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An evaluation of the 1977 Canadian firearm legislation: robbery involving a firearm

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The effect of the 1977 Canadian firearm legislation on robberies involving firearms is evaluated between 1974 and 1992 using a pooled cross-section, time series model. The results show that the 1977 legislation did not reduce robbery involving firearms, nor did it have a significant effect on the total robbery or armed robbery rates. The legislation may even have acted perversely in that it may have increased robberies with firearms. In general, these results are consistent with previous published findings but contrast with unpublished governmental studies. The implication that this legislation may have acted perversely is new and requires further investigation.

I. INTRODUCTION

Concern about firearm violence has led many countries around the world to introduce increasingly restrictive firearm control regimes. Australia recently prohibited semi-automatic and pump rifles and shotguns; Canada introduced universal firearm registration and banned more than half of all handguns (Greenspan, 1996); and the United Kingdom banned all handguns (Reuters, 1997). Unfortunately, there are few empirical studies that examine the effectiveness of such laws in reducing violent crime rates (Kopel, 1992; Kleck, 1997). Restrictive firearm control regimes, much like modern drug control laws, necessarily involve large and complex governmental bureaucracies which are expensive and pose significant risks for civil rights of individuals (Lueders, 1999; Olson and Kopel, 1999). In order to begin to assess the costs and benefits of such legislation, it is necessary to empirically evaluate the impact of this type of gun control law on crime. Given the costs involved, it would seem prudent to require similar laws to be shown to be effective in reducing criminal violence, before introducing increasingly restrictive laws.

The theoretical argument for restrictive firearm laws and regulations is relatively straightforward. Firearms are viewed as dangerous and as a 'contributing cause' of lethal violence (Friedland, 1975; Cook, 1981). Gun violence, particularly criminal violence involving firearms, can be reduced by restricting access to firearms. Thus, a variety of legal restrictions on firearms are introduced that encompass the general public with an eye to reducing firearms availability to anyone who is seen as being likely to be involved in criminal violence (Zimring and Hawkins, 1997, pp. 121–5). For example, many jurisdictions prohibit children, felons, or the mentally ill from owning firearms (Kleck, 1991). As well, special types of firearms are prohibited that are felt are particularly problematic (e.g., handguns or military-styled rifles).

An alternative theoretical framework for examining firearm laws, utility theory, has been introduced from economics (Lott, 1998). In this framework, criminals are seen as motivated by utility. Since self-preservation has a high utility, criminals can be deterred from committing some crimes by threat of violence. Because they are afraid of getting hurt, they pick other targets, or give up.[1]

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[1] This theory has been criticized as relying overly much upon the 'rationality' of common criminals, who as a rule are not very intelligent (Wilson and Herrnstein, 1985). However, economists reply that the level of rationality being assumed here is not particularly higher than the 'pain avoidance' frequently observed in the behaviour of dogs or young children.

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Criminals are afraid of burglarizing homes or businesses where they suspect the home owner is armed (Wright and Rossi, 1986, pp. 141–5). Increasingly restrictive laws may inadvertently remove firearms from the home or business of potential victims. To the extent that firearm laws remove the deterrent of widespread citizen firearm ownership, stricter gun control regimes may result in more, not less, criminal violence. Criminals, as they become aware that their victims are less likely to be armed, due to the stricter gun laws, will be motivated to rob or to attack targets they would have been afraid to tackle had they believed their victims were armed (Lott and Mustard, 1997; Ouimet, 1999).

A recent review of studies that efforts to control firearms in the USA concluded that 'the most technically sound evidence indicates that most types of gun control have no measurable net effect, for good or ill, on rates of most types of crime and violence' (Kleck, 1997, p. 377). Outside of the USA, the situation is no different. Surprisingly, very few government reports are available which evaluate the effectiveness of firearm legislation in democratic countries that have them (e.g., Australia, Canada, New Zealand, the United Kingdom). Few of these meet minimum methodological standards, such as including before and after comparisons, or controlling for alternative independent variables. The bulk of the sound studies that are available conclude that firearm legislation is not effective (Bakewell, 1985; Greenwood, 1972; Maybanks, 1992; Newgreen, 1987)

Canada is one of the few countries outside of the United States where a number of sound empirical studies of their firearm regime have been conducted.[2] In 1977 Canada amended its firearm law as part of an omnibus piece of legislation that proved to be a harbinger of the subsequent firearm legislation that has since swept around the world. The 1977 legislation introduced a police permit to purchase a firearm (the Firearm Acquisition Certificate), introduced requirements for safe storage of firearms, and banned certain types of firearms (e.g., the M-1 carbine, which had been used in a rash of bank robberies in Montreal).[3] This bill also introduced 'prohibition orders' where a court could prohibit a person from having firearms for a certain period of time. Arguably, all of these amendments reduced criminal access to firearms which may have acted to reduce armed robberies.

At the same time, this omnibus bill, and its associated regulatory changes, tightened controls on handguns by centralizing the registration requirements for 'restricted weapons' (mostly handguns), eliminating the option of keeping a handgun in a place of business, and removing 'protection of property' as a legitimate reason for owning handguns.[4] The net result of the tighter controls on handguns arguably decreased the abilities of shopkeepers to defend their businesses from robbery.

The results of published studies of the 1977 Canadian legislation have been mixed. Researchers have almost exclusively limited themselves to examining the impact of this legislation upon homicide (Scarff, 1983; Sproule and Kennett, 1988; Mundt, 1990; Mauser and Holmes, 1992; Department of Justice, 1996). Three of these studies did not find a significant impact of the 1977 legislation on homicide (Sproule and Kennett, 1988; Mundt, 1990; Mauser and Holmes, 1992), while the other two did (Scarff, 1983; Department of Justice, 1996).

The results remain mixed even if the analysis is limited to those studies which use cross-sectional time-series. The Department of Justice (1996) found a significant impact of the 1977 legislation on homicide, but Mauser and Holmes (1992) did not. The study by the Department of Justice (1996) is unique in that it included a comprehensive effort to evaluate the effects of the 1977 firearm legislation on reducing crimes involving firearms. In addition to exploratory analyses, they used a cross-sectional, time-series analysis to examine homicide, suicide and firearm accidents. Despite the comprehensive nature of this study, the Department of Justice did not report a complete analysis for robbery involving a firearm, they only reported exploratory analyses.

