Decomposing Violence: Political Murder in Colombia, 1946-1999

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Abstract: We apply the Hodrick-Prescott and Beveridge-Nelson business-cycle decomposition methods to a time-series of homicides in Colombia (1946-1999). Separating out "permanent" from "cyclical" murder, we hypothesize that the cyclical part coincides with the periodic political unrest in the country. The results show a good match between the political events in the country and the computed cyclical murder component.

Keywords: Colombia, homicide, Beveridge-Nelson, Hodrick-Prescott, business cycle, decomposition, time-series, domestic terrorism

JEL classification codes: C22, D63, D74, H56, K42, N46, O54

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Introduction

The countries of Latin America record, by far, the highest homicide rates in the world, averaging 20 to 30 murders per 100,000 people, i.e., two to three times as many as in the next most violent regions of the world (see, e.g., Guerrero, 1998; and, especially, Londoño, 1998, p. 72). And within Latin America, Colombia is known for its extremely high levels of homicidal violence, resulting in one of the highest murder rates in the world. According to Colombian National Police statistics, homicides increased from around 5,000 per year in the 1950s and 1960s to about 10,000 per year by 1980 and to about 25,000 per year by 1990 (figure 1). A further surge to nearly 30,000 murders per year was seen in the early 1990s. This has moderated somewhat but, in absolute numbers, still hovers between 20,000 to 25,000 per year.

When adjusted for population growth, i.e., homicides per 100,000 people in the population, a somewhat different pattern emerges. A rapid per capita murder increase occurred from 1946 to the late 1950s, followed by a ten-year period of sustained murder reductions (figure 1). This downward trend reversed in the 1970s and then shows exactly the same pattern as for the absolute numbers. The country's murder rate varies substantially not only over time, but also from region to region (e.g., Dinar and Keck, 1997, pp. 9-10; Guerrero, 1998, pp. 96-97; Londoño, 1998, p. 76), with rates as low as 16/100,000 (nearly "normal" as compared to the rest of the world) to rates as high as 900/100,000 in the city of Apartado (Guerrero, 1998, p. 97).

Frightful as the absolute and population-adjusted numbers are, they underestimate the truth. Following a survey, Rubio (1998a, p. 606) writes that even for murder, "more than half of the households victimized stated that they had 'not done anything,' and only 38 percent reported that they had made a formal complaint" to the authorities. Incredibly, by comparing separate statistical reporting by the police and by the justice

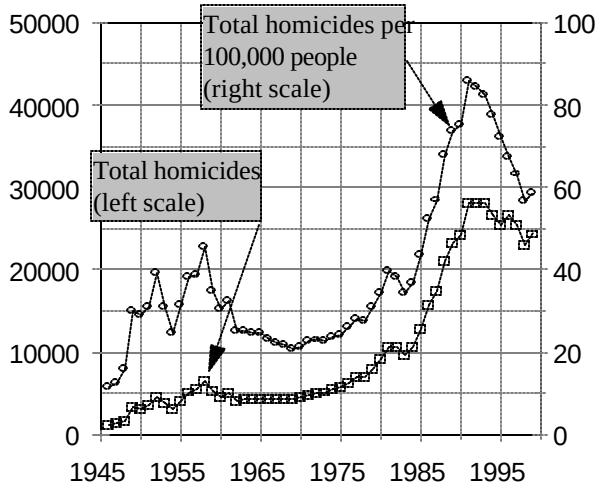

Figure 1: Total homicides, Colombia, 1946-1999

agencies Rubio finds wide disparities for more than a quarter of Colombia's municipalities. The disparities are largest in municipalities characterized by the presence of any armed force (military, para-military, drug-gangs, guerrillas; Rubio, 1998a, p. 607). Apparently, victims' families fear reprisals.

Without doubt, Colombia's murderous violence is related to two of its most salient features, the drug trade and its civil war, which have marred the country for decades. Less well-known and appreciated is that these two factors account only for a portion of all murders in the country (Guerrero, 1998, p. 98). For murder, the primary risk factors are alcohol consumption, possession of firearms, and weekends. For example, a quarter of all murders take place on Sundays, more than half on Friday, Saturday, and Sunday, with disproportionate increases on holidays. Most murders are patently non-political, take place at night, in urban areas, are committed by poor people on poor people, and alcohol is frequently found in the victims (Londoño, 1998, especially p. 75; Guerrero, 1998). But Guerrero observes that while alcohol consumption might explain the high levels of murder it cannot explain the drastic murder *increase* in Colombia in the 1980s and 1990s (1998, p. 98).

Also contrary to popular perception, several studies have failed to establish links between murderous violence and poverty rates, unemployment rates, urbanization rates, or rates of economic growth (Londoño, 1998, p. 74; Guerrero, 1998, p. 97). Indeed, Rubio (1997) and others have made persuasive arguments according to which the educated *and* uneducated classes both engage in criminal and violent activity for the simple reason that crime pays well. Income and education are no longer linked, but income and crime are (Rubio, 1997, p. 812). Average annual incomes from crime have been variously estimated at up to $70,000 per person, a huge premium over Colombia's *per capita* 1995 GDP of around $1,800 (Bejarano, 1997, p. 12). The break-down of the Colombian justice system further encourages criminal and violent behavior as the probability of being caught, tried, and convicted is becoming smaller over time. By 1994, convictions rates had dropped to below four percent (Rubio, 1998a, p. 606), and sentences rarely exceeded six months of jail time (Rubio, 1998b, p. 91).

