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

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

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Abstract: I apply the Beveridge-Nelson business cycle decomposition method to the time series of per capita murder of Missouri State (1933-2005). Separating out "permanent" from "cyclical" murder, I hypothesize that the cyclical part 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 affected Missouri, creating estimated turning point dates marked by the most tragic terrorist attacks to the nation: the shut down in power in NYC in 1965, the World Trade Center bombing in 1993, and 9/11 2001 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 Missouri. 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., Ohio http://mpra.ub.uni-muenchen.de/4605/01/MPRA_paper_4605.pdf., Philadelphia City, http://mpra.ub.uni-muenchen.de/4783/01/MPRA_paper_4783.pdf, Arkansas http://mpra.ub.uni-muenchen.de/4606/01/MPRA_paper_4606.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; terrorist murder, cycles of violence, and terrorist attacks in New York City during the last two centuries.

JEL classification codes: C22, D74, H56, N42, O51.
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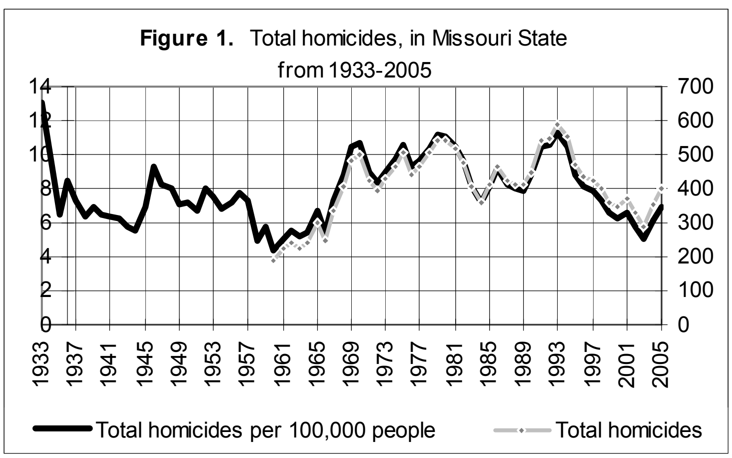
1. Introduction.

After decomposing violence, and creating the cyclical terrorist murder and attacks index for the United States (Gómez-Sorzano 2006), *terrorist murder, cycles of violence, and terrorist attacks in New York City during the last two centuries* (Gómez-Sorzano 2007A), and *terrorist murder, cycles of violence, and attacks index for the City of Philadelphia during the last two centuries* (Gómez-Sorzano 2007H) this paper continues that methodology research applied at the State level. The current exercise for Missouri State is the eighth one at decomposing violence at the state level on the purpose of constructing murder and attacks indices preventing the closeness of attacks or tragic events.

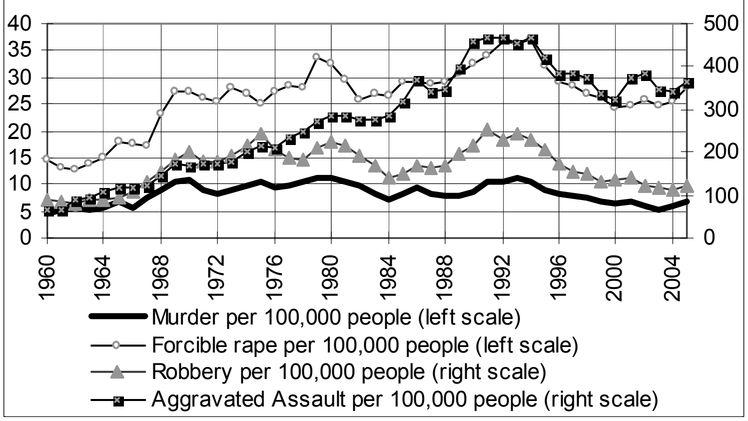
According to the Federal Bureau of Investigation, Uniform Crime Reporting System, total homicides in Missouri State increased from an average of 289 per year in the 1960s to 467 in the 1970s, 442 in the 1980s, and 477 in the 1990s (Fig. 1), for year 2005 the State reported 402 homicides.

