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GENDER CONVERGENCE IN CRIME:

EVIDENCE FROM CANADIAN ADULT OFFENCE CHARGE DATA

Jyh-Yaw Joseph Chen
&
David E. A. Giles

Department of Economics, University of Victoria
Victoria, B.C., Canada V8W 2Y2

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ABSTRACT

This paper contributes new evidence relating to the hypothesis that there has been convergence between certain male and female offences over time. Using time-series data for adults charged with offences in Canada over the period 1983 to 2000, we conduct several formal econometric tests of the convergence hypothesis. This study allows for the non-stationarity of the data; structural breaks in some of the time-series; and it employs several new tests that have not previously been applied to this problem. Our results provide the first strong evidence of gender-convergence for a range of offences in Canada.

Author Contact:

Professor David E.A. Giles, Department of Economics, University of Victoria, P.O. Box 1700, STN CSC, Victoria, B.C., Canada V8W 2Y2; email: dgiles@uvic.ca; Voice: (250) 721-8540; FAX: (250) 721-6214

I. INTRODUCTION

Crime is a major social problem presenting a challenge to every authority of government in the world. Historically, sociologists and criminologists have been the principal contributors to crime research. Indeed, economists were not highly involved in such research until their interest was sparked by Gary Becker's seminal paper, "Crime and Punishment: An Economic Approach."[1] This led to an extensive research literature on the general topic of the role of (dis)incentives in the determination of criminal behavior. Subsequently, the modeling of various aspects of crime has been the focus of many theoretical and empirical economic studies. A particularly good example of this is the extensive research that has been undertaken to model the relationship between criminal behavior and unemployment. Indeed, this is a major research field at the interface of criminology and labor economics. Other examples of areas of research into crime in which empirical economic analysis has been fruitful include explaining the financial pay-offs from crime; accounting for geographic concentrations in criminal activity; and cost-benefit appraisals of crime-reduction programs.[2]

Theoretical explanations for women's crime are well documented, and early contributions portrayed women as sexual beings and focused on their supposed inferiority to men.[3] Subsequently, explanations focused on sex role socialization, and then with the emergence of the women's movement attention turned to the possibility that women may be gaining more opportunity to commit crime as a result of their changing role in society.[4] Later work introduced the so-called 'power-control theory', in which gender differences in crime rates is seen to be determined by parents' social status and parenting style.[5] Finally, recent authors have based their arguments on socialist feminist theories, in which female crime is linked to patriarchal subordination and to inequities with respect to race and social status.[6]

Early studies of female criminality were limited by the quality and extent of the available data. Indeed, few observations of female criminal activity were sometimes interpreted as reflecting a low crime rate for this group. Some of these studies drew attention to evidence of both biological and psychological abnormality among these few female offenders, and this led to female criminality being explained largely in terms of psychological and physiological factors.[7] In contrast to this, Otto Pollak argued that women's lower criminality (as compared with males) is only a myth, and that the impression that women commit less crime is really due to the types of crimes involved.[8] The latter, such as shoplifting, are less likely to be detected or even reported if these crimes are detected. Moreover, he argued that women tend to receive better treatment from police officers than do men.

Against this background, there emerged an important question: “Has there been convergence in male and female crime rates?” As Robert O’Brien has noted, interest in this question dates back as far as Clarence Darrow’s comment that as women enter the labour force, “the fields of industry formerly occupied by men [….] she will be more and more judged as men are judged, and will commit the crimes that men commit, and furnish her fair quota of the penitentiaries and jails”.[9] The empirical literature on this ‘convergence hypothesis’ can be divided essentially into two parts – one considers whether or not the hypothesis is supported empirically, and if so, for which crimes; and the other seeks to isolate the causes of any such convergence.[10] Interestingly, however, this convergence literature is virtually devoid of any studies that relate to crime in Canada, and part of the contribution of this paper is to add to this small literature.[11]

In research that is related peripherally to this issue, John Fox and Timothy F. Hartnagel undertake regression analysis to explain Canadian female conviction rate data for the period 1931 to 1968 in terms of the fertility rate, labor force participation rate, post-secondary degree rate and male indictable offence conviction rate. Their interest was to test the hypothesis that “changes over time in the female crime rate are a function of the changing social roles occupied by females: as females occupy, to a greater extent, extra-familial roles and are less tied to their traditional social roles the female crime rate will show a corresponding increase.”[12] In terms of role convergence, their hypothesis can be interpreted as that while “females’ roles have become similar to (converged with) those of men, the crime rate among women has increased.”[13] They found evidence of a positive relationship between increases of female involvement in extra-familial roles and female arrest and conviction rates, and they suggested that the convergence of the social roles of females and males affects female crime rates.

Judging by Roy Austin’s review of the various empirical convergence studies that have been undertaken, the majority of them find very little evidence of male-female convergence in crime rates.[14] A notable is exception is the work of Freda Adler, who concluded on the basis of her 1960 and 1972 arrest data that female crime rates were rising faster than male rates (and hence ‘converging’) for robbery, larceny, embezzlement and burglary.[15] In addition, Sheila Balkan and Ronald Berger found such convergence in relation to murder, manslaughter and assaults.[16] Austin himself used data obtained from the FBI's *Uniform Crime Report* for the period between 1965 and 1986 to re-examine earlier studies that had failed to detect gender convergence in arrest rates.[17] He defined convergence to arise "…when the male and female crime rate trends are such that their continuing in the same direction will result ultimately in the trend lines crossing"[18]. His findings differed from those of many previous studies - he found evidence supporting Adler's claim of gender convergence in a range of different crimes.

The pioneering contributions of Robert O'Brien have brought a modern statistical methodology, that used by econometricians in their analysis of non-stationary time-series data, to re-define the notion of gender convergence in crime rates and to test for such convergence in certain U.S. crimes over the period 1960 to 1995.[19] Using the econometrics 'tool-kit' associated with 'unit roots' and 'cointegration', O'Brien tested arrest rates for six types of crime in the U.S.A.. He found convergence between male and female arrest rates in the case of robbery, burglary and motor vehicle theft, and divergence in the case of arrests for homicide. In this paper, we follow O'Brien's lead by applying the up-to-date time-series methodology associated with the econometrics literature to test for male-female convergence in Canadian offence charges. Not only does our study appear to provide the first *direct* testing of the convergence hypothesis in the Canadian context, but it also breaks new ground by linking this topic to the important and well-established methods for testing for 'output convergence' in the recent empirical macroeconomic growth literature.