There is wide-spread agreement among analysts of all stripes that Colombia's violence is costly, both at the microeconomic level (e.g., Dinar and Keck, 1997) and at the macroeconomic level, estimated at up to 15 percent of GDP (Bejarano, 1997, p. 10), and there is some evidence that major perpetrators of violence – the military and paramilitary forces, the drug-traders, and the various guerrilla groups – act in semi-collusive fashion to keep the spoils of war going (Richani, 1997), evidence almost perfectly in line with the theory suggested by Brito and Intriligator (1992).

While on-going research will have to identify and disentangle the various causes and possible intervention mechanisms of extreme, generalized violence in Colombia, our concern in this paper is much more narrow and limited. On the hypothesis that political unrest and politically motivated murder are cyclical, we apply business-cycle decomposition methods to the murder time-series and then compare the estimated (quantitative) cyclical or "transitory" component to a narrative (qualitative) account of cycles of political violence in Colombia. We find a good overlap between our estimates of turning points in the cycle and the narrative of the country's political ups and downs: when the political context suggests much unrest, the cyclical component of murder increases, and vice versa. The trend or "permanent" component of the series is interpreted as that part of the murder time-series that would have occurred without political violence.

The research reported here is a pure time-series study. We make no claim as to the *magnitude* of "political" murder, but we do suggest that we may have found a way to gauge *turning points* in the "political" murder cycle. This would be an important advance, especially for countries facing domestic terrorism, possibly permitting "real-time" assessment of whether a country finds itself in a cyclical murder upswing or downswing. Once the time-series is separated into "political" and "non-political" murder, further research can build underlying structural models for each part of the series.[1]

The paper proceeds as follows. We begin with the technical aspects, so that the next section presents a discussion of the data and the decomposition methods employed. This is followed by the interpretation of our findings, i.e., the matching of the cyclical component to the political narrative. The final section concludes.

Data and methods

The Colombian National Police has a record of crime statistics that reaches back to 1946 (various issues of *Revista Criminalidad*). It distinguishes among various types of crime (see text box 1). Item number 13 (crimes against life and person) contains some 20 categories, such as murder, abortion, and personal injury. Apart from abortions, car-accident related deaths, and so on, the murder categories are primarily murder (*homicidio*) and aggravated murder (*homicidio agravado*). Since 1993, there is also an attempt to separate out further types of murder, e.g., murder with terrorist intent (*homicidio con fin terrorista*) and death associated with the exercise of official police duties (*homicidio con función, razón cargo o ejercicio de sus funciones*). For our analysis we use the number of murders for these four categories combined,

i.e., we collapse all these categories of murder into a single group.[2]

01 Crimes against the state and its security
02 Crimes against the constitution
03 Crimes against public administration
04 Crimes against the administration of justice
05 Crimes against public safety
06 Crimes against public faith
07 Crimes against the social and economic order
08 Crimes against suffrage
09 Crimes against the family
10 Crimes against individual freedoms
11 Crimes against sexual freedom and human dignity
12 Crimes against moral integrity
13 Crimes against life and person
14 Crimes against economic interests

Text box 1: Crime categories in Colombia

As is well known, time series can be broken into constituent components. The seasonal component does not apply to our case since we have annual data. The long-run trend component is often simply modeled as a linear or non-linear trend line over time, and the cyclical component is the remaining variation around this trend. We apply the Hodrick-Prescott (1997) and the Beveridge-Nelson (1981) decomposition techniques.

Hodrick-Prescott

To estimate a trend line, a variety of smoothing techniques are available, from simple time-trend lines to various forms of moving averages, to diverse exponential smoothing methods. Exponential smoothing is a method that assigns an exponentially increased weight the more recent a particular observation is to the current-time data point. The analyst sets the smoothing parameter arbitrarily. Smaller parameters produce smoother trend series; larger parameters track the original series better because the observations closest in time to the point being estimated are weighted most heavily. Analysts will use a variety of smoothing parameters and then choose the one yielding the best (smallest) of various forecast error values. Econometric software can automatically search for and estimate this "best" parameter. One or two-parameter double exponential smoothing is used for data with trend (to adjust the slope of the forecast). Without going into any detail here, none of these methods are appropriate for our purpose.[3]

For business cycle research, a popular method to smooth a time series and produce its long-run trend component is the Hodrick-Prescott filter (1997). Technically, consider

$$(1)\ \sum_{t=1}^{T} (y_t - s_t)^2 + l \sum_{t=2}^{T-1} ((s_{t+1} - s_t) - (s_t - s_{t-1}))^2 ,$$

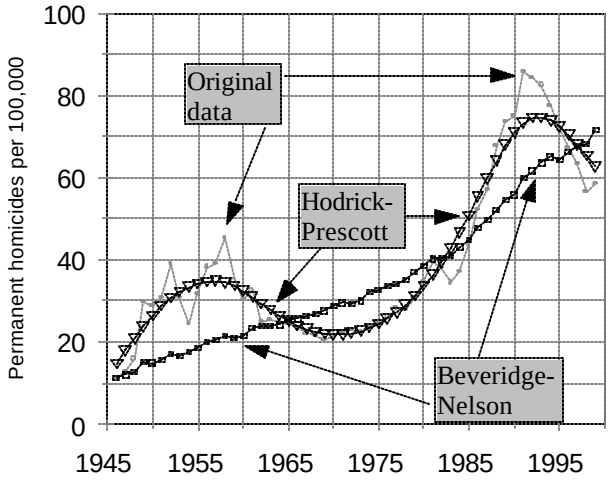

Figure 2: Original data (total homicides per 100,000 people) and permanent component according to HP and BN methods.