Robbery, and especially armed robbery, constitute an important threat to the peace and security of Canadians. In contrast with the decline in homicide rates, the robbery rates continue to increase in Canada. Robberies in Canada cost residents an estimated \$90 million in 1996 (Brantingham and Easton, 1998). Statistics Canada reported that there were 29 590 robberies in Canada in 1997, in about half of these (15 411) the perpetrator was armed with a weapon of some sort. Over one-third of armed robberies (5478) involved a firearm (Kong, 1998). Armed robbery statistics are reported on an annual basis using a Uniform Crime Reporting system; although detailed information on the type of weapon involved in a robbery is only available after 1974. Even though there are many more robberies than homicides, police are much less successful in dealing with robbery than they are with homi-

[2] Since 1977, Canada has introduced further amendments to the firearm legislation in 1991 and in 1995. Due to the relatively brief time periods since these changes, no methodologically solid studies have been yet published evaluating these amendments.

[3] The 1977 legislation also introduced penalties for the criminal use of a firearm, but this section has been applied very infrequently (Meredith *et al*., 1994). Had this section been applied with any frequency, it too may have had a negative effect on armed robbery.

[4] Almost all 'restricted weapons' are handguns and their registration requires a 'legitimate' reason as well as a location. Thus, these changes effectively removed the option business people had of keeping a handgun to defend themselves and their businesses against armed criminals.

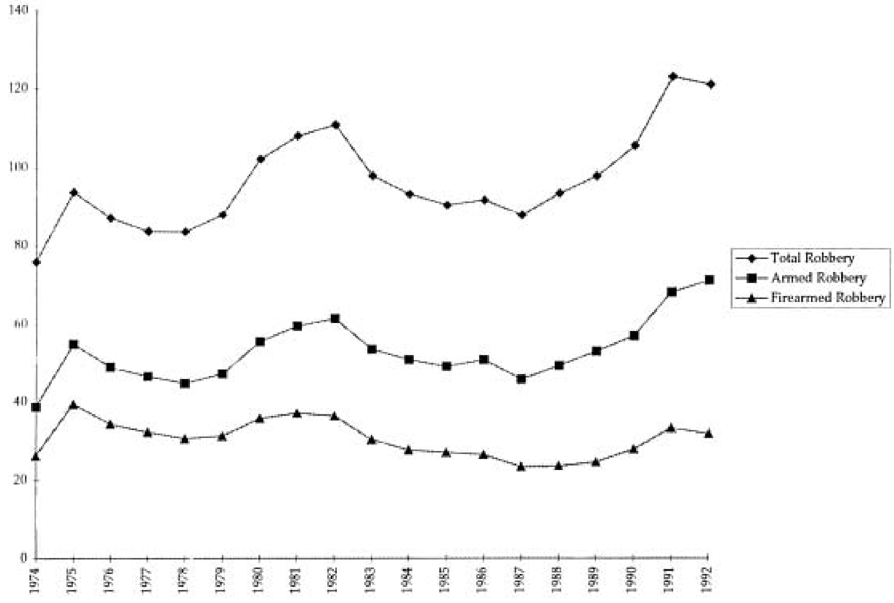

Fig. 1. *Total robberies, armed robberies, and robberies involving firearms. Canada national data, 1974–1992.*

cide. Out of the 596 homicides known to police in Canada in 1994, the police 'cleared' 80% of them, while only 33% of the 28 888 robberies that year were cleared by the police (Brantingham and Easton, 1998). Figure 1 shows the trend in robbery in Canada since 1974.

Theoretically, it is also important to look at the impact of gun control law on the rates of armed robbery. The mix of tighter controls on firearms introduced in the 1977 firearm legislation, on the one hand, may have reduced criminal access to firearms, or it may, on the other, have reduced the deterrent effect by reducing the abilities of shopkeepers to defend their place of business.

This is the first paper to empirically examine the effect of the 1977 Canadian firearm legislation on armed robbery using a cross-sectional, time-series analysis. Specifically, this model will be used to examine three dependent variables: robbery, armed robbery, and robbery involving a firearm. To the authors' knowledge, the only previous papers that have used this model to examine the impact of any firearm legislation upon armed robbery have looked at the impact of concealed handgun legislation in the United States (Lott and Mustard, 1997; Lott, 1998).

II. METHODOLOGY

A pooled cross-sectional, time-series model is used to estimate the statistical importance of the independent variables including the 1977 firearm legislation (Kmenta, 1986). Building upon the independent variables used in similar studies, we included as wide a set of relevant independent variables in this time-series model as insight and data availability allowed. These independent variables are an attempt to include the most important social and economic forces acting on Canadians during the past 30 years. It is believed that the breadth of this set will increase the power of tests designed to isolate the effects of the 1977 firearm legislation while simultaneously reducing the probability of erroneously attributing to that legislation the effects of other variables.

Three classes of independent variables are included in the model: (a) variables pertaining to deterrence (e.g., clearance rates), (b) socio-economic variables (e.g., percentage male youth), and (c) index variables (e.g., effect of the 1977 firearm legislation). Previous studies have demonstrated the importance of variables pertaining to the likelihood of deterrence such as arrest and conviction rates (Ehrlich, 1975; Lott and Mustard, 1997). The clearance rate is a useful index of the probability of a perpetrator being arrested and convicted (Lott, 1998). Following Lott (1998), the number of police effectives are also included as a proxy for the probability of a perpetrator being caught, or for the differences in the proportion of crimes that are committed which are reported. (See the Appendix for details of the model.)

A number of researchers have argued that sociological variables, principally sex or ethnic differences, are important factor in crime rates (Williams, 1984; Lenton, 1989; Ouimet, 1999). This model includes the percentage of male youth in the population, various indices of immigration, as well as the aboriginal share of the population. Immigration, both internal and international, has been linked with violent crime (Wilson and Herrnstein, 1985; Gurr, 1989; Lane, 1989). A few unpublished Canadian studies have looked at immigration and crime rates (Samuel and Santos, 1990; Thomas, 1990; Department of

Justice, 1996). This paper follows the other studies including measures of inter-provincial migration and international migration (Mauser and Holmes, 1992; Department of Justice, 1996). Immigrants may contribute to crime rates both as perpetrators and as victims. Both immigration and ethnicity were found in one study to be important factors in the Canadian homicide rate (Mauser and Holmes, 1992). Ethnicity is an important factor in identifying who commits robbery in both Canada and the United States (Desroches, 1995). In Canada, aboriginal status has been found to be strongly linked with criminal violence and specifically homicide (Silverman and Kennedy, 1993).

The independent variables also include a broad set of socio-economic and legal indices as have previous studies (Mauser and Holmes, 1992; Department of Justice, 1966). In this study the unemployment rate and the unemployment insurance benefits are used as measures of business cycle effects on crime rates. All independent variables are measured at the provincial level for all ten Canadian provinces.

In Canada, responsibility for firearm legislation is shared between the federal government and the provinces and is included in the national criminal code. In principle, firearm legislation is identical across the country and is introduced at the same time in all provinces and territories. However, there are important differences between provinces in how legislation is introduced and enforced that stem from the provinces having the constitutional responsibility for administering the criminal code. Some provinces may not enforce certain sections of the criminal code as energetically as do others, if they enforce them at all. Thus, in testing the effectiveness of the legislation, each province represents a replication.

