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IS THERE A NATURAL RATE OF CRIME?

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ABSTRACT

Studies in the economics of crime literature have reached mixed conclusions on the deterrence hypothesis. One explanation which has been offered for the failure to find evidence of a deterrent effect in the long run is the natural rate of crime. This paper applies the univariate Lagrange Multiplier (LM) unit root test with one and two structural breaks to crime series for the United Kingdom and United States and the panel LM unit root test with and without a structural break to crime rates for a panel of G7 countries to examine whether there is a natural rate of crime. Our main finding is that when we allow for two structural breaks in the LM unit root test and a structural break in the panel data unit root test, there is strong evidence of a natural rate of crime. The policy implications of our findings is that governments should focus on altering the economic and social structural profile which determines crime in the long run rather than increasing expenditure on law enforcement which will at best reduce crime rates in the short run.

KEYWORDS: Natural rate of crime; Deterrence hypothesis; unit root.

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IS THERE A NATURAL RATE OF CRIME?

1. INTRODUCTION

The economic approach to crime pioneered by Becker (1968) postulates that optimizing individuals engage in criminal activities depending upon the expected returns from crime relative to the costs including the probability of apprehension, conviction and punishment. Beginning with Ehrlich (1973) a large empirical literature has emerged using a 'supply of offences' function which sets out to test whether an increase in criminal sanctions reduces crime rates. These studies have, at best, reached mixed conclusions as to whether there is a deterrent effect. While some studies have found that an increase in criminal sanctions reduces crime rates (see *e.g.* Ehrlich, 1973; Levitt, 1997; Corman and Mocan, 2000; Di Tella and Schargrodsky, 2004), other studies suggest either a weak relationship or no relationship at all between the two variables (see *e.g.* Myers, 1983; Buck *et. al,* 1983; Cornwall and Trumbull, 1994). Various explanations have been offered as to why an increase in criminal sanctions need not deter crime (see *e.g.* Cameron, 1988, pp. 302-307). Some of these explanations focus on measurement problems such as simultaneity between crime and criminal sanctions, while others emphasize that the economic approach to crime does not necessarily predict that an increase in criminal sanctions will deter potential offenders. One economic argument as to why there might be no deterrent effect in the long-run is the concept of a natural rate of crime (Buck *et al.* 1983, 1985; Friedman *et al.,* 1989; Philipson and Posner, 1996).

The notion of the natural rate of crime was introduced into the economics of crime literature by Buck et al. (1983, 1985) through drawing an analogy with the natural rate of unemployment. There is an extensive empirical literature which has applied unit root testing to examine whether there is a natural rate of unemployment. The contribution of this paper is that we study the natural rate of crime as an extension of this approach; specifically, for the first time in the literature, we apply the same unit root testing methodology which has been used to examine whether there is a natural rate of unemployment to test for the existence of a natural rate of crime. If we are able to reject the null hypothesis of a unit root in the crime rate, this is consistent with the existence of a natural rate of crime. This implies that while deterrence activities, such as a police crackdown, can cause deviations from the natural rate of crime, in the long-run the crime rate will return to its equilibrium level. If, on the other hand, we find that the crime rate is non stationary, this is consistent with the crime hysteresis hypothesis which states that cyclical fluctuations have permanent effects on crime rates. If the hypothesis of hysteresis in crime rates is correct, this provides an empirical foundation for increased government expenditure on police activities to fight crime, particularly in periods of high crime.

We begin through examining the unit root properties of annual time series data for aggregate total crime as well as specific types of crime for the United States for the period 1960 to 2002 and for the United Kingdom for the period 1898 to 1999. To accomplish this task, in addition to the Augmented Dickey Fuller (ADF), Phillips-Perron and DF-Generalized Least Squares (GLS) unit root test proposed by Elliot et al. (1996), we employ the Lee and Strazicich (2003a, 2003b) Lagrange Multiplier (LM) unit root test with one and two structural breaks. The Zivot and Andrews (1992) and Lumsdaine and Papell (1997) ADF-type endogenous break unit root tests have become popular tests among researchers to accommodate structural breaks. A limitation on these ADF-type endogenous break unit root tests, however, is that the critical values are derived while assuming no break(s) under the null. Nunes et al. (1997) show that this assumption leads to size distortions in the presence of a unit root with one or two breaks. As a result, when utilizing ADF-type endogenous break unit root tests, one might conclude that a time series is trend stationary, when in fact it is nonstationary with break(s), meaning that spurious rejections might occur. In contrast to the ADF test, the LM unit root test has the advantage that it is unaffected by breaks under the null (see Lee and Strazicich, 2001).

After examining the unit root properties of specific crimes in the United Kingdom and United States we proceed to examine the unit root properties of aggregate total crime for a panel of G7 countries over the period 1980 to 2002. We applied the LM panel unit root test without a structural break and the LM panel unit root test with one structural break developed by Im et al. (2005) to the G7 panel as well as smaller panels consisting of G7 civil law countries and G7 common law countries. The remainder of the paper is set out as follows. The next section discusses the natural rate of crime concept in more detail. Section 3 sets out the econometric methodology. The data and empirical results are presented in Section 4. Section 5 contains a discussion of the implications of the results for the deterrence hypothesis and the final section summarizes the main conclusions.

Briefly foreshadowing our main results, we find that the LM unit root test with one structural break suggests that there is a natural rate of crime for assault, violent crime and motor vehicle theft in the United States, while the LM unit root test with two structural breaks finds that the total crime rate as well as well as five of the seven specific crime series have a natural rate in the United Kingdom. The LM panel data unit root test is unable to reject the joint null hypothesis of a unit root in the aggregate total crime rate for the G7 panel as well as smaller panels of G7, civil and common law countries, but when we allow for a structural break, the LM unit root test rejects the joint null hypothesis in each case, suggesting that crime rates in G7 countries are characterized by a natural rate.

