Cycles of violence, riots, and terrorist attacks index for the State of California

Gómez-sorzano, Gustavo

LeasingMetrix Group, Inc

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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 California. (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 as riots, crime legislation, social, and political unrest, and recently with the periodic terrorist attacks to the U.S. The estimated cyclical component of murder, or attacks index found is optimal, and warns that terrorist attacks against the U.S., and riots in California have created estimated turning point dates marked by those tragic events. The index peaked to point out the World Trade Center Bombing in 1993, and 9/11 2001, and for California it amazingly well captured the riots of 1965 and 1992. This paper belongs to the series of papers helping the U.S, and Homeland Security identify the closeness of terrorist attacks through the construction of Attacks indexes across the U.S. Other indexes 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. 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.
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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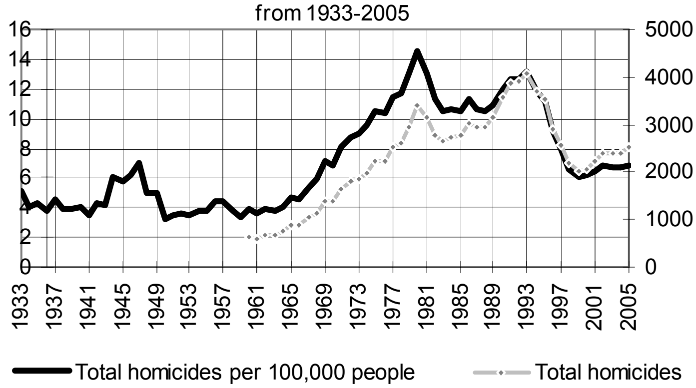
1. Introduction.

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 California State is the fourth 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 carefully pointed out the date of occurrence of the disruption in social order in California in 1965 and 1992, and as well the last terrorist attacks against the U.S, particularly, the World Trade Center bombing in 1993, and 9/11 2001.

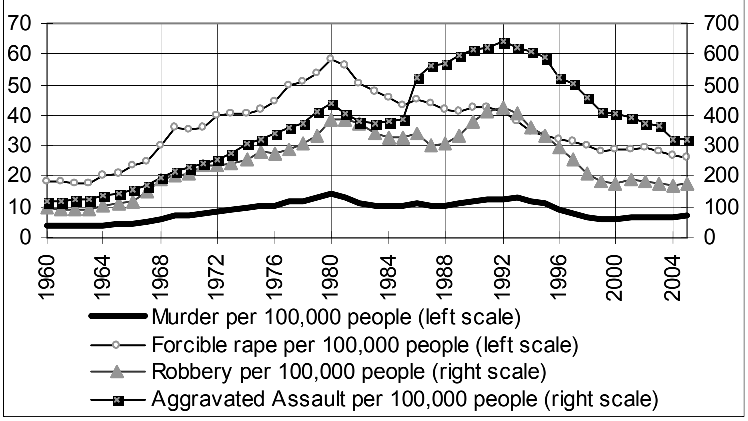
According to the Federal Bureau of Investigation, Uniform Crime Reporting System, total homicides in California State increased from an average of 861 per year in the 1960s to 2,116 in the 1970s, 2,952 in the 1980s, and 3,233 in the 1990s (Fig. 1). When adjusted for population growth, i.e., homicides per 100,000 people in the population, an almost identical pattern emerges, reaching a first peak in 1947 with 7 murder per capita, and subsequent peaks in 1974, 1980, and 1993 respectively with 9, 15, and 13 per capita respectively; while for 2005 it gets 7.

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



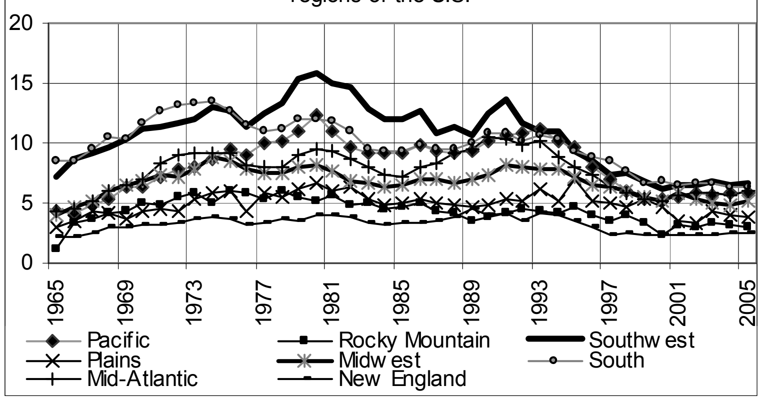
Out of the state's four categories of crimes, measuring violent crime (murder, forcible rape, robbery, and aggravated assault) murder is the one that varies the less showing a stabilization tendency (Fig. 2).