where y is the original series, t is time (t = 1, ..., T), and s is the smoothed series. The filter produces the smoothed series by minimizing equation (1) whose first term denotes the squared difference between an original and its smoothed value at time t (i.e., the variance) and whose second term defines upper and lower bounds of s, where $l = 0$ returns the original series and l 6 4 produces a linear smoothed series. Since we deal with annual data, we use the recommended default value of $l = 100$. E-Views 4 contains a Hodrick-Prescott routine that produces the relevant smoothed trend estimates which, along with the original data and the Beveridge-Nelson results, are displayed in figure 2.[4] (The data are also recorded in appendix 1.) Deviations from the trend constitute the cyclical component (figure 3).

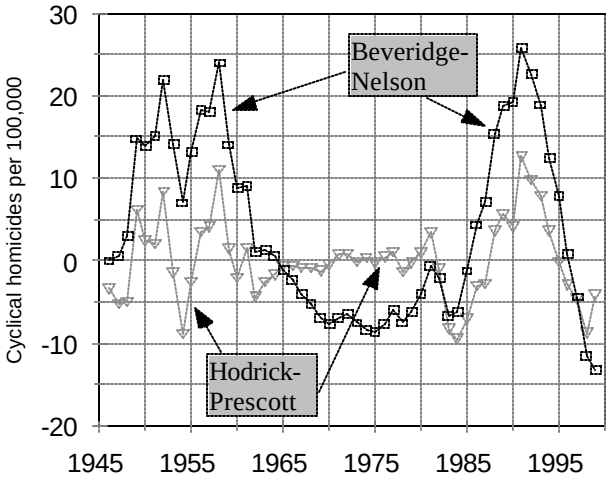

Figure 3: Cyclical component according to HP and BN methods.

Our hypothesis is that, in figure 3, an upward movement of the cyclical component of the homicide time-series corresponds to time-periods with marked political unrest whereas a downward movement of the cyclical component denotes relative political calm in Colombia. We offer a discussion in the "Interpretation" section.[5]

Beveridge and Nelson

In 1981, Beveridge and Nelson (BN) introduced a new business cycle decomposition technique. Their objective was to produce a better dating technique, i.e., a technique with superior turning-point performance. Since the estimation of data points in time t completely relies on past values, t-1, t-2, ..., t-n, BN describe their method as a "real time" technique: plug new data points into the model as data become available, and it will tell you whether the business cycle is turning. The technique requires to first fit an ARIMA model on the first-differenced natural logs of the dependent variable. Since in the spirit of BN we do not propose any structural model explaining the data movement, nor propose to engage in any forecasting of the data points, we conducted an unabashed best-fit search which resulted in an ARIMA(0,1,13) model with moving average terms at lags 1, 5, and 13. The results are:

d(lthompc) =	*c*	*+ ma(1)*	*+ ma(5)*	*+ ma(13)*
Coefficients	0.0324	0.2569	-0.4911	-0.5376
t-stats	3.2710	3.2132	-5.7861	-5.8794
p-values	0.0005	0.0023	0.0000	0.0000

Adj R^2 = 0.1024; DW = 2.0445; F = 2.9780; p-value(F) = 0.0404

where d(lthompc) is the first difference of the natural log of total homicides per 100,000 persons in Colombia, 1946 to 1999. Estimating this model minimized the Akaike Information Criterion (AIC) as well as the Schwartz Criterion (SC). We ran the model with RATS 4 as well as with E-Views 4 and, except for rounding, obtained the same estimates.[6]

Once a model that best fits (or reproduces) the original data is estimated, the permanent and cyclical components can be extracted from the estimated data points. The resulting data are displayed in figures 2 and 3 (and reported in appendix 1).[7, 8]

Interpretation of results

It would appear that the Hodrick-Prescott (HP) and Beveridge-Nelson (BN) methods yield substantially different permanent trend information (figure 2). But both result in comparable estimates of the cyclical movement (not in magnitude but in turning points), at least for the early (up to 1965) and the late years (as from 1980) of the series. From

1965 to 1980, the HP method tracks the actual data almost without deviation because there is nothing to be smoothed in the original data series. In contrast, the BN method produces cyclical information throughout the entire time-period. (HP is a smoothing technique whereas BN is a trend extraction technique.) We therefore focus here on interpreting the political events of Colombia in light of the BN cyclical component we extracted from the data series. The chronology and event description is taken from Bushnell (1993).[9]

It appears, in figure 3, that there are three major periods in the cyclical component of murder in Colombia. The first occurs from 1946 to 1958, with a short-term decline in the rate of increase from 1952 to 1957. The second period occurs from 1958 to the late 1970s. One could also argue that the second period lasts from 1965 to 1985, a twenty-year period during which the estimated cyclical ("political") murder lies below the permanent trend line. But since we cannot be sure about the actual number of murders, it is best to focus on turning-points and movements, rather than magnitudes, of the series. The third period occurs as from the late 1970s when an upsurge in murder is observed, until the series peaks in 1991. Thereafter the cycle declines once more.

