AFTER 9/11: IS IT ALL DIFFERENT NOW?

by

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Abstract

Using time-series procedures, we investigate whether transnational terrorism changed following 9/11 and the subsequent US-led "war on terrorism." Perhaps surprising, little has changed to the time series of overall incidents and most of its component series. When 9/11 is prejudged as a break date, we find that logistically complex hostage-taking events have fallen as a proportion of all events, while logistically simple, but deadly, bombings have increased as a proportion of deadly incidents. These results hold when we apply the Bai-Perron procedure where structural breaks are data identified. This procedure locates earlier breaks in the mid-1970s and 1990s. Reasonable out-of-sample forecasts are possible if structural breaks are incorporated fairly rapidly into the model.

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> Thousands of dangerous killers, schooled in the methods of murder, often supported by outlaw regimes, are now spread throughout the world like ticking time bombs, set to go off without warning… In a single instant, we realized that this will be a decisive decade…(George W. Bush, "State of the Union" Speech on January 29, 2002, http://www.whitehouse.gov/news/releases/2002/01/20020129-11.html).

President Bush's remarks strongly suggest that everything changed on 11 September 2001 (henceforth, 9/11) with the world now confronting a far-flung network of terrorists, bent on heinous attacks. While there is no question that perceptions changed and deep-seated fears arose that fateful day, there has been no data-based analysis on how transnational terrorism (i.e., terrorism with international implications or genesis) differs, if at all, since 9/11. The perception on the street and the reporting in the news media is that terrorism is now different. But is transnational terrorism really different after 9/11 and, if so, how is it different?

The four simultaneous hijackings on 9/11 represent watershed terrorist events in a number of ways. First, the carnage associated with 9/11 was unprecedented: the number of people killed was as great as all deaths from transnational terrorism for 1988-2000 (Sandler, 2003). Prior to 9/11, no terrorist incident, domestic or transnational, resulted in more than 500 casualties (Quillen, 2002a, 2002b; Hoffman, 2002). Second, 9/11 demonstrated that terrorists did not require a weapon of mass destruction (WMD) to cause mass casualties and over $90 billion in losses. Third, 9/11 underscored the brutality that some fundamentalist terrorists will undertake. Terrorist experts had warned prior to 9/11 that religious-based terrorists viewed nonbelievers as legitimate targets and sought maximum carnage (Hoffman, 1997). Fourth, 9/11 created a greater vigilance on the part of industrial countries that have greatly augmented their expenditure on homeland security. Since 2002, the budget supporting the activities of the US Department of Homeland Security (DHS) grew by over 60% to $36.2 billion for fiscal year 2004 (DHS, 2003). An even greater expenditure goes to fighting the war on terrorism beginning with the invasion of the Taliban and al-Qaida in Afghanistan on 7 October 2001. Other spending involves augmenting intelligence capabilities and underwriting efforts to enhance international cooperation, including the freezing of terrorist assets.

Using linear time-series methods on quarterly data of terrorist incidents from 1970 through the second quarter of 2003 (i.e., 2003:2), this paper shows how transnational terrorism has changed following 9/11 and the subsequent war on terrorism. In particular, we apply formal tests for structural breaks in a number of time series including incidents involving casualties, hostages, and bombings as well as proportion series made from these basic series. We first look for structural breaks at 9/11 and then apply the Bai and Perron (1998, 2003) procedure to identify breaks at unknown dates based on the data. When compared, the alternative methods provide consistent evaluations of the impact of 9/11 on the pattern of transnational terrorism. We use the identified break to obtain one-step-ahead and multi-step-ahead forecasts.

1. Background

Terrorism is the premeditated use or threat of use of violence by individuals or subnational groups to obtain a political or social objective through intimidation of a large audience beyond that of the immediate victims. Although definitions of terrorism have varied, violence and political motives are always key ingredients. By making attacks appear to be random, terrorists intimidate a larger audience and enhance its anxiety. The targeted society must then expend large outlays to protect a wide range of vulnerabilities. Terrorists rely on numerous modes of attack that include hostage taking, bombings, suicide attacks, assassinations, armed attacks, and threats. Terrorism can be divided into two categories: domestic and transnational. Domestic terrorism begins and ends in the host country: the perpetrators and targets are homegrown. Moreover, domestic incidents have ramifications for only the host country. When, however, a terrorist incident in one country involves victims, targets, institutions, *or* citizens of another country, terrorism assumes a *transnational* character. The hijackings on 9/11 are transnational terrorist events for a number of reasons: the incidents were planned abroad; the terrorists came from outside of the United States; support came from abroad; victims were from over 80 countries; and the incidents had economic and security implications worldwide. The near-simultaneous bombings of the US embassies in Nairobi, Kenya, and Dar es Salaam, Tanzania, on 7 August 1998 as well as the two suicide car bombings aimed at British targets in Istanbul on 20 November 2003 are transnational terrorist incidents.

We are interested in examining transnational terrorism before and after 9/11, because this form of terrorism poses the greatest threat to developed countries. Since the late 1980s, most industrial countries have relatively little domestic terrorism (Hoffman, 1998; Wilkinson, 2001). The al-Qaida network with its affiliate terrorist groups in some 60 nations engages in transnational terrorism. Changes in visa procedures, airport security, target fortification, and other counterterrorism measures indicate that transnational terrorism represents the greater concern to the authorities. By augmenting international flows of all kind, globalization has given potential terrorists greater cover and ability to cause larger economic repercussions from their attacks. Because 9/11 was a transnational event, the impact of 9/11, if any, is anticipated to be on transnational terrorism.

Once economists turned their attention to analyzing terrorism, they have emphasized that terrorists are rational actors who maximize some goal subject to resource constraints (Landes, 1978; Sandler, Tschirhart, and Cauley, 1983). These constraints are influenced by government policies that can change the expected price associated with different terrorists' actions. Terrorists have been shown to respond rapidly to changes in relative risks stemming from government actions: terrorists switched intended targets away from recently fortified venues to relatively softer targets (Enders and Sandler, 1993; Sandler and Enders, 2004). Thus, efforts following 9/11 to curb hijackings and attacks on embassies through increased security and better intelligence should induce terrorists to use other modes of attack so that hostage-taking events (e.g., skyjackings, and barricade and hostage-taking missions) should decrease both in number and as a proportion of total terrorist events following post-9/11 measures.

