Cycles of violence, and terrorist attacks index for the State of Washington.

Gómez-Sorzano, Gustavo
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Cycles of Violence, and Terrorist Attacks Index for the State of Washington

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 Washington. (1933-2005). Separating out "permanent" from "cyclical" murder, I hypothesize that the cyclical part coincides with documented waves of organized crime, internal tensions, breakdowns in social order, crime legislation, social, and political unrest, and recently with the periodic terrorist attacks to the U.S. The estimated cyclical component of murder warns that terrorist attacks against the U.S. have affected Washington creating estimated turning point dates marked by the most tragic terrorist attacks to the nation: the World Trade Center Bombing in 1993, and 9/11 2001. This paper belongs to the series of papers helping the U.S identify the closeness of terrorist attacks, and constructs the attacks index for Washington. 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., Ohio, and Arkansas. 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, N46, 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 Washington State is the fifth 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 pointed out the occurrence date of the last terrorist attacks against the U.S, particularly, the World Trade Center bombing in 1993, and 9/11 2001.

According to the Federal Bureau of Investigation, Uniform Crime Reporting System, total homicides in Washington State increased from an average of 83 per year in the 1960s to 159 in the 1970s, 222 in the 1980s, and 244.8 in the 1990s (Fig. 1), for year 2005 the State reported 205 homicides.

When adjusted for population growth, i.e., homicides per 100,000 people in the population, peaks are found in 1946, 1972, 1975, 1980, 1988, and 1994 with values of 5 murders per capita, 4, 6, 5, 6, and 6 for 1994. For 2005 it gets a per capita value of 3.30.

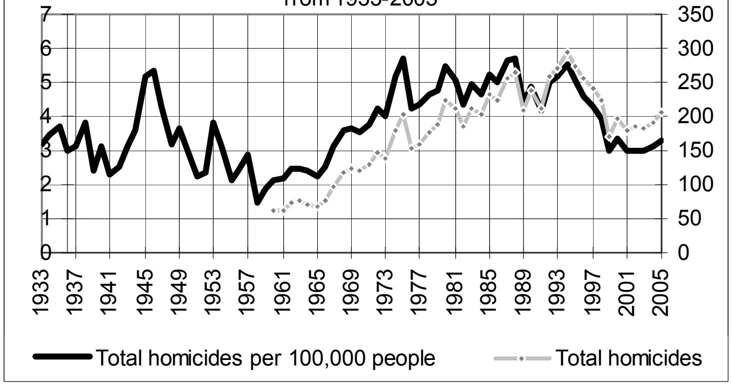
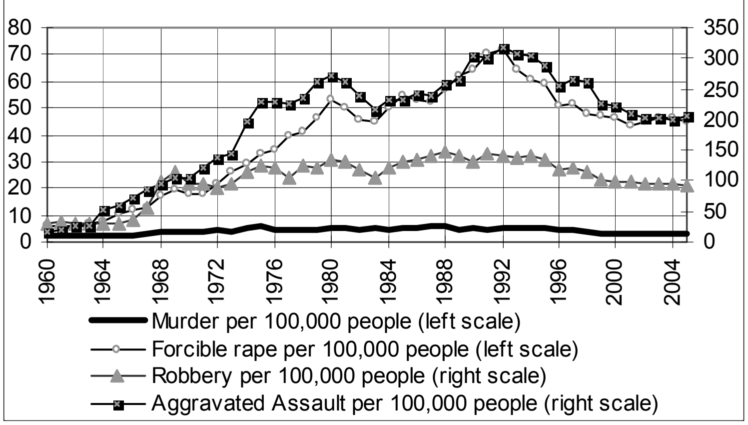


Figure 1. Total homicides, in Washington State from 1933-2005

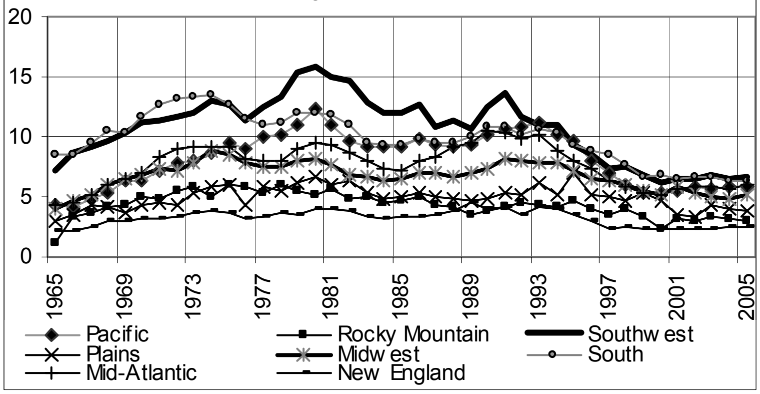
Out of the state's four categories of crimes, measuring violent crime (murder, forcible rape, robbery, and aggravated assault) murder is the one that varies the less showing a stabilization tendency (Fig. 2).