When adjusted for population growth, i.e., homicides per 100,000 people in the population, peaks are found in 1933, 1946, 1952, 1970, 1975, 1979, and 1993 with values of 13.1 murders per capita, and 9.2, 8.0, 10.67, 10.60, 11.15, and 11.2 respectively for those years, and 6.90 for 2005.



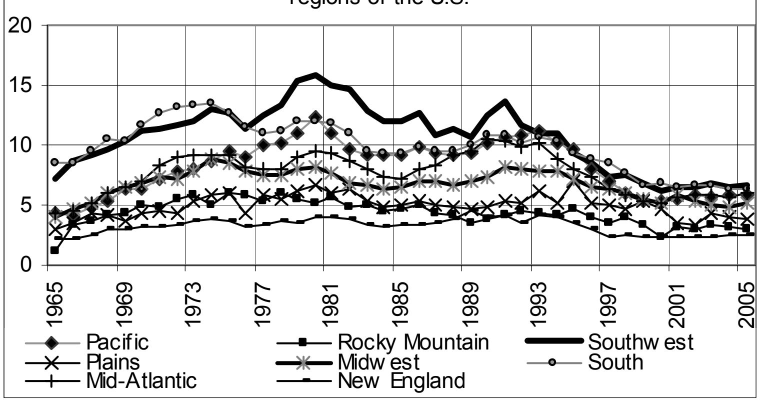
Out of the state's four categories of crimes, measuring violent crime (murder, forcible rape, robbery, and aggravated assault) murder is the one that varies the least, but shows a slight growing tendency from 2003 to 2005 (Fig. 2).

Figure 2. Categories of violent crime in Missouri 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 Midwest region where Missouri belongs appears as the fifth highest rate across the nation with a rate of 5.11 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 Missouri State series of per capita murder.

[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) ϕ=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(Lhmissu) – per capita murder series	23	1.20	0.004	-0.6834	No
Missouri State , 1933-2005		2.224	1.3516	-2.1000	

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)

An additional test for unit roots uses equation (2) with the series ran in levels, its results are reported on table 2A.

$$L\,\text{hom}_t = \alpha + \theta.\,t + \phi\, L\,\text{hom}_{t-i} + \sum_{i=1}^{k} \gamma_i\, L\,\text{hom}_{t-i} + \varepsilon_t \qquad (2)$$

Table 2A Dickey & Fuller test for Unit Roots

	K	Alpha	Theta	Phi	Stationary
(Lhmissu) – per capita murder series	24	1.20	0.004	0.9043	No
Missouri State , 1933-2005		2.224	1.3516	5.6200	

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 rejecting the null for a unit root (accepting the series is non stationary), I technically can perform the BN decomposition.

The selection of the right ARIMA model for Missouri was computationally intense. The procedure begins by fitting the logarithm of the per capita murder series to an ARIMA model as shown on equation (2):

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

Where k, and h are respectively the autoregressive and moving average components. For Missouri, and using RATS 4, I estimated two initial ARIMA models, (7,1,18)-model 1, and (7,1,16)-model 2, whose results are reported on table 3, and its transitory and permanent signals displayed on figure 4.

Table 3. Estimated ARIMA models for per capita murder for Missouri State

Annual data from 1933 to 2005 - Model 2 (Bold figures)

Variables	Coeff	T-stats	Std Error	Signif
Constant	0.0550	2.04	0.0260	0.0450
	0.0630	**2.23**	**0.0280**	**0.0290**
AR(1)	-0.2995	-2.38	0.1253	0.0200
	-0.3653	**-2.80**	**0.1301**	**0.0067**
AR(7)	0.2113	3.15	0.0670	0.0025
	0.2109	**3.35**	**0.0628**	**0.0013**
MA(1)	0.8207	18.25	0.0440	0.0000
	0.8288	**22.46**	**0.0369**	**0.0000**
MA(6)	0.9048	7.31	0.1237	0.0000
	0.7646	**5.77**	**0.1324**	**0.0000**
MA(17)	-0.2913	-2.44	0.1192	0.0170
MA(18)	-0.3228	-3.05	0.1055	0.0033