Figure 2. Categories of violent crime in California 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 California 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 California 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).

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

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(Lhcalif) – per capita murder series	26	0.4225	0.0118	-0.5358	No
California State , 1933-2005		2.9617	2.500	(-2.809)	

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):

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

Where k, and h are respectively the autoregressive and moving average components. The selection of the ARIMA model for California was particularly difficult and computationally intense. I carefully show all the steps involved at creating the attacks index for California. The modeling effort started by initially using the per capita murder followed by using the raw series of homicides. The per capita model preliminary selected for the period 1933-2005 is an ARIMA (28,1,19) ran with RATS 4, shown in table 2A as model 1, and including autoregressive components of order 1, 2,6, and 28, and moving average terms of order 1,5 and, 19. The model barely fulfills the technical requirement of providing a cyclical component oscillating around a zero average (Fig.4), its Durbin Watson index of 2.25 indicates negative autocorrelation, and its cyclical signal does not peak for the 1992 Los Angeles riots, neither for 9/11 attacks.

In search for a model with an optimum D.W. indexes between 1.95 and 2.09, I undertook a second round of estimations. Table 2A shows two additional ARIMAS (models 2 and 3) not providing an oscillatory cyclical component of murder, and DW indexes of 1.41, and 1.97 respectively. Both models however show the huge impact felt on California as a consequence of 9/11 terrorist attacks (Fig.5). e.g., model 2 signaled 9/11 attacks when peaked in year 2001, after passing from -139,972 in 2000 to -3,024 in 2001; model 3 as well did the same peaking in 2001 when its signal moved from -211 in year 2000 to -45.1 in 2001. Both models are rejected for not oscillating around a zero average and reproducing main attacks to the U.S and riots in California.

Table 2A. Estimated ARIMA models for per capita murder for California
Annual data from 1933 to 2005- **MODELS 1, 2 and 3**
(Underlined numbers model 1, regular numbers model 2, bold numbers for Model 3)

Variables	Coeff	T-stats	Std Error	Signif
Constant	0.0496	5.269	0.0094	0.0000
	0.0130	**1.0000**	**0.0130**	**0.3192**
	0.0733	7.0530	0.0100	0.0000
AR(1)	**0.2943**	**3.51**	**0.0838**	**0.0000**
	-0.2899	-2.682	0.1080	0.0110
AR(2)	0.6697	11.47	0.0583	0.0000
	0.6770	**7.36**	**0.0920**	**0.0000**
	0.5844	9.148	0.0638	0.0000
AR(6)	-0.2209	-3.707	0.0596	0.0000
	-0.3204	-13.114	0.0244	0.0000
AR(8)	**-0.2077**	**-1.641**	**0.1265**	**0.1064**
AR(28)	0.2013	11.953	0.0168	0.0000
	0.3032	7.162	0.0423	0.0000
MA(1)	0.4835	5.436	0.0889	0.0000
	-0.1300	**-2.4**	**0.0540**	**0.0190**
	1.0420	2.644	0.3930	0.0120
MA(2)	**-0.4872**	**-4.09**	**0.1191**	**0.0000**
MA(4)	**-0.4359**	**-3.08**	**0.1413**	**0.0030**
MA(5)	-1.3780	-7.92	0.1740	0.0000
	-3.2392	-4.598	0.7043	0.0000
MA(6)	**-0.5240**	**-3.33**	**0.1573**	**0.0000**

MA(8)	**0.3957**	**2.35**	**0.1670**	**0.0220**
MA(12)	0.3980	2.79	0.1420	0.0700
MA(19)	-0.8099	-3.218	0.2516	0.0026
	-2.8509	-2.625	1.0859	0.0126

