Cycles of violence and terrorist attacks index for the State of Arizona

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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 Arizona (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 in the U.S. soil, and foreign wars fought by the country from 1941 to 2005, have affected Arizona creating estimated turning point dates clearly 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. Other indexes already constructed include the attacks indexes for the U.S (http://mpra.ub.uni-uenchen.de/1145/01/MPRA_paper_1145.pdf), New York City (http://mpra.ub.uni-muenchen.de/4200/01/MPRA_paper_4200.pdf), and Massachusetts (http://mpra.ub.uni-muenchen.de/4342/01/MPRA_paper_4342.pdf). These indexes 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, cycles of violence, and terrorist attacks index for the State of Massachusetts.

JEL classification codes: C22, D74, H56, N46, K14, K42, N42, O51.

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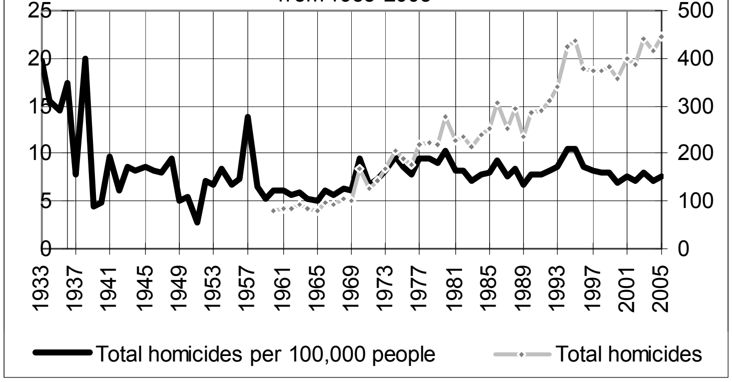
1. Introduction.

After decomposing violence, and creating the cyclical terrorist murder and attacks index for the United States and New York City: *decomposing violence: cycles of violence in the twentieth century in 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 2007B), and *cycles of violence, and terrorist attacks index for the State of Massachusetts* (Gómez-Sorzano 2007C), this paper continues that methodology research applied at the State level. The current exercise for Arizona State is the third 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 all over the U.S. This research shows that the estimated cyclical component of murder peaked pointing out the dates of occurrence of the last four terrorist attacks in U.S soil, particularly, the shut down in power in New York City in 1965, the World Trade Center bombing in 1993, the bombing of the Alfred P. Murrah Federal Building in Oklahoma in 1995, and 9/11 2001. The paper suggests that the State of Arizona has been able to break up the cycle of violence e.g., the estimated cyclical component of murder decreases from 1996 to 2004 (Fig. 4).

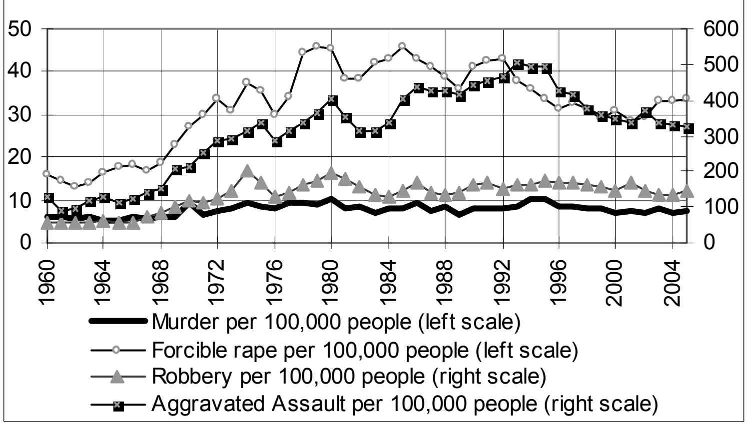
According to the Federal Bureau of Investigation, Uniform Crime Reporting System, total homicides in Arizona State increased from an average of 90 per year in the 1960s to 183 in the 1970s, 254 in the 1980s, and 360 in the 1990s (Fig. 1). When adjusted for population growth, i.e., homicides per 100,000 people in the population, an almost identical pattern emerges, reaching a first peak in 1938 with 20 murder per capita, and subsequent peaks in 1948, 1957, 1970, 1974, 1980, and 1994 respectively with 20, 9, 14, 9, 10, 10, and 10 per capita respectively.

Figure 1. Total homicides, in Arizona 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 and stabilization tendency (Fig. 2).

Figure 2. Categories of violent crime in Arizona State



Although the U.S., murder rates appear stabilizing during the last years, the highest per capita rates are found in the southwest where (Arizona belongs), and south regions with 6.67 and 6.39 per capita respectively (Fig. 3).