Another important factor in anticipating a potential change in the pattern of transnational terrorism involves the changing motives of terrorists since the November 1979 takeover of the US embassy in Tehran and the Soviet invasion of Afghanistan in the same time period (Hoffman, 1998). From the late 1960s until the latter 1980s, transnational terrorism has been primarily motivated by nationalism, separatism, Marxist ideology, and nihilism (Wilkinson, 2001). These terrorists were interested in maintaining a constituency and, hence, tried to limit casualties. By the 1990s, a driving force of transnational terrorism was religious-based fundamentalist groups that are less constrained by social norms and view violence against all nonbelievers including women and children as a sacramental duty (White, 2003). The affiliates of the al-Qaida network abide by this desire to cause casualties. Since the start of 1980, religious-based groups grew from 2 of 64 active terrorist groups to about half of 58 active groups in 1995 (Hoffman, 1997, p.3). Enders and Sandler (2000) demonstrated that events with casualties rose from 1979:4 onwards as fundamentalist-based terrorism grew.

Another crucial consideration in understanding the potential pattern of transnational terrorism following 9/11 involves the US-led “war on terrorism,” which has targeted al-Qaida and its allied groups. Recent reports estimated that about two-thirds of al-Qaida leaders have been either killed or captured; such attrition would severely limit the amount of command and control that al-Qaida’s highest echelon can exercise over its far-flung cells (Gerges and Isham, 2003). These same reports indicated that al-Qaida has had 3,400 suspects arrested worldwide since 9/11 and has lost many operatives during the Afghanistan War in 2001. Additionally, significant financial assets ($135 million since 9/11) of the network have been frozen (*The Economist,* 2003), which also compromises al-Qaida's capabilities. These manpower, leadership, and financial losses are anticipated to limit the network's ability to engage in logistically complex modes of attacks such as hostage taking. As a consequence, the al-Qaida network will turn to logistically simple, but deadly, bombings. Such bombings can also be more attractive than assassinations, which can be logistically complex and yield just a single victim. Given events following 9/11 and the preferences of many of today's terrorist groups for carnage, we anticipate fewer hostage-taking events and assassinations and a greater reliance on deadly bombings. Such expected changes in the composition of the overall series of transnational terrorism would be more evident by analyzing the proportion of hostage-taking attacks or the proportion of deadly attacks due to bombings.

Other structural breaks are anticipated prior to 9/11. The modern era of transnational terrorism began in 1968 following the Arab-Israeli conflict and Israel's subsequent occupation of captured territory. In frustration, the Palestinians resorted to international terrorism to publicize their cause to the global community and gain recognition by the Israelis (Hoffman, 1998). The level of transnational terrorism hit a new plateau in the early to mid-1970s as Palestinian frustration achieved new heights and their terrorist methods were copied by non-Palestinian groups. For example, left-wing nihilist groups sprung up throughout Western Europe (Alexander and Pluchinsky, 1992) and ethno-nationalist movements worldwide employed transnational terrorism to further their cause.

Another potential structural break is anticipated in the early 1990s following the end of the Cold War when many of the left-wing terrorist groups in Europe (e.g., in France, Germany, Spain, Portugal, and the United Kingdom) either ended their operations or were brought to justice (Alexander and Pluchinsky, 1992; Chalk, 1996). This terrorism decline was also due to a reduced interest in Marxism following the collapse of so many communist regimes. At the same time, there was less state sponsorship of leftist terrorists by East Europeans and Middle Eastern countries (Chalk, 1996; Clutterbuck, 1994). These factors in combination should lead to structural downturns in terrorism in the early 1990s following the Gulf War, which generated some terrorist backlash. Although terrorism is expected to decrease in the early 1990s, this time frame also marked the rising influence of fundamentalist terrorism, so that a greater degree of casualties is expected to characterize the anticipated reduced level of terrorism.

2. Data

Data on transnational terrorist incidents were drawn from International Terrorism: Attributes of Terrorist Events (ITERATE), a data set that records the incident date, location, type (e.g., bombing or hostage event), number of people killed, and number of people wounded. ITERATE relies on the world's news print and electronic media for its information with a large reliance on the Foreign Broadcast Information Service (FBIS) *Daily Reports*, which surveyed a couple hundred of the world's newspapers and related sources. By splicing together earlier ITERATE data sets, ITERATE 5's "common" file contains 40 or so key variables common to all transnational terrorist incidents from 1968:1 to 2003:2 (Mickolus et al., 2004). Coding consistency for ITERATE events data was achieved by applying identical criteria and maintaining continuity among coders through the use of overlapping coders and monitors. ITERATE excludes terrorist incidents associated with declared wars or major military interventions and guerrilla attacks on military targets of an occupying force. Even though ITERATE records events on a daily basis, we used quarterly, rather than monthly or weekly, data to avoid periods with zero or near-zero observations what would violate the underlying normality assumptions of the time-series techniques applied.

We extracted eight primary time series to do our structural analysis. The ALL series includes quarterly totals of all types of transnational terrorist incidents; the most important component of this quarterly series is BOMBINGS, accounting for over half of all annual terrorist attacks on average. BOMBINGS combines seven types of events: explosive bombings, letter bombings, incendiary bombings, missile attacks, car bombings, suicide car bombings, and mortar and grenade attacks. The HOSTAGE series includes quarterly totals of kidnappings, skyjackings, nonaerial hijackings, and barricade and hostage-taking missions, whereas assassinations (denoted by ASSNS) consist of politically motivated murders. Two additional primary series are: (i) a quarterly DEATH series recording the number of terrorist incidents where one or more individuals (including terrorists) died; and (ii) a more-inclusive CASUALTIES series recording the quarterly total number of incidents where one or more individuals were injured or died. We further broke down the bombing series by identifying the quarterly number of bombings with one or more deaths (i.e., BOMB_K) and the number of bombings with one or more casualties (i.e., BOMB_CAS).

