Cycles of violence, and terrorist attacks index for the State of Arkansas

Gómez-Sorzano, Gustavo
LeasingMetrix Group, Inc

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Cycles of Violence, and Terrorist Attacks Index for the State of Arkansas

By Gustavo Alejandro Gómez-Sorzano*

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Abstract: I apply the Beveridge-Nelson business cycle decomposition method to the time series of per capita murder in the State of Arkansas. (1933-2005). Separating out "permanent" from "cyclical" murder, I hypothesize that the cyclical part does not coincide with documented waves of organized crime, internal tensions, crime legislation, social, and political unrest, and with the periodic terrorist attacks to the U.S. The estimated cyclical component of murder shows that terrorist attacks against the U.S. have not affected Arkansas, presenting this State as immune to the suffering of the nation, and to the occurrence of attacks. This paper belongs to the series of papers helping the U.S, and Homeland Security identify the closeness of terrorist attacks, and constructs the attacks index for Arkansas. Other indices constructed include the Index for the U.S. http://mpra.ub.uni-uenchen.de/1145/01/MPRA_paper_1145.pdf, New York State http://mpra.ub.uni-muenchen.de/3776/01/MPRA_paper_3776.pdf, New York City http://mpra.ub.uni-muenchen.de/4200/01/MPRA_paper_4200.pdf, Arizona State http://mpra.ub.uni-muenchen.de/4360/01/MPRA_paper_4360.pdf, Massachusetts State http://mpra.ub.uni-muenchen.de/4342/01/MPRA_paper_4342.pdf., California http://mpra.ub.uni-muenchen.de/4547/01/MPRA_paper_4547.pdf., Washington http://mpra.ub.uni-muenchen.de/4604/01/MPRA_paper_4604.pdf. , and Ohio http://mpra.ub.uni-muenchen.de/4605/01/MPRA_paper_4605.pdf. These indices must be used as dependent variables in structural models for terrorist attacks and in models assessing the effects of terrorism over the U.S. economy.

Keywords: A model of cyclical terrorist murder in Colombia, 1950-2004. Forecasts 2005-2019; the econometrics of violence, terrorism, and scenarios for peace in Colombia from 1950 to 2019; scenarios for sustainable peace in Colombia by year 2019; decomposing violence: terrorist murder in the twentieth in the United States; using the Beveridge and Nelson decomposition of economic time series for pointing out the occurrence of terrorist attacks; decomposing violence: terrorist murder and attacks in New York State from 1933 to 2005; terrorist murder, cycles of violence, and terrorist attacks in New York City during the last two centuries.

JEL classification codes: C22, D74, H56, N42, K14, K42, N42, O51.

alexgosorzano@yahoo.com, Gustavo.gomez-sorzano@reuters.com
Econometrician M.Sc., Research Analyst for Reuters, U.S. The opinions expressed do not compromise the company for which I currently work.

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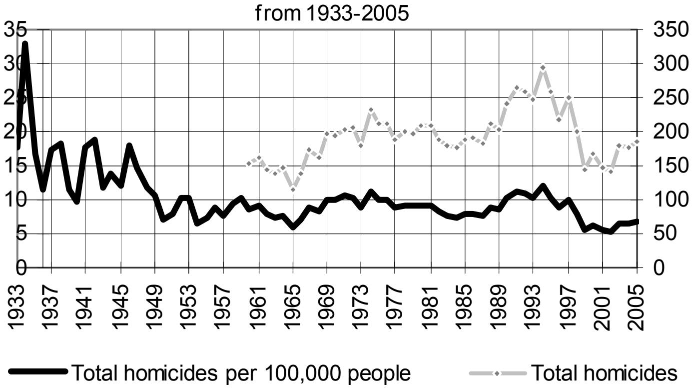
1. Introduction.

After decomposing violence, and creating the cyclical terrorist murder and attacks index for the United States (Gómez-Sorzano 2006), and *terrorist murder, cycles of violence, and terrorist attacks in New York City during the last two centuries* (Gómez-Sorzano 2007B), this paper continues that methodology research applied at the State level. The current exercise for Arkansas State is the seventh one at decomposing violence at the state level on the purpose of constructing murder and attacks indexes preventing the closeness of attacks or tragic events. This research shows that the estimated cyclical component of murder as shown on figure 8 is stable pointing out Arkansas as one the safest place across the nation.

According to the Federal Bureau of Investigation, Uniform Crime Reporting System, total homicides in Arkansas State increased from an average of 153 per year in the 1960s to 203 in the 1970s, 193 in the 1980s, and 238 in the 1990s (Fig. 1), for year 2005 the State reported 186 homicides.