A dummy variable (GUNLAW) was used to evaluate the 1977 firearm legislation ('0' before its introduction; '1' afterwards). It is crucial to correctly select the year for the dummy to match the year the law is seen as coming into effect. This legislation was passed in Parliament late in 1977, but while almost all of its provisions came into force during 1978, the introduction of the requirement that a Firearm Acquisition Certificate was necessary for purchasing a firearm was delayed until January 1979. Thus, it was decided that 1978 was the best choice for the 'start' of this legislation since 1978 is the first full year that the legislation was in effect.[5] Setting the dummy at 1978, gives four years as a 'before' measurement (1974–1977). This is relatively short, but it is all the data available to researchers. Statistics Canada did not collect information concerning the principal dependent variable, firearm involvement in robbery, until 1974.

In addition to 'robbery involving a firearm' rate, two other dependent variables were also investigated: the total robbery rate and the 'armed robbery' rate (involving either firearms or other weapons). All dependent variables are 'actual crimes' calculated per 100 000 provincial population.

In sum, nine independent variables were included in this model: (1) the clearance rate, which is the percentage of known crimes 'cleared' by bringing charges or resolved in an acceptable manner; (2) population per serving police officer in the province; (3) unemployment rate (for both sexes); (4) weeks of Unemployment Insurance (UI) benefits paid per capita; (5) percentage male youth (between 15 and 24); (6) percentage Status Indian; (7) percentage of the population that immigrated to Canada and settled in a province over the past three years; (8) inter-provincial migration rates over the past five years; and (9) the percentage of the population that are non-permanent residents. Finally, linear time trends were included for each province as well as provincial dummy variables. The study is of course limited by the availability of data. (See Table 1 for more details about these variables.)

Ideally, the goal was to get complete information on all variables for all ten provinces and for both territories. This proved possible in all ten provinces for almost all years. Unfortunately, the territories had to be excluded because neither unemployment rates nor immigration data were available before the mid-1980s. It was necessary to interpolate the number of Status Indians for Newfoundland for 7 out of the 18 years included in the data set.

Some researchers have argued that it is necessary to lag the clearance rate. The argument is that perpetrators' decisions are influenced by the chance of being caught and convicted in the past. Even if the validity of lagging is accepted, there is still the question of choosing the proper time frame. It is argued that criminals are more influenced by last month's probability of being caught than by the previous year's value.[6] Hence, it is believed that the current value of the clearance rate is more important than the previous year's value. In this paper, both lagged and unlagged versions of the clearance rate will be investigated to determine if this difference is important empirically. (The data set is described more fully in Table 2.)

The authors recognize the difficulties in using provinces as the unit of analysis. Ideally, neighbourhoods or census tracts should be used because they would provide a closer link between social indices and criminality. Provinces were used here because they are the smallest units for which such a wide range of information is available over the entire time period since 1974. Despite the methodological limits of this study, the authors believe that the results will shed light on

[5] In practice, this was not as important as we had initially believed. No differences were found if the starting year is set at 1979 instead of 1978.

[6] Research shows that criminals have a limited time frame (Wilson and Herrnstein, 1985).

Table 1. *The variables in this model*

Independent variables

Deterrence variables

CRFR – Clearance rate for armed robbery involving a firearm
Source: Statistics Canada, Centre for Justice Statistics (Publication 85-205)

CRAR – Clearance rate for armed robbery
Source: Statistics Canada, Centre for Justice Statistics (Publication 85-205)

CRTR – Clearance rate for total robbery
Source: Statistics Canada, Centre for Justice Statistics (Publication 85-205)

POPPOL – Total provincial population per police effective.
Source: Statistics Canada, Centre for Justice Statistics (Cansim D93334 through D93343).

Socio-economic variables

INDIANR – Percentage of population Registered Status Indians
– number of legally registered Aboriginals divided by the total provincial population
Source: Department of Indian Affairs and Northern Affairs. (Numerator from Table 1, *Registered Indian Population by Region*, and *Indian Register*)

YOUTH – Male youth percentage of provincial population
– annual estimate of number of males, 15–24 years of age divided by provincial population
Source: Statistics Canada, the numerators are Cansim C892659 plus C892677 for Newfoundland, C892977 plus C892995 for P.E.I., C893295 plus C893313 for N.S., C893613 plus C893631 for N.B., C893931 plus C893949 for Que., C894249 plus C894267 for Ont., C894567 plus C894585 for Man., C894885 plus C894903 for Sask., C895203 plus C895221 for Alta. C895521 plus C895539 for B.C.

UNEMP – Unemployment rate
Source: Statistics Canada, Seasonally Adjusted Labour Force Statistics (71-201), various issues.

WPPC – Weeks of Unemployment Insurance (UI) benefits paid divided by total provincial population
Source: Statistics Canada (numerator from Cansim D730368 through D730377).

TYIMMR – Three year moving total of international immigrants divided by total provincial population
Source: Statistics Canada, Employment and Immigration Canada; (numerator from Cansim D125626 through D125635).

FYIPMR – Five year moving total of persons resident in a province who moved to that province from some other province in that year divided by total provincial population
Source: Statistics Canada, Family Allowance Payments; (numerator from Cansim D269457 through D269466).

NPRR – Non-permanent residents per total provincial population
Source: Statistics Canada; (numerator from Cansim D125644 through D125673).

Time trends and dummy variables

GUNLAW – DUMMY
1974–1977 = 0
1978–1992 = 1

DNFLD is unity for the 19 observations for Newfoundland, and zero otherwise. *DPEI*, *DNS*, *DNB*, *DQUE*, *DONT*, *DMAN*, *DSASK*, *DALTA* are defined analogously.

TIME is a sequence of consecutive integers for each province beginning with unity for 1974 through 19 for 1992.

TNFLD is a sequence of consecutive integers beginning with unity for the 1974 observation for Newfoundland, and ending with 19 for the 1992 observation for Newfoundland. It is zero elsewhere. Thus, TNFLD = TIME*DNFLD. Other provinces are defined analogously.

Population (the denominator for most variables) Cansim D2 through D11.

Dependent variables

FR – Robbery involving a firearm
– actual robbery involving a firearm per 100 000 total population
Source: Statistics Canada, Centre for Justice Statistics (Publication 85-205)

AR – Armed robbery
– actual robberies involving a weapon of any kind [including firearms] per 100 000 total provincial population
Source: Statistics Canada, Centre for Justice Statistics (Publication 85-205)

TR – Total robbery
– all actual robberies whether or not it involved a weapon of any kind per 100 000 total provincial population
Source: Statistics Canada, Centre for Justice Statistics (Publication 85-205)

important social questions. Policy decision makers cannot always wait for perfect data; decisions must be made on the best data available.