To analyze the composition of terrorist incidents, we constructed a number of proportion series. By dividing the quarterly entries of the HOSTAGE series by the number of overall terrorist incidents, we obtained the quarterly share of hostage events denoted by P_HOSTAGE. Similar divisions for ASSNS and BOMBINGS gave P_ASSNS and P_BOMBINGS. We also divided the quarterly totals of events with casualties or deaths by the quarterly totals of all events to construct the proportion of terrorist events with casualties and the proportion with deaths indicated by P_CASUALTIES and P_DEATHS. These two proportion series can show whether a typical incident is more threatening during the 1990s when the overall incident totals are down. If, for example, these incident proportions shift up in the 1990s, then victims in an incident are more likely to be injured or killed. Finally, we divided the quarterly total of deadly bombings and bombings with casualties by the quarterly total of deaths and casualties, respectively, to give the proportion of deadly incidents due to bombings (i.e., P_DEATHS_B) and the proportion of incidents with casualties due to bombings (i.e., P_CAS_B). These two constructed time series indicate whether a greater share of injurious terrorist events is now due to bombings.

3. Testing for Structural Breaks at 9/11

To determine whether the various incident series behave differently after 9/11, we first estimated each series as an autoregressive process. Consider the AR(p) model:

$$\Delta y_t = a_0 + \rho y_{t-1} + \sum_{i=0}^{p-1} \beta_{i+1} \Delta y_{t-1-i} + \varepsilon_t, \tag{1}$$

where y_t is the number of incidents of a particular type occurring in time period t. For each series, the lag length was selected by estimating eq. (1) beginning with $p = 6$. If the t-statistic for β_p was not statistically different from zero at the 5% significance level, we reduced the p by one and repeated the entire procedure. Once the lag length was determined, we tested for a unit root using a Dickey-Fuller test. If we reject the null hypothesis that $\rho = 0$, it is then possible to estimate the series and perform hypothesis tests using standard asymptotic distribution theory. We performed the tests without including *time* as a regressor, because there is no evidence of a deterministic trend in any of the incident series. The presence of a unit root may signify the presence of a structural break; i.e., Dickey-Fuller tests can have low power to reject the null of a unit root in the presence of a structural break (Perron, 1989).

3.1. Primary series

The results of the estimations for the eight primary incident series are shown in the top half of Table 1. For the ALL series, the lag length is such that $p = 3$ (so that we used two lagged changed for the augmented Dickey-Fuller test) and the estimated value of ρ is −0.31. Since the t-statistic for the null hypothesis that $\rho = 0$ is −3.20, we can reject the presence of a unit root at the 2.5% significance level. The critical values at the 2.5%, 5%, and 10% significance levels are −3.17, −2.89, and −2.58, respectively. Diagnostic checks indicated that the model is adequate in that the Ljung-Box Q-statistics using 4 and 8 lags of the residuals have *prob*-values of 0.95 and 0.77, respectively. An examination of the top half of the table shows that only the ASSNS (denoting assassinations) and CASUALTIES series are candidates to have unit roots. For CASUALTIES, we could reject the null hypothesis of a unit root at the 10%, but not 5%, significance level. The *prob*-value for the ASSNS series is just over 10%.

In an attempt to resolve the ambiguity regarding the CAUSALTIES and ASSNS series, we used Perron's (1989) test for a unit root in the presence of a structural break. Because 9/11 is very close to the end of the data, it is not surprising that the *prob*-values for this test are nearly identical to those of the Dickey-Fuller test. Insofar as the two tests can have low power in the presence of a structural break near the end of the data set, we do not difference the CAUSALTIES and ASSNS series. The results using the first differences of these two series are virtually identical to those reported in Table 1.

To test for a structural break at 9/11, we modified eq. (1) by estimating an equation of the form:

$$y_t = a_0 + \sum_{i=1}^{p} a_i y_{t-i} + \alpha_1 D_{Pt} + \alpha_2 D_{LT} + \varepsilon_t, \qquad (2)$$

where D_{Pt} and D_{Lt} are dummy variables representing 11 September 2001. In eq. (2), D_{Pt} is a dummy variable such that D_{Pt} = 1 if t = 2001:3 and D_{Pt} = 0 otherwise. This type of *pulse* variable is appropriate if the 9/11 attacks induced a temporary change in the { y_t } series. The magnitude of α_1 indicates the initial effect of 9/11 on { y_t } and the rate of decay is determined by the characteristic roots of eq. (2). To allow for the possibility that 9/11 had a permanent effect on the level of $\{y_t\}$, the second dummy variable in eq. (2) is such that D_{Lt} = 0 for t < 2001:3 and D_L = 1 for $t \geq$ 2001:3. The impact effect of 9/11 on $\{y_t\}$ is given by α_2, while the long-run effect is given by $\alpha_2/(1 - \Sigma a_i)$

For each type of incident series, the fourth column of Table 1 reports α_1, the fifth column reports α_2, and the sixth column reports the *prob*-value of the *F*-test for the joint hypothesis that $\alpha_1 = \alpha_2 = 0$. For the ALL series, neither dummy variable is significant at conventional levels and the joint test does not allow us to reject the null hypothesis that both dummy variables have zero coefficients. An examination of Table 1 reveals some striking similarities for all of the series reported. None of the pulse dummy variables are significant at conventional levels for the eight primary incident series. All of the *t*-statistics are below 0.6 in absolute value. In fact, only the HOSTAGE series exhibits any effects as a result of 9/11. The *t*-statistic for the α_2 coefficient of D_L for the HOSTAGE series is −2.35, and the magnitude of the coefficient is −6.05. This reflects the fact that the number of HOSTAGE incidents fell from a pre-9/11 mean of almost eleven incidents per quarter to slightly more than 3. However, even this finding is problematic because a careful inspection of the HOSTAGE series (reported later as Figure 1) shows that the sharp drop in hostage incidents actually occurred in 1999.

We performed a number of other break tests to determine if they identify 9/11 as a break. For example, a Chow test for a structural break was conducted by comparing the residual sum of squares for the pre-9/11 period to that for the entire period; but it did not reveal the presence of a break for any of the eight primary series. The CUSUM test also showed no evidence of structural change in any of the series occurring in the neighborhood of 2001:3.

