A Search for Monthly Fluctuation in Canadian Homicides: 1965-1980
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The effect of the ith season is measured by the seasonal coefficient, $\hat{\beta}_i$, and its statistical significance may also be assessed with a likelihood-ratio or Wald test.

4.3. Application to Murder Data.

Regression-ARIMA models were fitted to the monthly and quarterly data sets. The fitted models passed all diagnostic checks. For each model, $d = 1$ and $\theta_0 = 0$. For most models $p = 0$ and $q = 1$ was sufficient. The likelihood-ratio tests for significant seasonality are presented in Table 3. Note that the NDNC series exhibits significant seasonality at less than 1% for both monthly and quarterly aggregations. The quarterly TOT series is significant at 1%, but the monthly series is not significant at 5%. The quarterly SHOT series is significant at 5% but again the monthly aggregation is not significant at this level.

Tables 4 and 5 show the seasonal coefficients $\hat{\beta}_i$ and their significance levels when compared to their estimated standard deviations. The pattern originally found in the box plots and in the X-11−ARIMA analysis is confirmed.

Note the apparent anomaly in Table 5. None of the $\hat{\beta}_i$ coefficients is apparently significantly different from zero for the SHOT and NDNC quarterly series although the likelihood-ratio test indicates significant seasonality. As a check, the Wald test for seasonality (4.2.2) was computed, and it indicates the parameters are jointly significant (Table 3).

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A search for monthly fluctuation in Canadian homicides: 1965–1980

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1. OUR HYPOTHESES, VARIABLES, AND METHOD OF ANALYSIS

Our goal in this study was to determine whether there are monthly fluctuations in Canadian homicide activity. To do so, we performed a regression analysis in which the dependent variable, y_{ijk}, is the number of homicides of a given type by city (i), year (j) and month (k). Five types of homicides are considered: (1) all homicides, (2) homicides not involving strangers (Var. 18, Relationship of Suspect to Victim, is 1 = immediate family, 2 = kinship, or 3 = common-law), (3) homicides involving strangers (Var. 18 is 4 = nondomestic (other), 5 = nondomestic (criminal act), or 6 = unsolved), (4) homicides associated with robbery or theft (Var. 15, Apparent Motive, is 5 = robbery or theft), and (5) homicides associated with sexual assault or rape (Var. 15 is 6 = sexual assault or rape). In this study we treat the event of homicide. A homicide with more than one victim is counted as a single event and coded according to the information for the first victim. Homicides with more than one suspect are also coded according to the information for the first suspect. These somewhat arbitrary coding rules only affect the decision concerning inclusion of a homicide in groups for homicides of the types 2−5 defined above.

Monthly fluctuations in homicide activity may be due to monthly fluctuations in other observable factors that affect the level of homicide activity. Identification of such factors may lead to policy recommendations concerning ways of reducing homicide rates. In addition, there may be monthly fluctuations in homicide activity for which no cause can be found. Evidence of this sort would still be useful, for instance, in scheduling the deployment of law-enforcement personnel. It would also provide motivation for a continued search for the factors causing the monthly fluctuation.

Our reading concerning the nature and causes of homicides [see, for example, Gould (1983), Michael and Zumpe (1983), Mohr (1976), Pokorny (1977), and Wolfgang (1975)] led us to formulate the following three hypotheses concerning observable factors that display seasonal variation, and hence that might lead to monthly regularities in homicide activity:

(1) The numbers of homicides involving strangers, homicides associated with robbery or theft, and homicides associated with sexual assault or rape are expected to fall as the temperature falls below the freezing point because of decreased opportunity. The opposite pattern is expected for domestic homicide rates, since people are more likely to be at home when it is very cold.

(2) The numbers of homicides associated with robbery or theft will be higher when unemployment rates are higher, because robbery and theft rates are expected to be higher when opportunities for gainful employment are fewer. Also, domestic homicide rates are expected to be positively associated with unemployment rates due to increased domestic strife in hard economic times.

(3) More homicides of all sorts are expected to take place on Fridays and Saturdays because there are more social interactions and more alcohol is consumed on weekends, since many people do not have to get up for work on Saturday and Sunday, and because of the Friday paycheck phenomenon (collection of a paycheck makes individuals more tempting robbery targets, provides ready financing for going out and drinking, and may encourage fights over money).