Figure 2. Categories of violent crime in Washington 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 Pacific region where Washington belongs appears as the fourth highest rate across the nation with a rate of 5.90 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 Washington 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).

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

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(Lhwash) – per capita murder series	1	0.2059	0.0011	-0.1991	No
Washington State , 1933-2005		2.1637	0.982	(-2.419)	

Notes: 1. K is the chosen lag length. T-tests in parentheses 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 perform the BN decomposition which begins by fitting the logarithm of the per capita murder series to an ARIMA model of the form (2):

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

Where k, and h are respectively the autoregressive and moving average components. The selection of the ARIMA model for Washington was computationally intense. Two per capita models are preliminary selected for the period 1933-2005; ARIMA (6,1,13) as model 1, and ARIMA(28,1,18) as model 2. The models are estimated with RATS 4, and its results displayed on table 2. Model 1 includes an autoregressive parameter of order 6, and moving average terms of order 1,2,6,7, and 13, while model 2 enlarges its autoregressive structure to 1, and 28, plus includes moving average parameters of order 1, 3, 13, and 18.

Carefully technically checking the statistical fitting of both models; model 2 has an optimal DW index of 2.02, appearing as optimal, plus all its statistics t appear are significant, but its signal does not reproduce main attacks to the United States e.g., for the World Trade bombing its signal decreases from 4.41 in year 1992 to 4.36 in 1993, while for 9/11 attacks again it moves from 2.92 in year 2000 to 2.62 in 2001.

Model 1, on the contrary reproduces main attacks, appears as parsimonious, not having a long autoregressive structure of 28 lags permitting thus the estimation on a longer cyclical signal (Fig. 4). For the main attacks to the U.S. the model offers the right directional impact, for the World Trade Center bombing its signal moved from 3.64 in 1992 to 3.97 in 1993 (9%), while for 9/11 attacks from 2.70 in year 2000 to 2.72 in 2001 (0.74%).

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

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

(Bold numbers for Model 2)

Variables	Coeff	T-stats	Std Error	Signif
Constant	0.0491	2.98	0.0160	0.0041
	0.0651	**31.20**	**0.0020**	**0.0000**
AR(1)	**-0.3465**	**-5.31**	**0.0652**	**0.0000**
AR(6)	-0.6797	-6.85	0.0990	0.0000
AR(28)	**-0.1675**	**-8.78**	**0.0191**	**0.0000**
MA(1)	-0.2752	-2.08	0.1319	0.0413
	1.3792	**144.47**	**0.0095**	**0.0000**
MA(2)	-0.2279	-2.46	0.0920	0.0160
MA(3)	**-1.2954**	**-33.03**	**0.0392**	**0.0000**
MA(6)	0.8044	7.86	0.1022	0.0000
MA(7)	0.3044	2.00	0.1517	0.0494
MA(13)	0.4647	3.40	0.1365	0.0011
	2.3205	**10.18**	**0.2278**	**0.0000**
MA(18)	**1.9587**	**7.23**	**0.2705**	**0.0000**

Centered R^2 = 0.75 **(0.95)** DW= 1.97 **(2.02)**

Significance level of Q = 0.7724 **(0.0000)**

Usable observations = 66 **(44)**

The seven model parameters from table 2, model 1 are replaced in the equation for the permanent component of murder shown in (3)[2]:

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

The transitory or cyclical terrorist murder estimate is found by means of the difference between the original series, and the exponential of the permanent per capita

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[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.

component ($L\hom_t^{PC}$)[3], and is shown in Figure 4, that additionally shows the estimated cyclical signal from model 2. Figure 4A shows the permanent component of murder for Washington along with its terrorist attacks index, it matches the qualitative description of known waves of organized crime, internal tensions, crime legislation, social, and political unrest overseas, and disentangles, and presents the cycles of violence in the State. 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 Washington State 1940-2005