3.2. Proportion time series

We found somewhat different patterns when we looked at the seven proportion series. The results are reported in the bottom half of Table 1. There are several key results:

1. At the 10% significance level, we reject the null hypothesis of a unit root for all series except the P_DEATHS and the P_CASUALTIES series. As mentioned earlier, the unit-root test has low power in the presence of a structural break, so the failure to reject the null hypothesis of a unit root may be evidence in favor of a structural break. When we performed unit-root tests on the P_DEATHS and P_CASUALTIES series using only the data through 2001:2, the associated *t*-statistics for the null hypothesis that $\rho = 0$ are −4.27 and −4.85, respectively, leading to a rejection of a unit root.

2. The pulse dummy variable is statistically significant for the P_DEATHS and P_CASUALTIES series. For these two series, the *t*-statistics for the null hypothesis that $\alpha_1 = 0$ are 6.31 and 4.81, respectively. On impact, the proportion of incidents with deaths rose by 54 percentage points and the proportion of incidents with casualties rose by 48 percentage points. The level dummy variables are, however, not significant at conventional levels. Hence, the jumps in the P_DEATHS and P_CASUALTIES are not permanent.

3. The level dummy variable is highly significant for the proportion of hostage incidents (P_HOSTAGE) and the proportion of deadly incidents due to bombings (P_DEATHS_B). The intercept for the P_HOSTAGE series decreased by 8 percentage points and that for P_DEATHS_B rose by 25 percentage points. These changes are estimated to be permanent.

The P_HOSTAGE series falls precisely at 9/11. There is some evidence $(t = -1.74)$ that the proportion of assassinations (P_ASSNS) decreased by 16 percentage points after 9/11.

Generally, we did *not* uncover evidence that there were changes in the primary terrorist series following 9/11. We did, however, uncover evidence that the composition of the terrorist time series changed. This apparent switch from logistically complex hostage events to less complex bombings is consistent with our predictions based on post-9/11 pressures on the al-Qaida leadership and enhanced security given to airports, embassies, and high-profile targets. The reliance on deadly bombings also agrees with our priors concerning the changing nature of terrorism.

4. Multiple Structural Breaks

One criticism of these results is that there might be more than one structural break; e.g., Enders and Sandler (2000) reported significant changes in terrorism associated with the increase in religious fundamentalism. Ignoring the effects of early breaks might cloud the effects of 9/11; hence, one research strategy is to reestimate eq. (2) by including dummy variables for all such breaks. This strategy is problematic because there is a danger of *ex post* fitting if break points are selected as a result of an observed change in the variable of interest. Moreover, a number of events may roughly coincide with the selected break points. In addition, the efficacy of the estimates cannot rely on the usual asymptotic properties of an autoregression, because an increase in sample size does nothing to increase the number of points lying between two break points. Just as it is difficult to know what dummy variables to include, it can be difficult to know what factors to exclude. If important events influencing terrorism are excluded from the estimating equation, there is still a specification problem.

An alternative methodology is to use a purely data-driven procedure to select the break dates. Bai and Perron (1998, 2003) developed a procedure that can estimate a model with an unknown number of structural breaks that occur at unspecified dates. For our purposes, the key feature of the Bai-Perron procedure is that the number of breaks and their timing are estimated along with the autoregressive coefficients. Bai and Perron (1998, 2003) also showed how to form confidence intervals for the break dates. This is particularly important because there is evidence that key changes in some of the incident series actually began prior to 9/11; we want to ascertain whether the changes are due 9/11 or to forces already in progress.

The form of the Bai-Perron specification we considered is:

$$y_t = \alpha_j + \sum_{i=1}^{p} a_i y_{t-i} + \varepsilon_t, \tag{3}$$

where $j = 1, \ldots, m + 1$ and m is the number of breaks. Eq. (3) allows for m breaks that manifest themselves by shifts in the intercept of the autoregressive process. Our notation is such that there are $m + 1$ intercept terms denoted by α_j. The first break occurs at t_1 so that the duration of the first regime is from $t = 1$ until $t = t_1$ and the duration of the second regime is from $t_1 + 1$ to t_2. Because the m-th break occurs at $t = t_m$, the last regime begins at $t_m + 1$ and lasts until the end of the data set. In applied work, the maximum number of breaks needs to be specified. We allowed for a maximum of number of 5 breaks. The procedure also required that we specified the minimum regime size (i.e., the minimum number of observations between breaks). Because our data runs through the second quarter of 2003, we used a minimum break size of 6 to permit a break occurring as late as the first quarter of 2002. In principal, we could allow all coefficients (including the autoregressive coefficients) to change; but this would necessitate estimating a separate AR(p) model for each regime. Since the data include only a small number of post-9/11 observations, this procedure is not possible here. Instead, we adopted what Bai and Perron call the "partial change" model; this specification allowed us to estimate only one new coefficient (i.e., the intercept) for each regime.

For each series, Table 2 reports the number of breaks (*m*), the point estimate of each break date, the lower and upper bounds of a 95% confidence interval around the break dates (Lower and Upper, respectively), the sample mean in the first regime (Initial Mean), and the short-run (SR) and long-run (LR) changes due to the break(s). The short-run effect of break *j* is measured by $\alpha_{j+1} - \alpha_j$, whereas the long-run effect is measured by $(\alpha_{j+1} - \alpha_j)/(1 - \Sigma a_i)$.

The results for the various incident series reinforce the results regarding 9/11, reported in Section 3. For example, a single structural break, not at 9/11, is found for the ALL series. The most likely estimate of this break is 1994:3; a 95% confidence interval for the break date spans the period 1993:4 through 1996:4. This confidence interval is not symmetric around 1994:3, because the break is unlikely to have occurred much earlier than this date. In the first regime (i.e., until 1994:3), the initial mean number of incidents per quarter is 106.62. After this break, we estimated a short-run decline of 46.46 incidents and a long-run decline of 62.63 incidents. The crucial point is that a 95% confidence interval for the break date does not include 9/11. This structural break is consistent with our priors about the influence of reduced state sponsorship and the demise of many terrorist groups in the late 1980s and early 1990s. Given that bombings constitute half of the ALL series, a similar structural break characterizes BOMBINGS at 1994:1 in Table 2.