One of the more intractable problems in econometric modelling is the problem of specification error. The results of a model are highly dependent upon the variables specified as important enough to include. But, since only a few variables may be included, researchers never know if the addition or deletion of another variable would radically alter the results. This problem is particularly pernicious in criminology because there are so many variables that might be included, and because researchers differ so widely about which variables are theoretically important. Despite the large number of independent variables included in this

Table 2. *Variable descriptions*

Variable	Mean	Variance	Minimum	Maximum
FR	16.851	487.23	0.00	108.98
AR	32.875	997.31	0.81	140.90
TR	65.628	2547.0	4.92	212.66
CRFR	40.171	310.18	0.00	133.30
CRAR	39.661	178.10	0.00	96.30
CRTR	34.163	129.49	11.80	92.10
INDIANR	1.907	3.91	0.00	8.23
YOUTH	8.759	1.11	6.58	10.84
UNEMP	9.985	14.51	2.80	20.80
TYIMMR	0.012	0.75E-04	0.16E-02	0.04
POPPOL	547.000	7599.00	346.00	734.00
WPPC	0.221	0.02	0.04	0.63
FYIPMR	0.116	0.24E-02	0.02	0.23
NPRR	0.005	0.17E-04	0.48E-03	0.02

model, not all variables that have been theoretically hypothesized as important are included. Nor have the authors included all of the variables they would have liked to have included: e.g., arrest rates, conviction rates, the expected length of prison sentence, or the recidivism rates.

A way of dealing with this type of problem has been suggested by Leamer (1983), using an example from the economics of crime, with a response by Ehrlich (1999). We suggest herein a simpler, more easily understood alternative approach that provides full information for the benefit of all parties who are concerned with a specific question.

It is assumed in the discussion below that there is only one interest variable. There are four steps to this approach:

(1) determine which independent variables are simultaneously of theoretical interest and have data available for measurement,
(2) estimate regressions using all possible combinations of these independent variables,
(3) report 'box scores' of how often an interest variable is significant (separately by sign in the case of a two-tailed test), and
(4) note the patterns of included variables associated with significant results for the interest variable.

Aside from simplicity and transparency, this approach should facilitate convergence to a common understanding (or at least to agreement on what is the point of disagreement) between persons with strong opposing views on a question. It is thus particularly useful when the question of interest is contentious.

Consequently, in this paper all possible subsets of independent variables are analysed for each dependent variable to ensure that the results are not simply due to a unique combination of independent variables. Since there were nine IVs, this gives 512 equations (one with no independent variables, nine with only one variable, 36 with two variables, 84 with three variables, 126 4-tuples, 126 5-tuples, 84 6-tuples, 36 7-tuples, nine 8-tuples, and one with all nine variables).

III. RESULTS

The data for FR (robbery involving a firearm) are plotted in Fig. 2, with the sequence shown being time series of 19 annual observations (1974–1992) within each province; provinces are arranged from east-to-west. Quebec's spike juts up boldly near the centre. Three characteristics of the data are apparent by observing the data: (1) the mean of *FR* varies greatly among provinces, with Quebec having a much higher mean than any other province; (2) the trends in *FR* vary among provinces, with the Atlantic provinces displaying virtually no trend, Quebec displaying a strong negative trend, and the western provinces displaying positive trends; and (3) the variance of *FR*, even adjusted for trend, is noticeably higher in some provinces than in others. Each of these data characteristics has implications for the estimation of equations.

It is of course possible that the three characteristics of the raw data apparent in Fig. 2 could be 'explained' by the set of independent variables introduced into the estimated equations. This happy circumstance usually does not occur, due to the very large number of factors which cause these differences among provinces coupled with either the lack of insight on the part of the researchers specifying the equations and/or lack of available data to measure some factors which might be deemed relevant. A common approach to this problem is to introduce provincial dummy variables (intercept shifts) to deal with variation in means, province-specific time trend variables to capture variation in trends, and some form of estimated generalized least squares estimation to deal with heteroscedasticity (Gujarati, 1995). Tests are available to help determine

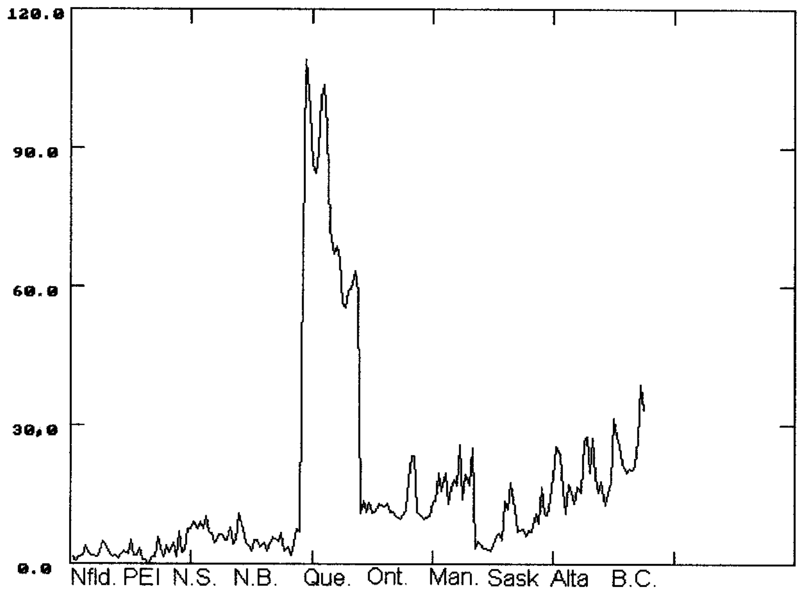

Fig. 2. *Firearm robbery rate by province, 1974–1992.*

whether these adjustments to the estimation procedure are necessary.

In the preliminary analysis, OLS was used to estimate the most appropriate pooled regression model. Testing to see whether provincial dummy variables are necessary, given the set of nine independent variables plus *GUNLAW*, produces an *F*-test value of 118.26, with (9,170) degrees of freedom, easily significant at the 0.001 level. Hence, the data indicate provincial dummy variables are necessary. Testing to see whether province-specific time trends are necessary, given the set of nine independent variables, *GUNLAW* and the provincial dummy variables, produces an *F*-test value of 13.38, with (10,160) degrees of freedom. This is again easily significant at the 0.001 level. Hence, provincial dummy variables and province specific trend variables are included in all estimations that are reported and discussed in this paper.