The homicide data provided to us are for 11 designated cities, as well as an "other or unknown" category for city of offence, over the time period of 1961−1980. We confine our analysis to homicides in the 11 designated cities, since there is no way of collecting corresponding temperature or unemployment data for an unknown city. Average monthly temperature data for cities are taken from Environment Canada (1961−1980). Provincial monthly unemployment-rate data are available from 1975−1980, and regional monthly unemployment-rate data are available for 1965−1974, in Statistics Canada (1965−1980). Since no data on provincial or regional unemployment rates are available prior to 1965, we confine our analysis to the time period of 1965−1980. The unemployment rate variable used in this study, x_{3ijk}, is not seasonally adjusted, since we are interested in relating homicide activity over months to unemployment conditions, rather than in judging trends in unemployment after accounting for seasonal fluctuations. Temperatures are expressed in Celsius degrees in our analysis. We have also counted the number of Fridays, x_{1jk}, and the number of Saturdays, x_{2jk}, in each month in each year. From our temperature data we have created two variables: (1) a positive temperatures variable x_{4ijk}, set equal to the average monthly temperature when this is positive and set equal to zero otherwise, and (2) a negative temperatures variable x_{5ijk}, set equal to the average monthly temperature when this is negative and set equal to zero otherwise. Thus we include five explanatory variables in our analysis, which are related in an obvious manner to our three hypotheses stated above.

Of course, we do not have data for a number of other factors which could lead to differences among cities or over time in homicide activity. Some of these factors do not fluctuate appreciably from month to month. For instance, there are more people in some cities than others, and the populations of cities usually change gradually over time. There are persistent differences in the age structure of the population from one city to another, and the age structure of a population changes slowly over time. There may be city-specific and persistent differences in the level and nature of policing activities. Persistent unobservable city-specific factors are denoted by z_{ij}. From the subscripts of this error term, it can be seen that we make the simplifying assumption that these persistent city-specific factors change over years, but do not change from month to month within any given year. Unobservable factors which change from month to month as well as over years are denoted by u_{ijk}.

The equation of interest for city i, year j, and month k is given by

$$y_{ijk} = a_0 + a_1 x_{1jk} + a_2 x_{2jk} + a_3 x_{3ijk} + a_4 x_{4ijk} + a_5 x_{5ijk} + a_6 z_{ij} + u_{ijk}, \tag{1}$$

where the error term u_{ijk} is assumed to have zero mean and variance σ^2 and to satisfy all the standard assumptions of ordinary least squares (OLS). In order to eliminate the persistent unobservable city-specific factors z_{ij}, we reformulate Equation (1) in terms of monthly deviations from annual averages. (If a variable is city-specific, the corresponding annual averages are also city-specific.) Thus we have

$$Y_{ijk} = a_1 X_{1jk} + a_2 X_{2jk} + a_3 X_{3ijk} + a_4 X_{4ijk} + a_5 X_{5ijk} + U_{ijk}, \tag{2}$$

where $Y_{ijk} = y_{ijk} - (\Sigma_{k=1}^{12} y_{ijk}/12)$, $X_{1jk} = x_{1jk} - (\Sigma_{k=1}^{12} x_{1jk}/12), \ldots, U_{ijk} = u_{ijk} - (\Sigma_{k=1}^{12} u_{ijk}/12)$. In estimating Equation (2), the constant term, if included, should be found to be insignificantly different from zero. If we sum both sides of Equation (2) over $k = 1, 2, \ldots, 12$, we get the identity

$$0 = a_1(0) + a_2(0) + a_3(0) + a_4(0) + a_5(0) + 0, \tag{3}$$

which indicates that the equations are linearly dependent but that no restrictions are imposed on the parameters $a_1, a_2, \ldots, a_5$ to be estimated. Finally, all the standard OLS assumptions regarding the error term still hold, except that for each city i and year j we have correlated errors. In particular, the 12-by-12 variance-covariance matrix for city i and year j, given by

$$\Omega_{ij} = \{Cov(U_{ijk}, U_{ijk'});\ k = 1, 2, \ldots, 12,\ k' = 1, 2, \ldots, 12\}$$

with

$$\begin{aligned} Cov(U_{ijk}, U_{ijk'}) &= -\tfrac{1}{12}\sigma^2 \quad \text{if } k \neq k' \\ &= \tfrac{11}{12}\sigma^2 \quad \text{if } k = k', \end{aligned} \tag{4}$$

is singular, since for every column the sum of the off-diagonal elements equals the negative of the diagonal element. The condition (4) implies as well that the complete variance-covariance matrix

$$\Omega = \{\Omega_{ij};\ i = 1, 2, \ldots, 11,\ j = 1, 2, \ldots, 16\}$$

is also singular. The application of OLS to Equation (2) may result in some loss of efficiency (and hence some distortion of the estimated standard errors), although the OLS estimates will still be unbiased. In our present case the loss of efficiency is likely to be quite small because the off-diagonal elements of Ω_{ij} are one-eleventh of the magnitude of the diagonal elements. To obtain efficient estimates, one would need to apply a generalized least-squares procedure for the case where the variance-covariance matrix is singular. [For example, see Theil, 1971.]