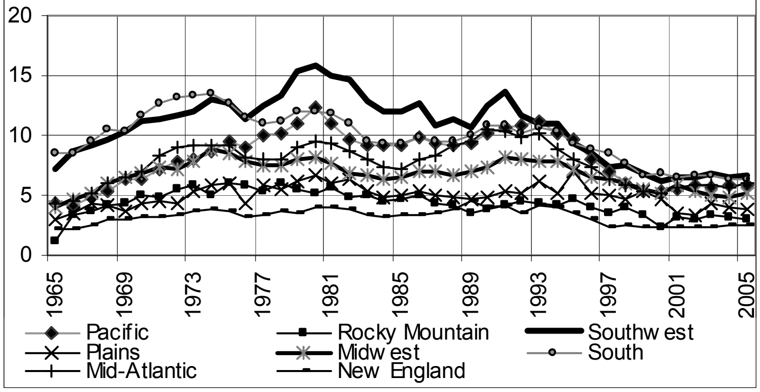


Figure 3. Murder per capita rates per 100,000 across regions of the U.S.

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 Arizona State series of murders.

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) 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 1.

[1] Taken from FBI, Uniform Crime Reports.

Table 2 Dickey & Fuller test for Unit Roots

Series	K	Alpha	Theta	Phi	Stationary
D(Lhariz) – murder series	1	0.9496	0.001068	-0.4925	Yes
Arizona State , 1933-2005		(3.66380	(0.6851)	(-4.0738)	

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 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 transitory component oscillating with a cero average that covariates inversely with the permanent component, as is technically required, and whose estimated turning point dates coincide with major terrorist attacks suffered, and with wars fought by the U.S. The procedure begins by fitting the logarithm of the per capita murder series to an ARIMA model of the form (2):

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

Where k, and h are respectively the autoregressive and moving average components. The selection of the ARIMA model is computationally intense. My search for the right model for the period 1933-2005 stopped with an ARIMA (7,1,7) ran with RATS 4, shown in table 2, and including autoregressive components of order 1, 2, and 7, and moving average terms of order 1,2,3, and 7; the model is unique at providing a cyclical component oscillating around a zero average:

Table 2. Estimated ARIMA model for murder for Arizona State

Annual data from 1933 to 2005

Variables	**Coeff**	**T-stats**	**Std Error**	**Signif**
Constant	0.0254	2.76	0.0090	0.0000
AR(1)	-0.8696	-13.21	0.0650	0.0000
AR(2)	-0.5506	-16.77	0.0320	0.0000
AR(7)	0.2027	4.91	0.0410	0.0000
MA(1)	0.7434	4.33	0.1700	0.0000
MA(2)	-0.8025	-3.49	0.2298	0.0000
MA(3)	-1.1039	-5.09	0.2168	0.0000
MA(7)	-1.5144	-5.32	0.2842	0.0000

Centered R^2 = 0.6066

DW= 1.89

Significance level of Q = 0.001

Usable observations = 65

[2] Although according to Beveridge and Nelson (1981), the data series should be non-stationary for performing the procedure, I proceeded with it finding and attacks index for Arizona that coincides with major attacks on U.S soils and wars fought by the country.

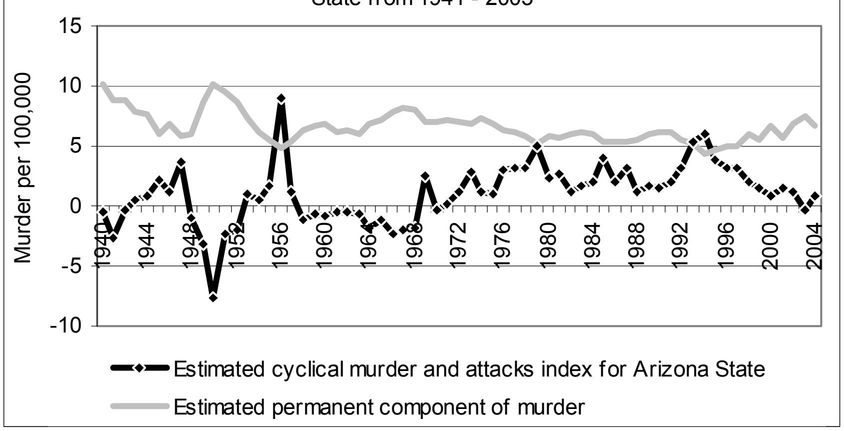
The six model parameters are replaced in the equation for the permanent component of murder shown in (3)[3]:

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

The transitory or cyclical terrorist murder estimate is found by means of the difference between the original series, and the exponential of the permanent per capita component ($L\,\mathrm{hom}_t^{PC}$)[4], and is shown in Figure 4, that additionally shows the estimated permanent component. 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 of Arizona. 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), and Monkkonen (2001), Wikepedia.

Figure 5 for informational purposes shows, the terrorist murder and attacks indicator for Arizona State, and New York City.