Centered R^2 = 0.9840, 0.97 **(0.947)** DW= 2.25, 1.41 **(1.97)**
Significance level of Q = 0.0049, 0.0000 **(0.1619)**
Usable observations = 44, 44 **(64)**

Figure 4. Cyclical and permanent signals for California State 1962-2005 - MODEL 1 -

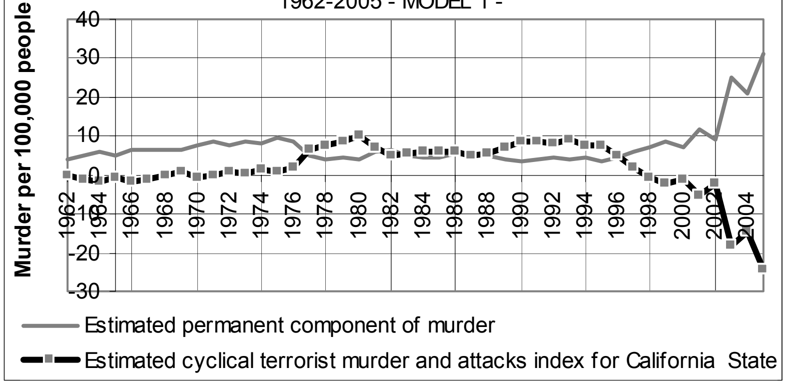
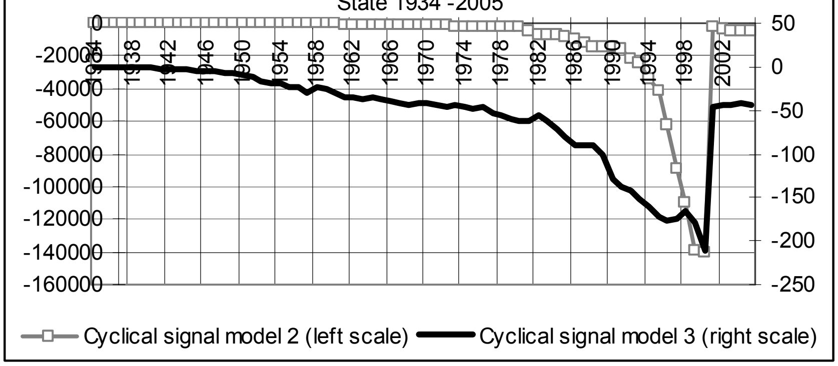


Figure 5. Cyclical terrorist signals from models 2 and 3. California State 1934 -2005



Estimating an ARIMA model using the raw series of homicides.

In this section I start searching for an optimal ARIMA using the original raw series (series in levels) of homicides for the State.

Table 3, presents the statistical fitting of model 4 as displaying an optimal DW index of 2.03, but its cyclical signal again is not providing an estimated index fluctuating around a zero average (Fig. 6), suggesting that although the model preserves excellent statistical fitting can not be accepted for not reproducing attacks suffered by the U.S and riots that historically have occurred in California.

Table 3. Estimated ARIMA model for murder for California State

Annual data from 1933 to 2005 – **MODEL 4**

Variables	Coeff	T-stats	Std Error	Signif
Constant	0.0490	3.68	0.0130	0.0000
AR(1)	0.9631	7.32	0.1314	0.0000
AR(3)	-0.2708	-2.16	0.1248	0.0360
MA(1)	-0.8746	-19.93	0.0430	0.0000
MA(4)	0.4768	12.18	0.0390	0.0000
MA(16)	-0.5582	-4.06	0.1374	0.0000