Table 3 shows the complete pooled regression model on all three dependent variables: (1) *FR* – robbery involving a firearm, (2) *AR* – armed robbery, and (3) *TR* – total robbery. These models include all independent variables considered in this paper.[7] The effect of the legislation on *FR* is positive but not significant. The direction is somewhat surprising, as the effect of the legislation was hypothesized to decrease, not increase, firearm crime. However, the direction is unimportant as the effect is statistically insignificant.

In order to investigate the sensitivity of the model to specification error, all possible combinations of the nine independent variables were run. Significance (for both *GUNLAW* and the nine independent variables) was based on an absolute *t*-value of 1.65, which approximates a 5% significance level for one-tailed tests. If each of the 512 different estimations were independent of each other, and if a variable (e.g. *GUNLAW*) had no real effect, one would expect the coefficient to obtain a *t*-value less than −1.65 5% of the time, or approximately 26 times out of 512. Similarly a *t*-value greater than 1.65 would obtain in approximately 26 estimations out of 512 under the same assumption of no real effect. The different estimations performed here are not independent of each other, as they differ from one another only in the inclusion or exclusion of independent variables. Hence deciding when a variable is 'significant' becomes subjective, and this is dealt with by presenting full results, together with the interpretation of these results.

The results (see Table 4) for OLS estimation using robberies involving firearms (*FR*) as the dependent variable and *CR* unlagged produced 192 of 512 runs where the *t*-value of *GUNLAW* was greater than 1.65 in absolute value. Of these, 101 were negative values and 91 were positive. Note that each of these latter numbers is almost four times as large as the number of significant values expected if there is no effect of *GUNLAW* on *FR*. This would lead to the conclusion that there is a significant effect of *GUNLAW* on robbery rates involving firearms, but that this effect is approximately as likely to be positive as it is to be negative. Our initial conclusion is that the 1977 firearm legislation had no significant effect on robberies involving firearms.

[7] In Table 3, since no dummy variable is defined for British Columbia, the Constant is the intercept for that province. The intercept for Newfoundland is the Constant plus the coefficient of *DNFLD*, and similarly for other provinces. The coefficient of *TIME* is the estimated change in the dependent variable per year in British Columbia. The analogous concept for Newfoundland is the sum of the coefficient of *TIME* and *TNFLD*. Again, time trends for other provinces are interpreted similarly.

Table 3. *Pooled regression models for evaluating the impact of the 1977 Canadian firearms legislation (OLS, Clearance Rate Unlagged).*

Independent variables	Dependent variables					
	FR Firearm robberies		AR Armed robbery		TR Total robberies	
	Coeff.	*t*-ratio	Coeff.	*t*-ratio	Coeff.	*t*-ratio
GUNLAW	0.156	0.08	0.836	0.30	1.739	0.40
DNFLD	−9.798	−1.29	−20.540	−1.89	−57.338	−3.42
DPEI	−2.386	−0.39	−6.807	−0.78	−39.406	−2.92
DNS	1.973	0.36	−1.157	−0.15	−17.890	−1.51
DNB	−5.947	−1.08	−12.954	−1.63	−41.294	−3.21
DQE	78.284	7.84	64.089	4.51	56.564	2.60
DONT	−14.583	−1.95	−37.991	−3.57	−68.581	−4.19
DMAN	5.402	1.03	4.407	0.59	−14.801	−1.29
DSASK	4.623	0.61	3.317	0.31	−27.864	−1.68
DALTA	−1.327	−0.25	10.398	1.40	−4.494	−0.39
TIME	1.807	4.03	3.115	4.88	4.472	4.57
TNFLD	−1.959	−3.87	−3.391	−4.69	−4.486	−4.01
TPEI	−1.718	−3.94	−3.120	−5.02	−4.056	−4.26
TNS	−1.463	−4.25	−2.477	−5.05	−3.742	−4.97
TNB	−1.279	−3.36	−2.355	−4.35	−3.609	−4.32
TQUE	−3.252	−9.28	−2.079	−4.17	−1.791	−2.34
TONT	−0.309	−1.00	0.040	0.09	0.102	0.15
TMAN	−0.233	−0.52	0.081	0.13	0.776	0.79
TSASK	−0.437	−0.85	−0.655	−0.89	−1.587	−1.41
TALTA	−0.353	−1.08	−1.345	−2.88	−1.463	−2.05
INDIANR	−2.478	−0.98	−4.415	−1.23	−2.082	−0.38
YOUTH	3.756	1.90	4.004	1.42	7.704	1.77
UNEMP	−0.037	−0.08	−0.147	−0.23	−0.238	−0.24
TYIMMR	658.71	4.77	1178.4	5.98	1564.9	5.19
CR[1]	−0.008	−0.35	−0.037	−0.80	−0.170	−1.69
POPPOL	−0.013	−0.75	−0.028	−1.18	−0.047	−1.30
WPPC	26.562	1.06	37.697	1.05	37.570	0.69
FYIPMR	−56.760	−1.13	−147.08	−2.06	−196.94	−1.80
NPRR	−429.02	−1.27	−902.32	−1.88	−1076.7	−1.46
Constant	−21.551	−0.99	7.038	0.22	32.769	0.69
R square	0.964	0.964	0.967			

Note: [1] CR [clearance rate] differs for each dependent variable.

The results noted above mean that anyone who wanted to show that *GUNLAW* had a significant negative effect on *FR* (or have the expectation that this is true) because they believe the legislation makes it more difficult for potential robbers to obtain access to firearms or makes them less likely to use available firearms can find a large number of empirical specifications to support their position. Similarly those who wanted to show a significant positive effect on *FR* (or have the expectation that this is true) because they believe the legislation makes it more difficult for potential victims to defend themselves, or makes potential robbers believe potential victims are less able to defend themselves, can find a large number of empirical specifications to support their position. Since these specifications differ only as to the set of independent variables included, it becomes important to examine: (a) which independent variables appear to 'matter', and (b) any patterns among which groups of independent variables lead to positive versus negative significance for the coefficient of *GUNLAW*.

Dealing with the first question, *YOUTH*, tested one-tailed with a positive expectation is significant in 91.8% of the 256 equations in which it appears using *FR* as the dependent variable, OLS as the estimation technique, and no lag on the clearance rate. Using the same convention, *UNEMP* is significant 43.0% of the time, *TYIMMR* 99.6% of the time, *FYIPMR* is significant 22.3% of the time, and *NPRR* 13.9% of the time. Testing two-tailed, *POPPOL* is significant 27.7% of the time (always negative) and *WPPC* is significant 46.9% of the time (always negative). *INDR* and *CRFR* are never significant.