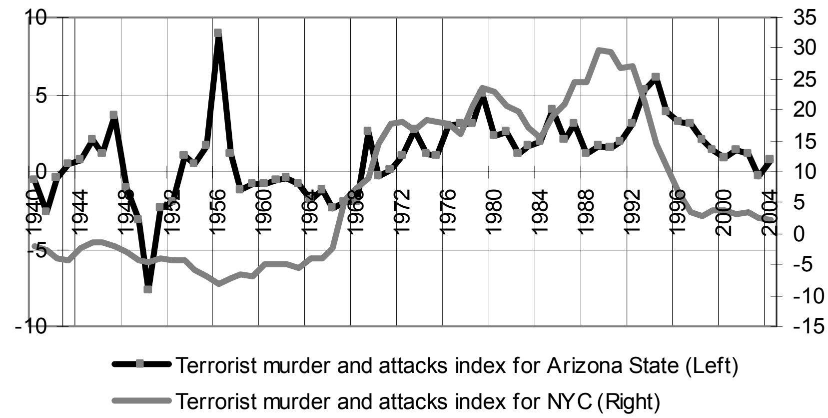
Figure 4. Cyclical terrorist murder and attacks index for Arizona State from 1941 - 2005



[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 murder and attacks index for Arizona State and New york City from 1941 to 2005



3. Interpretation of results.

The State of Arizona historically has not had a terrorist attack, but its index captures pretty well the cycles experienced by the U.S. as a whole, and most importantly, predicting sometimes with a sluggish response, the recent tragic terrorist attacks experienced by the nation.

The Arizona index felt the impact of the attacks to Hiroshima and Nagasaki on September 6 and 9 of 1945; the index moved from 1944 to 1945 from 0.49 to 0.83 (33.3%), and jumped in year in 1946 again to 2.11 (128.2%), decreasing in 1947 to 1.22.

The assassination of president Kennedy on 22 November 1963 appears as responsible for the ascension this year from an initial value of -0.52 in 1962 to -0.42 in 1963 (19.25). The shut down in power in NYC on 9 November 1965 affected the index with a sluggish response: it was decreasing from -0.73 in 1964 to -1.85 in 1965 (-153.4%) but one year later in 1966 jumped to -1.14 (62.2%).

The terrorist murder of Dr. Martin Luther King on 4 April 1968 moved the index up from 1967 to 1968 from -2.22 to -1.93 (15%). During the Vietnam Conflict period the index moved continuously for Massachusetts getting its higher historical value of 1.93 in 1973 once the conflict was over. From 1973 to 1974 the index moved from 1.93 to 1.90 (-1.57%). Additional facts include the World Trade Center bombing in 1993 which moved the index from 1.98 in 1992 to 3.09 in 1993 (56%); the terrorist bombing of the Alfred P. Murrah building in Oklahoma occurred on 19 April 1995, additionally pushed the index up from 5.35 in 1994 to 6.06 in 1995 (71.1%). Finally 9/11 2001 caused a sluggish response for the index which was coming down from 1.48 in 2000 to 0.86 in 2001 (-61.7), but jumped in 2002 to 1.44 (57.7 %).

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 Arizona State. The index works amazingly well at pointing out terrorist attack dates; it particularly foretold with amazing precision major recent tragic events occurred in the country as the World Trade Center bombing of 1993, and 9/11 2001 attacks. Immediate research should be done headed towards the construction of a model for terrorist attacks, and permanent murder for Arizona.

Data Source: FBI, Uniform Crime reports.

Acknowledgements

I thank the organizers of the Stockholm Criminology Symposium 2007, Lina Nilsson, and the Jerry Lee Center of Criminology (Dr. Lawrence W. Sherman) 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, and many other anonymous lecturers around the world.

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

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

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

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

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

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

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

And considering long forecasts, I approximately have

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

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 $\overline{L\hom_t}$ I have

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

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.

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

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

$$
\overline{L\hom_t} - \overline{L\hom_{t-1}} = \mu + \frac{(1-\theta_1 - \dots \theta_q)}{(1-\phi_1 - \dots \varphi_p)}\varepsilon_t = \mu + \frac{\theta(1)}{\varphi(1)}\varepsilon_t \quad (9)
$$

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

$$W_t = \overline{L\hom_t} - \overline{L\hom_{t-1}} = \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_t \qquad (10)$$

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

:

$$W_1 = \overline{L\hom_1} = \overline{L\hom_0} + \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_1 \quad (\textit{this is the value for year } 1941)$$

:

$$W_{65} = \overline{L\hom_{65}} = \overline{L\hom_0} + \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_{65} \quad (\textit{this is the value for year } 2005)$$