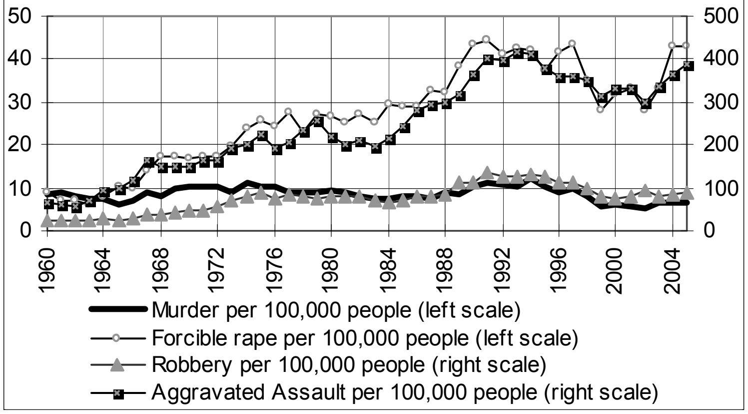
When adjusted for population growth, i.e., homicides per 100,000 people in the population, peaks are found in 1934, 1942, 1946, 1952, 1971, 1974, 1991, and 1994 with values of 32.9 murders per capita, and 18.7, 17.8, 10.3, 10.4, 11.2, 11.1, and 12 respectively for those years, and 6.70 for 2005.

Figure 1. Total homicides, in Arkansas State from 1933-2005



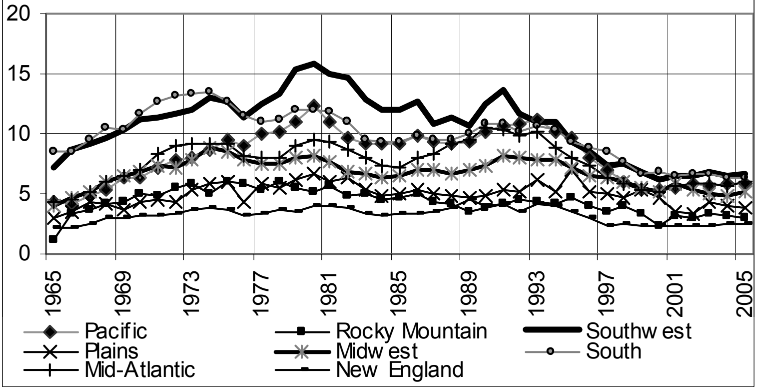
Out of the state's four categories of crimes, measuring violent crime (murder, forcible rape, robbery, and aggravated assault) murder is the one that varies the less showing a slight growing tendency recently (Fig. 2).

Figure 2. Categories of violent crime in Arkansas State



Although the U.S., murder rates appear stabilizing during the last years, the highest per capita rates are found in the southwest and, south regions with 6.67 and 6.39 per capita, the South region where Arkansas belongs appears as the second highest rate across the nation with a rate of 6.39 for 2005 (Fig. 3).

Figure 3. Murder per capita rates per 100,000 across regions of the U.S.



2. Data and methods

The Bureau of Justice Statistics has a record of crime statistics that reaches back to 1933, (for this analysis I use the murder rates per 100,000 people[1]). As is known, time series can be broken into two constituent components, the permanent and transitory component. I apply the Beveridge-Nelson (BN for short 1981) decomposition technique to the Arkansas State series of per capita murder.

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[1] Taken from FBI, Uniform Crime Reports.

Beveridge and Nelson decomposition

I use the augmented Dickey Fuller (1981), tests to verify the existence of a unit root on the logarithm of murder 1933-2005. These tests present the structural form shown in equation (1).

$$\Delta L\,\text{hom}_t = \alpha + \theta.\,t + \phi\, L\,\text{hom}_{t-i} + \sum_{i=1}^{k} \gamma_i\, \Delta L\,\text{hom}_{t-i} + \varepsilon_t \qquad (1)$$

The existence of a unit root, is given by (phi) $\phi=0$. I use the methodology by Campbell and Perron (1991), in which an auto-regression process of order k is previously selected in order to capture possible seasonality of the series, and lags are eliminated sequentially if: a) after estimating a regression the last lag does not turn out to be significant, or b) if the residuals pass a white noise test at the 0.05 significance level. The results are reported on table 2.

Table 2 Dickey & Fuller test for Unit Roots

	K	Alpha	Theta	Phi	Stationary
D(Lhark) – per capita murder series	30	13.58	-0.01119	-5.93	Yes
Arkansas State , 1933-2005		4.297	-4.2312	-4.2361	

Notes: 1. K is the chosen lag length. T-tests in second row, refer

to the null hypothesis that a coefficient is equal to zero.