The HOSTAGE series experiences a single break after 2000:3 (i.e., the new regime begins in 2000:4). The 95% confidence interval *does include* 2001:3; hence, the decline in the mean number of HOSTAGE incidents from 13.79 to about 3.85 (13.79 − 9.94 = 3.85) may be attributable to 9/11. There is no evidence of a break in the ASSNS series. Although casualties due to bombings and incidents with deaths, each displays two structural breaks, none of the 95%

confidence intervals of these breaks include 9/11. For BOMB_CAS, the two breaks took place at 1992:3 and 1994:3 as incidents dropped in number but became more lethal on average as fundamentalist-based terrorism grew in importance. For the DEATHS series, the structural break at 1975:3 coincides with the growing importance of transnational terrorism in the early to middle 1970s. In contrast, the structural break for the DEATHS series at 1996:2 came as the number of transnational terrorist events decreased greatly.

In the bottom portion of Table 2, the structural breaks for six proportion series are listed. These proportion series display a larger number of structural breaks compared with the primary series. Notably, three of the proportion series – P_HOSTAGE, P_DEATHS_B, and P_DEATHS – have structural breaks whose confidence intervals include 9/11. In particular, we estimated four breaks in the P_HOSTAGE series with break dates of 1994:1, 1996:2, 2000:1 and 2001:3. The confidence interval for this last regime, spanning 2001:1 through 2002:1, is associated with a short-run decline of 37.6 percentage points. Clearly, terrorists have reduced their reliance on hostage events since 9/11.

The proportion of incidents with deaths (P_DEATHS) is estimated to have 5 breaks. The point estimate of the fifth break is 2001:2, so that beginning in 2001:3 the short-run increase in the proportion of death incidents is 17.8 percentage points. Because the confidence interval for the fifth break is entirely contained within that for the fourth break, there may have been an ongoing increase in the proportion of deadly incidents that included the incidents on 9/11. Nevertheless, the estimates are consistent with the rise in P_DEATHS being primarily due to more deadly bombs. As shown in the Table 2, there is a short-run jump in P_DEATHS_B of 20 percentage points that is estimated to occur at 2001:2. Moreover, we find no evidence of breaks associated with 9/11 in the proportion series associated with assassination and casualty incidents.

Table 2 is also consistent with our priors about transnational terrorism becoming more of a threat in the early to mid 1970s – i.e., the 1975:3 structural break for DEATHS, P_ASSNS, and P_DEATHS, and the 1974:1 structural break for P_DEATHS_B. Moreover, the structural breaks for B_DEATHS_B and P_DEATHS during the early to mid 1990s are consistent with our priors that the period following the Gulf War had deadlier events on average than earlier periods. Clearly, transnational terrorism changed in character at three times: in the mid-1970s; in the 1990s; and in and around 9/11.

5. Forecasting Beyond 9/11

We now use the previously identified structural breaks to forecast the various incident series. Based on eq. (3), the *k*-step ahead forecast of y_{t+k} follows from:

$$E_t y_{t+k} = E_t \alpha_j + \sum_{i=1}^{p} a_i E_t y_{t+k-i}, \tag{4}$$

where $E_t y_{t+k}$ is the expectation of y_{t+k} conditional on the information set at *t*. Since a break may occur between period *t* and period *t* + *k*, the appropriate value of α_j is unknown at *t*. We assumed that a break date becomes known in the period containing the break. Although the structural break at 9/11 could not be forecasted in period 2001:2, forecasts beginning in 2001:3 can use the fact that a break occurred. Of course, the magnitude of the break is unknown, so its size must be estimated. As is standard practice, to obtain $E_t y_{t+k}$, we estimated eq. (3) with data through period *t* and then used the estimated coefficient to form eq. (4). If a break in the intercept occurs in period *t* + 1 to *t* + *k*, the forecasts will be poor, since they do not incorporate the appropriate α_j.

The break in the HOSTAGE series prior to 9/11 (indicated by a vertical line) is shown in the top portion of Figure 1, where the HOSTAGE series fluctuates around the pre-break mean of

13.79 incidents per quarter until 2000:3. Thereafter there is a sharp drop in the series, so that the new long-run mean is about 3.85. The lower portion of the Figure 1 shows the 1-step-ahead (unbroken line) and 8-step-ahead forecast errors, $y_{t+k} - E_t y_{t+k}$, for t = 1999:2 through 2003:2. The two forecast errors are reasonably similar until 2000:4, and the series of 1-step-ahead errors does not exhibit any unusual behavior at the breakpoint. Clearly, the 1-step-ahead forecasts quickly capture the influence of a structural break so the forecast errors remain small; however, the 8-step-ahead forecasts perform poorly beginning with the breakpoint. The forecasts $E_{1998:4}y_{2000:4}$ through $E_{2000:3}y_{2002:3}$ are all quite negative. Because the long-term forecasts do not include any information concerning the change in the intercept beginning in 2000:4, they all perform poorly. These long-term forecasts reinforce the point that the HOSTAGE series began to decline prior to 9/11. Moreover, the forecasts of the post-9/11 values that use the 2000:3 break date appear adequate.

The actual time series (1970:1 – 2003:2) and the forecast results for the DEATH series are shown in Figure 2. Although the breaks are not as pronounced as those in Figure 1, the Bai-Perron break date of 1996:2 seems quite reasonable. The lower forecast portion of the figure reinforces the point that 1996:2 is a critical point in the data. The 8-step-ahead forecasts sharply depart from the 1-step-ahead forecasts at 1996:2. In the top portion of Figure 2, there appears to be a steady increase in the number of DEATH incidents following 9/11. However, the negative finding concerning a break at 9/11 suggests that such an increase is not atypical. Moreover, the 1-step-ahead and 8-step-ahead forecasts are similar for the post-9/11 period, which is consistent with 9/11 not being a structural break for the DEATH series.