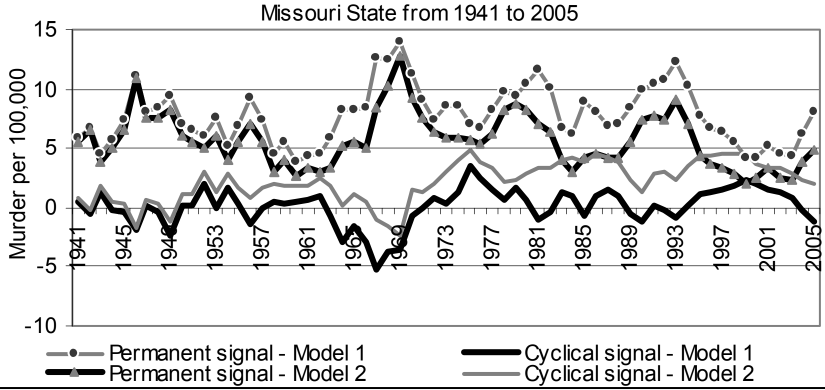
Centered R^2 = 0.7627, **0.7352**

DW= 1.89, **1.87**

Significance level of Q = 0.0091, **0.02764**

Usable observations = 65, **65**

Figure 4. Permanent and cyclical signals for per capita murders in Missouri State from 1941 to 2005



Models 1 and 2 do not reproduce to perfection major attacks to the country as the World Trade Center bombing and 9/11 2001, for that reason the model finally selected is model 3, shown on table 3A.

Table 3A. Estimated ARIMA models for per capita murder for Missouri State
Annual data from 1933 to 2005 - Model 3

Variables	Coeff	T-stats	Std Error	Signif
Constant	-0.0023	-2.13	0.0010	0.0360
AR(1)	-0.1473	-5.47	0.0260	0.0000
AR(3)	0.2921	20.99	0.0139	0.0000
MA(1)	0.5957	3.86	0.1539	0.0000
MA(3)	-1.4485	-8.95	0.1617	0.0000
MA(14)	-0.8340	-4.8	0.1734	0.0000
MA(15)	-0.5344	-3.68	0.1449	0.0000

Centered R^2 = 0.8343
DW= 2.14
Significance level of Q = 0.04825
Usable observations = 69

The 7 model parameters from table 3A or model 3 are replaced in the equation for the permanent component of murder shown in (3)[2]:

$$L\hom_t^{PC} = L\hom_0 + \frac{\mu . t}{1-\gamma_1 - . . . \gamma_k} + \frac{1+\Psi_1 + ... \Psi_h}{1-\gamma_1 - . . . \gamma_k} \sum_{i=1}^{t} \varepsilon_i \quad (3)$$

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 ($L\hom_t^{PC}$)[3], and is shown on figure 5 along with the permanent component of murder for the State. The attacks index for Missouri matches 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 affected by major attacks across the union. 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), Dosal (2002), Hewitt (2005), Monkkonen (2001), Wikepedia, the Military Museum, and Henrreta et al. (2006).

[2] 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.
[3] Turning the estimated permanent per capita component into the level of the permanent component.