Under the null of non-stationarity, it is necessary to use the Dickey-Fuller critical value that at the 0.05 level, for the t-statistic is -3.50 , -3.45 (sample size of 50 and 100)

After accepting the null for a unit root (accepting the series is stationary), I technically can not perform the BN decomposition[2], but I proceed further finding a several models with transitory components oscillating around a zero average inversely covariating with the permanent component, as is technically required. The procedure begins by fitting the logarithm of the per capita murder series to an ARIMA model of the form (2):

$$\Delta Lt\,\text{hom}_t = \mu + \sum\nolimits_{i=1}^{k} \gamma_i \Delta Lt\,\text{hom}_{t-i} + \sum\nolimits_{i=1}^{h} \psi_i \varepsilon_{t-i} + \varepsilon_t \qquad (2)$$

Where k, and h are respectively the autoregressive and moving average components. For Arkansas, and using RATS 4, I estimated five ARIMA models, (9,1,8)-model 1, (6.1,18)- model 2, (22,1,16)-model 3, (22,1,18)–model 4, and model 5-(28,1,10) whose results are reported on table 2.

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[2] Although according to Beveridge and Nelson (1981), the data series should be non-stationary for performing the procedure, I proceeded with it, as I did for Arizona State finding an attacks index for Arkansas that does not coincides with major attacks on U.S soil.

Table 2. Estimated ARIMA models for per capita murder for Arkansas

Annual data from 1933 to 2005- **MODELS 1,2,3 and 4**

Regular type, model 1, bold model 2, Italic model 3, underlined 4

bold and underlined model 5

Variables	**Coeff**	**T-stats**	**Std Error**	**Signif**
Constant	-0.0906	-2.72	0.0330	0.0084
	-0.0077	**-5.65**	**0.0013**	**0.0000**
	0.0070	*1.95*	*0.0030*	*0.0580*
	0.0060	2.27	0.0026	0.0280
	-0.0800	**-2.70**	**0.0029**	**0.0100**
AR(1)	*-0.7371*	*-5.92*	*0.1243*	*0.0000*
	-0.7569	-5.87	0.1288	0.0000
	-0.8371	**-15.72**	**0.0530**	**0.0000**
AR(2)	*-0.4627*	*-5.11*	*0.0900*	*0.0000*
	-0.5335	-5.61	0.0940	0.0000
	-0.2894	**-1.99**	**0.1450**	**0.0530**
AR(3)	0.2344	3.16	0.0740	0.0024
AR(5)	0.5787	18.38	0.0310	0.0000
AR(6)	**-0.3604**	**-25.92**	**0.0139**	**0.0000**
	-0.1642	*-2.27*	*0.0720*	*0.0280*
	-0.1658	-2.59	0.0630	0.0130
	0.5506	**4.91**	**0.1121**	**0.0000**
AR(9)	-0.2254	-3.81	0.0590	0.0003
AR(22)	*-0.1120*	*-2.29*	*0.0480*	*0.0270*
	-0.1083	-2.29	0.0470	0.0270
AR(28)	**-0.1752**	**-15.62**	**0.0110**	**0.0000**
MA(1)	**-0.4868**	**-8.47**	**0.0575**	**0.0000**
	0.3316	*3.33*	*0.0990*	*0.0000*
	0.2609	2.45	0.1060	0.0180
	1.0900	**9.54**	**0.1148**	**0.0000**
MA(2)				
MA(5)	-0.9456	-9.91	0.0953	0.0000
MA(6)	**0.2166**	**3.76**	**0.0575**	**0.0003**
	-0.7963	*-4.01*	*0.1984*	*0.0000*
	-0.7662	-4.84	0.1581	0.0000
MA(7)	*-1.0970*	*-7.56*	*0.1449*	*0.0000*
	-1.0144	-6.62	0.1530	0.0000
	-1.4700	**-12.57**	**0.1170**	**0.0000**
MA(8)	-0.8547	-8.18	0.1044	0.0000
	-1.0120	**-14.98**	**0.0676**	**0.0000**
MA(10)	**-1.2800**	**-3.91**	**0.3200**	**0.0000**
MA(12)	*0.5278*	*5.06*	*0.1042*	*0.0000*
	0.6544	4.57	0.1429	0.0000
MA(13)	**-0.6133**	**-7.47**	**0.0821**	**0.0000**
	0.5653	*3.62*	*0.1559*	*0.0000*
	0.6975	4.34	0.1600	0.0000
MA(15)	*0.4758*	*4.1*	*0.1159*	0.0000
	0.4557	4.19	0.1087	0.0001
MA(16)	0.9529	*7.21*	*0.1320*	*0.0000*
	1.0420	5.92	0.1760	0.0000