The upper portion of Figure 3 shows the P_HOSTAGE series. The increases in the series in 1994:1, 1996:2, and 2000:1 as well as the drop in 2001:3 are quite pronounced. The appropriateness of the breakpoints is also shown in the lower portion of the figure, because the long-term forecasts diverge from the 1-step-ahead forecasts at these break dates. For example, the 8-step-ahead forecasts beginning from 2001:2 are all too high relative to the actual values of P_HOSTAGE and to the 1-step-ahead forecasts. Thus, a little hindsight to recognize structural breaks shortly after they occur can greatly assist the accuracy of forecasts.

6. Concluding Remarks

Over two years have passed since 9/11. In reaction to these attacks, targeted governments have bolstered security at airports, embassies, and other high-profile targets. The US-led offensive against al-Qaida and its network has taken a toll on al-Qaida's leadership and finances. As a consequence, post-9/11 policies should have hampered al-Qaida's ability to direct operations. We have applied time-series methods to uncover what, if anything, is now different since 9/11. Surprisingly, little has changed to the series of all transnational terrorist incidents or its major component of all bombing incidents. Moreover, the DEATHS and CASUALTIES series have not changed following 9/11. The main influence of 9/11 has been on the composition of the ALL series. In particular, hostage-taking incidents have fallen after 9/11 as terrorists, bent on carnage, have substituted into deadly bombings. As a consequence, the proportion of deadly incidents due to bombings has increased as the proportion of hostage-taking and assassination attacks have decreased. Given official antiterrorist measures after 9/11, these changes are understandable as terrorists substitute from hard to soft targets in the wake of security changes. Additionally, stress on al-Qaida leadership may be responsible for a substitution from logistically complex attacks (e.g., hostage taking and assassinations) to logistically simpler bombings. The lack of a reversal to this composition effect in recent quarters suggests that a replacement to al-Qaida is not yet on the scene.

When we do not prejudge structural breaks and apply the Bai-Perron method to identify these jumps, a number of interesting results follow. First, the Bai-Perron findings regarding 9/11 are entirely consistent with our results when 9/11 is prejudged as a structural break. Second, structural breaks characterize two earlier periods: (i) the early to mid 1970s when transnational terrorism became more deadly; and (ii) the 1990s when there was a reduction in transnational terrorism as state sponsorship fell. Third, the 1990s is also seen on average to have more deadly events. The movement to greater casualties, underscored by 9/11, was foreshadowed by the proportion series associated with deaths and casualties well before 9/11. Finally, we show that reasonable forecasts are possible if structural breaks are incorporated fairly rapidly in the underlying forecast model. Our results suggest that the war on terrorism has had effects – some good (e.g., the absence of an increase in incidents and fewer hostage incidents) and some bad (e.g., a greater reliance on deadly bombings).

References

Alexander, Yonah and Dennis Pluchinsky (1992), *Europe's Red Terrorists: The Fighting Communist Organizations* (London: Frank Cass).

Bai, Jushan and Pierre Perron (1998), "Estimating and Testing Linear Models with Multiple Structural Changes," *Econometrica*, 66(1), 47-78.

Bai, Jushan and Pierre Perron (2003), "Computation and Analysis of Multiple Structural Change Models," *Journal of Applied Econometrics*, 18(1), 1-22.

Chalk, Peter (1996), *Western European Terrorism and Counter-Terrorism* (Houndsmills, UK: Macmillan).

Clutterbuck, Richard (1994), *Terrorism in an Unstable World* (New York: Routledge).

Department of Homeland Security (2003), "Budget in Brief," [http://www.dhs.gov/interweb/assetlibrary/FY_2004_Budget_IN_BRIEF.pdf], assessed 20 November 2003.

The Economist (2003), "Al-Qaeda Operations are Rather Cheap," *The Economist,* 369(8344), 45.

Enders, Walter and Todd Sandler (1993), "The Effectiveness of Anti-Terrorism Policies: Vector-Autoregression-Intervention Analysis," *American Political Science Review*, 87(4), 829-844.

Enders, Walter and Todd Sandler (2000), "Is Transnational Terrorism Becoming More Threatening? A Time-Series Investigation," *Journal of Conflict Resolution*, 44(3), 307-332.

Gerges, Fawaz A. and Christopher Isham (2003), "Sign of Weakness? Do Overseas Terror Strikes Suggest Al Qaeda Inability to Hit US?," ABC News, November 22, 2003.

Hoffman, Bruce (1997), "The Confluence of International and Domestic Trends in Terrorism," *Terrorism and Political Violence*, 9(1), 1-15.

Hoffman, Bruce (1998), *Inside Terrorism* (New York: Columbia University Press).

Hoffman, Bruce (2002), "Rethinking Terrorism and Counterterrorism Since 9/11," *Studies in Conflict & Terrorism,* 25(5), 303-316.

Landes, William M. (1978), "An Economic Study of Aircraft Hijackings, 1961-1976," *Journal of Law and Economics,* 21(1), 1-31.

Perron, Pierre (1989), "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis," Econometrica, 57(6), 1361-1401.

Mickolus, Edward F., Todd Sandler, Jean M. Murdock, and Peter Flemming (2004), *International Terrorism: Attributes of Terrorist Events,* 1968-2003 (ITERATE 5) (Dunn Loring, VA: Vinyard Software).

Quillen, Chris (2002a), "A Historical Analysis of Mass Casualty Bombers," *Studies in Conflict & Terrorism,* 25(5), 279-292.

Quillen, Chris (2002b), "Mass Casualty Bombings Chronology," *Studies in Conflict & Terrorism,* 25(5), 293-302.

Sandler, Todd (2003), "Collective Action and Transnational Terrorism," *World Economy,* 26(6), 779-802.

Sandler, Todd and Walter Enders (2004), "An Economic Perspective on Transnational Terrorism," *European Journal of Political Economy*, 20(2), forthcoming.

Sandler, Todd, John T. Tschirhart, and Jon Cauley (1983), "A Theoretical Analysis of Transnational Terrorism," *American Political Science Review,* 77(1), 36-54.

White, Jonathan R. (2003), *Terrorism: 2002 Update*, 4th Ed. (Belmont, CA: Wadsworth/Thomson Learning).

Wilkinson, Paul (2001), *Terrorism Versus Democracy: The Liberal State Response* (London: Frank Cass).