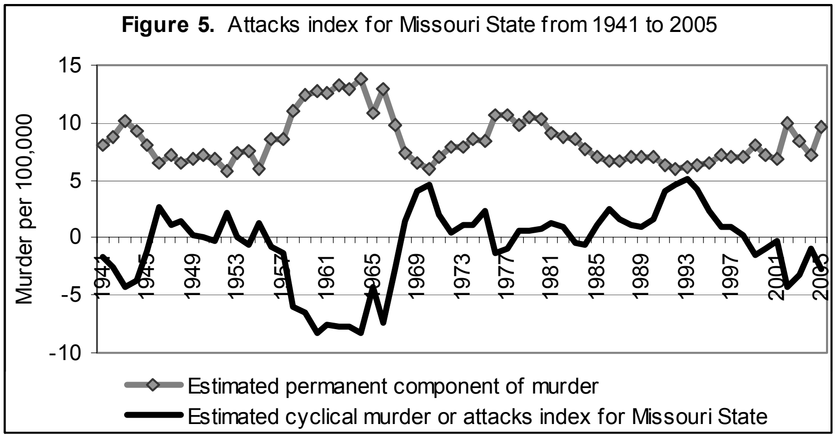
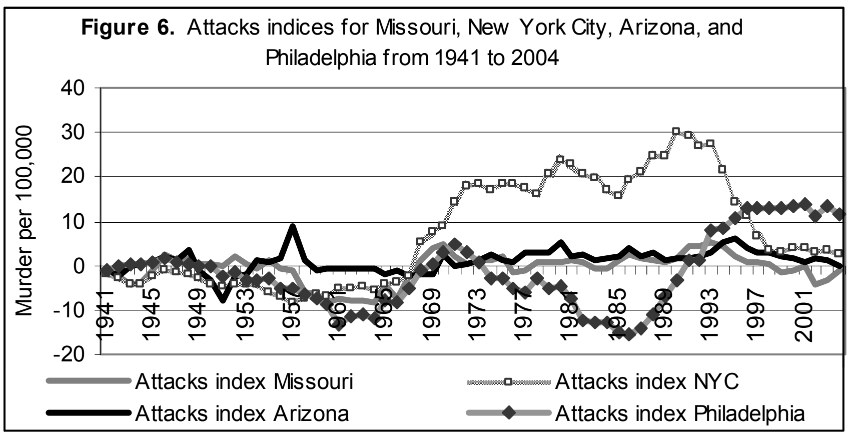


Figure 6 for informational purposes presents the attacks indices for Missouri, New York City, Philadelphia City, and the State of Arizona.



3. Interpretation of results.

I have been able to surpass the technical difficulties, and have split the per capita series for Missouri State finding both, its terrorist attacks index and its permanent component of murder. The attacks indicator presents as a whole 5 main cycles.

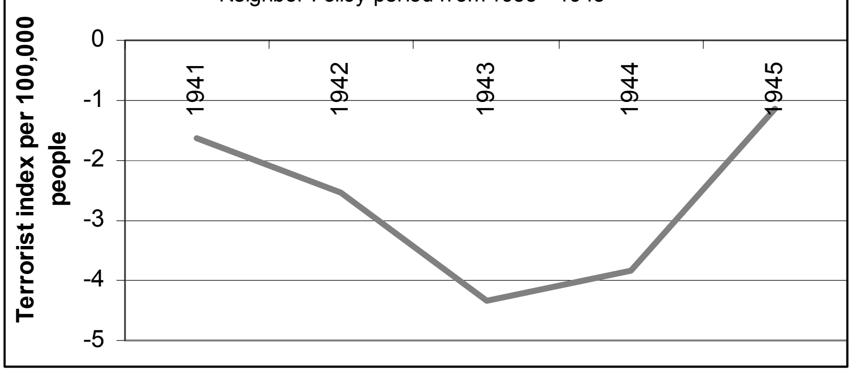
Descending cycle 1941–1967, characterized by the U.S Good Neighbor policy period or second phase of America's Caribbean War (1933-1945); the Korean War (1950-1953), World War II (1941-1946), the terrorist assassination of John F. Kennedy, the beginning of the Vietnam conflict (1964), the shut down in power in New York City on 9 November 1965 and los Angeles riots of 11 August 1965..

A general policy period for the U.S., called the U.S. good neighbor policy period from 1933 to 1945 reduced the attacks index for Missouri as shown on figure 6. From 1941 to 1944 the index, moved from -1.62, to -2.54, -4.32, and jumped in 1944 to -3.82

showing increased pressure from World War II. For the year of the surrendering of Japan on 2 September 1945, the index jumped one more time to -1.14 (235%), and to 2.69 in 1946.