2. THE NATURAL RATE OF CRIME

The natural rate of crime as a long-run equilibrium phenomenon as formulated by Buck *et al.* (1983, 1985) and Friedman *et al.* (1989) has similar theoretical underpinnings to the natural rate of unemployment. Friedman *et al.* (1989) makes the relationship between the two concepts explicit through presenting a modified Phillips Curve to illustrate the natural rate of crime which substitutes moves of the short-run trade-off curve between crime and police expenditure in response to the learning behavior of criminals for moves of the short-run trade off curve between inflation and unemployment in response to the adaptive behavior of the public. The notion of a natural rate of unemployment is well known (Friedman, 1968). The natural rate of unemployment hypothesis states that a long-run equilibrium level of unemployment exists which is the result of given structural features of the economy and the frictional effects of workers searching for new positions. If there is a natural rate of unemployment, demand management policies which stimulate aggregate demand will reduce short-run unemployment at the expense of increasing inflation, but have no long-run effect on the natural rate of unemployment.

Buck et al. (1983, 1985) hypothesized that property crimes have similar features to unemployment and that while increases in police expenditure deter crime in the short run, crime returns in the long run to its natural level. Buck et al. (1983, pp. 479-480) postulate that in the short run the crime level is affected by crime prevention policies and community characteristics such as demographic composition and income level, while in the long run, the economic and social structural profiles which exhibit little variation over time dictate the natural rate level. Their argument is “that police activity might deter only marginal crimes at the ‘bottom’ of the crime ordering. Thus the crimes with high net returns [are] basically unaffected in the long …. run by conventional police outlays” (Buck et al., 1983, p. 473). This conjecture is based on the premise that there is a pool of potential criminals who experience decreasing marginal returns to legal activity, for whom the expected return to property crime is so high that any feasible increase in police surveillance would not reduce the number of crimes in the long run (Buck et al., 1983; Friedman et al., 1989). Possible reasons for this outcome is that over time, potential criminals become more sophisticated in their assessment of higher levels of police activity and may even research possible targets (Buck et al., 1983) or that there is a learning-by-doing effect where over time criminals learn by doing how to cope with police practices (Friedman et al., 1989). Either way, with the increased professionalism of criminal activity, in the long run the marginal benefits of committing property crime are restored, resulting in an increase in the crime rate in spite of increased expenditure.

The pool of potential criminals whose marginal benefits of an additional unit of time in legal activity are diminishing include the long-term unemployed. While job search is a legitimate activity, continued unemployment makes one less employable (Buck et al., 1985). Lippman and McCall

(1976) show that ongoing unsuccessful job search results in depreciation of human capital stock and a reduced reservation wage. Buck et al. (1985, p. 247) argue that the pool of potential criminals also includes unskilled, minimum wage workers with few prospects for advancement, who endure reduced job attachment. Freeman (1996) argues that the deterioration in real wages for those on the bottom rungs of the earnings distribution since the mid-1970s and the collapse in the job market for less skilled males in the United States in the 1980s and 1990s contributed to increased crime.

The pool of potential criminals who commit property crime in the long run also includes individuals who have a target income such as those with drug or gambling addictions. In the United States a high proportion of individuals arrested for non-drug crimes test positive for drug use. In the 1992 census, between 50 and 80 per cent of those arrested for non-drug offences tested positive for drug use (U.S. Bureau of Census, 1993, Table 315 cited in Freeman, 1996, p. 32). In a study of 23 U.S. cities, up to 83 per cent of males and 80 per cent of females arrested were under the influence of at least one illicit drug at the time of arrest, (Jofre-Bonet and Sindelar, 2002). Corman and Mocan (2000) reached mixed conclusions about the relationship between drug use and crime rates using time series data for New York. They found no significant relationship between drug use and assault, murder or motor vehicle theft, but found that drug use has a statistically significant effect on burglaries and robberies. There are a number of studies based on interviews with convicted criminals which suggest that the need to finance a drug habit is a primary reason for committing property crime. In one study Boyum and Kleiman (1995) found that 39 per cent of cocaine and crack users claim to have committed crime to finance their drug habits. A survey by Petersilia et al. (1978) of incarcerated armed robbers in the United States found that a desire to purchase drugs was the most often cited reason for committing crime. Chaiken and Chaiken (1982) who interviewed inmates entering prison in California, Michigan and Texas found that the robbery rate was generally higher among daily heroin users than less frequent users or non-users.

There is an extensive empirical literature which has utilized unit root testing to examine whether there is a natural rate of unemployment. If the null hypothesis of a unit root in the level of unemployment is rejected, meaning that the data are stationary, this implies that there is a natural rate of unemployment. If the level of unemployment is characterized as a non-stationary or unit root process, there is unemployment hysteresis, meaning that cyclical fluctuations will have permanent effects on the level of unemployment. The initial studies on this topic applied Augmented Dickey-Fuller (ADF) tests to examine whether there is a natural rate of unemployment, including Blanchard and Summers (1986) (France, Germany, the United Kingdom, and the United States); Brunello (1990) (Japan) and Mitchell (1993) and Roed (1996) (sample of OECD countries). More recent studies apply the Zivot and Andrews (1992) and Lumsdaine and Papell

(1997) unit root tests with one or two structural breaks to test for a natural rate in OECD unemployment rates (see e.g. Papell et al., 2000) or various panel data unit root tests. The latter have examined unemployment data for panels of states in Australia (Smyth, 2003); states in the United States (Song and Wu, 1997), European Union countries (Leon-Ledesma, 2002) and OECD countries (Song and Wu, 1998).

Our approach is to build on the logic underpinning this literature to test the natural rate of crime hypothesis using the univariate LM unit root test with one and two structural breaks and the panel LM unit root test with and without a structural break. By analogy with the unit root literature testing for the natural rate of unemployment, if the null hypothesis of a unit root in the crime rate is rejected, this is evidence of a natural rate of crime; otherwise the crime hysteresis hypothesis is supported. Buck et al. (1983, p. 473) suggest that the natural rate of crime hypothesis is valid for all types of property crime motivated by the profit-maximization attitude of offenders, including burglaries, robberies, motor vehicle thefts and larcenies. In addition to testing the natural rate of crime hypothesis using data for various property crimes we also examine the natural rate of crime hypothesis for various crimes against the person such as assault, rape and murder. The reason we examine crimes against the person in addition to property crime is that while the economic model of crime is really a model of property crime, studies using the Ehrlich (1973) 'supply of offences' approach have also attempted to explain crimes against the person. The rationale for applying the economic model to crimes against the person is that these are often extensions of property crime – for example assault or even murder is often a by-product of burglaries or robberies if the offender is disturbed. There is even some evidence from criminology studies that homicide rates are positively correlated with income inequality across U.S. cities (Land et al., 1990). However, having said this, the economic model has not had much success explaining crimes against the person. Even studies which have found a deterrent effect for property crime often fail to find a deterrent effect for crimes against the person. This result is often explained in terms of the latter being 'crimes of passion' (see e.g. Withers, 1984).