Turning to the second question, which deals with patterns of independent variables, in the estimations using OLS, *FR* as the dependent variable and no lag on CR, the following generalizations hold:

- *TYIMMR* is never present in any estimations where *GUNLAW* is negative and significant,
- *YOUTH* is never present in any estimations where *GUNLAW* is positive and significant, and
- when *TYIMMR* and *YOUTH* are both included *GUNLAW* is never significant.

Since any given independent variable is included in 256 estimations and there are 'only' 101 significant negative coefficients and 91 significant positive coefficients for *GUNLAW*, it is obvious that the presence of any independent variable is not sufficient to guarantee significance. *WPPC*, *FYIPMR* and *NPRR* are relatively weak variables, and it appears not to matter for purposes of significance of *GUNLAW* whether these variables are included. Finally, *INDIANR*, *UNEMP*, *CRFR* and *POPPOL* are found in some specifications where *GUNLAW* is significant and negative and some specifications where *GUNLAW* is significant and positive. Hence, in order to make a case that the gun law has reduced rates of robberies involving firearms, it is necessary to argue that *TYIMMR* does not belong in the equation. Symmetrically, in order to make a case that the gun law has increased rates of robberies involving firearms, it is necessary to argue that *YOUTH* does not belong in the equation. Since both of these variables were found to be reasonable on a priori grounds, it is concluded on the basis of the OLS runs that the 1977 Firearm Act has had no effect on robbery rates involving firearms.

If firearm legislation has no significant effect on robberies involving firearms (*FR*), one would hardly expect the legislation to have an impact upon armed robberies (*AR*), or upon total robberies (*TR*). As may be seen in Table 3, no significant effect was found for the firearm legislation on either armed robbery or total robbery.

Analysing the full set of 512 OLS equations for both total robbery or armed robbery gave results similar to that of robbery involving a firearm, i.e., that the results were highly sensitive to which variables were included in (or excluded from) the model. For armed robbery, 115 models where *GUNLAW* is negative versus 88 where it is positive; and for total robbery, there were 66 models where *GUNLAW* is negative and 123 where it is positive. Thus, it was concluded, on the basis of the OLS estimates, that there was no significant effect of the 1977 firearm legislation upon either armed robberies or total robberies.

The original intent was to examine possible substitution between firearm robberies and other types of robberies by comparing the coefficients of *GUNLAW* in equations with different dependent variables. Since *GUNLAW* is generally non-significant, this is not a useful exercise. The three dependent variables are quite similar to each other: the simple correlations between *FR* and *AR* is 0.957, between *FR* and *TR* is 0.872 and between *AR* and *TR* is 0.965. In the 6144 runs reported, the largest negative value obtained for *GUNLAW* was −2.8614. The largest positive value was 4.7491.

Table 4. *Comparing OLS regression models with lagged and unlagged clearance rates*

$DV = FR$,
OLS nolag = 101 negative, 91 positive
OLS lag = 101 negative, 93 positive
$DV = AR$,
OLS nolag = 115 negative, 88 positive
OLS lag = 119 negative, 95 positive
$DV = TR$,
OLS nolag = 66 negative, 123 positive
OLS lag = 76 negative, 117 positive

NB. The following uses +/− 1.65 to determine significance.

The effect of lagging the clearance rate on the result was also examined. Lagging made no important changes in the interpretation on any of the three dependent variables (see Table 4). For robberies involving a firearm (*FR*), the proportion shifted from 101 negative: 91 positive, when the clearance rate was unlagged, to 101 negative: 93 positive, for the lagged clearance rate. For armed robberies (*AR*), the changes were similarly trivial: from 115 negative: 88 positive, when the clearance rate was unlagged, to 119 negative: 95 positive, for the lagged situation. For total robberies (*TR*), the ratio went from 66 negative: 123 positive, when unlagged, to 76 negative: 117 positive, when lagged.

While OLS estimation of the model provides unbiased coefficient estimators, these estimators are not efficient due to the simultaneous presence of heteroscedasticity and autocorrelation. These problems may be dealt with by using a pooled data estimation technique, called generalized least squares (GLS),[8] which simultaneously corrects for first order autocorrelation in the time series within each province (allowing for different estimated rho values for each province), as well as heteroscedasticity of the form where variances differ among provinces. The nature of these corrections can be illustrated by noting the estimated rho values and variances (diagonal values of the phi matrix) for the GLS estimation using *FR* as the dependent variable and including provincial dummies, province-specific time trends, all nine independent variables plus *GUNLAW*. The rho values are: 0.28, 0.04, 0.31, 0.18, 0.17, 0.31, −0.28, 0.50, 0.02 and 0.23 (in east-to-west province order). The variances are: 1.18, 8.63, 3.16, 2.20, 106.75, 4.20, 9.98, 7.19, 8.64 and 12.11 (in the same order). The autocorrelation is thus generally minor, and the main effect of the GLS estimation is to reduce the importance of the Quebec observations, due to the large relative variance for that province.

[8] The POOL command in SHAZAM.

Table 5. *Pooled regression models. (EGLS, clearance rate unlagged)*

Dependent variable	Independent variables: FR Firearm robberies Coeff.	FR t-ratio	AR Armed robbery Coeff.	AR t-ratio	TR Total robberies Coeff.	TR t-ratio
GUNLAW	1.578	1.81	1.563	0.99	4.518	2.11
DNFLD	−4.970	−1.07	−21.801	−2.54	−64.178	−4.75
DPEI	−8.723	−2.09	−18.195	−2.43	−64.616	−5.16
DNS	0.374	0.10	−7.712	−1.13	−32.453	−2.73
DNB	−5.317	−1.53	−16.506	−2.49	−55.255	−4.94
DQE	92.295	11.18	75.298	5.74	71.831	3.53
DONT	−5.794	−1.23	−31.329	−3.53	−54.017	−3.96
DMAN	3.522	0.93	1.479	0.21	−21.727	−1.80
DSASK	4.116	0.76	1.927	0.21	−34.172	−2.33
DALTA	−2.819	−0.80	8.291	1.16	−7.573	−0.59
TIME	1.105	3.83	2.187	4.03	2.146	2.41
TNFLD	−1.248	−4.62	−2.453	−4.82	−3.175	−3.82
TPEI	−1.042	−3.64	−2.309	−4.74	−2.658	−3.27
TNS	−1.184	−5.01	−2.031	−4.51	−2.764	−3.31
TNB	−0.932	−3.95	−1.890	−4.18	−2.553	−3.34
TQUE	−3.456	−6.15	−2.197	−2.75	−1.723	−1.29
TONT	−0.295	−1.27	0.233	0.49	0.153	0.19
TMAN	0.011	0.04	0.518	0.85	1.677	1.58
TSASK	−0.403	−1.00	−0.450	−0.64	−0.994	−0.87
TALTA	−0.240	−0.98	−1.159	−2.22	−0.888	−0.90
INDIANR	−2.417	−1.36	−4.942	−1.63	−2.253	−0.47
YOUTH	−0.805	−0.72	−1.292	−0.76	−2.146	−0.85
UNEMP	0.085	0.46	0.016	0.05	0.144	0.34
TYIMMR	522.13	6.14	928.42	5.83	958.79	4.14
CR[1]	−0.003	−0.44	−0.008	−0.38	−0.074	−1.91
POPPOL	−0.008	−0.98	−0.015	−1.10	−0.032	−1.74
WPPC	9.993	0.90	19.260	1.10	37.701	1.55
FYIPMR	31.731	1.11	−64.358	−1.25	−45.737	−0.63
NPRR	−435.59	−2.37	−872.64	−2.67	−592.33	−1.27
Constant	11.386	0.85	47.925	2.23	109.89	3.36
Buse R square		0.521		0.600		0.576

Note: [1] CR differs for each dependent variable.