The first period: 1946 to 1958

Between 1930 and 1946, the Liberal Party was in continuous power, indeed so much so that Colombians refer to this time period simply as the "Liberal Republic." But with the election of 1946, the Conservative Party's Mariano Ospina Perez assumed the country's presidency in August 1946. Then, on 9 April 1948, Jorge Eliecer Gaitán, a charismatic, leftist Liberal Party presidential candidate was murdered by unknown assailants. This murder initiated a violent outburst in Botogá – the *Bogotazo* – which began the period commonly known as *La Violencia*, hence the upsurge in murder tracked in figure 3. This period lasted until 1957, a period where political violence primarily, but not only, emerges from the confrontation between the adherents to the two major political parties. Following Gaitán's murder, the Liberals achieved victory in congressional elections in June 1949, but presidential victory is obtained by the Conservative Party's Laureano Gómez in November 1949. Meanwhile, political violence with leftist guerrillas – who view both the Liberal and the Conservative Party as establishment parties of land-owners and other vested economic interests – continued from 1950 to 1953 to such an extent that the military took power in 1953 under General Gustavo Rojas Pinilla. This resulted in an initial decrease in the pace of violence (see the decline in figure 3 in 1953 and 1954) but picked up in the latter years

of Rojas Pinilla's tenure. Put differently, murderous violence first declined as killings originated by guerrillas were stopped but then increased as the military began to kill increasing numbers of the guerrillas (which was to become, in 1963, the Fuerzas Armadas Revolucionarias de Colombia, or FARC). Rojas Pinilla's initial success led the national assembly to elect him to a full four-year presidential term in 1954. But by May 1957 Rojas Pinillas' inability to actually put an end to *La Violencia* led to a nation-wide general strike, a military junta took control, and Rojas Pinilla went into exile.

The second period: 1958-1978

The military junta yielded to a bipartisan coalition, called the National Front, which remained in control until 1978. The National Front essentially was an agreement between the Liberal and Conservative Parties to trade presidential terms and to adhere to a quota system in the assignment of ministerial and other government posts. This should reduce the amount of murder due to the clash between the parties' adherents, as indeed it did (see the cyclical decline in figure 3). The first National Front president was Alberto Lleras Camargo (Liberal, who also briefly held the presidency in 1945-1946). President from 1958 to 1962, he was followed by Conservative Party member Guillermo León Valencia (1962-1966). The third president (1966-1970) was Liberal Carlos Lleras Restrepo (not related to the first Lleras), during whose term murder rates fell to 20/100,000, the lowest since the *Bogotazo* and almost "normal" by other countries' standards. The fourth National Front president was Conservative Misael Pastrana Borrero (1970-1974), father of a later Colombian president, Andrés Pastrana (1998-2002).

Various old and new guerrilla movements, which had been active for several decades, were formalized in the 1960s. The Fuerzas Armadas Revolucionarias de Colombia (FARC) was formed in 1963, the Ejército de Liberación Nacional (ELN) in 1965, the Ejército Popular de Liberación (EPL) in 1967, and the M-19 (Movimiento 19 de Abril) in 1970. The end of the National Front period occurred between 1974-1978, the presidency of Liberal Alfonso López Michelsen. During his tenure, Colombia experienced considerable economic growth, driven by a commodity export boom (coffee, coal, oil, and marijuana; not yet cocaine). It is generally accepted and acknowledged that Michelsen's administration suffered from wide-spread corruption and involvement with the emerging drug-trade. It is also the period when guerrilla activity takes an upward turn, reflected in figure 3 in the cyclical upswing of homicides.

The third period: 1978 to 1999

The twenty-year period of the National Front ends – as does the relative political calm – when another Liberal wins the presidential election (Julio César Turbay Ayala; 1978-1982). His term of office sees an upsurge in revolutionary activity and Colombia's economic boom also ends. For example, in December 1979, in a dramatic move that made the world's news headlines, the M-19 guerrilla group seized the Embassy of the Dominican Republic in Bogotá and held thirteen ambassadors hostage who had met at the embassy. The hostages included the US envoy. Both the HP and the BN cyclical murder series show an upward movement of murder for the Turbay years (figure 3). The next election is won by Conservative Belisario Betancur Cuartas (1982-1986). He begins peace negotiations between government and guerrillas (except with the relatively small ELN). The cyclical component of our series declines in 1982 and 1983, holding even in 1984 (HP shows a further decline in 1984). But the peace negotiations ultimately did not result in guerrilla demobilization and weapons surrender. Instead, in 1985, three presidential candidates were assassinated; moreover, in a spectacular move, the M-19 occupied the Colombian Justice Palace (the seat of Colombia's Supreme Court) and many judges were murdered. Betancur broke off peace negotiations, and our series shows an up-tick in homicides. Indeed, the period of the greatest number of murders in Colombia is now ushered in.

Liberal Virgilio Barco Vargas, an MIT-trained civil engineer, was elected president (1986-1990). Even though a former M-19 member, Bernardo Jaramillo Ossa, founded a new political party, the Unión Patriótica, there is now open violent conflict among government, various guerrilla and paramilitary groups, and – increasingly – drug traffickers as cocaine replaces marijuana and the dollar-volume at stake becomes ever larger.