While Buck et al. (1983, 1985) focus on the high returns to property crime, the same argument is equally applicable for other crimes such as drug dealing. Reuter et al. (1990) surveyed drug dealers in Washington DC on their income from dealing and on the basis of their responses, estimated that the illegitimate earnings of drug dealers exceeded their legitimate earnings by enough to make it financially worth their while to spend one year in jail for every two years they sold drugs. Because there is an increasing amount of drug-related violent crime in the United States, violent crimes against the person - including murder - become an extension of the argument that there is a natural rate of drug crime due to the high returns to dealing. Using data on FBI crime rates for 27 metropolitan areas, Grogger and Willis (2000) found that crack cocaine use in the United States had a substantial positive effect on the prevalence of violent crime. Levitt and Venkatesh (2000) focus on the rise of gang violence commensurate with the prevalence of crack cocaine, discussing how the crack cocaine market proved lucrative for gangs, leading to violence as rival gangs competed to sell the drug. In legal markets, governments protect and enforce property rights; however, governments do not protect property rights in illegal markets, so participants must take it upon themselves to do so. As a result, in the absence of property rights, most disputes are resolved with threats or acts of violence, as there are no other means available. As Resignato (2000) puts it:

> "Drug market participants tend to arm themselves as protection from robbery or attack. … Drug market participants know that violent acts are less likely to be reported, lowering the expected legal repercussions, thus lowering the expected loss of perpetuating violence. All these factors lead to an environment characterized by violence or the continuing threat of violence. Victims of this violence are usually drug users or dealers, but many times violent spillovers claim non-participating victims such as law enforcement officers and bystanders".

3. ECONOMETRIC METHODOLOGY

Unit Root Tests Without Structural Breaks

We start through testing for the presence of a unit root in crime rates using the ADF unit root test. To select the lag length (*k*), we use the 't-sig' approach proposed by Hall (1994). We set the maximum lag length equal to eight (k_{max}=8) and use the approximate 10 per cent asymptotic critical value of 1.60 to determine the significance of the *t*-statistic on the last lag. We do not increase the upper bound when $k = k_{max}$ is selected. To ensure the robustness of the ADF test results, we also apply the Phillips-Perron and DF-GLS test for unit roots. While the ADF test corrects for higher order serial correlation by adding lagged difference terms to the right-hand side, the Phillips Perron test makes a non-parametric correction to account for residual serial correlation. Monte Carlo studies suggest that the Phillips-Perron test generally has greater power than the ADF test (see e.g. Banerjee *et al.,* 1993). Elliot *et al.* (1996) show that the DF-GLS test has substantially improved power over the ADF test when an unknown trend is present.

LM Unit Root Test with One and Two Structural Break(s)

To examine the effect of structural break(s) on the null hypothesis of a unit root in crime rates, we employ the univariate LM test, which entails estimating the following equation:

$$\Delta CRIME_t = \kappa_i^{'} \Delta X_{it} + \delta_i \tilde{P}_{i,t-1} + o_{it} \qquad (1)$$

Here, $CRIME_t$ is the crime rate at time t, Δ is the first difference operator and following Schmidt and Phillips (1992) $\tilde{P}_{i,t-1}$ is the detrended value of $CRIME_{t-1}$. The term o_{it} is a stochastic disturbance term. If the specified crime rate has a unit root then $\delta_i = 0$, which is the null hypothesis tested against the alternative hypothesis that $\delta_i < 0$. To select the lag length we use Hall's (1994) 't sig' approach as described above.

Lee and Strazicich (2003a, b) expand Equation (1) to allow for one structural break in the intercept and one structural break in the slope. Lee and Strazicich (2003a, b) also propose a model that accounts for two structural breaks in the intercept and slope. A structural break in the model is incorporated by specifying X_{it}, which is a vector of exogenous variables defined by the data generating process as $[1, t, D_{it}]'$, where D_{it} is a dummy variable that denotes the time when a structural break occurs. If a break for a specified crime i occurs at TB_i, then the dummy variable $D_{it} = 1$ if $t > TB_i$, zero otherwise, and $DT_t = t - TB$ if $t > TB_i$, zero otherwise. In a similar vein, two structural breaks can be incorporated into the series by specifying X_{it} as $[1, t, D1_{it}, D2_{it}]'$, where $D1_{it}$ and $D2_{it}$ are dummy variables that capture the first structural break and the second structural break, respectively. Here, $DU1_t = 1$ if $t > TB1$, zero otherwise; $DU2_t = 1$ if $t > TB2$, zero otherwise, and $DT1_t = t - TB1$ if $t > TB1$, zero otherwise; and $DT2_t = t - TB2$ if $t > TB2$, zero otherwise. To determine the break point endogenously in each time series, Lee and Strazicich (2003a, b) suggest the "minimum LM" test. The "minimum LM" test involves using a grid search to determine the break at the location where the t-test statistic is minimized: $LM_{\tau i} = \underset{\lambda i}{Inf}\, \tilde{\tau}(\lambda_i)$, which is carried out at each combination of break points $\lambda = T_B / T$ over the trimming region (0.15T, 0.85T), where T denotes sample size. Critical values for the one break case are tabulated in Lee and Strazicich (2003b), while critical values for the two break case are tabulated in Lee and Strazicich (2003a).