Table 1. AR estimation using 9/11 as a structural break

Series	Lags	ρ	α_1	α_2	F	Q(4)	Q(8)
ALL	3	−0.31	−22.26	−15.31	0.47	0.95	0.77
		(−3.20)	(−0.54)	(−0.89)			
HOSTAGE	2	−0.55	−1.03	−6.05	0.04	1.00	0.98
		(−5.38)	(−0.16)				
ASSNS	3	−0.18	−1.99	−0.71	0.77	0.65	0.14
		(−2.56)	(−0.44)	(−0.41)			
BOMBINGS	3	−0.37	−13.80	−9.55	0.52	0.87	0.39
		(−3.64)	(−0.48)	(−0.84)			
BOMB_K	2	−0.54	−0.75	0.51	0.95	0.71	0.33
		(−5.40)	(−0.16)	(0.30)			
BOMB_CAS	6	−0.32	−3.88	0.13	0.87	0.99	0.99
		(−3.09)	(−0.50)	(0.05)			
DEATHS	2	−0.31	1.80	−0.63	0.95	0.74	0.74
		(−3.97)	(0.28)	(−0.26)			
CASUALTIES	3	−0.22	−4.83	−1.46	0.87	0.96	0.60
		(−2.84)	(−0.48)	(0.37)			
P_HOSTAGE	4	−0.28	0.14	−0.08	0.05	0.99	0.87
		(−2.77)	(1.37)	(−2.36)			
P_ASSNS	3	−0.38	−0.22	−0.16	0.06	0.89	0.46
		(−3.74)	(−0.93)	(−1.74)			
P_BOMBINGS	3	−0.31	−0.02	0.04	0.62	0.90	0.91
		(−3.26)	(−0.12)	(−0.96)			
P_DEATHS_B	2	−1.08	−0.26	0.25	0.01	0.82	0.85
		(−8.48)	(−1.25)	(3.32)			
P_CAS_B	2	−0.99	−0.10	0.07	0.48	0.21	0.18
		(−8.30)	(−0.57)	(1.21)			
P_DEATHS	4	−0.24	0.54	0.03	0.00	0.84	0.32
		(−2.47)	(6.31)	(0.72)			
P_CASUALTIES	4	−0.25	0.48	0.04	0.00	1.00	0.96
		(−2.36)	(4.81)	(0.96)			

Note: *t*-statistics are in parentheses

Table 2. Estimates of multiple structural breaks

Series[a]	Break Date	Lower	Upper	Initial Mean	SR[b] Effect	LR[c] Effect
ALL	1994:3	1993:4	1996:4	106.62	−46.46	−62.63
HOSTAGE	2000:3	2000:1	2002:3	13.79	−6.69	−9.94
BOMBINGS	1994:1	1993:3	1996:1	61.50	−33.92	−40.43
BOMB_CAS	1992:3	1989:4	1993:3	15.79	11.20	17.17
	1994:3	1994:1	1996:1		15.64	23.97
DEATHS	1975:3	1973:2	1976:2	8.89	7.17	11.01
	1996:2	1994:2	1998:4		−5.81	−8.91
P_HOSTAGE	1994:1	1991:3	1994:4	0.131	0.102	0.071
	1996:2	1994:1	1998:1		0.115	0.079
	2000:1	1998:4	2000:4		0.207	0.143
	2001:3	2001:1	2002:1		−0.376	−0.259
P_ASSNS	1975:3	1974:1	1975:4	0.039	0.070	0.078
	1990:1	1984:4	1993:2		−0.37	−0.041
P_BOMBINGS	1977:4	1973:3	1980:1	0.679	−0.097	−0.180
P_DEATHS_B	1974:1	1972:2	1974:3	0.039	0.050	0.036
	1993:2	1992:1	1993:3		0.112	0.079
	1997:3	1992:3	2000:2		−0.064	−0.045
	2001:2	2000:4	2001:4		0.200	0.142
P_DEATHS	1975:3	1974:3	1976:1	0.103	0.104	0.081
	1994:1	1992:3	1994:2		0.167	0.130
	1997:1	1995:2	1998:3		−0.144	−0.112
	1999:4	1998:1	2002:2		0.108	0.084
	2001:2	1999:1	2001:4		0.178	0.139
P_CASUALTIES	1999:4	1995:2	2001:1	0.292	0.123	0.279

[a]Lag lengths are not necessarily those shown in Table 1.
[b]SR denotes the short-run magnitude of the break.
[c]LR denotes the long-run magnitude of the break.