A major break occurs when Liberal César Augusto Gaviria Trujillo (1990-1994) became president and pushed the legislature to adopt a new constitution in 1991 (to replace the constitution of 1886). *A priori*, there is no particular reason why a mere change in the country's constitution should mark the beginning of the pronounced fall in the cyclical murder series (figure 3). But at age 43 Gaviria was the first person of the post-*La Violencia* generation to become president, and the new constitution was received to general acclaim across the country, swept up as it was in a spirit of renewed hope for peace. More substantially, Gaviria did appoint a former guerrilla leader to his cabinet, and he pushed through large-scale increases in the government's social expenditure budget, moves that might be interpreted as accommodating rebel demands and leading to declining "political" (i.e., cyclical) murder. At the same time,

the increasing dollar-value of the drug-traffic may have pushed up the slope of the permanent murder series (figure 2), reflecting entangled political and economic interests. Indeed, Colombian "popular" knowledge across the spectrum of opinion asserts that the administration of Liberal Ernesto Samper Pizano (1994-1998) was "controlled" by the predominant drug cartels (Medellín y Cali), with increasing participation in that trade by the main guerrilla groups. If so, there would be no "need" for political violence which switches to become non-political permanent violence. Another Liberal president, Andrés Pastrana Arango (1998-2002), in fact went so far as to grant in 1999 the largest rebel group, the FARC, a demilitarized zone the size of Switzerland (42,000 km^2) and placed it under the FARCs administrative control. The post-1991 period might be summarized as inclusion (Gaviria), collusive cooption (Samper), and appeasement (Pastrana).[10]

Colombia's future

Despite the cyclical decline in murder in the 1990s, a stable collusive arrangement to jointly exploit the country's resources (á la the National Front of 1958 to 1978) appears not possible among the major vested interests – the government and its military units, the paramilitary units, the drug-producers, and the various guerrilla groups – and there remains, in our opinion, only the possibility of a renewed upsurge in political violence and murder. Indeed, Pastrana's appeasement arrangement with the FARC ended in February 2002 as it became clear that it had no intention of keeping a peace that would leave it restricted to only part of the country. It's ideological concerns not having been met, and unwilling to be locked into a limited territory from which to extract financial resources, it has resumed its terrorist attacks on life and property of ordinary Colombians as well as on government property and officials. All sides to the conflict still appear to believe that each can triumph over the others, for an ever larger share of the spoils. As further data points become available we would expect an upturn in the BN and HP-cyclical component of Colombia's murder time-series.

Conclusion

This paper is, primarily, a statistical exercise to demonstrate how one might get at turning points in (state and non-state) domestic terrorist activity. Other techniques could be, and will be, tried. It bears repeating, though, that our approach here, in contrast to the political-business cycle literature and other approaches, is a pure time-

series and not a structural regression effort. Our narrow interest is not to match quantitative RHS variables with a quantitative LHS variable. In fact, we do not *have* a LHS variable unambiguously called "political murder." Instead, the effort here is to *create* (a proxy of) such a variable – the cyclical murder component – and to learn if we can match it with the generally accepted political narrative of political events in Colombia. It would appear that we can: the cyclical component of Colombia's homicides strongly coincides with the country's political events.

In future research, we plan to apply other statistical techniques as well as to construct structural models to explain the movement of the permanent and cyclical murder series in Colombia and also to repeat the decomposition exercise with sub-national data (i.e., by administrative *departamento*). Provided that consistently collected figures are available, we believe that an application of the decomposition method is also possible and worthwhile for countries other than Colombia.

Notes

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1. A working paper, "A Structural Model of Political Murder in Colombia, 1950-1999," is available at http://www.aug.edu/~sbajmb/paper-colombia-02.PDF . Apart from methodological issues, there are two ways to extend our work. One is to extend our approach to other countries to learn if we find similar overlaps between qualitative accounts of political violence and our quantitative approach as we claim here for Colombia. The other, in which we are currently engaged, is to collect and decompose data for each of Colombia's 33 provinces (*departamentos*) to see if we get the expected cycles at the departmental level.

2. It may be useful to state up-front that whereas data for transnational terrorism are available (see, e.g., Sandler and Enders, 2002), data for domestic terrorism (including murder due to terrorism) are generally not available. In most instances, data cannot be collected as events data from domestic news media reports or law enforcement and

justice agencies. As one of this paper's authors personally attests, certainly in the case of Colombia one would write one's own death warrant if one were to request to re-examine police or justice records in order to classify them into "political" or "non-political" murder categories (also see Giraldo, 1996). In such cases, our approach of time-series decomposition may be the only feasible alternative to get a statistical handle on political murder.

3. We nonetheless applied the single, double, and Holt-Winter smoothing techniques. In all instances, the estimated series is simply shifted to the right of the original series (i.e., all peaks and troughs are right-shifted), thereby consistently missing all turning points of the actual homicide series.