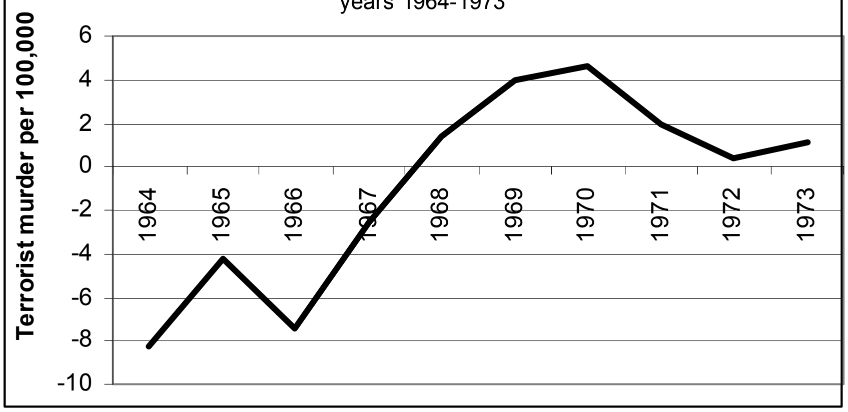
Dosal (2002) mentions how strongmen were maintaining order on behalf of American troops, General Somoza in Nicaragua, and Trujillo in the Dominican Republic. This good neighbor policy said nothing about indirect interventions, so occupation and intervention by proxy became the norm. During this second phase of America's Caribbean War, the Caribbean enjoyed relative peace at the high price of democracy, it was the time for dictators. Dictators Fulgencio Batista (1934-1944, 1952-1958), Trujillo (1930-1961), Jorge Ubico (1931-1944), Tiburcio Carias Andino (1932-1948), and Somoza (1934-1956) maintained domestic order so well in Cuba, the Dominican Republic, Guatemala, Honduras, and Nicaragua that the United States did not have to use its forces to protect American interests.

Figure 6. The attacks index for Missouri during the U.S. Good Neighbor Policy period from 1933 - 1945



The entrance to the Vietnam Conflict fueled the index moving from -8.26 in 1964 to -4.23 in 1965 (95.25%, the year of the shut down in power in New York City, and Los Angeles riots of 1965), to -7.40 in 1966, -2.54 in 1967, (figure 7).

Figure 7. The attacks index for Missouri during the Vietnam Conflict years 1964-1973



Ascending cycle 1968 – 1975. The period is characterized by the assassination of Dr. Martin Luther King Jr., which jumped the index from -2.54 in 1967 to 1.41 in 1968; and the ending up of Vietnam Conflict in 1973 which still jumped the index for consecutive years from 1.13 in 1973 to 1.15 in 1974, and 2.25 in 1975.

Descending cycle 1976-1984. The period begins with an index of -1.39 in 1976, ending up with -0.59 in 1984.

Ascending cycle 1985-1993. A period characterized by the U.S. invasion of Panama, the war on drugs in Colombia 1985-1991, the World Trade Center bombing, and the Long Island Train massacre.

In 1992 the U.S. with cooperation of Colombian authorities Kill Pablo Escobar, this year additionally the U.S. experience military operations in Los Angeles, and as well the FBI successfully prosecutes New York's Gambino family crime boss John Gotti on 13 charges of murder, gambling, racketeering, and tax fraud; the attacks index for Missouri ascends from 1991 to 1992 from 4.13 to 4.53 (9.65). Finally 1993 marks the end of this ascending cycle for the State and the nation, where the index with precision move up pointing out the World Trade Center attack, and the Long Island Train massacre, the index moved to 5.16 in 1993 (13.90%).

Descending cycle 1994-2005. A period marked by the enacting of the Crime Act of 1994 , the arresting of Larry Hoover, 9/11 2001, and the beginning of the Global War on terrorism.

This descending cycle is marked by President's Clinton enacting of the Violent Crime and Law Enforcement Act of 1994 (the "Crime Act") stopping the upward trend in violence all over the U.S and Missouri, where the index moved down to 4.20 (-18.6%); additionally federal agents caught, and arrested Larry Hoover, according to Wikepedia in Vienna on August 1995, sent to prison in Dixon Illinois, been later sentenced in 1998 to six life terms in prison; prosecutors alleged he controls a 50,000 – member cultish drug gank known as the "Ganster Disciples" from his prison cell in Dixon, Illinois. Prosecutors consider the gang had members in 35 States, approximately 5,000 of which were in prison. The index continues its abrupt descent in 1995 to 2.26, 1996 to 0.91, 1997 (0.87), 1998 (0.24), and becomes negative in 1999 with -1.46. Finally the attacks index for Missouri foretold 9/11 2001 attacks to the nation when jumping with amazing precision from -1.00 in year 2000 to -0.24 in 2001 (316%), the index moves down from 2002 to 2005 as the permanent component of murder for the States goes up.