2. EMPIRICAL RESULTS

When we estimated Equation (2) including a constant term, the constant term was found to be statistically insignificant in all cases, as it should be. Thus we reestimated Equation (2), suppressing the constant term. These estimation results are shown in Tables 6–10. (No estimation results are shown for a city for those classifications of homicides for which there were no occurrences for that city over the specified time period.) Although the equations we have estimated explain very little of the variation in our dependent variables, nevertheless there seem to be some sign patterns in our estimated coefficients. For instance, the coefficients of the Friday variable are generally positive for all types of homicides, and for each of our categories of homicides except those associated with robbery or theft. This finding is consistent with hypothesis (3). On the other hand, there is no tendency for any category of homicides for the estimated coefficients of our Saturday variable to be positive. This result is surprising given the finding by Pokorny (1977, p. 87), using 1960 data for the city of Houston in the U.S., that ". . . Homicide and Aggravated Assault . . . both tend to occur on weekends with a peak on Saturday." Nor do we find any evidence of a positive relationship between homicide activity and the unemployment rate; so hypothesis (2) is not supported. If we had used an unemployment rate for, say, men 16–25 years of age instead of the general unemployment rate, perhaps this aspect of our results would be different. Only the general unemployment rate is published, however, for regions and provinces.

Others have suggested that homicides might be more prevalent when it is uncomfortably warm [see, for instance, Gould (1983, p. 38) and Michael and Zumpe (1983)]. It is dubious whether such a theory is relevant in Canada. Certainly there is no evidence in

TABLE 6: OLS coefficient estimates for equations for monthly deviations in all types of homicides.

	Monthly deviations in					
	Number of Fridays	Number of Saturdays	Unemployment rates	Positive temperatures	Negative temperatures	R^2
All cities	0.109[b]	−0.010	−0.009	−0.0058[a]	0.0100	0.0037
St. John's	0.021	0.039	0.008	−0.0025	0.0276[b]	0.0332
Charlottetown	0.008	0.040[b]	0.003	−0.0007	0.0044	0.0400
Halifax	0.029	−0.017	−0.001	−0.0105[a]	0.0450[a]	0.0236
St. John	0.007	−0.101[a]	0.023	0.0027	0.0038	0.0217
Montreal	0.735[b]	−0.324	−0.363[a]	−0.0559[b]	0.0062	0.0484
Ottawa/Hull	0.166	0.043	−0.047	−0.0075	0.0120	0.0163
Toronto	0.197	−0.432[a]	0.077	−0.0047	0.1223[a]	0.0303
Winnipeg	−0.271[a]	0.374[b]	0.069	−0.0055	0.0211[a]	0.0497
Regina	−0.011	−0.003	0.042[a]	0.0020	0.0030	0.0217
Calgary	0.077	0.288[b]	−0.098	−0.0007	−0.0127	0.0403
Vancouver	0.149	0.020	0.060	0.0257	−1.34[b]	0.0357

[a]Significant at level 0.20.
[b]Significant at level 0.05.

TABLE 7: OLS coefficient estimates for equations for monthly deviations in homicides not involving strangers.

	Monthly deviations in					
	Number of Fridays	Number of Saturdays	Unemployment rates	Positive temperatures	Negative temperatures	R^2
All cities	0.047[a]	−0.006	0.001	−0.0021	−0.0024	0.0037
St. John's	0.030	0.019	−0.008	−0.0040	0.0023	0.0210
Charlottetown						
Halifax	0.006	−0.075[a]	0.005	−0.0054	0.0243[a]	0.0263
St. John	−0.002	−0.029	0.024[b]	0.0020	−0.0004	0.0419
Montreal	0.213[a]	0.005	−0.091	−0.0105	−0.0247	0.0259
Ottawa/Hull	0.114[a]	0.027	0.036	0.0015	−0.0053	0.0220
Toronto	0.177	−0.165	−0.060	−0.0056	−0.0143	0.0131
Winnipeg	−0.089	0.239[b]	0.046	−0.0013	0.0003	0.0407
Regina	−0.000	0.002	0.032[b]	0.0006	0.0013	0.0378
Calgary	0.082	−0.116[a]	0.026	0.0034	−0.0025	0.0155
Vancouver	−0.002	0.020	0.054	0.0108	0.0305	0.0088

[a]Significant at level 0.20.
[b]Significant at level 0.05.

TABLE 8: OLS coefficient estimates for equations for monthly deviations in homicides involving strangers.