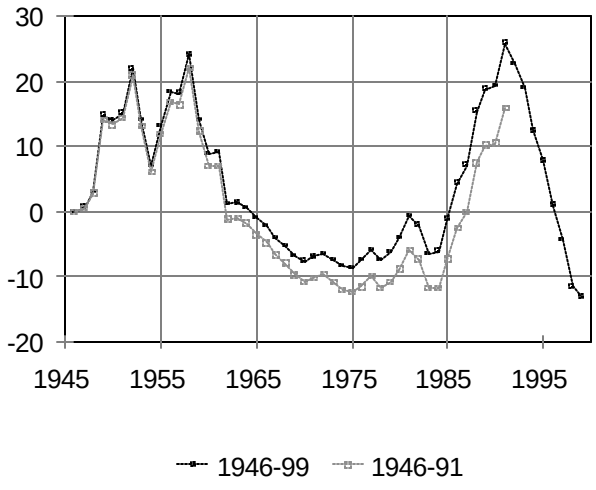
4. In E-Views, double-click on the original data series icon, click on Procs, select Hodrick-Prescott Filter, and type in the desired smoothing parameter, l , or accept the default value l = 100. To test the robustness of the resulting series we varied the smoothing parameter drastically but did not obtain materially different results. For example, according to Ravn and Uhlig (2002), the optimal smoothing parameter should be between 6.25 and 8.25 for annual data, not 100. We used those values, as well as 20, 40, 60, 80, and 800, in addition to the default value of 100. With 54 observations, runs for eight different smoothing parameters result in eight series of estimates with a total of 432 data points. With a mere handful of exceptions, the 432 data points in the eight estimated series of cyclical murder result in essentially identical turning points, and it is the turning points, not the magnitudes of the estimates, that interest us. See Maravall and del Río (2001) for a discussion of the filter default values. On problems with the mechanical application of the Hodrick-Prescott filter, see Harvey and Jaeger (1993).

5. There are of course no "negative" murders in figure 3. The negative numbers merely represent homicides falling below the trend line. In our interpretation, it is precisely the lack of political unrest that accounts for the observed below-trend homicides and, vice versa, for above-trend homicides that the cyclical data turns positive.

6. E-Views and RATS use different implementations of the Schwartz Criterion (SC). E-Views works off the log likelihood function, whereas RATS works off the sum of squared residuals. We confirmed both formulas by hand-computing the respective criterion to check the computer printouts. Running a variety of ARIMA models, the model with moving average model with lags at 1, 5, and 13 returns the lowest SC in E-Views and RATS, respectively. (RATS does not report the AIC.)

7. Neither E-Views nor RATS contains a Beveridge-Nelson routine (although there is a user-supplied routine available on the RATS web site at www.estima.com). Using the original BN (1981) method, the extraction of permanent and cyclical components from the original series is computationally very intense. Cuddington and Winters (1987), Miller (1988), and Newbold (1990) provide computationally easier methods. In his dissertation, Cárdenas (1991) provides an exceptionally easy and conceptually appealing way to compute the components, and that is the method we apply. Since we failed to locate a published account of Cárdenas' method, we provide the mathematical details in appendix 2. To ensure correctness we computed the permanent and cyclical components by BN's original method, by the Cuddington/Winters method, and by the Cárdenas method, using the first actual observation as the initial value. All three methods resulted in identical estimates.

8. One reader observed that if the BN method were run for a different time period, say 1946-1991, instead of 1946-1999, the estimates of the permanent and transitory components would change. This is true and changes the estimated magnitudes (we re-ran the underlying ARIMA which also is (0,1,13) with MA lags at 1, 5, and 13) but does *not* change the turning points at all (see figure below). Our interpretation thus remains entirely unchanged.



Colombia's estimated cyclical murder for different periods

9. A more dramatic, sometimes personal account is Giraldo (1996). It takes particular aim at the Colombian military and paramilitary forces' contribution to the violence.

10. One might therefore consider the suggestion that the character of Colombia's "political" violence may have changed during the 1990s, i.e., that even though it was cloaked in terms of revolutionary and counter-revolutionary language, the observed violence is linked to economics, the economics of the drug-traffic in particular. Greed takes preference over grievance, and an attempt at collusive exploitation of the country is made. Revolutionaries and counter-revolutionaries become bandits who defend their respective territories and interests with murder. If this is correct, the war in Colombia in the 1990s was essentially an economic war, not unlike those we observed in Africa in the 1990s (e.g., Sierra Leone, Liberia, Angola), a war over access to and exploitation of natural resources. This war is unlikely to cease unless the major sources of funding – US military aid and US drug-purchases – cease. But this interpretation, even if correct for the 1990s, is probably moot as the FARC and Colombia's new president (Álvaro Uribe Vélez, 2002-2006) have openly resumed their war.

On "greed and grievance" see, e.g., Paul Collier, 1999 and 2000. See Sambanis (2002) for an overview of the quantitative literature on civil war.