Panel LM Unit Root Test

Consider the following model which tests for stationarity of a specific type of crime:

$$CRIME_{it} = \kappa_i' X_{it} + \mu_{it}, \qquad \mu_{it} = \lambda_i \mu_{i,t-1} + \varepsilon_{it} \qquad (2)$$

Here, i represents the cross-section of countries $(i = 1,...,N)$, t represents the time period $(t = 1,...,T)$, μ_{it} is the error term and X_{it} is a vector of exogenous variables. The test for the unit root null hypothesis is based on the parameter λ_i, while ε_{it} is a zero mean error term which allows for heterogeneous variance structure across cross-sectional units, but assumes no cross correlations. The parameter λ_i allows for heterogeneous measures of persistence. Structural breaks are incorporated into the model using the same criteria as in the univariate case. The panel LM test statistic is obtained by averaging the optimal univariate LM unit root t-test statistics for each country. This is denoted as LM_i^{τ}:

$$LM_{barNT} = \frac{1}{N}\sum_{i=1}^{N} LM_i^{\tau} \qquad (3)$$

Im *et al.* (2005) then construct a standardized panel LM unit root test statistic by letting $E(L_T)$ and $V(L_T)$ denote the expected value and variance of LM_i^{τ}, respectively under the null hypothesis. They then compute the following test statistic:

$$\psi_{LM} = \frac{\sqrt{N}\left[LM_{barNT} - E(L_T)\right]}{\sqrt{V(L_T)}} \qquad (4)$$

Im *et al.* (2005) provide the numerical values for $E(L_T)$ and $V(L_T)$. The asymptotic distribution is unaffected by the presence of structural breaks and is standard normal.

4. DATA AND EMPIRICAL RESULTS

Data

Annual time series data for aggregate total crime per 100,000 people as well as crime rates per 100,000 people for specific types of crime for the United States for the period 1960 to 2002 are from the Federal Bureau of Investigation, Uniform Crime Report, Index of Crime.[i] The specific types of crimes which we examine for the United States are assault, burglary, motor vehicle theft, murder, rape, robbery and theft as well as the generic categories, property and violent crimes. Annual time series data for aggregate total crime rates per 100,000 people as well as crime rates per 100,000 people for specific types of crime for the United Kingdom for the period 1898 to 1999 are from the British Home Office.[ii] The specific types of crime which we examine for the United Kingdom are burglary, criminal damage, fraud, robbery, sexual, theft and violent crime. Note that the British Home Office changed the manner in which it defined various crimes after 1999, meaning that the United Kingdom crime data is not comparable before and after 1999. The data on aggregate total crime rates per 100,000 people for each of the G7 countries for the period 1980 to 2002 are from the United Nations crime statistics.[iii]

Results for the United States

We begin through applying the ADF, Phillips-Perron and DF-GLS unit root tests to the aggregate crime rate as well as the nine specific types of crime for the United States for the period 1960-2002 in levels. The results are reported in Table 1. According to the ADF and Phillips-Perron unit root tests, the null of a unit root hypothesis cannot be rejected at conventional levels of significance for the levels of the crimes rates. However, when we subject the crime rates to the unit root tests on the first difference of the data, we are able to reject the unit root null hypothesis at the 10 per cent level or better. Thus, the ADF and Phillips-Perron unit root tests suggest crime rates in the United States are integrated of order one. However, for assault the result from the DF-GLS test differs from the ADF and Phillips-Perron tests, in that we are unable to reject the null of a unit root on the first difference of the assault series, implying that assault is in fact integrated of order two.

Insert Table 1

Failure to reject the unit root hypothesis using the ADF, Phillips-Perron and DF-GLS unit root tests may reflect the fact that these tests do not take into account potential structural breaks in the crime series. Thus, in Table 2, we report the results from the LM one break unit root test for the United States. In contrast to the results in Table 1, we are able to reject the unit root null hypothesis for three specific types of crime; namely, assault, violent crime and motor vehicle theft at the 5 per cent level of statistical significance. This finding is consistent with there being a natural rate for these three specific crimes, but crime hysteresis for aggregate total crime as well as the six other specific crimes.

For the crime categories other than rape, robbery and violent crime the coefficient on the intercept and/or slope for the structural break is statistically significant. The structural break occurs either in the mid-1970s for murder or the 1980s. The structural break for burglaries, homicides, theft and property crime more generally occur within a few years of the peak in each of these crime series in the United States. The homicide rate peaked at 10.2 per 100,000 in 1980; the burglary rate peaked at 1684 per 100,000 in 1980; the theft rate peaked at 3229 per 100,000 in 1991; and property crime peaked at 5140 per 100,000 in 1991. The structural break for assault and motor vehicle theft occurred in the early to mid 1980s, while these crimes peaked in the early 1990s. Since the early 1990s there has been a decline in crime in the United States across the board. Reasons offered for this decline include increases in the number of police, rising prison population, waning crack epidemic and legalization of abortion (Imrohoroglu *et al.,* 2004; Levitt, 2004).

Insert Table 2

It is possible that we would find evidence of a natural rate for the other series if we allowed for two structural breaks, but we do not attempt this for the United States because of the relatively short time span. Instead, we apply the LM unit root test with two structural breaks to the United Kingdom data, for which there is a longer time series.

Results for the United Kingdom

In Table 3, we report the results from the ADF, PP and DF-GLS tests for the United Kingdom for the aggregate total crime rate and the seven specific crime series. The ADF and Phillips-Perron unit root tests suggest that all series are integrated of order one. However, using the DF-GLS unit root test we are unable to reject the unit root null hypothesis for burglary, theft, violent crime and aggregate total crime, even when taking the first difference of these crime series This implies that based on the ADF, Phillips-Perron and DF-GLS unit root tests, none of the crime rate series in the United Kingdom are stationary and that they are either integrated of order one or order two

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Insert Table 3

In Table 4 we present the results for the LM unit root test with one structural break for the United Kingdom. We are able to reject the unit root null hypothesis for criminal damage and violent crime at the 5 per cent level or better. For those crime series for which there is a statistically significant structural break in the intercept and/or slope, the structural break either occurs in the late 1950s (violent crime), early to mid-1970s (criminal damage, theft and aggregate total crime), or late 1980s (burglary). The 1970s and 1980s was a period of rapid rise in crime in the United Kingdom and the structural break in the criminal damage and aggregate total crime series occurs around the beginning of sustained upswing in crime rate. The structural break in burglary rates in 1988 corresponds to the peak in this series in the late 1980s and early 1990s. The burglary rate in the United Kingdom has fallen since the early 1990s, which can possibly be explained by the increased prevalence of neighborhood watch schemes which were introduced in the early 1980s and have became widespread since the 1990s.