Adding these equations I obtain W_1 (the value for year 1941), and W65 (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

$$\overline{L\hom_t} = \overline{L\hom_0} + \mu.t + \frac{\theta(1)}{\phi(1)}\sum_{i=1}^{t}\varepsilon_i \qquad (11)$$

This is, Newbold's (1990, 457, Eq.(6), which is a differential equations that solves after replacing the initial value for $\overline{L\hom_0}$, 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 Arizona (Table 2), 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

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

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

$$L\,\mathrm{hom}_t - L\,\mathrm{hom}_{t-1} = \frac{0.025}{1+0.86+0.55-0.20} + \left(\frac{1+0.74-0.80-1.10-1.51}{1+0.86+0.55-0.20}\right)\varepsilon_t \quad (15)$$

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

$$L\,\mathrm{hom}_t - L\,\mathrm{hom}_0 = \frac{0.025.\,t}{1+0.86+0.55-0.20} + \left(\frac{1+0.74-0.80-1.10-1.51}{1+0.86+0.55-0.20}\right)\sum_{i=1}^{t}\varepsilon_i \quad (16)$$

And rearranging,

$$L\,\mathrm{hom}_t = L\,\mathrm{hom}_0 + \frac{0.025.\,t}{1+0.86+0.55-0.20} + \left(\frac{1+0.74-0.80-1.10-1.51}{1+0.86+0.55-0.20}\right)\sum_{i=1}^{t}\varepsilon_i \quad (17)$$

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

Appendix B : data table

	Original Data		BEVERIDGE – NELSON Terrorist murder and attacks index	
year	Murder	Murder per capita	Cyclical – component	Permanent component
1933		19.80		
1934		15.50		
1935		14.40		
1936		17.50		
1937		7.80		
1938		19.90		
1939		4.50		
1940		4.90		
1941		9.63	-0.5678	10.1978
1942		6.19	-2.6281	8.8181
1943		8.56	-0.3528	8.9128
1944		8.28	0.4992	7.7808
1945		8.57	0.8331	7.7369
1946		8.14	2.1151	6.0249
1947		8.00	1.2208	6.7792
1948		9.45	3.6534	5.7966
1949		5.04	-1.0152	6.0552
1950		5.42	-3.1778	8.5978
1951		2.63	-7.6143	10.2443
1952		7.06	-2.3764	9.4364
1953		6.70	-1.9824	8.6824
1954		8.40	0.9950	7.4050
1955		6.70	0.5350	6.1650
1956		7.30	1.7251	5.5749
1957		13.90	9.0139	4.8861
1958		6.60	1.2170	5.3830
1959		5.20	-1.1402	6.3402
1960	78	5.99	-0.7414	6.7314
1961	84	6.04	-0.7670	6.8058
1962	86	5.70	-0.5289	6.2281
1963	93	5.97	-0.4221	6.3874
1964	83	5.25	-0.7382	5.9880
1965	80	4.98	-1.8571	6.8322
1966	98	6.06	-1.1434	7.2002
1967	91	5.57	-2.2921	7.8613
1968	105	6.29	-1.9376	8.2250
1969	102	6.02	-1.8969	7.9217
1970	168	9.48	2.5593	6.9190
1971	124	6.71	-0.2671	6.9734
1972	142	7.30	0.0892	7.2116
1973	167	8.11	1.0934	7.0213
1974	206	9.57	2.7575	6.8105
1975	191	8.59	1.2242	7.3639
1976	177	7.80	0.9761	6.8212
1977	217	9.45	3.0466	6.4046
1978	221	9.39	3.1564	6.2318
1979	219	8.94	3.1053	5.8335

1980	279	10.27	5.0678	5.2071
1981	227	8.13	2.3152	5.8123
1982	236	8.25	2.6446	5.6071
1983	213	7.19	1.1494	6.0392
1984	238	7.80	1.6470	6.1486
1985	254	7.97	1.9733	5.9965
1986	307	9.26	3.9928	5.2625
1987	253	7.47	2.0821	5.3898
1988	294	8.48	3.1657	5.3167
1989	237	6.66	1.1051	5.5597
1990	284	7.75	1.6729	6.0756
1991	291	7.76	1.5735	6.1865
1992	312	8.14	1.9807	6.1613
1993	339	8.61	3.0967	5.5161
1994	426	10.45	5.3509	5.1031
1995	439	10.41	6.0624	4.3454
1996	377	8.51	3.8853	4.6287
1997	375	8.23	3.2263	5.0064
1998	376	8.05	3.1043	4.9488
1999	384	8.04	2.0158	6.0204
2000	359	7.00	1.4870	5.5102
2001	400	7.50	0.8693	6.6307
2002	387	7.10	1.4467	5.6533
2003	441	7.90	1.1047	6.7953
2004	414	7.20	-0.3059	7.5059
2005	445	7.50	0.8037	6.6963

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