	Monthly deviations in					
	Number of Fridays	Number of Saturdays	Unemployment rates	Positive temperatures	Negative temperatures	R^2
All cities	0.062[a]	−0.004	−0.010	−0.0038	0.0123[b]	0.0038
St. John's	−0.009	0.019	0.016[a]	0.0015	0.0253[b]	0.0354
Charlottetown	0.008	0.040[b]	0.003	−0.0007	0.0044	0.0400
Halifax	0.023	0.058	−0.007	−0.0051	0.0207[a]	0.0290
St. John	0.009	−0.072	−0.001	0.0007	0.0042	0.0107
Montreal	0.522[a]	−0.330	−0.272[a]	−0.0454[a]	0.0309	0.0357
Ottawa/Hull	0.052	0.017	−0.083	−0.0090	0.0173	0.0206
Toronto	0.021	−0.267[a]	0.138	0.0009	0.1372[b]	0.0395
Winnipeg	−0.182[a]	0.136	0.023	−0.0042	0.0208[b]	0.0404
Regina	−0.010	−0.005	0.010	0.0014	0.0017	0.0156
Calgary	−0.004	0.404[b]	−0.125[a]	−0.0042	−0.0102	0.0818
Vancouver	0.151	0.000	0.005	0.0149	−1.3731[b]	0.0388

[a]Significant at level 0.20.
[b]Significant at level 0.05.

Tables 6−10 of a positive relationship between our positive temperatures variable and homicide activity. For our negative temperatures variable, however, we find weak evidence of a positive relationship between this variable and homicides involving strangers, homicides associated with robbery or theft, and homicides associated with sexual assault or rape; but not domestic homicides. Thus hypothesis (1) is partially confirmed.

When monthly dummy variables were introduced into our equations *in addition to* our five explanatory variables listed across the tops of our tables, the contribution of these dummies taken as a group was never found to be significantly different from zero. Nor were we able to detect any sign pattern in the estimated coefficients for these dummies. Thus we have found no evidence of any remaining unexplained monthly fluctuation.

Table 9: OLS coefficient estimates for equations for monthly deviations in homicides associated with robbery or theft.

	Monthly deviations in					
	Number of Fridays	Number of Saturdays	Unemployment rates	Positive temperatures	Negative temperatures	R^2
All cities	−0.020	0.029[a]	−0.008	−0.0043[b]	0.0026	0.0052
St. John's	−0.005	−0.006	0.004	−0.0005	0.0045[a]	0.0218
Charlottetown						
Halifax	0.007	0.003	0.004	−0.0005	0.0071[a]	0.0161
St. John	−0.011	−0.009	0.002	−0.0002	−0.0032	0.0296
Montreal	−0.133	0.327[b]	−0.111[a]	−0.0272[b]	0.0138	0.0644
Ottawa/Hull	0.031	−0.006	−0.023	−0.0093[b]	0.0043	0.0422
Toronto	−0.048	−0.037	0.072	−0.0005	0.0059	0.0143
Winnipeg	−0.102[b]	0.034	0.007	0.0031	0.0038	0.0402
Regina						
Calgary	−0.017	0.078[a]	−0.050[a]	−0.0045	−0.0064	0.0344
Vancouver	0.039	−0.039	0.007	0.0101	−0.4420[b]	0.0318

[a]Significant at level 0.20.
[b]Significant at level 0.05.

Table 10: OLS coefficient estimates for equations for monthly deviations in homicides associated with sexual assault or rape.

	Monthly deviations in					
	Number of Fridays	Number of Saturdays	Unemployment rates	Positive temperatures	Negative temperatures	R^2
All cities	0.009	0.013[a]	0.000	0.0018[b]	−0.0009	0.0053
St. John's	0.011	0.009	−0.005[a]	−0.0023[a]	0.0026	0.0342
Charlottetown						
Halifax	−0.006	−0.007	−0.007[b]	−0.0018[a]	0.0016	0.0282
St. John	0.000	−0.004	−0.004	−0.0002	0.0022	0.0114
Montreal	0.067	−0.057	−0.017	0.0103[b]	−0.0112	0.0497
Ottawa/Hull	0.031	−0.007	−0.023	−0.0005	−0.0019	0.0168
Toronto	0.002	0.014	0.103[b]	0.0008	0.0196[a]	0.0531
Winnipeg	−0.001	−0.000	0.007	−0.0014	0.0009	0.0097
Regina						
Calgary	−0.032	0.123[b]	−0.020	0.0042	−0.0034	0.0592
Vancouver	0.017	0.067[a]	0.016	0.0065[a]	−0.0221	0.0315

[a]Significant at level 0.20.
[b]Significant at level 0.05.

3. IMPLICATIONS

We have found monthly fluctuations in homicide activity associated with the number of Fridays in the month, and with negative temperatures. These findings suggest that information on the day of occurrence, as well as perhaps the outside temperature at the time of occurrence, should be added to the information Statistics Canada currently compiles on homicides. This would allow hypotheses involving day of the week and temperature patterns in the occurrence of homicides in Canada to be more rigorously tested. If it were possible to control more precisely for monthly fluctuations due to these factors, it might also be easier to identify fluctuations associated with other variables such as the unemployment rate.