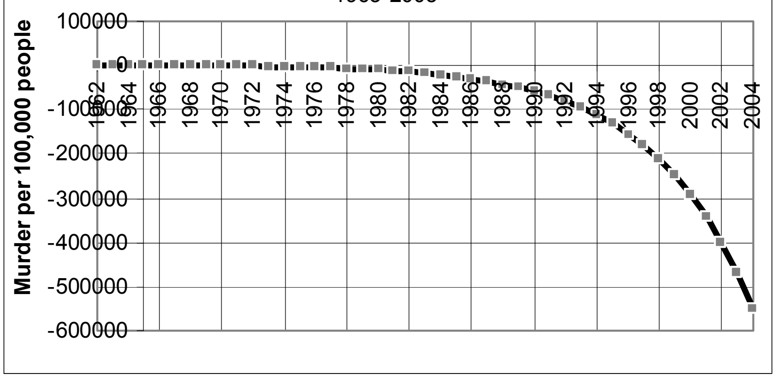
Centered R^2 = 0.9729

DW= 2.03

Significance level of Q = 0.4479

Usable observations = 42

Figure 6. Cyclical terrorist signal for Model 4. California State 1963-2005



In search for the right model for the State of California

I get back to my initial search for an ARIMA model using the per capita murder series that provides a cyclical signal oscillating around a zero average. Models 5, and 6 shown on table 4 display optimal D.W. indexes of 2.03 and 2.09 respectively.

Table 4. Estimated ARIMA models for per capita murder for California
Annual data from 1933 to 2005- **MODELS 5 and 6**
(Bold numbers for Model 6)

Variables	Coeff	T-stats	Std Error	Signif
Constant	0.0587	11.33	0.0051	0.0000
	-0.0189	**-4.0500**	**0.0046**	**0.0000**
AR(1)	0.7110	24.71	0.0287	0.0000
AR(28)	-0.1576	-4.89	0.0322	0.0000
MA(1)	-1.6023	-3.41	0.4697	0.0000
MA(3)	1.5478	3.34	0.4627	0.0019
	-0.2719	**-2.74**	**0.0990**	**0.0000**
MA(4)	**-0.3243**	**-3.99**	**0.0812**	**0.0000**
MA(6)	**-0.7273**	**-9.06**	**0.0802**	**0.0000**
MA(8)	**-0.3303**	**-2.93**	**0.1124**	**0.0045**
MA(10)	1.0313	3.03	0.3400	0.0044
MA(13)	**-0.5996**	**-6.03**	**0.0994**	**0.0000**
MA(16)	-1.2920	-2.89	0.4462	0.0064
MA(22)	0.8704	2.17	0.4005	0.0360

Centered R^2 = 0.97 **(0.956)** DW= 2.03 **(2.09)**
Significance level of Q = 0.00030 **(0.4959)**
Usable observations = 44 **(72)**

Model 5 although having a DW index of 2.03, does not give a signal fluctuating around a zero average (Fig. 6); model 6 on the contrary is a parsimonious six parameter ARIMA model (0,1,13), with no autoregressive structure, but a simple moving average structure with parameters of order 3,4,6,8, and 13 that reproduces U.S., and California cycles.

Technically, although model 5 did jump for 9/11 attacks, where its signal went up from -46 in year 2000 to -41 in year 2000, it did not jump for the World Trade Center bombing where it moved down from -20.5 in 1992 to -25 in 1993. Model 6 however displays and optimal oscillation pattern around a zero average, having an optimal DW index of 2.09, plus the advantages of replicating to perfection the main U.S attacks, e.g., for 9/11 2001 it went up from -0.85 in year 2000 to -0.55 in 2001 (54.5%), while for the Trade Center attack, it passed from 6.29 in 1992 to 7.63 in 1993 (21.30%), figure 6.

In regards to the California riots the model also peaks in 1965, when passing from -7.05 in 1964 to -5.84 in 1965, and much better now, it peaks amazingly well again for the 1992 Los Angeles riots when moving from 5.90 in year 1991 to 6.52 in 1992. The terrorist attacks index thus found is optimal, and I show the technical details for its construction.

The six model parameters from table 4 are replaced in the equation for the permanent component of murder shown in (3)[2]:

[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.