Failure to reject the unit root null hypothesis for the remainder of the crime rate series may be due to the presence of two structural breaks. We investigate this possibility by applying the LM two structural break unit root test. The results are reported in Table 5. We are able to reject the unit root null hypothesis for the total crime rate at the 1 per cent level as well as five of the seven specific crime series; namely, violent crime, robbery, burglary, theft and criminal damage, each at the 1 per cent level. The only crimes for which we cannot reject the null hypothesis of a unit root for the United Kingdom are fraud and sexual offences. For each crime series the second structural break has a statistically significant intercept and/or slope. For burglary and violent crime the location of the structural break in the one break case is close to the location of one of the breaks in the two break case, but this is not the case for the other crime series. For each of the crime series the second structural break occurs in the 1970s or 1980s, with five series including aggregate total crime in the second half of the 1980s during the period of rapid increase in crime in the United Kingdom under the Thatcher Conservative government.

Insert Tables 4 & 5

Results for the G7 Panel

In Table 6 we report the ADF, Phillips-Perron and the DF-GLS unit root test results for the total crime rate for the G7 countries over the period 1980-2002 for six of the seven G7 and 1980 to 1999 for the United Kingdom. The ADF, Phillips-Perron and DF-GLS unit root tests reject the unit root null hypothesis for the total crime rate in France, but suggest that the total crime rate in the other G7 countries is either integrated of order one or two. However, as is well-known, the ADF and Phillips-Perron tests have low power against stationary alternatives in small samples (see *e.g.* Cochrane, 1991; De-Jong *et al.,* 1992). Thus, in order to exploit the extra power in the panel properties of the data we applied the LM panel unit root test results with and without a structural break to the entire panel as well as smaller panels over the period 1980 to 1999 and 1980 to 2002.

Insert Table 6

We constructed four different panels. The first panel consists of all the G7 countries. Leon-Ledesma (2002), however, suggests that because the advantage of panel data unit root tests is that they provide higher power relative to univariate unit root tests, it is more meaningful to apply panel data tests to those series for which we cannot reject the null. Thus, the second panel is a 'unit root six' consisting of the G7 countries, excluding France. The third panel consists of the G7 countries with a civil law system (France, Germany, Italy and Japan), while the fourth panel consists of the G7 countries which have a common law system (Canada, the United Kingdom and the United States).

The reason for constructing different panels for common law and civil law countries is that the institutional arrangements in the two systems differ and this potentially has implications for optimal law enforcement. Civil law countries have codified law, limited jurisprudence and centralized judicial systems relative to common law countries whose legal systems are characterized by a collection of disparate doctrines largely judge-made in a decentralized fashion. These different institutional arrangements mean that in civil law countries there is less complexity and less uncertainty of information relative to common law countries (Garoupa, 2005). However, as Garoupa (2005) notes, the effect of different levels of certainty, complexity and information on law enforcement is unclear. Complexity and uncertainty could increase deterrence, allowing governments to save on enforcement costs if, for instance, criminals were averse to uncertainty. On the other hand, if the social costs of mistakes in estimating legal policy instruments increases more with the sanction than the probability of detection, uncertainty might lead the government to reduce the sanction and increase the likelihood of detection leading to higher enforcement costs. There is some empirical evidence that deterrence to commit harmful acts differ between civil law and common law countries. Smith (2003) examines differences in various types of fatalities including motor vehicle deaths between civil law and common law countries and finds lower fatality rates in common law countries.

Insert Table 7

The results of the LM panel data tests are reported in Table 7. For all four panels, with the panel LM test without a structural break, the test statistics are all greater than the critical values at the conventional levels of significance, implying that we cannot reject the joint unit root null hypothesis. However, when we include a structural break in the LM unit root test for the four panels, we are able to reject the joint unit root null hypothesis, as each test statistic is smaller than the critical value at the 1 per cent level.

5. DISCUSSION OF RESULTS

Overall, the results provide strong support for the hypothesis that there is a natural rate of crime. At first blush, we appear to find less support for the natural rate of crime hypothesis in the United States than the United Kingdom. However, this conclusion is misleading. Comparing the results from the LM unit root one break test, we actually find more support for the natural rate hypothesis in the United States than the United Kingdom. In the one break case there is support for the natural rate hypothesis in the United States for three crime series (assault, motor vehicle theft and violent crime) relative to two crime series in the United Kingdom (criminal damage and violent crime). It is only when we allow for two structural breaks in the LM unit root test for the United Kingdom, that we are able to reject the unit root null hypothesis for each crime series except fraud and sexual offences. This result suggests that the failure to reject the unit root null for the United States for more crime series is likely to reflect the fact that we only allow for one structural break in the LM unit root test in the United States case because of the shorter time series span. If we had a longer time series which permitted us to allow for two structural breaks, we would most likely find more support for the natural rate of crime hypothesis for the United States. The importance of allowing for structural breaks is also highlighted by the G7 panel data tests. With the LM panel data test without a structural break we were unable to reject the natural rate hypothesis for any of the panels, but allowing for a structural break we find support for the natural rate of crime hypothesis for the full panel as well as the smaller common law and civil law panels.

As discussed above, Buck *et al.* (1983, 1985) stated the natural rate of crime hypothesis in terms of blue collar property crime for which they argued that there is a pool of potential offenders who experience long run diminishing marginal returns to legitimate earning opportunities. In the one break LM unit root case the only property crime for which there is a natural rate in the United States is motor vehicle theft, while criminal damage has a natural rate in the United Kingdom. The results for criminal damage are surprising in the sense that while criminal damage is a form of property crime, it is unlikely to be profit motivated as burglary, robbery or theft. The results for criminal damage, however, are consistent with the sociological argument in Buck *et al.* (1985, pp. 257-258) that economic and social tensions within local communities produce a pool of individuals who “possess or who have developed demoralization costs towards society” which make them detached from society and whose frustration is exhibited in destructive behavior.

