features of the Research

Several features of this research are noteworthy:

- This research breaks new ground by including information not previously available in Canada. The monthly data from UCR1 on homicides and robberies is an example of information not previously analysed. Statistics Canada, specifically the Canadian Centre for Justice Statistics, was instrumental in helping us to access data classified as confidential that have not been previously analysed for policy purposes. This presented both a unique opportunity as well as some challenges. Because much of the data had not been processed statistically, many inconsistencies and errors had to be diagnosed and corrected. Accordingly, we spent considerably more time and effort than originally planned to prepare information suitable for statistical processing.

- The statistical modelling strategy has been comprehensive, but not complicated. By proceeding from exploratory analysis through to time series modelling and then to structural modelling, we have presented a successively more elaborate test of the basic proposition -- namely has the firearms control legislation affected the rate of homicide, suicide, robbery and accidents involving firearms?

  At the same time, we have maintained the statistical testing within the scope of current techniques used for evaluating legislation. The structural models are based on a single equation framework; we have not experimented with systems of equations that feature feedback mechanisms and require complex estimation strategies for three reasons. First, in our assessment there are many problems with the data that need to be resolved before these procedures are used. Second, in our judgment, the criminological literature provides little guidance on what feedback one might expect. Third, to model feedback successfully requires micro-level data at the incident level.

- We have spent considerable effort examining threats to the reliability and validity of the models estimated. In general, researchers who have studied gun control have applied regression models without acknowledging the problems caused by auto-correlation, heteroscedasticity, and multicollinearity. In part, our use of pooled cross-section, time-

series data mitigates the first two of these problems, but all of our statistical testing routinely evaluated each regression for data problems.

With respect to multicollinearity, we experimented with the time base and the inclusion and exclusion of independent variables in order to better understand the strengths and weaknesses of the structural models. This testing qualifies the findings. Most other studies have used a narrow focus on a single type of firearms incident and have not tested data that may present a number of statistical and stability problems.

- An important issue, and an unavoidable feature of the available data, is aggregation bias. A homicide, robbery or suicide is committed by an individual or individuals. Micro, incident-level data are needed to understand the cause and effect mechanisms that relate incidents to social, economic, institutional and legal environments. Each incident should be documented with the background of victims and perpetrators, context of the incident, location, etc.

  The information that is used in this research is at the provincial level. For example, relationships between alcohol and gun accidents are inferred by correlating provincial alcohol consumption per capita with provincial per capita gun accidents. We are using variation at the provincial level to infer a process that occurs at the individual level. This can lead to all forms of counterintuitive results and biases.

- Despite the qualifications that need to be acknowledged when examining the results presented in this report, it is important to stress that the exploratory analysis, time series models and structural equations are useful for assessing the impacts of the firearms control legislation. From a statistical perspective, the overall measures of goodness of fit on the structural models are well within an acceptable range. In the vast majority of instances, the variables are statistically significant (at the 1% level).

7.2 Synopsis of the Findings

At the time that the compilation of data for this study was undertaken, homicide, suicide and accident data did not extend beyond 1993 and therefore, the 1991 legislation could not be evaluated. Figure 7.1 presents a synopsis of findings in graphical form.

7.2.1 Exploratory Analysis

The Exploratory analysis showed a number of patterns, some of which are inconsistent, in death rates and the proportion of deaths involving firearms.

- The trends in death rates for total and firearms homicides at the national level have been declining steadily since between 1975 and 1978. The peak for the firearm homicide rate was reached between 1975 and 1978 depending upon the specific region examined. However, in all regions of Canada, there has been a steady decline in firearm homicides since the 1977 legislation was implemented.

- At a national level, the time series on suicides decline steadily after 1978. This pattern is also evident in Western Canada and Ontario. For firearm suicides, there is a distinct change from an increasing trend prior to 1978 to a decreasing trend since 1978.

- Fatal firearm accidents have shown a continuous downward trend since 1961 in all regions of Canada. There are no changes in observed patterns around 1978.

- Nationally, robberies have increased steadily during the period between 1974 and 1993. However, robberies with firearms have declined over the same period. In general, the use of firearms has continued to decrease, reaching an historic low of approximately 25 per cent of all robberies in recent years. In Quebec, there has been a general pattern showing a decline in both robberies and robberies involving firearms.

7.2.2 ARIMA Time Series Analysis

The ARIMA analysis also shows some interesting patterns, however, again there are some inconsistencies.

- For homicides, the models suggested that the 1977 legislation had some effect on the firearm homicide rate in Ontario and for Canada as a whole. In other regions, the same patterns were not evident.

- For suicides involving firearms, the models suggested that the legislation has had a lagged effect (i.e., 1979) for Ontario, Western Canada and Canada as a whole.

- Firearms accidents show a similar pattern. Nationally, the legislation has had a statistically significant impact for the 1979 model (i.e., delayed impact). For Western

Canada, all three models suggest the legislation has been successful in reducing the rate of accidental deaths involving firearms. However, no consistent patterns emerge for other regions.

7.2.3 Structural Analysis

A major limitation with both exploratory and ARIMA time series models is that they do not include other factors that could mask the effects of gun controls or that could mitigate the effects. As a result, this study also incorporated structural models which include social, demographic, economic and institutional variables, as well as a measure for the introduction of the legislation.

- The structural analysis suggests that the 1977 firearms legislation has reduced the number of homicides in Canada, both those involving firearms and those not involving firearms.

- The structural analysis also suggests that the 1977 legislation has had some effect on the incidence of fatal firearms accidents, buth the findings are tempered with an awareness that there appear to be important omitted variables in the models.

- The structural analysis does not demonstrate any clear patterns between the 1977 legislation and the reduction of firearm suicides.

Figure 7.1: Synopsis of Findings

	Exploratory Analysis	ARIMA Time Series Analysis	Structural Analysis
Firearm Homicides	Some effect, not totally consistent	Some effect, not totally consistent	Clear effect
Firearm Suicides	Clear effect	Clear effect	No clear effect
Firearm Accidents	No clear effect	Some effect, not totally consistent	Some effect, not totally consistent
Firearm Robberies	Some effect, not totally consistent	Not analyzed	Not analyzed

7.3 Next Steps

This report, while comprehensive and detailed, is not by any means the last word on empirical research into the effect of firearms control legislation.

- First, it is certainly possible to specify additional models. However, empirical studies need to be disciplined and complete. The literature on gun control is often clouded. As well, we note that in experimenting with the regression model specifications we found different results.

- Second, the aggregated data bases that are currently available for research in this area are limited in providing a strong foundation for inferring cause and effect between legislative intiatives and changes in death rates. Nevertheless, we conclude that the results are sufficient to say that the 1977 legislation did have some positive if not totally conclusive effects.

- On the other hand, evaluation of the 1991 and the 1995 legislative changes to the firearms control legislation need to be planned now to ensure that, to the extent possible, the necessary micro-level data are available. In particular, existing data need to be assessed in terms of coverage and the extent to which they include other various jurisdictions in the future.

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