MA(18)	**0.1336**	**2.01**	**0.0662**	**0.0470**
	-0.2464	-1.48	0.1657	0.1400

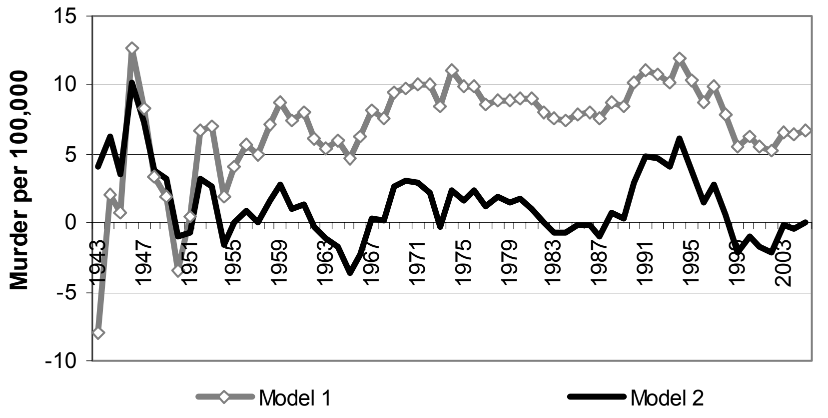
Centered R^2 = 0.68, 0.73, 0.80, 0.81, 0.83 **(models 1,2,3,4,5)**
DW = 1.86, 1.99, 2.13, 2.01, 1.70
Significance level of Q = 0.01, 0.01, 0.01, 0.000,0.000
Usable observations = 63, 66, 50, 50, 44

The 8 model parameters from table 2, and model 5 are replaced in the equation for the permanent component of murder shown in (3)[3]:

$$L\,\text{hom}_t^{PC} = L\,\text{hom}_0 + \frac{\mu . t}{1-\gamma_1 - . . . \gamma_k} + \frac{1+\Psi_1 + ...\Psi_h}{1-\gamma_1 - . . . \gamma_k} \sum_{i=1}^{t} \varepsilon_i \quad (3)$$

The transitory, terrorist murder estimate, or attacks index is found by means of the difference between the original series, and the exponential of the permanent per capita component ($L\,\text{hom}_t^{PC}$)[4], and is shown on figure 5 while figure 7 shows its permanent component of murder. The attacks index for Arkansas does not matche the qualitative description of known waves of organized crime, internal tensions, crime legislation, social, and political unrest overseas, and presents the cycles of violence in the State as independent of major attacks across the unio.. To compare this historical narrative of events with my estimates for cyclical terrorist murder and, attacks I use chronologies, and description of facts taken from Clark (1970), Durham (1996), Blumstein and Wallman (2000), Bernard (2002), Hewitt (2005), Monkkonen (2001), Wikepedia, the Military Museum, and Henrreta et al. (2006).

Figure 4. Terrorist attacks signals for Arkansas State 1943-2005



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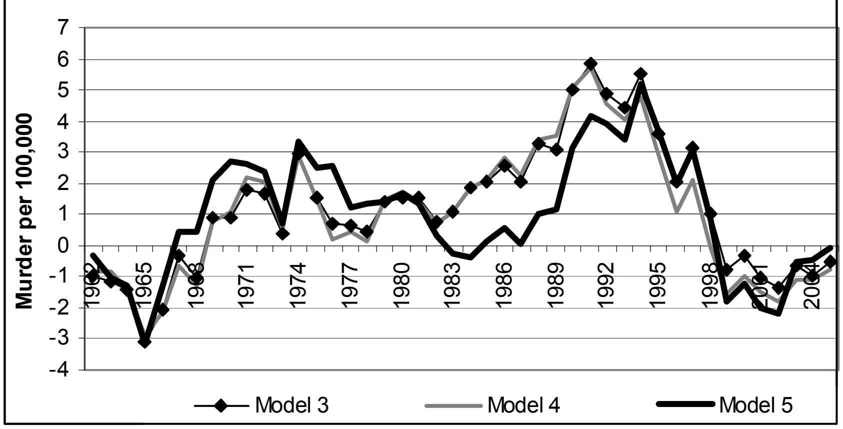
[3] The extraction of permanent and cyclical components from the original series is theoretically shown in BN (1981), Cuddington and Winters (1987), Miller (1998), Newbold (1990), and Cárdenas (1991). I show the mathematical details for the U.S.' case in appendix A. Eq.3 above, turns out to be Eq.17 in appendix A.

[4] Turning the estimated permanent per capita component into the level of the permanent component.

Figure 5. Terrorist attacks signals for Arkansas State 1962-2005



The permanent signals for both models are displayed on figures 6 and 7.