Figure 1: HOSTAGE Incidents and Forecast Errors

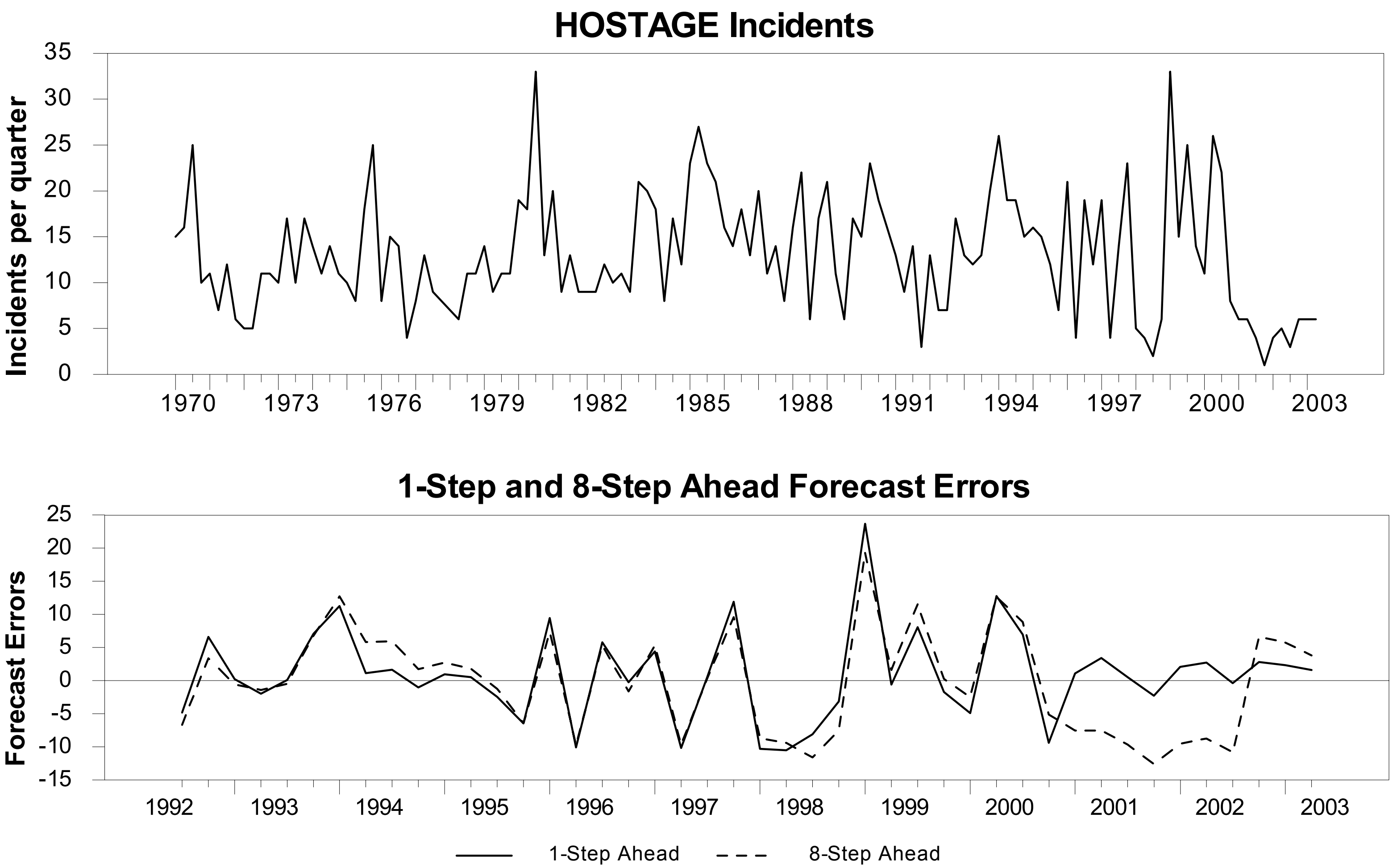

Figure 2: DEATH Incidents and Forecast Errors

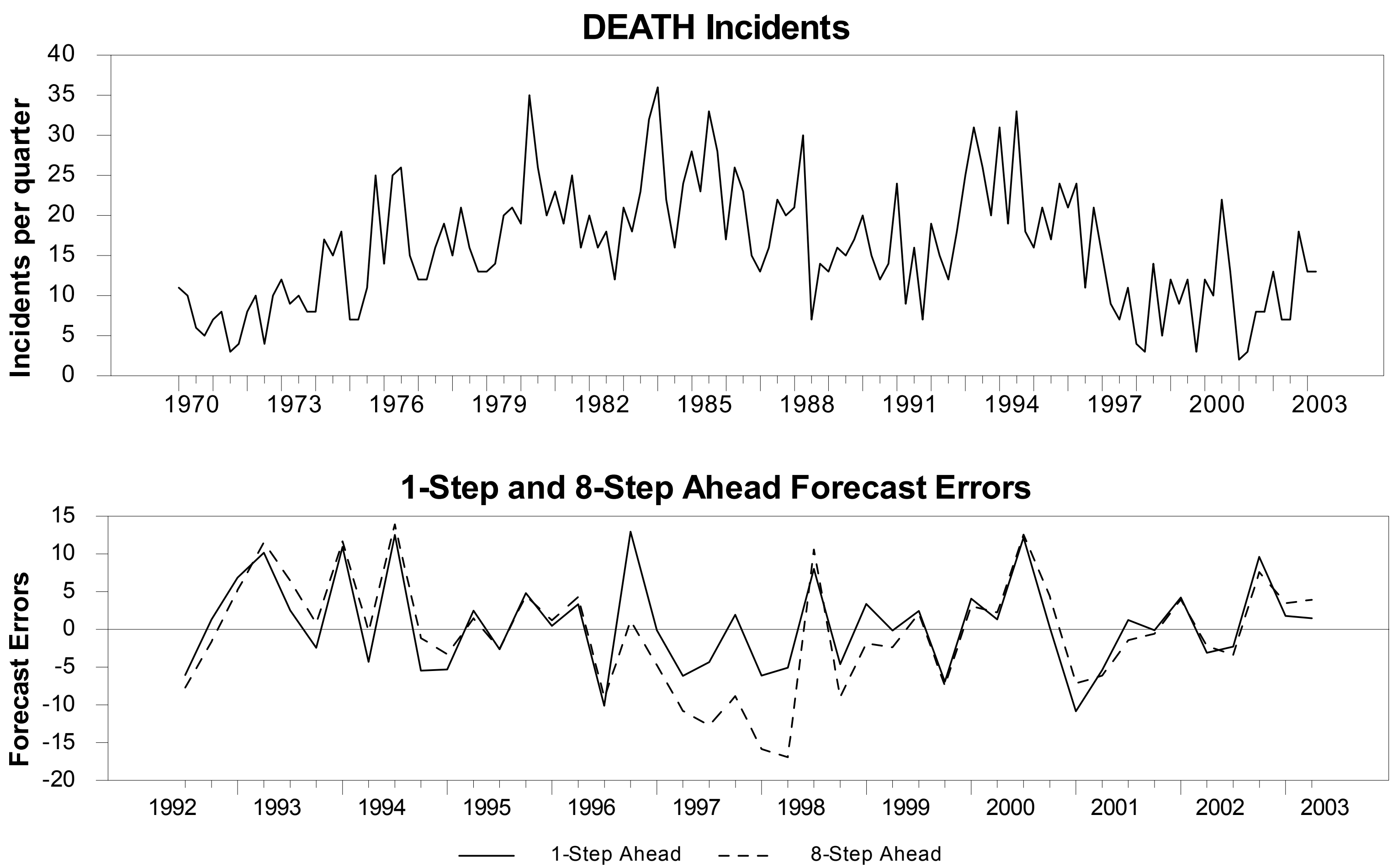

Figure 3: Proportion of Hostage Incidents and Forecast Errors