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 Missouri State. The index appears moving detecting major disasters and terrorist attack dates occurred across the nation, immediate research should be done, particularly headed towards constructing a model for attacks, and for permanent murder for this State.

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

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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 Missouri State per capita homicides from 1933 to 2005.

I denote the observations of a stationary series of the logarithm of per capita homicides for Missouri 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.

$$W_t = Lt\hom_t - Lt\hom_{t-1} \qquad (1)$$

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

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

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 $Lt\hat{\hom}(k)$, and is given by

$$Lt\hat{\hom}(k) = E(Lt\hom_{t+k} \mid . \ . \ . \ . \ . \ . \ . \ . \ , Lt\hom_{t-1}, Lt\hom_t) \quad (3)$$
$$= Lt\hom_t + E(W_{t+1} + . \ . \ . \ . \ . W_{t+k} \mid . \ . \ . \ ., W_{t+1}, W_t)$$
$$= Lt\hom + \hat{W}_t(1) + . \ . \ . \ . \ . + \hat{W}_t(k)$$

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

$$\hat{W}_t(i) = \mu + \lambda_i\varepsilon_t + \lambda_{i+1}\varepsilon_{t-1} + \ . \ . \ . \ . \ . \quad (4)$$
$$\mu + \sum_{j=1}^{\infty}\lambda_j \ \varepsilon_{t+1-j} \ ,$$

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

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

And considering long forecasts, I approximately have

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

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 $L\hom_t$ (intercept or first value of the series).

Denoting this level by $L\overline{\hom_t}$, I have

$$L\overline{\hom_t} = L\hom_t + \left(\sum_1^{\infty}\lambda_i\right)\varepsilon_t + \left(\sum_2^{\infty}\lambda_i\right)\varepsilon_{t-1} + \ . \ . \ . \ . \ . \ . \ . \quad .(7)$$

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.

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

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

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

The next step requires replacing the parameters of the ARIMA model (Table 3A) and iterating Eq.(9) recursively, i.e., replace t by (t-1), and (t-1) by (t-2), etc, I get

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

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

:

$$W_1 = \overline{L\,\text{hom}_1} = \overline{L\,\text{hom}_0} + \mu + \frac{\theta(1)}{\phi(1)} \varepsilon_1 \quad (\textit{this is the value for year } 1941)$$

:

$$W_{69} = \overline{L\,\text{hom}_{69}} = \overline{L\,\text{hom}_0} + \mu + \frac{\theta(1)}{\phi(1)} \varepsilon_{69} \quad (\textit{this is the value for year } 2005)$$

Adding these equations I obtain W_1 (the value for year 1962), and W69 (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

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

This is, Newbold's (1990, 457, Eq.(6), which is a differential equations that solves after replacing the initial value for $\overline{L\,\text{hom}_0}$, which is the logarithm of per capita murder in year 1941.

Cárdenas (1991), suggests that Eq.(11), should be changed when the ARIMA model includes autoregressive components. Since the ARIMA developed for Missouri (Table 3A), includes autoregressive, and moving average components, I formally show this now.

$$L\hom_t - L\hom_{t-1} = \mu + \sum_{i=1}^{p}\phi_i W_{t-i} + \sum_{j=1}^{q}\theta_j \varepsilon_{t-j} + \varepsilon_t \qquad (12)$$

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

$$L\hom_t - L\hom_{t-1} = \mu + \sum_{i=1}^{p}\phi_i \Delta L\hom_{t-i} + \sum_{j=1}^{q}\theta_j \varepsilon_{t-j} + \varepsilon_t$$

Bringing the moving average components to the LHS, I get

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

Expanding summation terms

$$(1-\phi_1 L^1 - \phi_2 L^2 - . . -\phi_p L^p)(L\hom_t - L\hom_{t-1}) = \mu + (1+\theta_1 L^1 + . . + \theta_q L^q)\varepsilon_t \quad (14)$$

Rearranging Eq. (14) and including the ARIMA parameters from Table 3A, I get.