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

The transitory 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 ($L\hom_t^{PC}$)[3], and is shown on figure 6. Figure 8 additionally shows jointly the selected attacks index, as well as the permanent component of murder. The attacks index 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 California. 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 6. Cyclical terrorist signals for models 5 and 6. California State 1962-2005

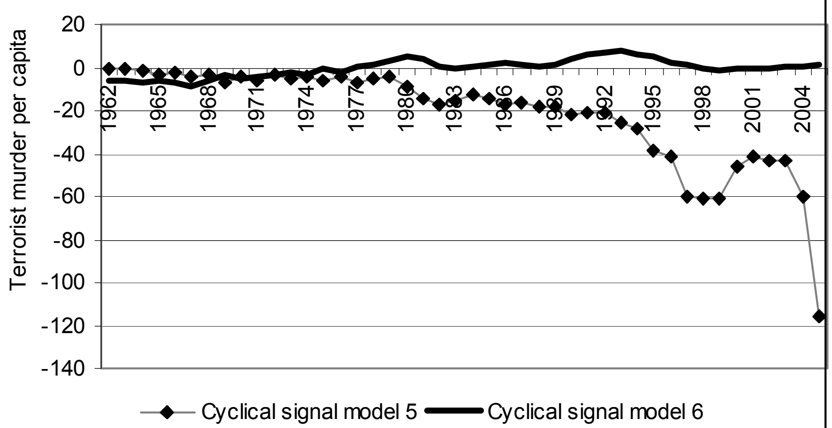
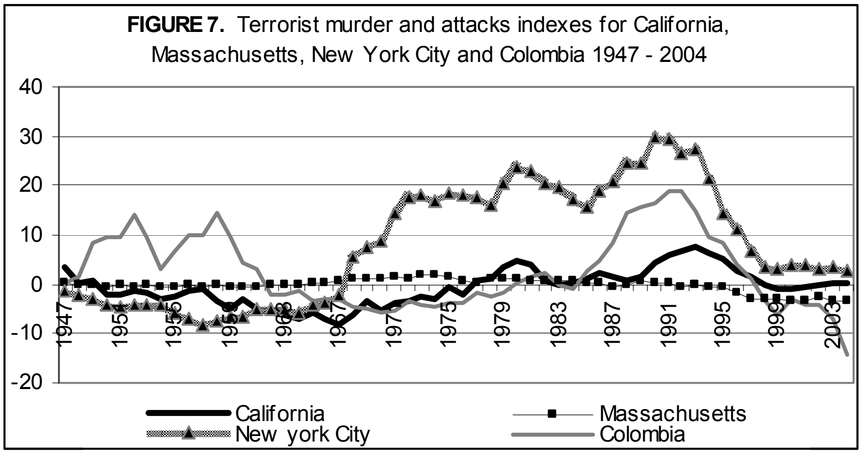
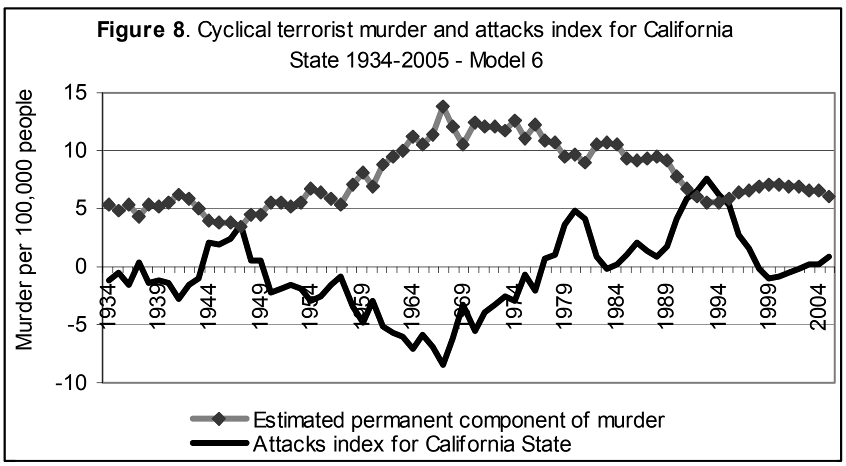


Figure 7 for informational purposes presents jointly the terrorist attacks index for the States of California, Massachusetts, New York City and Colombia.

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



The terrorist attacks index and the per capita component of murder for the State of California are displayed on Figure 8.