The rest of the paper is organized as follows. The data that form the basis of our study are described in Section II. In Section III we introduce the statistical tools that we will be using, and Section IV presents our main empirical results. The final section offers our conclusions, and some technical matters are dealt with in the Appendices.

II. DATA

The data for this research are collected from the CANSIM II databank made available by Statistics Canada[20]. This data set covers the period from 1983 to 2000, and provides annual information concerning the number of adult males and adult females charged with various types of offence in Canada. Accordingly, we are able to examine the issue of gender convergence at a relatively detailed level by type of alleged offence. We use the symbols M_1 to M_{20} and F_1 to F_{20} to denote the number of males and females charged, by category, and the gender differences are denoted D_1 to D_{20} respectively. The details of the offence definitions are provided in Appendix 1. Similar data are also available for the separate provinces and territories of Canada, but not over as long a time-period in all cases. Given that our sample period is already relatively short for the type of analysis that we are undertaking, we have not considered the sub-national data any further.

The graphs of the gender difference series, for each crime variable, are presented in Appendix 2. It is important to note that several of these series exhibit distinctive structural breaks. Specifically, D_1, D_2, D_7, D_{15} and D_{19} show a clear break in the trend of the series in 1991, D_3 and D_8 have a trend break in 1993, while D_{20} has a similar break in 1997. There is also a sharp change in the level of D_{13} in 1989.[21] The presence of these structural breaks in the data are of particular importance in this study. The usual tests for unit roots and cointegration need to be modified if they are to be reliable in such cases. Special attention is paid to this point in the statistical methodology that is described in the next section, and in Appendix 3.

III. STATISTICAL METHODOLOGY

The methodology that we use in this study is closely related to that described and used by Robert O'Brien, and more particularly it is based on the techniques proposed by Andrew Bernard and Stephen Durlauf in the context of testing for convergence in economic growth with time-series data.[22] Applying their notion of *stochastic* convergence to our problem, we have the following definition:

If $M_{i,t}$ and $F_{i,t}$ are the number of males and females charged with crime type i at time t, and I_t is the information set at time t, then male and female offences converge if their long-term forecasts are equal at a fixed time t:

$$\underset{k \to \infty}{Limit}\; E(M_{i,\,t+k} - F_{i,,t+k} \mid I_t) = 0 \quad . \qquad \textbf{(1)}$$

As is noted by David Greasely and Lesley Oxley, for example, this definition of convergence requires that the two time-series are cointegrated, with a cointegrating vector [1 , -1].[23] So, in practice convergence would be *rejected* if the series $(M_{i,t} - F_{i,t})$ contains a unit root.

The most common method of testing for a unit root in a time-series (and that adopted by Robert O'Brien) is *via* the tests of David Dickey and Wayne Fuller (DF), for which the null hypothesis is a unit root, and the alternative hypothesis is that the series is stationary.[24] That is, the null hypothesis is that the two series do *not* converge in the sense of the above definition. However, it is well known that the DF and ADF tests have rather low power in small samples, and in addition Pierre Perron has shown that the test is biased towards *not* rejecting the null hypothesis (even in very large samples) if the time-series has a structural beak.[25] Both of these shortcomings of the tests imply that they may err in the direction of leading us to conclude that there is *no convergence* in male and female crimes, when in fact such convergence does exist. Accordingly, we also consider various other tests in this study, including ones for which the null hypothesis is that the male and female series *converge*, and ones that allow for the presence of any structural breaks in the data. We also include more sophisticated and very recent tests that take advantage of the fact that we actually have a 'pooled' time-series/cross-section sample of data to work with. That is, we can construct a 'panel' of data on $D_{it} = (M_{i,t} - F_{i,t})$, for i = 1, 2, ……., c; t = 1, 2, ……., T; where c is the number of types of crimes or groups of crimes, and T is the number of time-periods. In our case, $c = 20$ and $T = 18$. The potential advantage of testing for convergence in this last manner is that the extra information that is used can add to the power of the test, at least asymptotically, when T is very large.

A brief summary of the various tests that we use is provided in Appendix 3. Technical discussions of the construction, application and properties of many of these tests are provided by Anindya Banerjee, Juan Dolado, John Galbraith and David Hendry, and by James Hamilton.[26] To reiterate, the notion of 'convergence' that we are adopting here is the one that has been used widely in the recent economics literature in the context of testing for output (income) convergence using time-series data. Our task is to test if the time-series relating to males for a particular type of crime, and that relating to females for the same crime, are cointegrated with a very specific cointegrating vector. In practical terms, given that we are looking at just a pair of time-series, we can achieve our objective by taking the difference between the male and female series, and testing to see if this new series is stationary, of if it has a unit root. Stationarity of the data will then be associated with convergence, and a unit root will be associated with non-convergence.

IV. EMPIRICAL RESULTS

The charts of the time-series representing the gender-differenced data in Appendix 2 exhibit a range of different characteristics. This suggests that the results of any tests for gender convergence may differ according to the type of crime in question, and it reinforces the merits of addressing this convergence issue using data relating to individual offences (and groups of offences), rather then just aggregated totals. In Table 1 we present the results of our basic convergence tests, applied separately to each of our twenty gender-differenced series. Results are given for both the levels and the logarithms of the data, but in this table no allowance is made for the structural breaks in several of these time-series.[27]

Regardless of the form of the data, the outcomes of the KPSS tests in Table 1 provide overwhelming support for the convergence hypothesis. For this test, convergence is the null hypothesis, and only in the cases of manslaughter (for the levels of the data) can this hypothesis be rejected. On the other hand, it is clear that the results for the ADF tests are very mixed. In this case the null hypothesis is 'no convergence', and this is rejected in twelve of the twenty cases for the levels of the data, and in eight cases for the logarithms of the data. Moreover, in the one case that the *KPSS* test rejects convergence, the ADF test suggests the opposite result. As was noted in Section III, the latter test is known to under-reject the null hypothesis when the data contain a structural break, and so the results of applying Pierre Perron's (P) modified ADF test are presented in Table 2, only for those time-series with distinguishable breaks. As a result, three additional series can be added to the twelve in Table 1 for which the ADF tests support gender convergence in the levels of the data. In contrast, Eiji Kurozumi's (K) test, which modifies the KPSS test to allow for an exogenous structural break, suggests the rejection of the convergence hypothesis in nine further cases for the levels of the data, and two (new) cases for the logarithms of the data.[28] It is important to note that the available critical values for this test are based on its asymptotic (infinitely large sample) distribution, and nothing is known about its quality in samples as small as ours.