The series which has a natural rate in the LM one break case in both the United States and United Kingdom is violent crime. While we do not test for drug crime because of lack of data, to the extent that drug crime and violent crime are correlated, the results for violent crime are consistent with the argument that the high pecuniary returns to drug crime mean that drug crime will be unaffected in the long-run by conventional police expenditures. In the two break case for the United Kingdom the results for burglary, robbery and theft are consistent with Buck *et al.’s* (1983, 1985) basic thesis about blue collar property crime. In the two break case for the United Kingdom we are unable to reject the unit root null hypothesis for fraud or sexual offences. This result is expected because while fraud is a property crime, it is a white collar crime committed by those who have high returns to legitimate earning opportunities, rather than those in Buck *et al.’s* (1983, 1985) pool of hard-core criminals who have few prospects and whose marginal benefits of an additional unit of time in legal activity are diminishing. Similarly, sexual offences are not profit motivated and, in contrast to other forms of violent crime are unlikely to be committed in the act of carrying out blue collar property crime.

The implications for the deterrence hypothesis from our results, at least for the United Kingdom and G7 panel is that for aggregate total crime and most specific types of crime increased expenditure on law enforcement will have no effect on the long-run equilibrium level of crime. This provides an economic explanation for those studies employing an Ehrlich (1973) 'supply of offences' function which have failed to find evidence of a deterrence effect. Neoclassical economics suggests that fiscal and monetary policies cannot lower the long-run unemployment level below its natural rate and instead it is necessary to address the root cause of unemployment in the form of policies such as better information on labor market demands, vocational training and anti-discrimination measures. In a similar vein, the policy implications of the findings in this study lend support to the argument often made by criminologists that governments should reconsider allocating resources from crime prevention to crime corrective measures which address the causes of criminal motivation rather than the symptoms. This approach involves addressing, in the language of Buck *et al.* (1983, p. 480) "the social and economic structural profiles …. [which] dictate the [natural rate of crime]". This entails adopting a suite of policies including education and income policies for disadvantaged families as well as policies designed to rehabilitate ex-offenders (see Friedman *et al.,* 1989, p. 190).

6. CONCLUSION

Studies which have utilized an Ehrlich (1973) supply of offences function have reached mixed conclusions on the deterrence hypothesis. This outcome has led some researchers to offer reasons why, within an economic framework, increased expenditure on crime need not lead to a reduction in crime rates. One such explanation is the concept of a natural rate of crime which suggests that there is no deterrent effect in the long run. This paper has applied the unit root testing methodology which has been widely employed in the labor market literature to examine whether there is a natural rate of unemployment to investigate whether there is a natural rate of crime. To do this we utilize the LM unit root test with structural breaks, which has the advantage that it is unaffected by breaks under the null. Our main finding from the LM unit root test with two breaks applied to the United Kingdom data and panel LM unit root test with one break applied to various panels of G7 countries is that there is a natural rate of crime. The policy implications of our results is that instead of spending more on law enforcement which will have no effect on the long-run crime rate, governments should consider policies which affect the economic and social structural factors which determine the crime rate in the long run.

We have allowed for at most two structural breaks. Given our finding that most crime series are breakpoint stationary, one avenue for future research would be to test for the presence of multiple structural breaks using the method proposed by Bai and Perron (1998). The Bai and Perron (1998) method can be applied to test for, and estimate, multiple structural changes in non-trending data once regime-wise stationarity has been established. The Bai and Perron (1998) method requires a long time series, but it could be applied for instance to the crime data for the United Kingdom. One could extend on the results from the Bai and Perron (1998) method, using the approach pioneered by Caporale and Grier (2000) to examine political influences on interest rates, to investigate the effects of changes in government policies on movements in the crime rate. For instance, one could examine the effects of gender differences on the natural rate of crime, based on changes in equal opportunity policies with successive governments.

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Table 1: ADF, Phillips-Perron and ADF-GLS tests for the United States 1960-2002

	ADF Test			PP Test			DF(GLS) Test		
	Levels	First Differences		Levels	First Differences		Levels	First Differences	
Assault	-1.458 (2)	-3.703 (0)**	I(1)	0.392 (3)	-3.557(1)**	I(1)	-2.216(2)	-2.202(1)	I(2)
Murder	-1.706 (1)	-3.750 (0)**	I(1)	-0.777 (2)	-3.607(4)**	I(1)	-1.737(1)	-3.483(0)**	I(1)
Burglary	-0.994 (2)	-6.016 (1) *	I(1)	-0.763 (10)	-4.200 (4)*	I(1)	-1.835(5)	-5.570 (1)*	I(1)
MVT	-2.220 (1)	-3.227 (0) ***	I(1)	-1.065 (3)	-3.205(4)***	I(1)	-2.184(1)	-3.153 (0)***	I(1)
Property	0.135 (2)	-6.996 (1)*	I(1)	0.630 (0)	-4.047(19)**	I(1)	-0.823 (3)	-6.318 (1)*	I(1)
Rape	-0.959 (1)	-4.630 (2)*	I(1)	0.199 (4)	-3.316(18)***	I(1)	-1.415 (1)	-3.556 (0)**	I(1)
Robbery	-0.566 (2)	-4.833 (1)*	I(1)	-0.538 (3)	-3.640(19)**	I(1)	-1.660 (1)	-4.551 (1)*	I(1)
Theft	0.536 (2)	-6.828 (1)*	I(1)	-2.053 (4)	-4.468(17)*	I(1)	-0.323 (2)	-6.333 (1)*	I(1)
Violent	-0.796 (1)	-3.625 (0) **	I(1)	0.417 (1)	-3.252(9)***	I(1)	-1.409 (1)	-3.442 (0)**	I(1)
Total	0.334 (2)	-6.790 (1)*	I(1)	0.735 (18)	-4.067(20)**	I(1)	-0.874 (3)	-6.097(1)*	I(1)

Note: All calculations use trend & intercept. MVT is 'motor vehicle theft'. Figure in parenthesis is lag length/bandwidth. Bandwidth for Phillips-Perron test is based on Newey West using Bartlett Kernel. Critical values for the ADF and Phillips-Perron unit root tests are compiled from MacKinnon (1991). Critical values for the DF(GLS) test are from Elliot *et. al.* (1996). *=1%; **=5%; ***=10%.