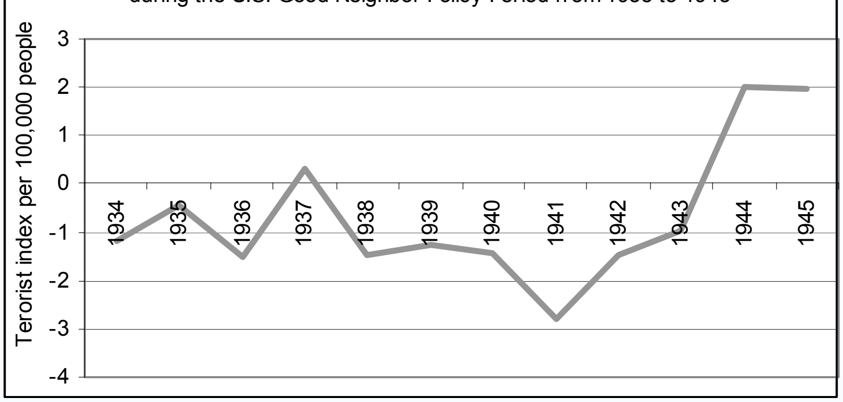


3. Interpretation of results.

I have surpassed all the technical difficulties encountered for constructing the attacks index for California. I estimated models 1,2,3,4,5, and 6. Model 1 barely suggested a cyclical component oscillating around a zero average, and although all its t-statistics were significant, it was plagued with negative autocorrelation. Models 2, and 3 on its part were not optimal; for model 2 all statistic T's were significant but suffered serial autocorrelation, model 3 missed having a full set of significant T's. Model 4 presented optimal statistical indexes, but it was estimated using homicides in levels, getting a signal not fluctuating around a zero average. Model 5 returned to the estimation process in per capita figures permitting concluding the rejection of an autoregressive structure for California, and so the finding of an optimal moving average structure for the State. Model 6 thus permitted the optimal splitting of the per capita murder series finding the terrorist index and the permanent component of murder for the State. For its many particularities the State of California historically has not had a terrorist attack, but its index captures amazingly well its riots, cycles of violence as well as terrorist attacks suffered by the U.S.

The California index, same as for the NYC case (Gómez-Sorzano, 2007A) 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 moved from -1.16 in 1934 to -0.95 in 1943, jumped to 2.02 in 1944 and slightly descended in 1945 to 1.94 (fig 9) 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 additionally in 1946 to 2.40 (23.7%), getting a turning point in 1947 with 3.54 (47.5%).

Figure 9. The terrorist murder and attacks index for California during the U.S. Good Neighbor Policy Period from 1933 to 1945



From 1948 to 1967 the California index decreased continually getting its lowest value or most peaceful historical time in 1967 with -8.42. 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 California it moved from -1.93 to -4.84. The assassination of President Kennedy did not affect the index where it still decreased from -5.68 in 1962 to -6.11 in 1963. At the entrance to the Vietnam Conflict in 1964 the index registered -7.05 and started slowly going up getting at its end in 1973 -2.63, and decreased again one year later to show diminished pressure in 1964 to -7.05 (-15.38%).

My index captures amazingly well the Los Angeles riots of 11 August 1965, in Watts, where according to Wikipedia[4], they were initiated by a minor incident when Lee Minikus, a California Highway Patrol Motorcycle officer, pulled over Marquette Frye,

[4] http://en.wikipedia.org/wiki/Watts_Riots

who Minikus believed was intoxicated because of his observed erratic driving. However, in this part of town specially, traffic stops were not so routine. While police questioned Frye and his brother Ronald Frye, a group of people began to gather. The mob began to throw rocks and other objects and shout at the police officers. A struggle ensued shortly after Frye's mother, Rena, arrived on the scene, resulting in the arrest of all three family members, in the aftermath as a result of the riots, 34 people were officially reported killed (28 of those were African American), 1,032 people were injured, and 4,000 people were arrested. Among the dead were a fireman, an LA County deputy sheriff and a Long Beach police officer. The injured included 773 civilians, 90 Los Angeles police officers, 136 firemen, 10 national guardsmen, and 23 persons from other governmental agencies. 118 of those injured were injured by firearms. 600 buildings were damaged or destroyed, and an estimated $35 million in damage was caused. Most of the physical damage was confined to businesses that were said to have caused resentment in the neighborhood due to perceived unfairness. Homes were not attacked, although some caught fire due to proximity to other fires. My index effectively jumps from -7.05 in 1964 to -5.84 in 1965 (20.7 % change), and then decreases again to -6.86 (-17.4%) in 1966.