Figure 6. Permanent murder signals for Arkansas State 1943-2005

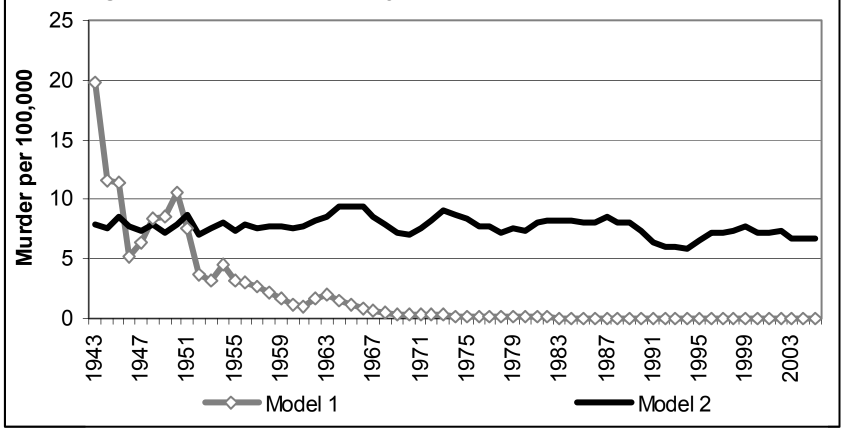


Figure 7. Permanent murder signals for Arkansas State 1962-2005

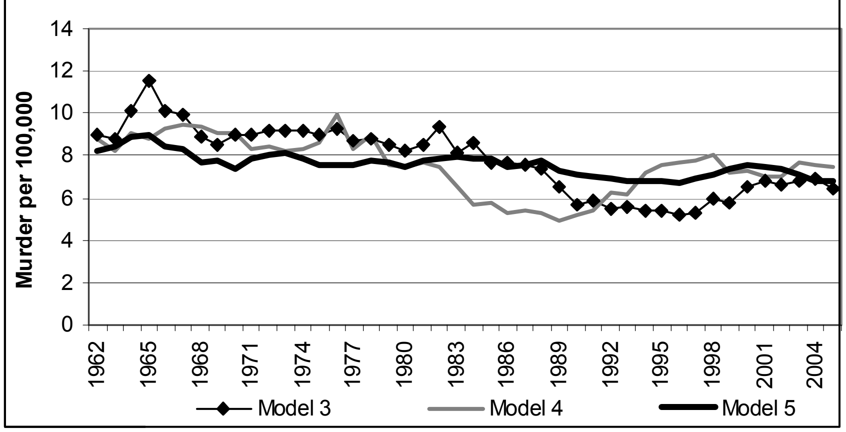
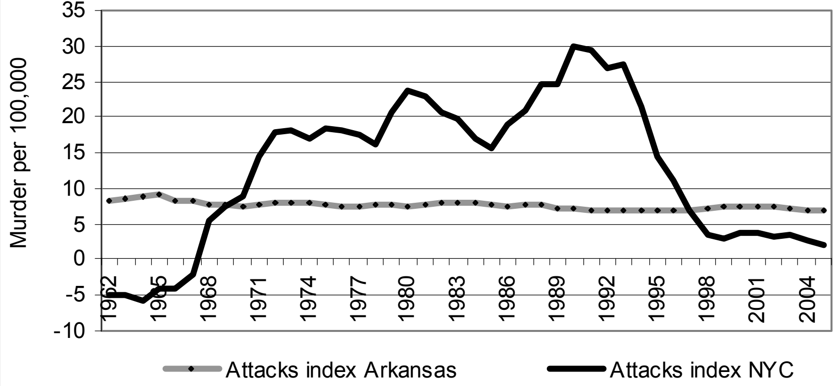


Figure 8 for informational purposes compares the attacks indices of Arkansas and New York City.

Figure 8. Attacks indices for Arkansas (model 5) and New york City, 1962 -2005



3. Interpretation of results.

I have been able to surpass the technical difficulties of, and have split the per capita series for Arkansas State finding both, its terrorist attacks index and its permanent component of murder. Arkansas appears as been as immune to the suffering of the nation or other States, its attacks index goes in opposite directions to the attacks suffered across the U.S.

After the surrendering of Japan on 2 September 1945, the index effectively decreases for models 1 and 2 from 2.13 in 1944 to 0.73 in 1945, and from 6.23 to 3.45 for model 2. For the assassination of President Kennedy in 1963 all indices from models 1 to 5 decreased from 1962 to 1963, for model 1 from 6.17 t 5.39, model 2 (-0.26 to -1.17), model 3 (-0.94 to -1.17), model 4 (-0.85 to -0.87), and model 5 (-0.32 to -1.05).

The entrance to the Vietnam Conflict in 1964 diminished the indices from models 2 to 5 from, -1.17 to -1.75 for model 2, model 3 (-1.17 to -1.42), model 4 (-0.87 to -1.43), and model 5 (-1.05 to -1.27). The termination of this war in 1973 reduced these indices from model 1 to 5 from, 10 to 8 for model 1, model 2 (2.27 to -0.28), model 3 (1.65 to 0.35), model 4 (2.03 to 0.58), and model 5 (2.35 to 0.72).