On balance, the results shown in Tables 1 and 2 indicate the following. First, considering those tests (ADF and P) for which non-convergence is the null hypothesis, the evidence based on the levels of the data suggests that there is gender convergence for all of the crimes (and groups of crimes) that we have considered, except for Violence, Murder, Other Violent Crimes, Frauds, and Federal Statutes. The extent to which these results can, or should, be compared with those of other authors is quite limited. Most of the earlier empirical studies relate to the U.S.A., and the crime categories are not comparable to ours for Canada in many cases. Moreover, only Robert O'Brien's study used statistical methods that are consistent with modern econometric methodology, and hence are comparable to ours.[29] However, it is worth commenting that our results are considerably more supportive of the convergence hypothesis than are those from previous studies. In part, this is likely to be due to the formal definition of convergence that we use. In addition, previous studies have not modified their methodology to allow for structural changes in the data, in the way that we have here. O'Brien recognizes that structural breaks are an issue in the case of two of the crime categories that he considers, but he does not use modified unit root tests to deal with this. It is also worth noting that our results for convergence in the cases of Robbery, Breaking and Entering and Motor Vehicle Theft match O'Brien's precisely. That author's definition of convergence is consistent with ours. Similarly, his rejection of convergence in the case of homicide accords with our finding for the series D_4 (Murder). Interestingly, the two cases for which he does not obtain a significant result (Aggravated Assault, and Larceny) are those associated with structural breaks in the data.

Second, those tests (KPSS and K) for which convergence is the null hypothesis have not been used previously in this literature. In addition, the quality of the second of these tests has not been explored for the case of small sample sizes. Superficially, the results associated with the KPSS test lend extremely strong support to the convergence hypothesis, and even if the outcomes for the K test in Table 2 are taken at face value, we find in favour of convergence in half of the categories considered. Moreover, the KPSS results based on the levels of the data match Robert O'Brien's findings for the U.S.A. with respect to Robbery, Breaking and Entering and Motor Vehicle Theft.

Table 3 shows the results that were obtained when we tested for convergence using unit root (or stationarity) tests designed for 'pooled' data. It is important to recall the definitions of the twenty crime categories that we are considering in this study. The series D_1 represents the difference between male and female adults charged for *all* offences. However, the corresponding male (M_1) and female (F_1) series are *not* the sum of the other nineteen individual male and female series. As will be apparent from their definitions in Appendix 1, some such series relate to the number of charges for a *group* of offences. That is, as a consequence of the way in which the data have been recorded and made available, there is some degree of overlap between certain of the categories under study. By way of illustration, the series D_3 (Violence) incorporates such categories as Murder, Attempted Murder, Manslaughter and Other Violent Crime. Accordingly, in order to apply the panel-data tests for gender-convergence we have considered several groupings of (some of) the individual series into different 'panels', as follows. Panel 1 comprises all twenty of the series. Panel 2 is based on those individual series that represent *distinct* offence categories, namely D_4 to D_{18} inclusive. Panel 3 is made up of those series that *do not* exhibit structural breaks. This is pertinent in view of the fact that no unit root tests are available for panel-data that have structural breaks. This panel comprises eleven series for data measured in levels, and eighteen series in the case of the logarithmic data.[30] Panel 4 comprises the intersection of Panel 2 and Panel 3.[31]

The results for the IPS test in Table 3 provide unambiguous support for the convergence hypothesis. This is particularly noteworthy, given that the application of this test involves finite-sample critical values that are exact for our sample size, and the number of series in each panel. In contrast, the H test is valid only for infinitely large samples, so the fact that the results associated with this test in Table 3 all *reject* the convergence hypothesis may not be of particular concern. The IPS results in Table 3 add further support to the results based on the single series for individual offence types (or categories of offences). There is strong evidence of convergence between the male and female offence data over the period 1983 to 2000 in Canada.

V. CONCLUSIONS

The empirical literature relating to the possibility of convergence between male and female crime over time has focused primarily on data for convictions in the U.S.A.. In this paper we have broadened the available evidence by presenting the results of what appear to be the first *direct* tests of such convergence for Canada, these relating to adults charged with various offences. Moreover, our results provide the only *recent* information relating to this general issue in Canada. While convergence in offence charges is different from convergence in convictions, one of the principal findings of our study is that there is more support for the gender-convergence hypothesis than might previously have been supposed from the results of earlier studies. The notion of convergence that we have considered is firmly rooted in the modern macro-econometrics literature associated with unit roots, cointegration, and testing for output (income) convergence. Consequently, this study places the empirical literature associated with gender-convergence in crime in a broader context in terms of the methodology that is used.

Our results have been obtained by applying several formal (and in some cases very recent) econometric tests to individual data series and panels of data, and by taking into account any structural breaks in the data, wherever possible. The categories of offence that are considered range from quite specific individual ones, such as murder, to broad groups such as all offences under the criminal code. The quality of some of our tests is limited by the relatively short sample of data (1983 to 2000), but once this is taken into account the results provide strong evidence in favor of gender-convergence for the majority of the twenty offence categories that we consider. By way of example, we find convergence for broad offense groups, such as 'all offences' and 'other crimes', as well as such specific offences as 'attempted murder' and 'prostitution'. The latter result is especially interesting as prostitution is the only offence for which the number of females charged exceeds the number of males, for every year in our sample, with the male and female data both exhibiting a downward trend since 1988.