Table 2: Lee and Strazicich (2003a) one break test for the United States 1960-2002

	Violent	Property	Murder	Rape	Robbery
TB	1983	1988	1976	1983	1983
α	-0.3595**	-0.2503	-0.4048	-0.3276	-0.3818
	(-4.7485)	(-3.5438)	(-4.0643)	(-3.5529)	(-4.1574)
T	25.8221*	257.787*	0.2240**	0.8728*	11.8466*
	(5.6279)	(5.7068)	(2.1970)	(3.3798)	(4.6975)
$B(t)$	-20.2816	228.735***	0.7922**	0.8337	-14.5935
	(-0.9366)	(1.7913)	(2.2206)	(0.7530)	(-1.2296)
$D(t)$	13.0829	-363.614*	0.0787	0.3673	-4.7105
	(1.4302)	(-6.903)	(0.4566)	(0.6271)	(-1.1961)
k	5	5	5	5	5
	Assault	Burglary	Theft	MVT	Total
TB	1985	1981	1988	1982	1982
α	-0.4895**	-0.4355	-0.2842	-0.2842***	-0.3319
	(-6.0994)	(-3.9232)	(-3.1942)	(-4.3203)	(-3.8118)
T	9.1630*	52.2482*	144.599*	31.1317*	249.333*
	(4.9906)	(4.7994)	(5.5057)	(5.0723)	(6.5773)
$B(t)$	-4.3788	-80.7280	137.932	-50.360*	-291.137**
	(-0.4630)	(-1.5685)	(1.6264)	(-2.4380)	(-1.9205)
$D(t)$	24.6494*	-94.8541*	-187.470*	188.240	-135.071**
	(4.0391)	(-6.1748)	(-6.1310)	(-0.3087)	(-2.434)
k	5	1	5	4	5

Notes: λ_j denotes the location of breaks. * (**) *** denote statistical significance at the 1%, 5% and 10% levels respectively. TB is the break date, α is the coefficient on the unit root parameter, T is the coefficient on the time trend, $B(t)$ is the coefficient on the break in the intercept, $D(t)$ is the coefficient on the break in the slope, and k is the optimal lag length. Critical values for the LM one break unit root test statistic are tabulated in Lee and Strazicich (2003b)

Table 3: ADF, Phillips-Perron and ADF-GLS tests for the United Kingdom, 1898-1999

	ADF Test			PP Test			DF(GLS) Test		
	Levels	First Differences		Levels	First Differences		Levels	First Differences	
Burglary	-2.196 (7)	-3.149 (8)***	I(1)	-1.454 (8)	-6.023 (4)*	I(1)	-1.624 (1)	-1.486 (8)	I(2)
Crim. dam.	0.355 (0)	-7.912 (0)*	I(1)	-0.002 (4)	-7.826(2)*	I(1)	-0.812 (2)	-7.641 (0)*	I(1)
Fraud	-0.071 (1)	-7.019 (0)*	I(1)	-1.862 (4)	-7.005 (2)*	I(1)	-1.519 (1)	-7.091 (0)*	I(1)
Robbery	9.808 (8)	-0.0709 (8)	I(2)	0.7843 (1)	-7.677 (1)*	I(1)	-1.016 (3)	-3.705 (2)*	I(1)
Sexual	-1.613 (0)	-8.837 (0)*	I(1)	-1.940 (6)	-8.827 (1)*	I(1)	-0.838 (0)	-8.905 (0)*	I(1)
Theft	0.212 (6)	-2.685 (8)	I(2)	-1.629 (3)	-5.411(9)*	I(1)	-0.963 (2)	-1.615 (8)	I(2)
Violent	1.409 (7)	-1.929 (6)	I(2)	4.660 (5)	-10.086(6)*	I(1)	-1.862 (6)	-1.461 (6)	I(2)
Total	-1.518 (1)	-2.326 (8)	I(2)	-1.195(3)	-5.852(5)*	I(1)	-1.120 (1)	-1.143 (8)	I(2)

Note: All calculations use trend & intercept. Crim. dam. Is ‘criminal damage’. Figure in parenthesis is lag length/bandwidth. Bandwidth for Phillips-Perron test is based on Newey West using Bartlett Kernel. Critical values for the ADF and Phillips-Perron unit root tests are compiled from MacKinnon (1991). Critical values for the DF(GLS) test are from Elliot *et. al.* (1996). *=1%; **=5%; ***=10%

Table 4: Lee and Strazicich (2003a) one break test for the United Kingdom, 1898-1999

	Violent	Sexual	Robbery	Burglary	Theft	Fraud	criminal damage	Total
TB	1958	1921	1965	1988	1972	1946	1975	1972
α	-0.2405**	-0.1283	-0.2228	-0.0783	-0.1295	-0.3066	-0.4259*	-0.1303
	(-4.5077)	(-3.4424)	(-3.1783)	(-2.7841)	(-3.0689)	(-3.5911)	(-6.2161)	(-3.021)
T	-801.052	37.254	-297.217	-9259.64	-24139.8***	222.365	-15813.4*	-46343***
	(-1.410)	(0.2119)	(-1.235)	(-1.1989)	(-1.7245)	(0.2896)	(-4.3393)	(-1.767)
$B(t)$	-27.231**	116.645	818.760	23440.54	-102534.2***	3611.31	-102611*	-248453**
	(-0.0070)	(0.1537)	(0.4654)	(0.5379)	(-1.6315)	(0.7230)	(-4.1363)	(-2.054)
$D(t)$	1816.453	89.806	256.143	39854.44**	121287.6*	762.94	124884*	257056*
	(1.6361)	(0.430)	(0.4494)	(2.0742)	(4.1074)	(0.6825)	(8.2067)	(4.693)
k	8	5	8	8	6	6	8	8