The assassination of Dr. Martin Luther King Jr. on 4 April 1968, jumped the index from -8.42 in 1967 to -6.12 in 1968 (37.5%) to -3.32 (84.3%) in 1969 and decreased again to -5.50 (-65.6%) in 1970. From 1971 to 1980 the California index begins a fast ascension getting its highest historical peak the latter year with a value of 4.77, according to Gómez-Sorzano (2006), a similar ascension for those years was noted for the U.S. index.

From 1981 to 1992 the California index descends, and ascends. During this sub period a lowest point is registered in 1983 with -0.19, but starts ascending afterwards peaking in 1992 as a consequence of the Los Angeles riots. The index passed from 5.93 in 1991 to 6.59 in 1992 (11.12%), 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.

My index captures amazingly well the military operations in Los Angeles occurred on 29 April 1992. According to the Military Museum[5] parts of Los Angeles can be extremely dangerous, the county had over 100,000 gang members and there were 771 gang-related homicides reported in 1991 that was the environment when the Rodney King verdict was announced. According to the BBC news[6], the riots in Los Angeles

[5] http://www.militarymuseum.org

[6] http://news.bbc.co.uk/onthisday/hi/dates/stories/april/29/newsid_2500000/2500471.stm

lasted several days. The violence killed 55 people, and included revenge attacks against whites and Asians. About 2,000 were injured, with a further 12,000 arrested

My California index as mentioned earlier captured this increased pressure by jumping the attacks index by (11.12%). Finally the World Trade Center bombing was the final trust to the attacks index for the U.S, and California, one more time the index proves its efficiency at showing to perfection that this attack jumped the index additionally from 6.59 in 1992 to 7.63 in 1993 (15.78%).

Finally California felt the huge impact caused by 9/11 attacks, jumping its index from -0.85 in year 2000 to -0.55 in 2001 (54.5%), later started coming down, butt increases again moving from 0.21 in 2004 to 0.93 in 2005 (342.8%).

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 California State. The attacks index works amazingly well at pointing out riots, and terrorist attack dates; it particularly foretold with amazing precision major recent tragic events occurred in the State as its riots of 1965, 1992, as well as the terrorist attack to NYC occurred in 1993, and 2001. The California attacks index appears as climbing. It is required immediate research towards the construction of model for attacks, and permanent murder.

Data Source: FBI, Uniform Crime reports.

Acknowledgements

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Appendix A. The Beveridge & Nelson decomposition of economic time series applied to decomposing the California State per capita homicides from 1934 to 2005.

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

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

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

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

And considering long forecasts, I approximately have

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

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

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

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

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.

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

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

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

The next step requires replacing the parameters of the ARIMA model (Table 4, model 6) and iterating Eq.(9) recursively, i.e., replace t by (t-1), and (t-1) by (t-2), etc, I get

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

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

:

$$W_1 = \overline{L\,\mathrm{hom}_1} = \overline{L\,\mathrm{hom}_0} + \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_1 \quad (\textit{this is the value for year } 1934)$$

:

$$W_{72} = \overline{L\,\mathrm{hom}_{72}} = \overline{L\,\mathrm{hom}_0} + \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_{72} \quad (\textit{this is the value for year } 2005)$$

Adding these equations I obtain W_1 (the value for year 1934), and W72 (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 1940.

Cárdenas (1991), suggests that Eq.(11), should be changed when the ARIMA model includes autoregressive components. Since the ARIMA developed for California (Table 4, model 6) does not include autoregressive structure, but 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

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

For the Californian case where its ARIMA model 6 shown in Table 4 does not have autoregressive structure Eq. (14) becomes.

$$(L\,\text{hom}_t - L\,\text{hom}_{t-1}) = \mu + (1+\theta_1 L^1 +.\ .+\theta_q L^q)\varepsilon_t \quad (14A)$$

And after replacing its parameters, I get

$$(L\,\text{hom}_t - L\,\text{hom}_{t-1}) = -0.018921531 + (1-0.27-0.32-0.72-0.33-0.59)\varepsilon_t \quad (14B)$$

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

$$L\,\text{hom}_t - L\,\text{hom}_0 = -0.018921531 + (1-0.27-0.32-0.72-0.33-0.59)\sum_{i=1}^{t}\varepsilon_i \quad (15)$$

And rearranging,

$$L\,\text{hom}_t = L\,\text{hom}_0 - 0.018921531 + (1-0.27-0.32-0.72-0.33-0.59)\sum_{i=1}^{t}\varepsilon_i \quad (16)$$

In the steady state, when L=1, Eq. (16) yields the permanent component of the per capita murder for California, the last step requires taking the exponential to the LHS of Eq. 16, 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.8.