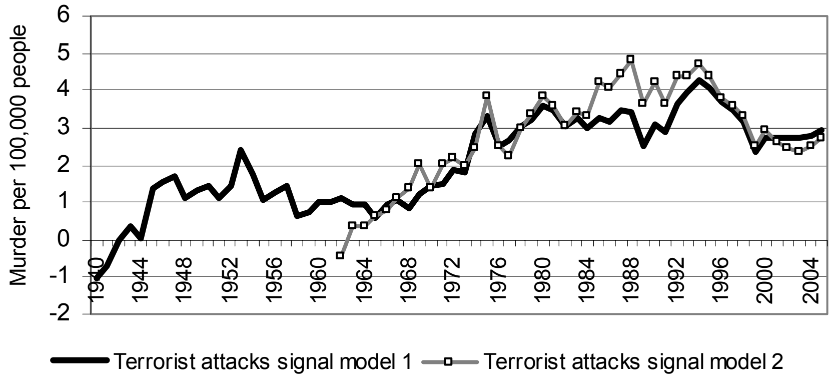

Figure 4A. Cyclical terrorist murder and attacks index for Washington State 1940-2005 - Model 1

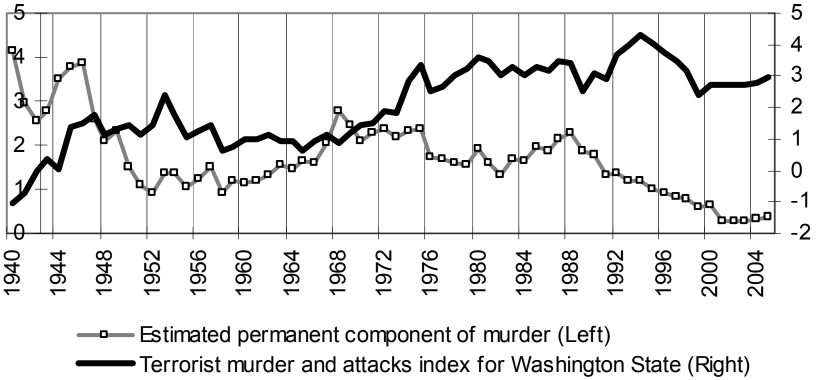

Figure 4B for information purposes presents jointly the terrorist attacks index for the States of Washington and California.

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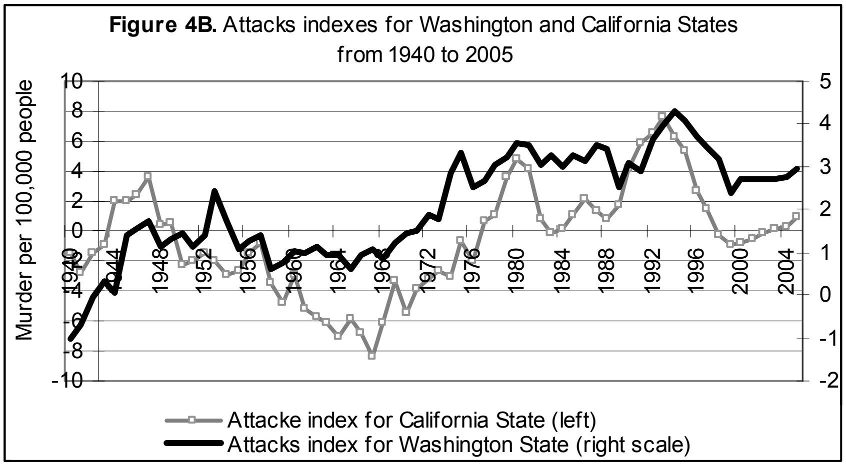
[3] Turning the estimated permanent per capita component into the level of the permanent component.



Remarks, model 2.

Model 2 captured in figure 2, appears at all times with better statistical fitting compared with number 1. In a future exercise constructing the model for attacks for Washington, both signals must be used on this purpose. The choosing of model number 1 was motivated for providing the right response to the attacks of the World Trade Center and 9/11. Because of the long autoregressive structure or order 28 reducing degrees of freedom for providing an optimal cyclical signal model 2 was not able to replicate the attacks, however its is worth mentioning that captures to perfection the remaining subset of historical facts of U.S wars, riots occurred in its closeness as riots in California and presidential assassinations. For President Kennedy's assassination its cyclical signal went up from -0.45 in 1962 to 0.35 in 1963; for the Vietnam Conflict (1964-1973), it jumped at its entrance in 1964 when moving 0.35 in 1963 to 0.36 in 1964, in identical way at its exit in 1973 descended when moved from 2.20 in 1972 to 1.98 in 1973.