These results raise some interesting issues. For example, in the literature relating to theories of criminology, there has been a debate in relation to theories for explaining female crime, and whether or not such theories should be gender-neutral. James Hackler provides a useful discussion of this debate, and cites studies that support the use of gender-neutral theories. The results of our own study can also be interpreted as being supportive of this stance, especially with regard to recent experience in Canada.[32] In addition, our finding of widespread gender-convergence in charges has to be considered in conjunction with an important feature of our data – namely, the narrowing of the gender-gap over time has been 'driven' effectively by increases in charges against females, rather than decreases in charges against males.[33] For example, for all offences combined, the number of females charged increased by over 7% during our sample period, while the corresponding figure for males was a *decrease* of 8%.[34] One is then compelled to ask, 'why has this occurred?' Further research is needed to determine the extent to which this outcome reflects a change in female criminal behavior, as opposed to possible changes in the role of enforcement agencies. Depending upon the outcome of this research, there may in turn be implications for social spending in such areas as education in crime prevention, the provision of counseling services, and policing.

TABLE 1

Basic Convergence Tests

		Levels of Data			Logarithms of Data	
		ADF t-Test	**KPSS Test**		**ADF t-Test**	**KPSS Test**
	H_0	*No Convergence*	*Convergence*		*No Convergence*	*Convergence*
All offences	D_1	-4.014**	0.151	LD_1	-1.591	0.153
Criminal code	D_2	-1.842	0.150	LD_2	-2.449	0.155
Violence	D_3	-1.830	0.150	LD_3	-2.442	0.154
Murder	D_4	-1.915	0.205	LD_4	-3.388*	0.252
Attempted murder	D_5	-3.343*	0.161	LD_5	-2.692	0.156
Manslaughter	D_6	-3.599*	0.335**	LD_6	-4.384**	0.182
Robbery	D_7	-1.778	0.160	LD_7	-3.755**	0.245
Other violent crime	D_8	-1.889	0.150	LD_8	-3.399*	0.156
Property crimes	D_9	-3.909**	0.190	LD_9	-1.733	0.153
Breaking & entering	D_{10}	-3.513*	0.198	LD_{10}	-2.910	0.165
Theft, motor vehicle	D_{11}	-3.695**	0.158	LD_{11}	-1.455	0.161
Theft, over & under	D_{12}	-3.962**	0.173	LD_{12}	-1.457	0.153
Have stolen goods	D_{13}	-3.052	0.156	LD_{13}	-2.711	0.209
Frauds	D_{14}	-2.794	0.151	LD_{14}	-1.574	0.151
Other crimes	D_{15}	-4.799**	0.151	LD_{15}	-3.738**	0.157
Prostitution	D_{16}	-7.231**	0.209	LD_{16}	-4.104**	0.154
Gaming & betting	D_{17}	-4.020**	0.227	LD_{17}	-4.025**	0.209
Offensive weapons	D_{18}	-3.436*	0.176	LD_{18}	-4.894**	0.169
Other criminal code	D_{19}	-5.244**	0.151	LD_{19}	-2.342	0.160
Federal statutes	D_{20}	-2.335	0.232	LD_{20}	-2.774	0.149

* Significant at the 10% level.

** Significant at the 5% level.

TABLE 2

Convergence Tests Allowing for Structural Breaks

	H_0	**Perron's P Test** *No Convergence*				**Kurozumi's K Test** *Convergence*		
All offences	**D_1**	-7.606**			**D_1**	0.269**		
Criminal code	**D_2**	-5.396**			**D_2**	0.249**		
Violence	**D_3**	-1.674			**D_3**	0.215**		
Robbery	**D_7**	-3.883*			**D_7**	0.242**		
Other violent crime	**D_8**	-1.527			**D_8**	0.192**		
Property crimes			**LD_9**	-2.531			**LD_9**	0.150**
Theft, over & under			**LD_{12}**	-2.325			**LD_{12}**	0.149**
Have stolen goods	**D_{13}**	-3.751**			**D_{13}**	0.173**		
Other crimes	**D_{15}**	-10.263**			**D_{15}**	0.238**		
Other criminal code	**D_{19}**	-9.358**			**D_{19}**	0.235**		
Federal statutes	**D_{20}**	-2.598			**D_{20}**	0.162**		

* Significant at the 10% level.

** Significant at the 5% level.

TABLE 3

Convergence Tests Based on Panel Data

Levels of Data		Logarithms of Data	
	IPS Test (= Mean ADF)		**IPS Test (= Mean ADF)**
Panel 1 (***All Series***)	-3.410**	**Panel 1** (***All Series***)	-2.891**
Panel 2 (***D4 to D18***)	-3.529**	**Panel 2** (***D4 to D18***)	-3.081**
Panel 3 (***11 No-Break Series***)	-3.765**	**Panel 3** (***18 No-Break Series***)	-3.035**
Panel 4 (***Intersection of Panels 2 & 3***) (***11 No-Break Series***)	-3.765**	**Panel 4** (***Intersection of Panels 2 & 3***) (***9 Series***)	-3.270**
	H Test		**H Test**
Panel 1 (***All Series***)	12.344#	**Panel 1** (***All Series***)	11.273#
Panel 2 (***D4 to D18***)	11.153#	**Panel 2** (***D4 to D18***)	10.319#
Panel 3 (***11 No-Break Series***)	10.424#	**Panel 3** (***18 No-Break Series***)	10.898#
Panel 4 (***Intersection of Panels 2 & 3***) (***11 No-Break Series***)	10.424#	**Panel 4** (***Intersection of Panels 2 & 3***) (***9 Series***)	7.993#

** Significant at the 5% level.

Significant at any reasonable level.

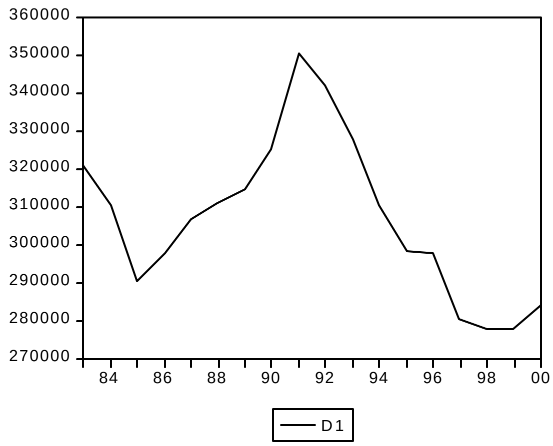
APPENDIX 1. Definitions of the Variables