Table 5 shows the complete pooled regression model using estimated generalized least squares (GLS) on all three dependent variables: (1) FR – robbery involving a firearm, (2) *AR* – armed robbery, and (3) *TR* – total robbery. These models include all independent variables considered in this paper. The effect of the legislation on both *FR* and *TR* is positive and significant, but it is not significant for *AR*. This implies that the 1977 firearm legislation acted to increase the numbers of robberies and robberies involving a firearm, but was not found to have an effect on armed robberies in general.

Table 6 shows that using estimated generalized least squares (GLS) estimation a large number of specifications yield positive significant coefficients for *GUNLAW* with almost no specifications yielding negative significance. This holds for all three dependent variables.

Analysing the GLS estimations for the *FR* dependent variable with *CR* used unlagged further, the smallest *t*-value for *GUNLAW* was −1.57, so there were no cases of negative significance at 5%, but there are some cases of 'near significance'. The patterns of significance for the nine independent variables are very similar to those reported for the OLS estimations. The main difference in

Table 6. *Comparing GLS regression models with lagged and unlagged clearance rates*

DV = *FR*,	
	GLS no lag = 0 negative, 236 positive
	GLS lag = 10 negative, 158 positive
DV = *AR*,	
	GLS no lag = 0 negative, 144 positive
	GLS lag = 0 negative, 183 positive
DV = *TR*,	
	GLS no lag = 0 negative, 246 positive
	GLS lag = 0 negative, 239 positive

NB. The following uses +/−1.65 to determine significance.

the OLS results compared to the GLS results is that in the former, when *TYIMMR* was included with *YOUTH* the result was non-significance for the coefficient of *GUNLAW*, while now the result is positive significance. These results are interpreted as providing evidence in favour of the hypothesis that gun control legislation can lead to an increase in robbery rates, presumably due to a perception on the part of potential robbers of greater vulnerability among potential victims.

Accepting that the results support a positive effect of *GUNLAW* on all three dependent variables, it is then relevant to look at patterns of substitution. Results for the coefficient (*t*-value) of *GUNLAW* in estimations using GLS, provincial dummies, province-specific time trends and all nine independent variables (full estimation results available from the authors upon request) are: *FR* dependent, 1.58 (1.81); *AR* dependent, 1.56 (0.99) and *TR* dependent 4.52 (2.11). Using the fact that the coefficient of *GUNLAW* in the *TR* equation is over twice as large as it is in the *FR* equation, one could argue that since total robberies increased more than robberies involving a firearm, there was a substitution away from firearms. Since even the 'relatively large' coefficient of *GUNLAW* in the *TR* equation is about twice its own standard error, any conclusion about substitution is based on very weak evidence.

The effect of lagging the clearance rate on the result was also examined for the GLS estimates. As with the OLS, lagging made no important changes in the interpretation on any of the three dependent variables (see Table 6). For robberies involving a firearm (*FR*), the results shifted from 0 negative: 236 positive, when the clearance rate was unlagged, to 10 negative: 158 positive, for the lagged clearance rate. For armed robberies (*AR*), the changes were even more trivial: from 0 negative: 144 positive, when the clearance rate was unlagged, to 0 negative: 183 positive, for the lagged situation. For total robberies (*TR*), the ratio went from 0 negative: 246 positive, when unlagged, to 0 negative: 239 positive, when lagged.

VI. CONCLUSIONS

This is the first paper to empirically examine the effect of the 1977 Canadian firearm legislation on robbery, armed robbery and robbery involving a firearm. Previous research in criminology has almost exclusively been limited to examining the impact of this legislation upon homicide. A pooled cross-sectional, time-series model was used to estimate the statistical importance of the 1977 firearm legislation. The results of the OLS (ordinary least squares) estimation show that the 1977 Canadian firearm legislation did not act to reduce robbery involving a firearm. Logically, given these results, one would not expect to find a significant effect on either the total robbery or armed robbery rates. That is what this analysis found: the 1977 legislation did not have a significant effect on either the total robbery or armed robbery rates. These results are consistent with previous published findings that looked at murder rates but contrast with two unpublished government studies. Not one of the independent empirical studies of the 1977 Canadian firearm legislation found that the legislation had a significant effect on reducing firearm crime. The only studies reporting finding a significant decrease have been reports issued by the Canadian Department of Justice.

However, the picture changes when the problems with heteroscedasticity and autocorrelation in OLS have been corrected by using GLS (generalized least squares). The GLS estimates indicate that the 1977 Canadian firearm legislation may have acted perversely to increase robbery involving a firearm, as well as increasing both total robbery and armed robbery rates. The primary difference between the OLS estimation and the GLS estimation is how the model treats the Quebec data. The Quebec robbery rates are dramatically higher and more variable than the rest of Canada; this means that Quebec has a tremendous impact upon the results. When generalized least squares (GLS) estimation is used, the impact of Quebec is reduced, the firearm law is found to be positively related to all three dependent variables: total robberies, armed robberies, and robberies involving firearms.

Thus, the GLS estimation implies that the 1977 firearm legislation acted to increase both robberies involving firearms and armed robberies by 1.6 points, and increasing the total robbery rate by 4.5 points. This implies that this legislation not only did not reduce armed robberies, but it is estimated to have increased the numbers of all classes of robberies. Between 1978 and 1992 this translates into an increase of 3322 armed robberies, and an increase in the number of total robberies of 17 069. Based upon the estimates of Brantingham and Easton (1998) each robbery costs Canadian residents around $3000. Using this approach, the 1977 firearm legislation cost Canadian residents an estimated $51 million between 1974 and 1992.