$$L\hom_t - L\hom_{t-1} = \frac{-0.0023}{1+0.14-0.29} + \left(\frac{1+0.59-1.44-0.83-0.53}{1+0.14-0.29}\right)\varepsilon_t \quad (15)$$

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

$$L\hom_t - L\hom_0 = \frac{-0.0023t}{1+0.14-0.29} + \left(\frac{1+0.59-1.44-0.83-0.53}{1+0.14-0.29}\right)\sum_{i=1}^{t}\varepsilon_i \quad (16)$$

And rearranging,

$$L\hom_t = L\hom_0 + \frac{-0.0023\,t}{1+0.14-0.29} + \left(\frac{1+0.59-1.44-0.83-0.53}{1+0.14-0.29}\right)\sum_{i=1}^{t}\varepsilon_i \quad (17)$$

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 figure 5.

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

	Original Data		**Terrorist murder and attacks index**	
year	Murder	Murder per capita	Cyclical – component	Permanent component
1933		13.10		
1934		10.20		
1935		6.50		
1936		8.50		
1937		7.30		
1938		6.30		
1939		6.90		
1940		6.50		
1941		6.39	-1.6256	8.0156
1942		6.25	-2.5428	8.7928
1943		5.79	-4.3263	10.1163
1944		5.52	-3.8202	9.3402
1945		6.93	-1.1438	8.0738
1946		9.26	2.6960	6.5640
1947		8.28	1.1458	7.1342
1948		7.96	1.4348	6.5252
1949		7.09	0.2678	6.8222
1950		7.23	0.1249	7.1051
1951		6.71	-0.2132	6.9232
1952		8.01	2.1327	5.8773
1953		7.50	0.1235	7.3765
1954		6.80	-0.6585	7.4585
1955		7.20	1.2765	5.9235
1956		7.80	-0.7276	8.5276
1957		7.30	-1.2509	8.5509
1958		5.00	-5.9978	10.9978
1959		5.80	-6.5410	12.3410
1960	189	4.38	-8.3286	12.7038
1961	223	5.09	-7.4953	12.5889
1962	241	5.55	-7.7089	13.2543
1963	223	5.15	-7.7186	12.8711
1964	240	5.44	-8.2636	13.7070
1965	300	6.67	-4.2320	10.9031
1966	245	5.43	-7.4003	12.8351
1967	337	7.32	-2.5450	9.8663
1968	408	8.82	1.4139	7.4040
1969	485	10.43	4.0077	6.4202
1970	499	10.67	4.6124	6.0559
1971	424	8.93	1.9380	6.9902
1972	396	8.33	0.4025	7.9291
1973	427	8.98	1.1337	7.8426
1974	466	9.76	1.1584	8.5966
1975	505	10.60	2.2521	8.3505
1976	443	9.27	-1.3982	10.6699

1977	462	9.62	-1.0503	10.6733
1978	505	10.39	0.6139	9.7771
1979	543	11.15	0.5930	10.5615
1980	544	11.10	0.7836	10.3155
1981	516	10.45	1.3512	9.0984
1982	479	9.67	0.9394	8.7354
1983	403	8.11	-0.4930	8.6017
1984	358	7.15	-0.5947	7.7432
1985	409	8.13	1.1072	7.0256
1986	464	9.16	2.4938	6.6653
1987	423	8.29	1.6059	6.6833
1988	413	8.04	1.0266	7.0100
1989	409	7.93	0.9448	6.9831
1990	449	8.77	1.7078	7.0668
1991	543	10.53	4.1367	6.3907
1992	547	10.53	4.5327	6.0007
1993	590	11.27	5.1621	6.1104
1994	554	10.50	4.2051	6.2913
1995	469	8.81	2.2605	6.5486
1996	433	8.08	0.9120	7.1678
1997	426	7.89	0.8783	7.0077
1998	399	7.34	0.2483	7.0877
1999	359	6.57	-1.4662	8.0313
2000	347	6.20	-1.0070	7.2087
2001	372	6.60	-0.2457	6.8457
2002	331	5.80	-4.1971	9.9971
2003	289	5.10	-3.3155	8.4155
2004	354	6.10	-1.0244	7.1244
2005	402	6.90	-2.7473	9.6473

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