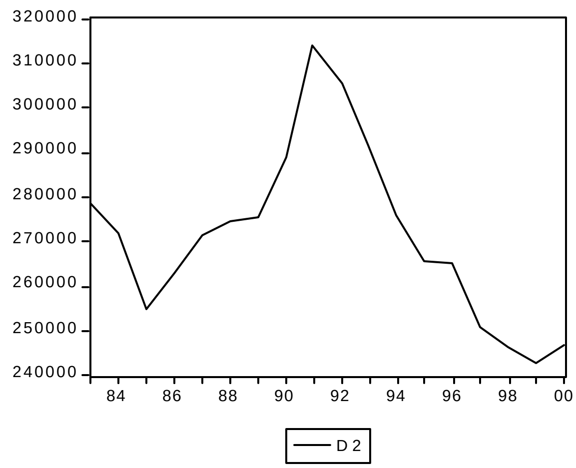
The basic variables used in our empirical analysis are named according to the nomenclature 'X_i' or 'LX_i', where 'L' denotes the natural logarithm of the data; 'X' = 'M' for adult males, and 'F' for adult females; and i = 1, 2, 3, ……, 20 according to the following scheme:

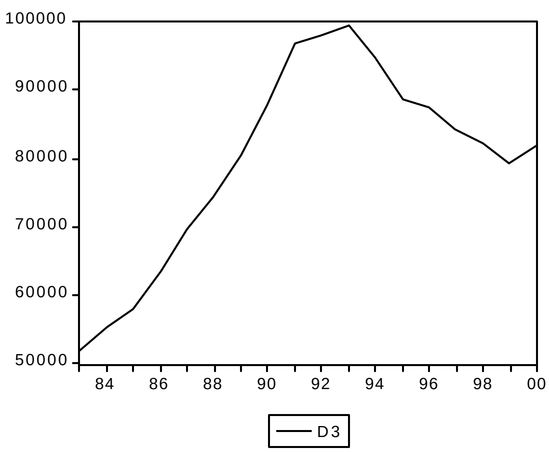
1. All Offences, Total
2. Criminal Code, Total
3. Crimes of Violence
4. Murder
5. Attempted Murder
6. Manslaughter
7. Robbery
8. Other Violent Crimes
9. Property Crimes
10. Breaking and Entering
11. Theft, Motor Vehicle
12. Theft, Over and Under
13. Possession of Stolen Goods
14. Frauds
15. Other Crimes
16. Prostitution
17. Gaming and Betting
18. Offensive Weapons
19. Other Criminal Code
20. Federal Statutes

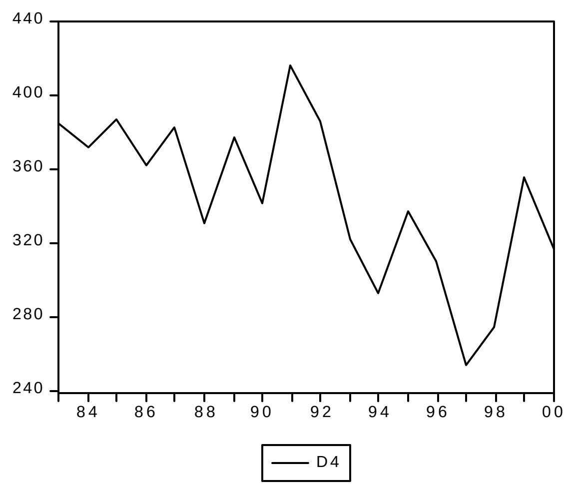
The differences between the male and female variables are then labeled "D_n" or "LD_n", where the latter is defined as LD_i = abs.(LMi – LF_i) for i = 1, 2, 3, ….., 20. Note that taking the absolute value of the difference is actually relevant only in the case of M_{16} and F_{16} (prostitution).

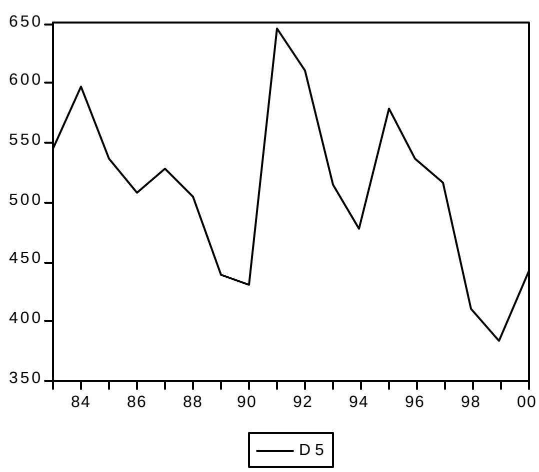
APPENDIX 2. Charts of the Gender-Difference Data

