Economic Modelling xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Intervention time series analysis of crime rates: The case of sentence reform in Virginia

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ARTICLE INFO

Article history:
Accepted 16 February 2016
Available online

Keywords:
Crime rates
Structural time series models
Outliers
Breaks

ABSTRACT

We review the basic concepts of intervention analysis in the context of structural time series models and we apply this methodology to investigate the possible reduction in monthly crime rates reported from January 1984 up to and including December 2010 after Virginia abolished parole and reformed sentencing in January 1995. We find that the change in legislation has significantly reduced the burglary rates and to a lesser extent the murder rates in Virginia. The robustness of our results is investigated with an automatic detection of breaks procedure as well as with analyses of quarterly rather than monthly data.

1. Introduction

The contributions of Levitt (2001) and Cantor and Land (2001) have prompted an active and interesting debate on effective intervention time series analysis. These discussions have become more prominent given the increasing interest in the effects of policy changes by governments promoting different crime-prevention programs. Different approaches to intervention time series analysis have been adopted in the evaluation of programs and policies in a number of criminal justice settings (McCleary and Hay,1980; McDowall et al.,1980; Orwin,1997). The standard approach to time series analysis in this framework aims at discriminating between the behaviour of the time series prior to the intervention and after the intervention. In other words, "given a known intervention, is there evidence that change in the series of the kind expected actually occurred, and, if so, what can be said of the nature and magnitude of the change," (Box and Tiao, 1975). From the effective crime policy perspective it is important to assess whether a known intervention (policy change) has had the intended effect. For example, it is important to know whether an increased reliance on prisons, an increased number of police, tougher gun control laws, and innovative criminal justice programs and policies reduce crime rates and deter potential criminals from committing crimes.

In this paper we investigate the impact of parole abolition and sentence reform in Virginia on crime rates reported from January 1984 up to and including December 2010. The crime rate series examined are monthly data on burglary, larceny, motor vehicle theft, robbery, aggravated assault, murder, and rape. The Commonwealth of Virginia abolished parole and reformed sentencing for all felony offences committed on or after January 1, 1995. This law was passed in a special legislative session in the autumn of 1994. Parole abolition was accompanied with substantially enhanced sentences for violent offenders.[1] Visual inspection of the crime time series analysed in this paper (Figs. 1 and 2) shows that most of them are declining from about the same time that Virginia enacted these major legislative initiatives to reduce violent crime. However, research to date is unable to determine if these reductions in crime rates are due to specific anti-crime initiatives.[2] Reductions have occurred in the types of crimes that were targeted by these initiatives, indicating that they may have had their intended effect.

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[1] Virginia Criminal Sentencing Commission (1995), Annual Report, Virginia Criminal Sentencing Commission, Richmond, VA.
[2] Crime in the Commonwealth, 1988–1998.

http://dx.doi.org/10.1016/j.econmod.2016.02.017
0264-9993/

To examine the impact of Virginia's abolition of parole on crime rates, we consider different empirical approaches to the intervention analysis. First, we adopt a univariate structural time series approach to the intervention analysis of time series data, which are serially correlated, often non-stationary, and with strong seasonal and/or cyclical effects. Second, in order to address the problem of confounding variables, we apply the approach of Harvey (1996) and estimate multivariate structural time series models with control groups. Finally, the robustness of our results is investigated with an automatic detection of breaks procedure, as well as with analyses of quarterly rather than monthly data, thus showing that our results are independent of a particular time series method applied or the data frequency used.

The contribution of our paper to the existing literature is threefold. Policy changes that increase the expected punishment per crime can lead to both greater deterrence and greater incapacitation. The empirical evidence which links increased punishment with lower crime rates is consistent.[3] According to Levitt and Dubner (2005), increases in the prison population account for roughly one-third of the drop in crime in the US. However, most empirical tests on deterrence do not differentiate between the effect of deterrence and of incapacitation. Short-run declines in crime are likely to be attributable to deterrence, whereas the incapacitation effect of sentence enhancements will occur only in the long-run (Kessler and Levitt, 1999). In the case of Virginia, the 1994 legislation abolishing parole and establishing a truth-in-sentencing system was a single, most significant factor affecting the size of the prison population. Although it took time for the longer prison sentences imposed under the 1994 sentencing reform to have a significant growth effect on Virginia's prison population, decrease in the parole grant rate had an almost immediate effect on the size of the prison population.[4] By looking at changes in crime immediately after the introduction of a sentence reform in Virginia, we hope to isolate a pure deterrent effect of the new legislation that is not contaminated by the effect of incapacitation. Hence, to the extent that severity of punishment serves as a deterrent to committing crimes in the short run, we would expect the reported crimes to drop especially for the violent offences. Disentangling deterrence and incapacitation effects of the introduced sentence reform in Virginia is the first contribution of our paper.