All model indices peaked in 1991 which is the year of the beginning of the crime drop in America (Blumstein and Wallman, 2000); from 10.2 to 11.1 for model 1, model 2 (2.90 to 4.80), model 3 (5.01 to 5.83), model 4 (5.06 to 5.69), and 3.15 to 4.14 for model 5. For the military operations in Los Angeles in 1992, all indices diminished one more time.

The Arkansas index did not captured the increased pressure felt across the nation as a consequence of the World Trade Center bombing, and 9/11 attacks; for the latter the indices reduced for model 1 (10.7 to 10.1 in 1993), model 2 (4.7 to 4.11), model 3 (4.8 to 4.40), model 4 (4.55 to 4.04), and model 5 (3.89 to 3.39).

For 9/11 attacks all indices moved down one more time, while for 2005, they jump across the spectrum of possibilities for model 1 (6.39 to 6.69- model 1), model 2 (-0.38 to -0.04), model 3 (-0.95 to -0.51), model 4 (-1.13 to -0.81), and model 5 (-0.44 to -0.067)

4. Conclusions.

Provided with a data series of per capita murder from 1933 to 2005, I have constructed both the attacks and the permanent murder indices for Arkansas State. The index appears moving in independent way to major disasters and terrorist attack dates occurred in the nation, Arkansas appears thus as one of the safest places of the union.

Data Source: FBI, Uniform Crime reports. United States Department of Commerce, Economics and Statistics Administration, U.S. Census Bureau.

Acknowledgements

I thank the organizers of the Stockholm Criminology Symposium 2007, particularly Dr. Lina Nilsson, and Dr. Lawrence W. Sherman from the Jerry Lee Center of Criminology for extending invitation to present this research. I additionally thank the Federal Bureau of Investigation (FBI), the Bureau of Economic Analysis (BEA) the U.S. Census Bureau, anonymous lecturers around the world, ***REUTERS,*** United Kingdom and Reuters - Lipper U.S, as well as University of Pennsylvania Department of Economics.

Appendix A. The Beveridge & Nelson decomposition of economic time series applied to decomposing the Arkansas State per capita homicides from 1933 to 2005.

I denote the observations of a stationary series of the logarithm of per capita homicides for Arkansas State. by *Lthom* and its first differences by w_t. Following Beveridge & Nelson, BN for short, (1981, p.154), many economic times series require transformation to natural logs before the first differences exhibit stationarity, so the w_t's, then are continuous rates of change.

$$W_t = Lt\hom_t - Lt\hom_{t-1} \tag{1}$$

If the w's are stationary in the sense of fluctuating around a zero mean with stable autocovariance structure, then the decomposition theorem due to Wold (1938) implies that W_t maybe expressed as

$$W_t = \mu + \lambda_0\varepsilon_t + \lambda_1\varepsilon_{t-1} + \ldots., \ \ where\ \lambda_0 \equiv 1 \tag{2}$$

Where, μ the $\lambda's$ are constants, and the $\varepsilon's$ are uncorrelated disturbances. According to BN, the expectation of $Lt\hom_{t+k}$ conditional on data for $Lt\hom$ through time t is denoted by $Lt\overset{\wedge}{\hom}(k)$, and is given by

$$\begin{aligned} Lt\overset{\wedge}{\hom}(k) &= E(Lt\hom_{t+k} \mid \ldots\ldots\ldots, Lt\hom_{t-1}, Lt\hom_t) \\ &= Lt\hom_t + E(W_{t+1} + \ldots\ldots W_{t+k} \mid \ldots., W_{t+1}, W_t) \\ &= Lt\hom + \hat{W}_t(1) + \ldots\ldots + \hat{W}_t(k) \end{aligned} \tag{3}$$

Since the $Z_t's$ can be expressed as accumulations of the $W_t's$. Now from (2) it is easy to see that the forecasts of W_{t+i} at time t are

$$\begin{aligned} \hat{W}_t(i) &= \mu + \lambda_i\varepsilon_t + \lambda_{i+1}\varepsilon_{t-1} + \ \ \ldots\ldots \\ &\mu + \sum_{j=1}^{\infty}\lambda_j\ \varepsilon_{t+1-j}\ , \end{aligned} \tag{4}$$

Now substituting (4) in (3), and gathering terms in each ε_t, I get

$$\begin{aligned} L\overset{\wedge}{\hom}_t(k) &= L\hom_t + \hat{W}_t(i) \\ &= L\hom_t + \left[\mu + \sum_{j=1}^{\infty}\lambda_j\varepsilon_{t+1-j}\right] \\ &= k\mu + L\hom_t + \left(\sum_1^k\lambda_i\right)\varepsilon_t + \left(\sum_2^{k+1}\lambda_i\right)\varepsilon_{t-1} + \ldots. \end{aligned} \tag{5}$$

And considering long forecasts, I approximately have

$$L\overset{\wedge}{\hom}_t(k) \cong k\mu + L\hom_t + \left(\sum_1^{\infty}\lambda_i\right)\varepsilon_t + \left(\sum_2^{\infty}\lambda_i\right)\varepsilon_{t-1} + \ldots.. \tag{6}$$

According to (6), it is clearly seen that the forecasts of homicide in period (k) is asymptotic to a linear function with slope equal to μ (constant), and a level $L\text{hom}_t$ (intercept or first value of the series).