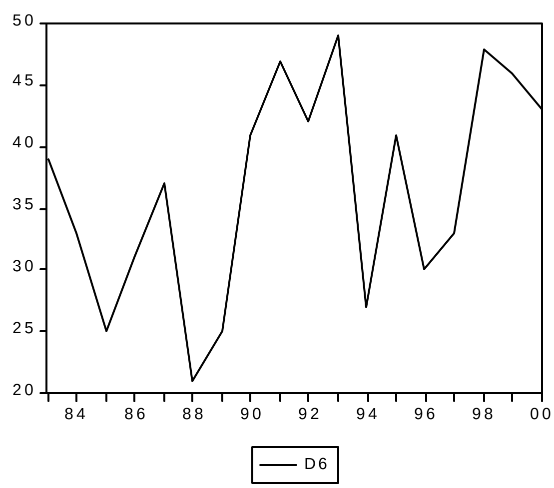


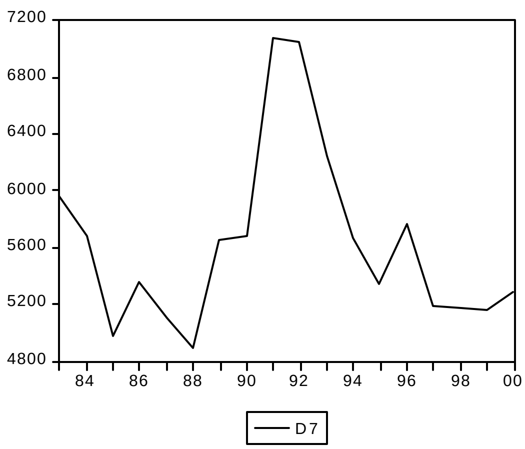








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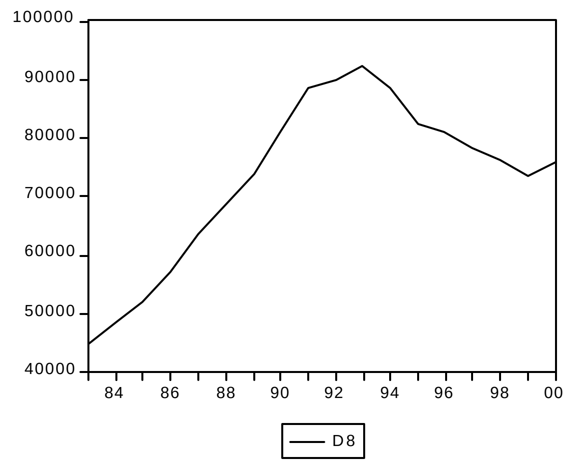
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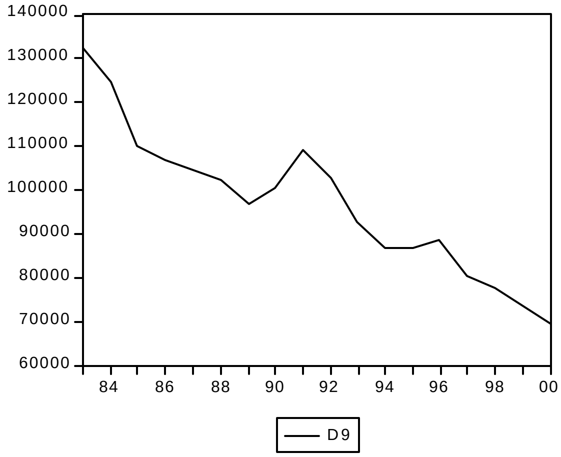
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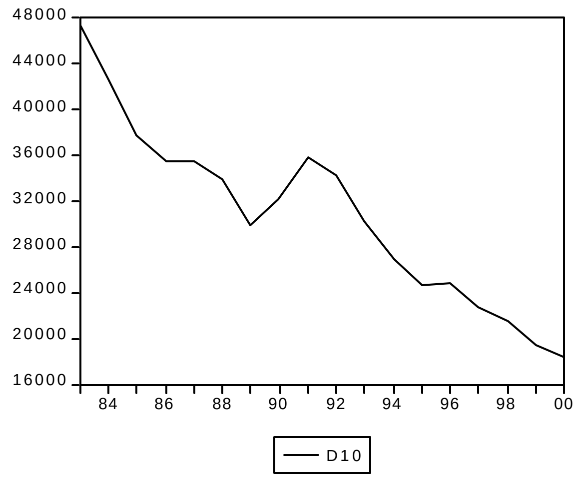
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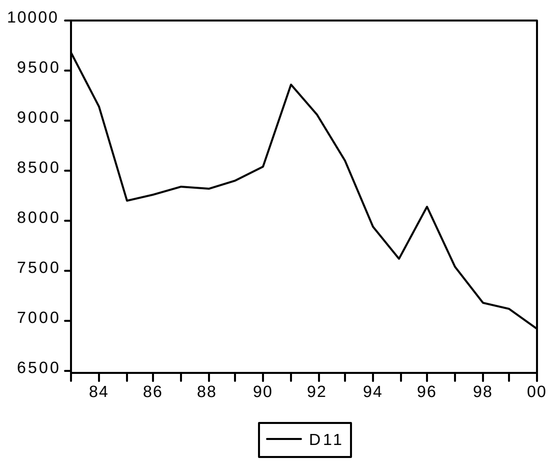
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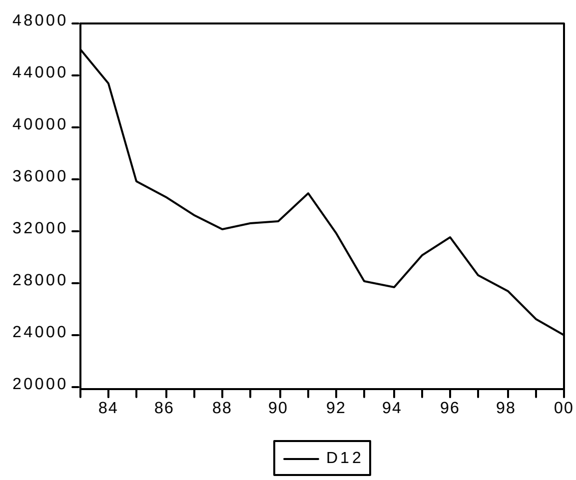
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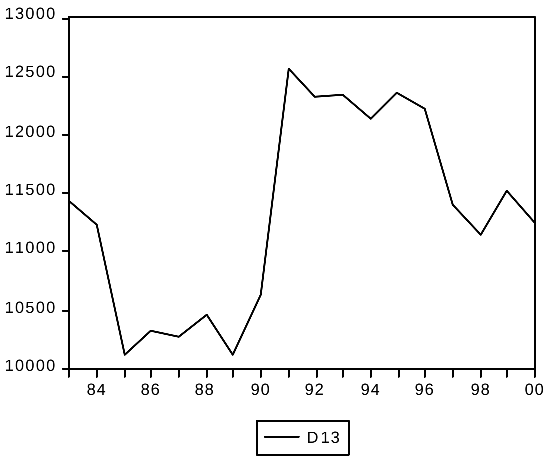