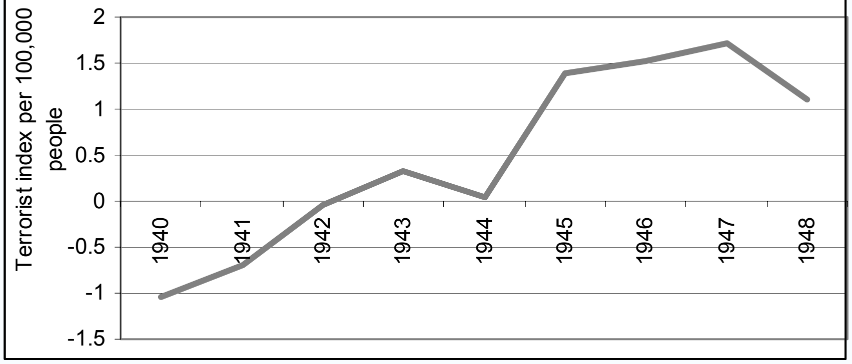
For its closeness to California, the Washington index suffered, and so Los Angeles riots of 1965, climbed this index from 0.36 in 1964 to 0.64 in 1965. The assassination of Dr. Martin Luther King moved it from 1.10 in 1967 to 1.36 in 1968; the military operations in Los Angeles in 1992, affected it when peaked from 3.64 in 1991 to 4.41 in 1992. The exceptions to this optimal behavior were years 1993 and 2001, where for the Trade Center bombing decreased from 4.41 in 1992 to 4.36 in 1993, and 9/11 where decreased again from 2.92 to 2.62. The choosing of model 1 was motivated for the fact that model 2 did not replicate this two last tragic events because of lacking data preventing the Gauss-Newton convergence routine to provide an optimal cyclical signal. For informational purposes the cyclical signal of model 2 is additionally provided on appendix B.

3. Interpretation of results.

Using the data series of per capita murder for the State of Washington, I have been able to split that series finding the terrorist index and the permanent component of murder for the State.

The Washington State index, same as for the NYC case (Gómez-Sorzano, 2007A) and California (Gómez-Sorzano, 2007D) captures pretty well a reduction in its attacks index during the Good Neighbor Policy period or Second phase of America's Caribbean War (1933-1945). The attacks index was negative from 1940 to 1942 became positive in 1943 with 0.33, jumped to 1.38 in 1945, and descended in 1948 to 1.11 (fig. 5) after the surrendering of Japan on 2 September 1945; same as for New York City following the nuclear attacks to Hiroshima and Nagasaki, the index additionally jumped in 1946 to 1.52 (10.1%), and peaked, getting a turning point date in 1947 with 1.72 (13.1%).

Figure 5. The terrorist murder and attacks index for Washington State during the U.S. Good Neighbor Policy period from 1933 to 1945



In a similar fashion to California (Gómez-Sorzano, 2007D) from 1948 to 1952 the Washington index decreased continually, and peaked in 1953 to 2.41. A sub period immerse here from 1953 to 1959 coincides with the diminishing of the terrorist index for the nation as a whole e.g., the U.S. index decreased from 1953 to 1959 from 0.81 to 0.34 (Gómez-Sorzano 2006); for identical period for Washington it moved from 2.41 to 0.73. The assassination of President Kennedy did not affect the index where it still decreased from 1.12 in 1962 to 0.94 in 1963. At the entrance to the Vietnam Conflict in 1964 the index registered 0.94, but started slowly going up getting at its end in 1973 1.79, but continued its tendency up two additional years where for 1974 registered 2.84, and for 1975, it peaked with a value of 3.32.

Neither the Los Angeles riots of 11 August 1965 nor the assassination of Dr. Martin Luther King in 1968 affected this index; where it went down from 0.94 in 1964 to 0.60 in 1965, and later from 1.08 in 1967 to 0.83 in 1968.