Our sample includes the 1990 to 1999 period when considerable social and economic changes occurred in the United States. There were declines in crime trends throughout the US during this decade. Furthermore, the second half of the 1990s was an economically prosperous period for the US. For example, unemployment rates declined sharply through most of this period. It was also a period in which a number of innovative criminal justice programs and policies were enacted both at the state level and at the local communities level. Favourable changes in patterns of drug use and access to guns were put in place. These factors could serve as alternative explanations for the decline in crime throughout the US in general, and Virginia in particular. Disentangling the impact of parole abolition on crime rates in Virginia from these other factors poses a considerable methodological challenge. We endeavour to tackle this problem of confounding variables by applying the approach of Harvey (1996) and estimating multivariate structural time series models with control groups. Understanding better the statistical relationship between Virginia anti-crime efforts and crime reductions over time in the presence of confounding variables is the second contribution of our paper.

Structural time series models may provide an effective approach to the modelling of interventions. The structural approach to time series analysis was popularized by Harvey (1989), Commandeur and Koopman (2007), and Durbin and Koopman (2012), and has been applied in various policy and intervention analysis applications. For example, Harvey and Durbin (1986) investigate the effects of the introduction of the seat belt law in 1983 in Great Britain on the number of car drivers killed and seriously injured. Harvey (1996) analyses the effects of the same British seat belt legislation using a multivariate structural time series framework with control groups. Balkin and Keith Ord (2001) investigate the relationship between speed limit increases and traffic-related fatalities in the US.

The structural time series approach has not been used extensively in crime data analysis.[5] To our knowledge, the structural time series methodology applied to crime data is carried out by Harvey and Fernandes (1989) and Atkinson et al. (1997), who look at the number of outliers and breaks in the monthly number of purse (handbag) snatches in Hyde Park in Chicago. Koopman et al. (2008) model recidivism behaviour of juveniles from a Dutch judicial juvenile institution, using a non-Gaussian structural time series model. Nunley et al. (2011b) examine the impact of inflation, unemployment, and stock market growth on a battery of property crime rates in the U.S. over the period from 1948 to 2009. The authors use the structural time series approach in order to circumvent the problem associated with omitted variable bias. Finally, Vujić et al. (2012) model cyclical behaviour in property crime series (burglary and theft) in relation to the macroeconomic activity indicators in England and Wales in the period from 1955 to 2001. This paper extends further the structural intervention time series approach to the crime data analysis. We consider this to be the third contribution of our paper.

The paper is organised as follows. In Section 2 we describe the data used in the analysis. The structural time series models for intervention analysis used in this paper are discussed in Section 3. The empirical results of the investigation of the effects of parole abolition and sentence reform on the crime rates in Virginia are presented in Section 4. In Section 5 we provide a discussion of our methodological approach in the context of other intervention approaches and we provide some evidence of the robustness of our findings. Section 6 concludes the paper.

2. Data description

A major crime sentence reform in Virginia was proposed during the 1993 campaign of George Allen running for Governor. A key element of the campaign was to reduce the disparity between the sentence imposed in court and the actual time-served. This reform abolished parole, established a guidelines-based truth-in-sentencing

[3] See for example Ehrlich (1973), Grogger (1991), Kessler and Levitt (1999), Levitt (1997), and Marvell and Moody (1994,1996).

[4] For example, between 1990 and 1993, Virginia's annual parole grant rate averaged about 41% (i.e., about four out of ten prisoners eligible for parole were granted parole). The parole grant rate began to decline in 1993, and by the end of 1994 it dropped to about 14%. After the parole system was abolished in 1994, the grant rate remained below 20% (Crime in the Commonwealth, 1988–1998). Further, sentencing reform applied to virtually all felony convictions, while repeated violent offenders had to spend from two to more than five times longer in prison than under the parole system.

[5] Existing literature on crime macroeconomics often applies univariate error correction models (ECM), vector autoregression (VAR) and vector error correction (VECM) models. Some of the time series references using the UK data are Pyle and Deadman (1994), Dhiri et al. (1999), Hale and Sabbagh (1991). Examples of papers using the U.S. data are Greenberg (2001), O'Brien (1999), Corman et al. (1987), Cappell and Sykes (1991), Witt and Dryden Witte (1998), Saridakis (2004), and Nunley et al. (2011a). For Switzerland, examples of papers which analyse crime rates using a time series approach are papers by Funk and Kugler (2003a) and Funk and Kugler (2003b). Interesting and recent empirical time series research on crime rates for Japan is carried out by Halicioglu et al. (2012) and for China by Cheng and Smyth (2015). Estimation results in most of these papers are based on the cointegration modelling approach, which assumes a stable long-run relationship between crime and underlying explanatory variables. An exception is a paper by Cappell and Sykes (1991), who base their results on the autoregressive integrated moving average (ARIMA) time series approach to modelling crime.

Please cite this article as: S. Vujić, et al., Intervention time series analysis of crime rates: The case of sentence reform in Virginia, Economic Modelling (2016), http://dx.doi.org/10.1016/j.econmod.2016.02.017