Appendix 1: data table

	Original Data		Hodrick-Prescott l =100		Beveridge-Nelson	
Year	Thom*	Thompc**	Permanent	Cyclical	Permanent	Cyclical
1946	1184	11.47	14.83	-3.36	11.47	0.00
1947	1334	12.66	17.88	-5.21	12.03	0.64
1948	1715	15.96	20.89	-4.93	12.95	3.01
1949	3285	29.96	23.78	6.18	15.17	14.80
1950	3227	28.85	26.42	2.42	14.93	13.92
1951	3608	30.80	28.73	2.07	15.73	15.07
1952	4670	38.99	30.67	8.33	17.06	21.93
1953	3772	30.81	32.19	-1.38	16.71	14.10
1954	3121	24.56	33.37	-8.81	17.54	7.02
1955	4156	31.68	34.24	-2.56	18.54	13.14
1956	5187	38.29	34.75	3.55	19.93	18.37
1957	5441	38.91	34.83	4.08	20.79	18.12
1958	6567	45.49	34.44	11.05	21.46	24.03
1959	5211	34.96	33.59	1.37	20.90	14.07
1960	4667	30.33	32.39	-2.06	21.47	8.86
1961	5167	32.52	30.97	1.56	23.35	9.17
1962	4103	25.01	29.43	-4.42	23.93	1.08
1963	4293	25.35	27.90	-2.55	24.03	1.33
1964	4327	24.75	26.46	-1.71	24.23	0.52
1965	4414	24.50	25.16	-0.66	25.54	-1.04
1966	4355	23.46	24.04	-0.58	25.71	-2.25
1967	4264	22.29	23.12	-0.84	26.35	-4.07
1968	4263	21.62	22.43	-0.81	26.84	-5.22
1969	4214	20.74	21.99	-1.25	27.62	-6.89
1970	4469	21.34	21.80	-0.45	28.97	-7.63
1971	4885	22.64	21.85	0.79	29.61	-6.97
1972	5118	23.02	22.14	0.88	29.49	-6.47
1973	5175	22.58	22.66	-0.08	30.10	-7.51
1974	5566	23.79	23.43	0.36	32.15	-8.36
1975	5788	24.22	24.43	-0.22	32.92	-8.70
1976	6349	26.13	25.70	0.43	33.72	-7.59
1977	7014	28.28	27.23	1.05	34.21	-5.93
1978	7013	27.72	29.03	-1.31	35.25	-7.53
1979	8000	30.92	31.13	-0.21	37.18	-6.25
1980	9122	34.50	33.54	0.96	38.55	-4.05
1981	10713	39.65	36.26	3.39	40.28	-0.63
1982	10580	38.31	39.31	-1.01	40.42	-2.12
1983	9721	34.43	42.74	-8.31	41.04	-6.60
1984	10694	37.07	46.59	-9.52	43.17	-6.11
1985	12899	43.76	50.82	-7.07	44.96	-1.20
1986	15672	52.21	55.29	-3.08	47.85	4.36
1987	17419	56.96	59.79	-2.83	49.85	7.11
1988	21100	67.76	64.08	3.68	52.37	15.39
1989	23312	73.49	67.89	5.60	54.70	18.79
1990	24267	75.13	71.00	4.13	55.89	19.24
1991	28204	85.88	73.23	12.66	60.04	25.84
1992	28140	84.28	74.44	9.84	61.63	22.64

1993	28026	82.55	74.63	7.92	63.65	18.90
1994	26756	77.51	73.89	3.62	65.10	12.41
1995	25362	72.28	72.38	-0.11	64.50	7.78
1996	26627	67.39	70.33	-2.94	66.45	0.94
1997	25345	63.26	67.92	-4.66	67.66	-4.40
1998	23089	56.55	65.35	-8.80	68.16	-11.61
1999	24355	58.56	62.73	-4.17	71.70	-13.14

* Thom is total homicides
** Thompc is total homicides per 100,000 population

Appendix 2: The Beveridge-Nelson decomposition of a time-series

Let w_t be the stationary first differences of a non-stationary series z_t

(1) $w_t = z_t - z_{t-1}$

Wold's (1938) decomposition theorem states that

(2) $w_t = m + l_0 e_t + l_1 e_{t-1} + \ldots, \; where \; l_0 \equiv 1$

and l_i are constants and the e's are uncorrelated errors. Beveridge and Nelson [BN] (1981) relate each z_t to its own future values or "forecast profile," where the profile in time t is interpreted as z_t's "permanent" component, $\bar{z}_t$. Thus, the estimated z_t forecast k periods ahead becomes the expected value of z_{t+k}, conditional on z_t's past values

(3) $\hat{z}_t(k) = E(z_{t+k} | \ldots, z_{t-1}, z_t)$

which, since w accumulates past z's, may be written as

(4) $$\begin{aligned} \hat{z}_t(k) &= z_t + E(w_{t+1} + \ldots + w_{t+k} | \ldots, w_{t-1}, w_t) \\ &= z_t + \hat{w}_t(1) + \ldots + \hat{w}_t(k) \end{aligned}$$

But from (2), each estimated w, say w_{t+i}, is

(5) $$\begin{aligned} \hat{w}_t(i) &= m + l_i e_t + l_{i+1} e_{t-1} + l_{i+2} e_{t-2} \ldots \\ &= m + \sum_{j=i}^{\infty} l_j e_{t+i-j} \end{aligned}$$

Substituting (5) recursively into (4) and approximating to an infinite time horizon, we obtain

$$\hat{z}_t(k) \approx km + z_t + \left(\sum_1^\infty l_i\right)e_t + \left(\sum_2^\infty l_i\right)e_{t-1} + \ldots$$

(6)

$$\hat{z}_t(k) - km \approx z_t + \left(\sum_1^\infty l_i\right)e_t + \left(\sum_2^\infty l_i\right)e_{t-1} + \ldots$$