From 1981 to 1992 the Washington index descends, and ascends erratically around an average of 3, but peaked in 1992 as a consequence of the Los Angeles riots, and military operations there on 29 April 1992. The index passed from 2.87 in 1991 to 3.64 in 1992 (26.82%), a fact marking this last year as the second highest historical peak for this index. Durham (1996, pp.1) reported that crimes of heinous nature dominate the national evening news around the country by the end of 1992, citizens reported this year 14.4 million offenses to law enforcement agencies around the country, meaning more than 5 percent of Americans were victimized by crimes, statistics also suggested that law enforcement agencies cannot keep up with the tide of crime, during this year only 21 percent of the offenses reported were cleared by arrest, according to the FBI, Uniform Crime Reporting System, someone was murdered every 22 minutes, robbed every 47 seconds, and raped every 5 minutes.

The Washington index as mentioned earlier captured the increased pressure felt across the nation as a consequence of the World Trade Center bombing, and 9/11 attacks where it moved from 3.64 in 1992 to 3.97 in 1993 (33%), while for 9/11 it jumped from 2.70 in year 2000 to 2.72 in 2001 (0.74%). From year 2002 onwards it ascends steadily getting a value of 2.75 for 2004 and 2.93 for 2005 (6.5%).

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 indexes for Washington State. The index works amazingly well at pointing out riots, and terrorist attack dates; it particularly foretold with precision recent tragic events occurred in the U.S as the World Trade Center bombing and 9/11 attacks. The Washington index for terrorist attacks appears climbing. It is required immediate research towards the construction of model for permanent murder and attacks.

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

Acknowledgements

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

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

$$W_t = Lt\,\mathrm{hom}_t - Lt\,\mathrm{hom}_{t-1} \qquad (1)$$

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

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

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

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

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

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

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

$$L\widehat{\text{hom}}_t(k) = L\text{hom}_t + \hat{W}_t(i) \tag{5}$$
$$= L\text{hom}_t + \left[\mu + \sum_{j=1}^{\infty}\lambda_j \varepsilon_{t+1-j}\right]$$
$$= k\mu + L\text{hom}_t + \left(\sum_{1}^{k}\lambda_i\right)\varepsilon_t + \left(\sum_{2}^{k+1}\lambda_i\right)\varepsilon_{t-1} + \ .\ .\ .\ .$$

And considering long forecasts, I approximately have

$$L\widehat{\text{hom}}_t(k) \cong k\mu + L\text{hom}_t + \left(\sum_{1}^{\infty}\lambda_i\right)\varepsilon_t + \left(\sum_{2}^{\infty}\lambda_i\right)\varepsilon_{t-1} + \ .\ .\ .\ .\ . \tag{6}$$

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

$$\overline{L\text{hom}_t} = L\text{hom}_t + \left(\sum_{1}^{\infty}\lambda_i\right)\varepsilon_t + \left(\sum_{2}^{\infty}\lambda_i\right)\varepsilon_{t-1} + \ .\ .\ .\ .\ .\ .\ . \qquad .(7)$$

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.

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

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

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

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

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

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

$$\vdots$$

$$W_1 = \overline{L\,\text{hom}_1} = \overline{L\,\text{hom}_0} + \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_1 \quad (\textit{this is the value for year } 1940)$$

$$\vdots$$

$$W_{44} = \overline{L\,\text{hom}_{66}} = \overline{L\,\text{hom}_0} + \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_{44} \quad (\textit{this is the value for year } 2005)$$

Adding these equations I obtain W_1 (the value for year 1940), 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

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

This is, Newbold's (1990, 457, Eq.(6), which is a differential equations that solves after replacing the initial value for $\overline{L\,\text{hom}_0}$, which is the logarithm of per capita murder in year 1940.

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

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

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

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

Bringing the moving average components to the LHS, I get

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

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.

$$L\,\mathrm{hom}_t - L\,\mathrm{hom}_{t-1} = \frac{0.049083999}{1+0.67} + \left(\frac{1-0.27-0.22+0.80+0.30+0.46}{1+0.67}\right)\varepsilon_t \quad (15)$$

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

$$L\,\mathrm{hom}_t - L\,\mathrm{hom}_0 = \frac{0.049\,t}{1+0.67} + \left(\frac{1-0.27-0.22+0.80+0.30+0.46}{1+0.67}\right)\sum_{i=1}^{t}\varepsilon_i \quad (16)$$

And rearranging,

$$L\,\mathrm{hom}_t = L\,\mathrm{hom}_0 + \frac{0.049\,t}{1+0.67} + \left(\frac{1-0.27+0.22+0.80+0.30+0.46}{1+0.67}\right)\sum_{i=1}^{t}\varepsilon_i \quad (17)$$

In the steady state, when L=1, Eq. (17) yields the permanent component of the per capita murder for Washington, 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 in Fig.4A.