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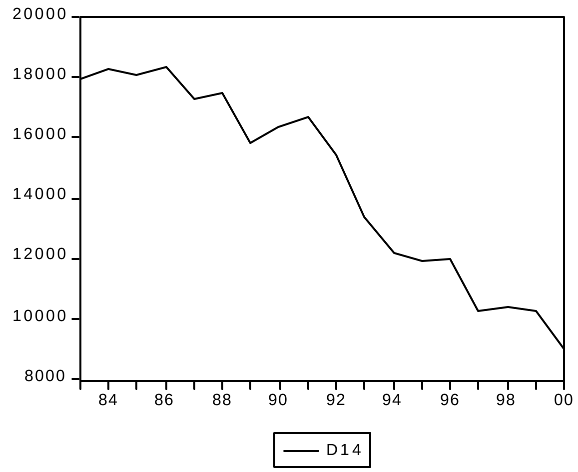
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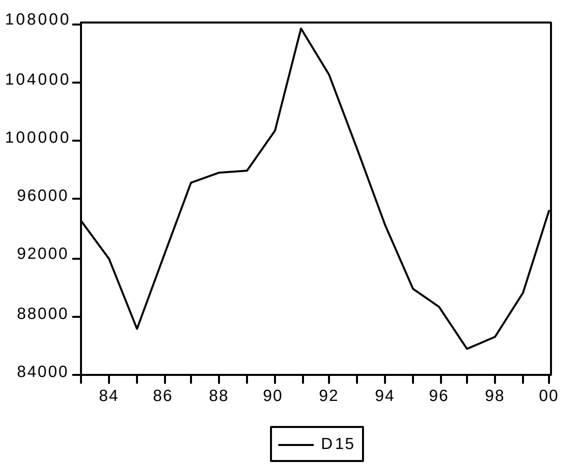
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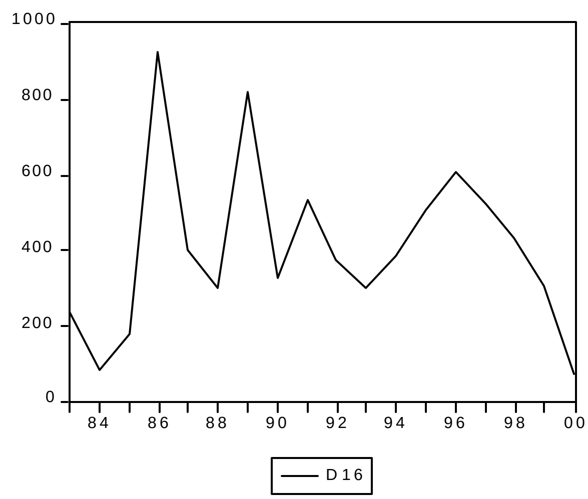
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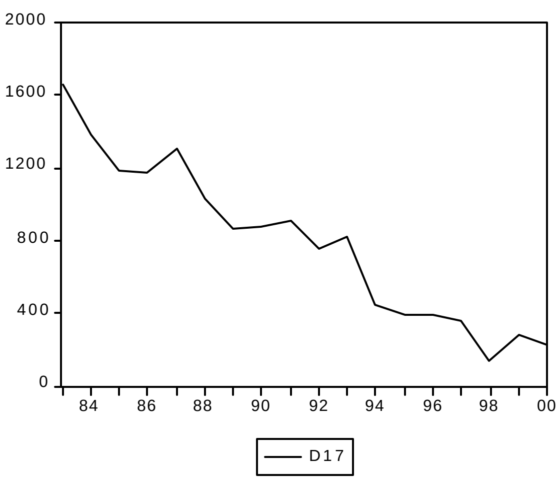
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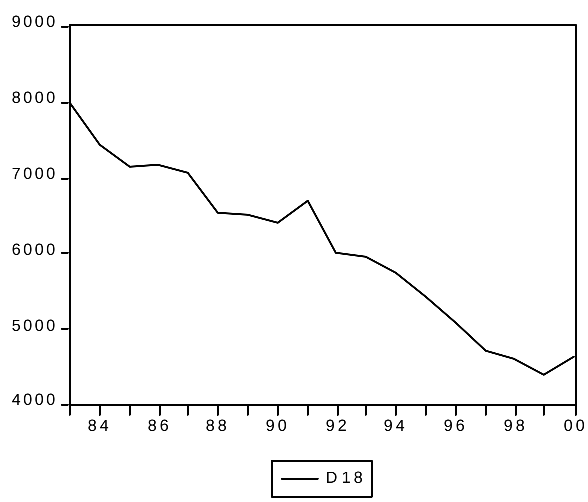
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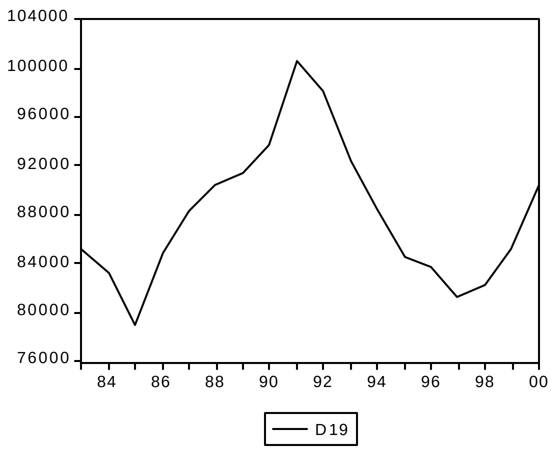
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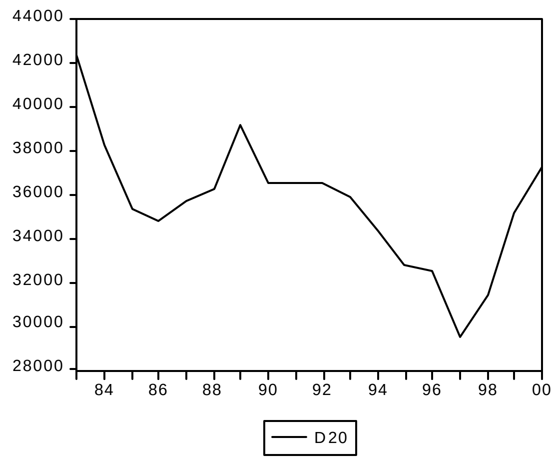
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APPENDIX 3. Tests for Convergence