Denoting this level by $\overline{L\text{hom}_t}$, I have

$$\overline{L\text{hom}_t} = L\text{hom}_t + \left(\sum_1^{\infty}\lambda_i\right)\varepsilon_t + \left(\sum_2^{\infty}\lambda_i\right)\varepsilon_{t-1} + \ldots\ldots\ldots \qquad .(7)$$

The unknown μ and $\lambda' s$ in Eq. (6) must be estimated. Beveridge and Nelson suggest and ARIMA procedure of order (p,1,q) with drift μ.

$$W_t = \mu + \frac{\left(1-\theta_1 L^1 - \ldots - \theta_q L^q\right)}{\left(1-\varphi_1 L^1 - \ldots - \phi_p L^p\right)}\varepsilon_t = \mu + \frac{\theta(L)}{\varphi(L)}\varepsilon_t \qquad (8)$$

Cuddington and Winters (1987, p.22, Eq. 7) realized that in the steady state, i.e., L=1, Eq. (9) converts to

$$\overline{L\text{hom}_t} - \overline{L\text{hom}_{t-1}} = \mu + \frac{(1-\theta_1 - \ldots \theta_q)}{(1-\phi_1 - \ldots \varphi_p)}\varepsilon_t = \mu + \frac{\theta(1)}{\varphi(1)}\varepsilon_t \quad (9)$$

The next step requires replacing the parameters of the ARIMA model (Table 2) and iterating Eq.(9) recursively, i.e., replace t by (t-1), and (t-1) by (t-2), etc, I get

$$W_t = \overline{L\text{hom}_t} - \overline{L\text{hom}_{t-1}} = \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_t \qquad (10)$$

$$W_{t-1} = \overline{L\text{hom}_{t-1}} - \overline{L\text{hom}_{t-2}} = \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_{t-1}$$

$$\vdots$$

$$W_1 = \overline{L\text{hom}_1} = \overline{L\text{hom}_0} + \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_1 \quad (\textit{this is the value for year } 1962)$$

$$\vdots$$

$$W_{44} = \overline{L\text{hom}_{44}} = \overline{L\text{hom}_0} + \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_{44} \quad (\textit{this is the value for year } 2005)$$

Adding these equations I obtain W_1 (the value for year 1962), and W44 (the value for year 2005), on the right hand side μ is added "t" times, and the fraction following μ is a constant multiplied by the sum of error terms. I obtain

$$\overline{L\,\mathrm{hom}_t} = \overline{L\,\mathrm{hom}_0} + \mu.t + \frac{\theta(1)}{\phi(1)} \sum_{i=1}^{t} \varepsilon_i \qquad (11)$$

This is, Newbold's (1990, 457, Eq.(6), which is a differential equations that solves after replacing the initial value for $\overline{L\,\mathrm{hom}_0}$, which is the logarithm of per capita murder in year 1962.

Cárdenas (1991), suggests that Eq.(11), should be changed when the ARIMA model includes autoregressive components. Since the ARIMA developed for Arkansas (Table 2), includes autoregressive, and moving average components, I formally show this now.

$$L\,\mathrm{hom}_t - L\,\mathrm{hom}_{t-1} = \mu + \sum_{i=1}^{p} \phi_i W_{t-i} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} + \varepsilon_t \qquad (12)$$

$$\Delta L\,\mathrm{hom}_t = W_t = Lt\,\mathrm{hom}_t - Lt\,\mathrm{hom}_{t-1}$$

$$L\,\mathrm{hom}_t - L\,\mathrm{hom}_{t-1} = \mu + \sum_{i=1}^{p} \phi_i \Delta L\,\mathrm{hom}_{t-i} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} + \varepsilon_t$$

Bringing the moving average components to the LHS, I get

$$L\,\mathrm{hom}_t - L\,\mathrm{hom}_{t-1} - \left(\sum_{i=1}^{p} \phi_i \Delta L\,\mathrm{hom}_{t-1} \right) = \mu + \sum_{i=1}^{q} \theta_j \varepsilon_{t-j} + \varepsilon_t \qquad (13)$$