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

	Original Data		**Terrorist murder and attacks index**		**Attacks index**
year	Murder	Murder per capita	Cyclical - component **MODEL 1**	Permanent component MODEL1	MODEL 2
1933		3.2			
1934		3.5			
1935		3.7			
1936		3			
1937		3.1			
1938		3.8			
1939		2.4			
1940		3.1	-1.0384	4.1384	
1941		2.27	-0.7039	2.9739	
1942		2.52	-0.0334	2.5534	
1943		3.12	0.3364	2.7836	
1944		3.56	0.0387	3.5213	
1945		5.18	1.3863	3.7937	
1946		5.37	1.5250	3.8450	
1947		4.32	1.7280	2.5920	
1948		3.2	1.1184	2.0816	
1949		3.65	1.3190	2.3310	
1950		2.98	1.4612	1.5188	
1951		2.23	1.1287	1.1013	
1952		2.33	1.4193	0.9107	
1953		3.8	2.4151	1.3849	
1954		3.1	1.7446	1.3554	
1955		2.1	1.0701	1.0299	
1956		2.5	1.2503	1.2497	
1957		2.9	1.4199	1.4801	
1958		1.5	0.6113	0.8887	
1959		1.9	0.7327	1.1673	
1960	61	2.14	1.0104	1.1275	
1961	63	2.17	1.0050	1.1659	
1962	74	2.46	1.1251	1.3366	-0.4505
1963	76	2.49	0.9428	1.5490	0.3510
1964	72	2.41	0.9441	1.4688	0.3684
1965	67	2.24	0.6029	1.6379	0.6451
1966	75	2.52	0.9292	1.5876	0.7848
1967	96	3.11	1.0868	2.0231	1.1095
1968	118	3.60	0.8371	2.7649	1.3698
1969	124	3.64	1.2055	2.4394	2.0082
1970	120	3.52	1.4310	2.0889	1.3868
1971	130	3.77	1.5163	2.2529	2.0222
1972	146	4.24	1.8673	2.3732	2.2099
1973	137	4.00	1.7938	2.2015	1.9863
1974	179	5.15	2.8459	2.3037	2.4358
1975	202	5.70	3.3226	2.3772	3.8262
1976	154	4.26	2.5285	1.7351	2.5226
1977	159	4.35	2.6600	1.6866	2.2521
1978	175	4.64	3.0451	1.5919	2.9734

1979	187	4.76	3.2047	1.5584	3.3568
1980	225	5.47	3.5726	1.8974	3.8292
1981	213	5.06	3.4844	1.5726	3.5714
1982	185	4.36	3.0348	1.3233	3.0575
1983	212	4.93	3.2689	1.6613	3.4063
1984	202	4.64	3.0118	1.6330	3.2924
1985	231	5.24	3.2696	1.9697	4.2530
1986	223	5.00	3.1285	1.8682	4.0855
1987	256	5.64	3.4904	2.1508	4.4623
1988	264	5.72	3.4351	2.2804	4.8216
1989	209	4.39	2.5209	1.8690	3.6487
1990	238	4.89	3.0977	1.7926	4.2310
1991	211	4.20	2.8794	1.3255	3.6406
1992	258	5.02	3.6422	1.3812	4.4122
1993	271	5.16	3.9721	1.1849	4.3680
1994	294	5.50	4.3006	1.2019	4.6873
1995	275	5.06	4.0528	1.0107	4.3983
1996	255	4.61	3.7147	0.8940	3.7731
1997	241	4.30	3.4573	0.8386	3.5709
1998	224	3.94	3.1582	0.7792	3.3266
1999	171	2.97	2.3733	0.5973	2.5056
2000	196	3.33	2.7085	0.6168	2.9212
2001	179	3.00	2.7296	0.2704	2.6257
2002	184	3.00	2.7067	0.2933	2.4807
2003	182	3.00	2.7098	0.2902	2.3673
2004	190	3.10	2.7592	0.3408	2.4861
2005	205	3.30	2.9386	0.3614	2.7272

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