Beveridge and Nelson (1981) suggest that it is natural to interpret the LHS of (6) as z_t's "permanent" component, denoted as $\bar{z}_t$. The cyclical component, c_t, then is

$$(7)\quad \bar{z}_t - z_t = \left(\sum_1^\infty l_i\right)e_t + \left(\sum_2^\infty l_i\right)e_{t-1} + \ldots$$

The unknown μ and l_i's in (5) must be estimated. Beveridge and Nelson suggest an ARIMA procedure of order (p,1,q) with drift μ.

$$(8)\quad w_t = m + \frac{\left(1 - q_1L^1 - \ldots - q_qL^q\right)}{\left(1 - f_1L^1 - \ldots - f_pL^p\right)}e_t = m + \frac{q(L)}{f(L)}e_t.$$

Cuddington and Winters [1987, p. 127, equation (7)] realized that in the steady state, i.e, L=1, (8) reduces to

$$(9)\qquad \bar{z}_t - \bar{z}_{t-1} = m + \frac{(1 - q_1 - \ldots - q_q)}{(1 - f_1 - \ldots - f_p)}e_t = m + \frac{q(1)}{f(1)}e_t$$

where μ will be the estimated mean, q_i the estimated moving-average terms, and f_i the estimated autoregressive terms. Now iterate (9) recursively, i.e., replace t by (t-1) and (t-1) by (t-2), etc. Then we get

$$\bar{z}_t - \bar{z}_{t-1} = \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_t$$

$$\bar{z}_{t-1} - \bar{z}_{t-2} = \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_{t-1}$$

(10) $$\vdots$$

$$\bar{z}_1 - \bar{z}_0 = \mu + \frac{\theta(1)}{\phi(1)}\varepsilon_1$$

Adding these equations, the terms on the LHS cancel out except for $\bar{z}_t$ and $\bar{z}_o$, and on the RHS μ is added "t" times and the fraction in the second term on the RHS is a constant to be multiplied by the sum of error terms. Thus, we obtain

(11) $$\bar{z}_t = \bar{z}_0 + \mu t + \frac{\theta(1)}{\phi(1)}\sum_{i=1}^{t}\varepsilon_i$$

This is, except for notation, Newbold's equation [Newbold, 1990, p. 457, equation (6)] and the problem reduces to finding an initial value for $\bar{z}_o$.

Mauricio Cárdenas (1991), in his unpublished dissertation, suggests that $\bar{z}_o = z_0$, i.e., the very first data point of the original series. This makes intuitive sense. Since a forecast profile conditional on past values cannot be computed in the absence of past values, $\bar{z}_o = z_0$ by definition. Formally, Cárdenas suggests the following (we changed the notation to conforms to ours here), where z_t refers to the original data series,

(12) $$z_t - z_{t-1} = \mu + \sum_{i=1}^{p}\phi_i \Delta z_{t-i} + \sum_{j=1}^{q}\theta_j \varepsilon_{t-j} + \varepsilon_t .$$

In words, the series of the first differences of z_t equals the series mean, adjusted for autoregressive and moving-average terms. Bring the autoregressive term to the LHS to get

$$(13)\quad (z_t - z_{t-1}) - \left(\sum_{i=1}^{p} f_i \Delta z_{t-i} \right) = m + \sum_{j=1}^{q} q_j e_{t-j} + e_t$$

and expand both summation terms

$$(14)\quad (1 - f_1 L^1 - f_2 L^2 - \ldots - f_p L^p)(z_t - z_{t-1}) = m + \left(1 + q_1 L^1 + \ldots + q_q L^q\right) e_t \, .$$

Rearrange (14) to obtain

$$(15)\quad z_t - z_{t-1} = \frac{m}{f(L)} + \frac{q(L)}{f(L)} e_t$$

Now, recursively replace t with (t-1), and (t-1) with (t-2), etc.

$$\begin{aligned} z_t - z_{t-1} &= \frac{m}{f(L)} + \frac{q(L)}{f(L)} e_t \\ z_{t-1} - z_{t-2} &= \frac{m}{f(L)} + \frac{q(L)}{f(L)} e_{t-1} \\ &\vdots \\ z_1 - z_0 &= \frac{m}{f(L)} + \frac{q(L)}{f(L)} e_1 \end{aligned} \qquad (16)$$

which, when added together "t" times, yield

$$(17)\quad z_t - z_0 = \frac{m}{f(L)} t + \frac{q(L)}{f(L)} \sum_{i=1}^{t} e_i \quad .$$

Rearranged, write

$$(18) \qquad z_t = z_0 + \frac{m}{f(L)}t + \frac{q(L)}{f(L)}\sum_{i=1}^{t} e_i \quad .$$

In the steady state, i.e., L=1, equation (18) readily yields the permanent component of z_t,

$$(19) \qquad \bar{z}_t = z_0 + \frac{mt}{f(1)} + \frac{q(1)}{f(1)}\sum_{i=1}^{t} e_i$$

which, except for notation, is Cárdenas' final formula [1991, p. 27, equation (15)]. In practice, it is easy to set up a spreadsheet for (19) by replacing $q(1)$ and $f(1)$ with $(1-\Sigma q_i)$ and $(1-\Sigma f_i)$, i.e., with the estimated ARIMA coefficients. In our particular case, where the ARIMA did not result in any AR terms at all, the denominators fell out of (19) altogether, making the computation of the permanent, and hence cyclical, components, of the Colombian murder series even easier.

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