Critical values for the LM test

λ	1 per cent	5 per cent	10 per cent
0.1	-5.11	-4.50	-4.21
0.2	-5.07	-4.47	-4.20
0.3	-5.15	-4.45	-4.18
0.4	-5.05	-4.50	-4.18
0.5	-5.11	-4.51	-4.17

Notes: See notes to Table 2

Table 5: Lee and Strazicich (2003b) two break test for the UK

	Violent	Sexual	Robbery	Burglary	Theft	Fraud	Criminal damage	Total
$TB1$	1956	1940	1958	1958	1959	1953	1969	1960
$TB2$	1986	1974	1979	1988	1987	1974	1988	1988
α	-0.622*	-0.290	-2.165*	-0.771*	-0.556*	-0.754	-0.872*	-0.698*
	(-8.203)	(-4.537)	(-6.979)	(-7.883)	(-7.475)	(-5.20)	(-7.734)	(-7.874)
T	1765.1*	-51.463	-1332.8*	-21144*	-47204*	-3763*	-506.1	-111138*
	(-3.777)	(-0.414)	(-4.979)	(-4.022)	(-4.688)	(-3.509)	(0.201)	(-5.436)
$B1(t)$	3992.1	-242.55	293.55	-48607.7	-3828.3	3119.4	-25328	-64584
	(1.338)	(-0.318)	(0.211)	(-1.472)	(-0.071)	(0.616)	(-1.203)	(-0.631)
$B2(t)$	-2821.1	-576.39	-1584.4	130452*	-302639*	11527**	-63540**	-267454**
	(-0.815)	(-0.684)	(-1.034)	(-3.175)	(-4.786)	(2.301)	(-2.609)	(2.144)
$D1(t)$	-710.14	1158.2*	59.902	49951*	56921*	-873.1	29042*	144649*
	(-0.826)	(5.043)	(0.1653)	(6.074)	(4.600)	(-0.596)	(5.303)	(5.941)
$D2(t)$	18279.7*	-1514.2*	4491.2*	171111*	189250*	2780.1**	87583*	518892*
	(8.850)	(-4.025)	(8.648)	(6.653)	(5.259)	(-1.886)	(5.839)	(6.375)
k	8	5	7	5	5	8	5	5

Critical values for the LM test

	λ_2								
λ_1	0.4			0.6			0.8		
	1%	5%	10%	1%	5%	10%	1%	5%	10%
0.2	-6.16	-5.59	-5.27	-6.41	-5.74	-5.32	-6.33	-5.71	-5.33
0.4	-	-	-	-6.45	-5.67	-5.31	-6.42	-5.65	-5.32
0.6	-	-	-	-	-	-	-6.32	-5.73	-5.32

Notes: λ_j denotes the location of breaks. * (**) *** denote statistical significance at the 1%, 5% and 10% levels respectively. $TB1$ and $TB2$ are the first and second breaks, respectively, α is the coefficient on the unit root parameter, T is the coefficient on the time trend, $B1(t)$ and $B2(t)$ are the coefficients on the first break and second break, respectively, in the intercept, $D1(t)$ and $D2(t)$ are the coefficients on the first break and second break, respectively, in the slope, and k is the optimal lag length.

Table 6: ADF, Phillips-Perron and ADF-GLS tests for G7 Total Crime 1980-2002

	ADF Test			PP Test			DF(GLS) Test		
	Levels	First Differences		Levels	First Differences		Levels	First Differences	
Canada	-1.026 (0)	-2.038 (8)	I(2)	-1.237 (2)	-2.967 (0)	I(2)	-1.237 (2)	-2.967 (0)	I(2)
France	-3.555 (0)***		I(0)	-3.548 (1)***		I(0)	-3.549(1)***		I(0)
Germany	-1.785 (1)	0.706 (8)	I(2)	-1.557 (0)	-3.929 (3)**	I(1)	-1.557 (0)	-3.929 (3)**	I(1)
Italy	-1.764 (0)	-6.993 (8)*	I(1)	-1.764 (0)	-3.720 (2)**	I(1)	-1.764 (0)	-3.720 (2)**	I(1)
Japan	-2.167 (7)	-3.577(7)***	I(1)	0.406 (2)	-3.247 (1)***	I(1)	0.406 (2)	-3.247 (1)***	I(1)
USA	-1.043 (8)	-4.303 (8)**	I(1)	-1.400 (1)	-3.721 (0)**	I(1)	-1.400 (1)	-3.721(0)**	I(1)
UK	-1.875 (1)	-2.686 (1)	I(2)	-0.835 (1)	-2.416 (1)	I(2)	-0.835 (1)	-2.416 (1)	I(2)

Note: All calculations use trend & intercept. Figure in parenthesis is lag length/bandwidth. Bandwidth for Phillips-Perron test is based on Newey West using Bartlett Kernel. Critical values for the ADF and Phillips-Perron unit root tests are compiled from MacKinnon (1991). Critical values for the DF(GLS) test are from Elliot *et. al.* (1996). *=1%; **=5%; ***=10%.UK figures are for 1980-1999 and for UK k_{max}=4.

Table 7: LM Panel unit root test results

Panels	LM test with no break	LM test with one break
G7	-0.720	-4.724*
G6 (G7 minus France)	-0.591	-4.183*
G4 (Civil Law Panel – France, Germany, Italy, and Japan)	0.055	-2.817*
G3 (Common Law Panel – US, UK, and Canada)	-1.177	-3.916*

Note: * denotes statistical significance at the 1% level. The 1%, 5% and 10% critical values for the panel LM test with and without a structural break are –2.326, -1.645 and –1.282, respectively.

NOTES

[i] Source: http://www.fbi.gov/ucr/02cius.htm; http://www.fbi.gov/ucr/cius_02/xl/02tbl01.xls
[ii] Source: http://www.homeoffice.gov.uk/rds/pdfs/100years.xls
[iii] Major Source: www.unodc.org/pdf/crime/ sixthsurvey/TotalRecordedCrime.pdf