Expanding summation terms

$$(1 - \phi_1 L^1 - \phi_2 L^2 - . . - \phi_p L^p)(L\,\mathrm{hom}_t - L\,\mathrm{hom}_{t-1}) = \mu + (1 + \theta_1 L^1 + . . + \theta_q L^q)\varepsilon_t \quad (14)$$

Rearranging Eq. (14) and including the ARIMA parameters from Table 2, I get.

$$L\,\mathrm{hom}_t - L\,\mathrm{hom}_{t-1} = \frac{-0.0080}{1+0.83+0.28-0.55+0.17} + \left(\frac{1+1.09-1.47-1.28}{1+0.83+0.28-0.55+0.17} \right) \varepsilon_t \quad (15)$$

Now, after recursively replacing, t with (t-1), and (t-1) with (t-2), etc, and after adding together "t" times, I have

$$L\,\mathrm{hom}_t - L\,\mathrm{hom}_0 = \frac{-0.0080t}{1+0.83+0.28-0.55+0.17} + \left(\frac{1+1.09+1.47+1.28}{1+0.83+0.28-0.55+0.17} \right) \sum_{i=1}^{t} \varepsilon_i \quad (16)$$

And rearranging,

$$L\mathrm{hom}_t = L\mathrm{hom}_0 + \frac{-0.0080t}{1+0.83+0.28-0.55+0.17} + \left(\frac{1+1.09+1.47+1.28}{1+0.83+0.28-0.55+0.17}\right)\sum_{i=1}^{t}\varepsilon_i \quad (17)$$

In the steady state, when L=1, Eq. (17) yields the permanent component of the per capita murder for Ohio, the last step requires taking the exponential to the LHS of Eq. 17, getting the level for the permanent component. The cyclical component is finally obtained by the difference of the level of the observed per capita murder minus the level of the permanent component. Both permanent and cyclical estimated components are shown on figures 5, and 7.

Appendix B : data table **BEVERIDGE - NELSON**

	Original Data		**Terrorist murder and attacks index**	Permanent
year	Murder	Murder per capita	Cyclical - component	component
1933		17.600		
1934		32.900		
1935		16.800		
1936		11.600		
1937		17.400		
1938		18.100		
1939		11.400		
1940		9.800		
1941		17.640		
1942		18.730		
1943		11.860		
1944		13.750		
1945		12.090		
1946		17.890		
1947		14.730		
1948		11.750		
1949		10.510		
1950		6.980		
1951		8.000		
1952		10.360		
1953		10.200		
1954		6.400		
1955		7.400		
1956		8.700		
1957		7.600		
1958		9.400		
1959		10.400		
1960	152	8.509		
1961	163	9.071		
1962	144	7.899	-0.3272	8.2262
1963	137	7.374	-1.0535	8.4270
1964	147	7.605	-1.2708	8.8756
1965	115	5.867	-3.1642	9.0315
1966	139	7.110	-1.2946	8.4046
1967	173	8.791	0.4200	8.3706
1968	163	8.101	0.4193	7.6821
1969	197	9.875	2.0794	7.7953
1970	195	10.139	2.7192	7.4196
1971	204	10.494	2.6453	7.8485
1972	206	10.415	2.3515	8.0630
1973	180	8.837	0.7276	8.1089
1974	231	11.203	3.3104	7.8923
1975	213	10.066	2.4791	7.5871
1976	213	10.100	2.5339	7.5657
1977	188	8.769	1.1961	7.5726
1978	199	9.103	1.3420	7.7614

1979	198	9.083	1.3929	7.6897
1980	210	9.194	1.6794	7.5148
1981	209	9.111	1.3362	7.7745
1982	187	8.162	0.3018	7.8606
1983	178	7.646	-0.2939	7.9399
1984	176	7.493	-0.3721	7.8647
1985	187	7.927	0.1049	7.8222
1986	191	8.052	0.5846	7.4676
1987	182	7.621	0.0257	7.5957
1988	211	8.712	0.9890	7.7228
1989	203	8.437	1.1483	7.2889
1990	241	10.252	3.1510	7.1012
1991	264	11.130	4.1438	6.9860
1992	259	10.796	3.8967	6.8995
1993	247	10.190	3.3996	6.7901
1994	294	11.985	5.1702	6.8151
1995	259	10.427	3.6239	6.8028
1996	219	8.725	1.9656	6.7595
1997	250	9.909	3.0442	6.8646
1998	201	7.920	0.8220	7.0976
1999	143	5.605	-1.7861	7.3910
2000	168	6.284	-1.2577	7.5418
2001	148	5.500	-1.9938	7.4938
2002	142	5.200	-2.1763	7.3763
2003	180	6.600	-0.4955	7.0955
2004	176	6.400	-0.4454	6.8454
2005	186	6.700	-0.0670	6.7670

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