Appendix B : data table

	Original Data		BEVERIDGE – NELSON Terrorist murder and attacks index Cyclical – component	Permanent Component
year	Murder	Murder per capita		
1933		5.1		
1934		4.1	-1.1639	5.2639
1935		4.3	-0.4518	4.7518
1936		3.8	-1.5166	5.3166
1937		4.6	0.3085	4.2915
1938		3.9	-1.4618	5.3618
1939		3.9	-1.2825	5.1825
1940		4.1	-1.4355	5.5355
1941		3.44	-2.7954	6.2354
1942		4.31	-1.4862	5.7962
1943		4.11	-0.9568	5.0668
1944		6.02	2.0223	3.9977
1945		5.79	**1.9462**	3.8438
1946		6.15	2.4039	3.7461
1947		7.05	**3.5412**	3.5088
1948		4.98	0.4498	4.5302
1949		4.97	0.4776	4.4924
1950		3.21	-2.2602	5.4702
1951		3.5	-1.9722	5.4722
1952		3.59	-1.5191	5.1091
1953		3.5	-1.9338	5.4338
1954		3.8	-2.9008	6.7008
1955		3.7	-2.6320	6.3320
1956		4.4	-1.4701	5.8701
1957		4.5	-0.8338	5.3338
1958		3.7	-3.4250	7.1250
1959		3.3	-4.8463	8.1463
1960	616	3.92	-2.9146	6.8339
1961	605	3.69	-5.1353	8.8250
1962	657	3.87	-5.6803	9.5518
1963	673	3.83	-6.1175	9.9436
1964	740	4.09	-7.0534	11.1454
1965	880	4.73	**-5.8424**	10.5730
1966	868	4.59	-6.8623	11.4506
1967	1039	5.42	-8.4222	13.8470
1968	1150	5.98	**-6.1209**	12.1039
1969	1386	7.13	-3.3234	10.4519
1970	1376	6.90	-5.5021	12.3983
1971	1642	8.12	-3.8990	12.0185
1972	1791	8.75	-3.2524	12.0026
1973	1862	9.04	-2.6526	11.6910
1974	1985	9.49	-3.0070	12.5014
1975	2209	10.43	-0.6115	11.0387
1976	2220	10.32	-2.0030	12.3190
1977	2515	11.49	0.6438	10.8423
1978	2611	11.71	1.0055	10.7061

1979	2952	13.01	3.5453	9.4614
1980	3411	14.49	4.7711	9.7237
1981	3143	13.01	4.1159	8.8937
1982	2779	11.24	0.8081	10.4320
1983	2639	10.48	-0.1937	10.6767
1984	2717	10.60	0.1535	10.4506
1985	2770	10.51	1.1143	9.3920
1986	3038	11.26	2.1347	9.1251
1987	2924	10.57	1.3033	9.2668
1988	2936	10.42	0.8549	9.5683
1989	3158	10.87	1.6863	9.1798
1990	3553	11.94	4.1368	7.8020
1991	3859	12.70	5.9307	6.7717
1992	3921	12.70	**6.5944**	6.1084
1993	4096	13.12	**7.6305**	5.4931
1994	3703	11.78	6.2648	5.5165
1995	3531	11.18	5.3054	5.8726
1996	2916	9.15	2.6883	6.4591
1997	2579	7.99	1.4920	6.5004
1998	2171	6.65	-0.2355	6.8813
1999	2005	6.05	-0.9908	7.0400
2000	2079	6.14	-0.8505	6.9884
2001	2206	6.40	**-0.5518**	6.9518
2002	2395	6.80	-0.1134	6.9134
2003	2407	6.70	0.1122	6.5878
2004	2392	6.70	0.2160	6.4840
2005	2503	6.90	**0.9337**	5.9663

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