The various unit root and stationarity tests that we use to test for non-convergence and convergence of the data are denoted ADF (Dickey and Fuller, 1979, 1981; Dickey and Said, 1981), P (Perron, 1989), KPSS (Kwiatowski *et al.*, 1992), K (Kurozumi, 2002), H (Hadri, 2000), and IPS (Im *et al.*, 2002) in the text. The tests are applied either to a single time-series for the gender difference associated with a single crime catregory (D_{it}), or to a panel of data for several such series at once. The contexts in which these tests are used can be categorized as follows:

	Null Hypothesis				Critical Values
	Non-Convergence (Unit Root)		**Convergence (Stationary)**		**Finite Sample or Asymptotic**
Single Series					
No Breaks	ADF	Finite Sample	KPSS		Finite Sample
Structural Break	P	Asymptotic	K		Asymptotic
Panel Data					
No Breaks	IPS	Finite Sample	H		Asymptotic

Given the nature of our data, as illustrated in Appendix 2, we apply the ADF and "t-tests" for a unit root with an allowance for both a drift (constant term) and linear trend in the so-called "Dickey-Fuller regression" that forms the basis for the application of the tests. The "augmentation level", p, that is used for the ADF tests (p = 0 for the DF tests) is determined automatically on the basis of the Schwartz criterion in the Eviews (2002) econometrics package, up to a maximum value of p = 5 (in view of our limited sample size). Exact finite-sample critical values come from MacKinnon (1991). The formulation of Perron's test (P) for a unit root depends on the nature of the (single) structural break in the series – a shift in the level; and break in the trend; or changes in both level and trend. The asymptotic distribution of the test statistic also depends on the proportion of the way through the sample that the break occurs. The critical values come from Perron (1989) and Perron and Vogelsang (1993), and have only large-sample validity. As our sample comprises only eighteen observations, the results for the P test in Table 2 should be treated with caution.

In the case of the KPSS test, the null hypothesis that we consider is trend-stationarity, and the construction of our test statistic involves the usual Bartlett window with the bandwidth parameter, *l*, chosen *via* the familiar "*l12* rule": $l = \text{int.}[12(T/100)^{1/4}]$. This implies $l = 7$ for our sample size. Exact finite-sample critical values for this test come from Hornok and Larsson (2000). The K test is a modified *KPSS* test that allows for a structural break in the level, trend, or both level and trend of the series, in the same way that the P test is a modification of the ADF test. Again, the null hypothesis is trend-stationarity, and the asymptotic distribution of the test statistic depends on the "position" of the break in the sample. Critical values for the test are given by Kurozumi (2002), and again the results in Table 2 should be treated cautiously as we are applying an asymptotic test in the context of a relatively small sample.

In the case of the two tests that take account of the panel nature of our data, we apply the IPS test with an allowance for both a drift and linear trend in the underlying Dickey-Fuller regressions, and we apply Hadri's (H) test with a null hypothesis of trend-stationarity. That is, these panel-data tests match their single-series counterparts in Table 1. The construction of the IPS test statistic involves constructing the arithmetic average of the ADF 't-statistics' for the various series that make up the panel. This average statistic has a non-standard distribution, but exact finite-sample critical values are provided by Im *et al.*(2002, Table 2). The H test statistic (Hadri, 2000, p. 154) is constructed by taking the arithmetic mean of the KPSS statistics for the series that comprise the panel, and then standardizing this value in an appropriate way. The resulting test statistic is asymptotically standard Normal. It is worth noting that to the best of our knowledge there are currently no tests for a unit root, or for stationarity, in panel data *with a structural break*.

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FOOTNOTES

1. See Becker (1968).

2. For a detailed overview of research in this overall field, see Freeman (1999).

3. See Linden (2000, p.165).

4. For example, see Simon (1975), Adler (1975) and Fox and Harnagel (1979)

5. For example, see Hagen, Gillis and Simpson (1985).

6. See Morris (1987) and Comack (1996).

7. Smart (1976, Chapter 1) provides a substantial review of the literature on the nature of female criminality.

8. See Pollack (1950).

9. See O'Brien (1999, p.97) for this attribution to Darrow (1922, p.78).

10. Authors who have considered the both of these issues include Simon (1975, 1976) and Steffensmeier (1980, 1993). Ivkovich (1995) is among those who have focused on the first of these issues, while Adler (1975) addressed the second. O'Brien (1999, p.98) extends this empirical literature significantly by asking the additional interesting economic question, "Is there an equilibrium between the crime rates for men and women?" His empirical research focuses on this question and on testing for the existence of convergence. It is noteworthy for its use of up-to-date econometric techniques that deal with non-stationary time-series.

11. Austin (1993) provides a substantial review of the literature on male-female convergence in crime rates

12. See Fox and Hartnagel (1979, p.98).

13. For a detailed overview of role convergence, see Linden (2000, p.106-08).

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14. Austin *supra* note 11.

15. Adler *supra* note 10.

16. Balkan and Berger (1979).

17. Austin, *supra* note 11.

18. Austin, *supra* note 11, p.449.

19. O'Brien, *supra* note 9.

20. Statistics Canada (2002), Table 252-0002.

21. The differences in the logarithms of the male and female series are generally free of such breaks. The only exceptions are for offense categories 9 (Property Crimes) and 12 (Theft, Over and Under), where the series have trend break in 1993.

22. O'Brien, *supra* note 9, and Bernard and Durlauf (1995). These authors actually consider the more general case of convergence between *p* (>2) time-series, but that is not of concern to us here.

23. See Greasley and Oxley (1997). These authors consider the special case of convergence in GDP between a pair of countries. They also pay special attention to allowing for structural breaks in the data when applying their test.

24. See Dickey and Fuller (1979, 1981). The DF tests assume that the errors in the "Dickey-Fuller regression" are white noise, but this is rarely the case in practice. Accordingly, it is usual to use the "augmented DF" (ADF) test proposed by Dickey and Said (1981). Our discussion and results focus on data that are either stationary (I(0)) or have a single unit root (I(1)) as none of the time series were integrated of order two (I(2)).

25. See Perron (1989).

26. See Banerjee *et al.* (1993) and Hamilton (1994).

27. See Appendix 1 for details regarding the construction of the logarithmic data.

28. See Kurozumi (2002).

29. See O'Brien, *supra* note 9. We mention only the results based on the levels of the data at this juncture.

30. The series in question in each case can be identified readily from Table 2.

31. In the case of data measured in levels, Panel 3 and Panel 4 are identical.

32. Hackler (2003, p.181-2). See also Canter (1982) and Smith and Paternoster (1987).

33. When charges against both males and females have declined in number, the former numbers have declined faster than have the latter, *etc*.

34. With regard to some specific offence types, the following examples are also illustrative of this point. For Other Crimes, females charged increased by 55.2% and males by 9% over our sample period. In the case of Property Crimes, females charged declined by 46.8% and males charged declined by 59.8% over this period; while the corresponding declines for Offensive Weapons were 45.5% and 53.6%. Finally, for Murder, the female and male declines were 58.5% and 24.5% respectively, which are consistent with our finding of *divergence* in this case.