How could such a thing happen? The goal of a firearm control regime is to reduce, not increase, violent crime, so to find the converse is somewhat surprising. However, it should be unsurprising to say that human intentions are not always translated into the expected results. The inevitable corollary is that government policy occasionally has unexpected consequences. It may be instructive to examine some examples where government policy has had unexpected consequences. Studies have shown that widening public roads may cause drivers to increase driving speeds and to take more risks (Adams, 1985, 1995). The Endangered Species Act is argued to imperil the very species that it is supposed to protect (Schrock, 1998). Though perverse, it is not completely unreasonable to discover that the firearm legislation, that had been introduced to reduce firearm crime, actually increased armed robberies.

The first explanation for why the 1977 firearm law failed to reduce armed robbery is that this law did not disarm those criminals who commit armed robbery. While this law acted to increase the legal difficulties in obtaining a firearm, as well as banning certain types of firearms, such as the M1 carbine which had been attractive to armed robbers, this legislation apparently did not have an important impact upon the availability of firearms for criminals. This is consistent with studies showing that the vast majority of firearms used by Canadian armed robbers had neither been obtained legally nor stolen from legal owners (Axon and Moyer, 1994; Francis, 1995). The British home office found similar results (Home Office, 1997).

We may be able to further understand how the firearm control could have acted perversely by hypothesizing that this legislation reduced the deterrent of widespread citizen firearm ownership. This could have happened in two ways. First, the Canadian media may have advertised the defenseless state of many Canadian businesses. It is not uncommon to read in newspapers, or to hear on the radio, a government official asserting that Canadians do not use firearms in self-defence (e.g., Rock, 1995; McLellan, 1998). According to utility theory, robberies of shopkeepers would be expected to increase as more criminals discover that their intended victims are disarmed. The second way in which this legislation may have removed the deterrent effect of firearm ownership is that the firearm control regime might have disarmed a number of individuals (or small businesses) who previously had kept a firearm for protection. As mentioned earlier, the 1977 legislation eliminated the protection of property as a legitimate reason for owning a handgun, and the associated regulations made it difficult if not impossible to keep a handgun at a place of business. Thus, because fewer businesses could legally keep handguns, and robbers were not likely to be disarmed, this legislation may have increased the number of successful armed robberies (with or without firearms). Utility theory then provides two arguments to help us understand how gun control laws might act perversely by removing the threat of civilian force as a deterrent to armed robbery.

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APPENDIX

Methodology, data, and model

Our estimates are obtained from pooled cross-section and time-series data using generalized least squares estimates of the cross-sectionally heteroscedastic and time-wise autoregressive model discussed in Kmenta (1986, 616–25). The estimation is performed with the SHAZAM computer program.

Our data include 19 years (1974 to 1992) and 10 provinces (all of the Canadian provinces, excluding the Yukon and the Northwest Territories). The model employed may be written as:

$$Y_{it} = \beta_1 X_{it1} + \beta_2 X_{it2} + \cdots + \beta_9 X_{it9} + \varepsilon_{it} \qquad (1)$$

where

i = 1, ... 10 (the 10 provinces)
t = 1, ... 19 (the years 1974–1992)
Y_{it1} = Total robbery
Y_{it2} = Armed robbery
Y_{it3} = Robbery involving a firearm
X_{it0} = Dummy variable for the Canadian gun law (0 in years 1974 to 1977, 1 in years 1978 to 1992)
X_{it1} = Registered Native Indians as a percentage of the provincial population
X_{it2} = Males age 15–24 as a percentage of the population
X_{it3} = Unemployment rate
X_{it4} = International immigrants as a percentage of the population
X_{it5} = Clearance rate
X_{it6} = Provincial population per police effective
X_{it7} = Weeks of UI benefits paid as a percentage of the population
X_{it8} = Inter-provincial migrants as a percentage of the population
X_{it9} = Non-permanent residents as a percentage of the population
TIMEt = A sequence of consecutive integers beginning with unity for the 1974 observation through 19 for the 1992 observation for each province
DNFLDi = Unity for the 19 observations for Newfoundland, and zero otherwise. DPEI, DNS, DNB, DQUE, DONT, DMAN, DSASK, DALTA are defined analagously
TNFLDt = A sequence of consecutive integers beginning with unity for the 1974 observation for Newfoundland, and ending with 19 for the 1992 observation for Newfoundland. Other provinces are defined analagously.

Assumptions about the error term ε_{it} are made to incorporate cross-sectional heteroscedasticity and time-wise autoregression in the model.

These assumptions are:

$$E(\varepsilon_{it}^2) = \sigma_i^2 \qquad (2)$$

$$E(\varepsilon_{it}\varepsilon_{jt}) = o \quad \text{if} \quad i \neq j \qquad (3)$$

$$\varepsilon_{it} = \rho_i \varepsilon_{it-1} + U_{it} \qquad (4)$$

The ρ_i are estimated from the OLS residuals ε_{it} as:

$$\hat{\rho}_i = \frac{\Sigma \varepsilon_{it}\varepsilon_{it-1}}{\Sigma \varepsilon_{it}^2} \qquad (5)$$

where $t = 2, \ldots 190$.

These estimates are used to transform the data as follows:

$$Y_{i1}^{*} = \sqrt{1-\hat{\rho}_i^2}\,Y_{i1}$$

$$Y_{i1}^{*} = Y_{it} - \hat{\rho}_i Y_{it-1}$$

$$Y_{i1k}^{*} = \sqrt{1-\hat{\rho}_i^2}\,X_{ik1}$$

$$X_{itk}^{*} = X_{itk} - \hat{\rho}_i X_{it-1k}$$

where $i = 1, \ldots 10$

$t = 2, \ldots 190$

$k = 1, \ldots 9$

The U_{it}^{*} are obtained from:

$$Y_{it}^{*} = \beta_i X_{it1}^{*} + \beta_2 X_{it2}^{*} + \cdots + \beta_9 X_{it9}^{*} + U_{it}^{*} \tag{7}$$

The σ_{ui}^2 is estimated from:

$$S_{ui}^2 = \Sigma U_{it}^{*}/181 \tag{8}$$

and σ_i^2 is estimated from:

$$S_i^2 = S_{ui}^2/(1-\hat{\rho}_i^2) \tag{9}$$

A second transformation of the variables (for heteroscedasticity) is then done as follows:

$$\begin{aligned} Y_{Lt}^{**} &= Y_i^{*}/S_{ui} \\ Y_{itk}^{**} &= Y_{itk}^{*}/S_{ui} \end{aligned} \tag{10}$$

This leads to the final estimation, which is:

$$Y_{it}^{**} = \beta_1 X_{it1}^{**} + \beta_2 X_{it2}^{**} + \cdots + \beta_9 X_{it9}^{**} + U_{it}^{**} \tag{11}$$

where U_{it}^{**} is assymptotically independent and nonautoregressive.

Our estimated vector of regression coefficients $\bar{\beta}$ is the generalized least squares estimator.