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Terror Attacks and Bond Yields in the European Union: An Autogressive Transfer Function Approach

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Abstract

This article seeks a connection between the rate at which governments can borrow money and terrorist activity within their country. Government borrowing habits can play a large role in economic growth, and understanding the determinants of the rate at which money can be borrowed is valuable. The traditional bond yield study includes various macroeconomic indicators and estimates the role that they play in the borrowing rate. A straightforward theory to connect utility theory of consumer choice to risk preferences and the decision to invest in a bond is derived. Using data from the International Monetary Fund and University of Maryland's Global Terrorism Database, this study will attempt a new approach. Instead of controlling for complicated and often endogenous macroeconomic indicators, an autoregressive estimation technique will be employed. A dual bond estimation structure (standard bonds as the dependent variable regressed on lagged values of the demeaned series) yields strong results to suggest that governments do pay a price in the rate at which they can borrow as a result of terrorist attacks. Homogenous estimation structures provide less convincing results.

Contents

List of Tables

List of Figures

I Introduction

This article seeks a connection between the rate at which governments can borrow money and terrorist activity within their country. The government issued bond yield is one of many measures that can be used to analyze the borrowing rate. There are, of course, two actors in the market: the government supplying bonds and the consumers purchasing bonds. The empirical work below will attempt to build a framework to understand whether or not terrorist attacks adjust the risk preferences on the demand side of the market sufficiently enough to shift the yield on the bonds.

The bond yield literature is historic and ever-changing. Government borrowing habits can play a large role in economic growth, and understanding the determinants of the rate at which money can be borrowed is valuable. The traditional bond yield study includes various macroeconomic indicators and estimates the role that they play in the borrowing rate. The most common of these is the debt-to-GDP ratio. Studies like Evans (1987) fail to find a strong link between these traditional indicators and the long term real bond yield.

Newer studies have gone in a different direction. In a world where bond yields can be traded on a day to day or even hour to hour basis, it is important to include short run controls in the model. Poghosyan (2014) found strong results suggesting the traditional macroeconomic indicators, such as debt-to-GDP, actually do play a role in the long run real bond yield, when appropriate short run controls are used.

Using data from the International Monetary Fund and University of Maryland's Global Terrorism Database, this study will attempt a new approach. Instead of attempting to seek and control for complicated and often endogenous macroeconomic indicators, an autoregressive estimation technique will be employed. The transfer function model uses lagged values of the dependent variable to allow for predetermined continuous shocks in an exogenous variable to 'transfer' an effect to the left hand side. A dual bond estimation structure (standard bonds as the dependent variable regressed on lagged values of the demeaned series) yields strong results to suggest that governments do pay a price in the rate at which they can borrow as a result of terrorist attacks. Homogenous estimation structures provide less convincing results.

In section II, literature on both bond yield determinants as well as international, domestic, and transnational terrorism is presented. Section III derives a straightforward theory to connect utility theory of consumer choice to risk preferences and the decision to invest in a bond. Section IV gives an overview of the data, and section V details the analysis. Section VI offers concluding remarks.

II Literature Review

II.1 Bond Yields

As noted by Poghosyan (2014), the bond yield literature can be split into two categories: single country studies and panel data studies. The advantages and disadvantages of each type will be explained in greater detail in the empirical section, but the basic idea is that panel provides more data (better for statistical inference), but requires potentially over-reaching assumptions about the economic homogeneity of very different countries. Single country studies use time series econometrics, while panel studies must use panel data techniques.

Much of the single country bond yield literature focuses on the United States. Brooke (2003) focuses on the connection between fiscal balances and interest rates. The decline in interest rates between 2000 - 2003 can be attributed to portfolio allocation decisions (Brooke 2003). Brooke (2003) goes on to find that the relationship between fiscal behavior and long term interest rates is persistent in the United States, but not strong. There was no statistically significant link found between risky U.S. fiscal policy decisions and the early 2000s and the rise in bond yields (Brooke 2003).

Many of the studies in the bond yield/interest rate literature attempt to empirically estimate determinants of short-term yields or nominal long-term yields. The ex-post real long-term interest rates are often ignored. Cebula (2000) focuses on the period between 1973 - 1995 and finds that the "structural federal budget deficit exercised a positive and significant impact on the ex-post real interest rate yield on ten-year Treasury notes." The study is careful to note that the results may insist that there is a 'crowding out' effect (Cebula

2000).

The above studies employed static specification, but Evans (1987) finds very different results with a dynamic vector autoregression specification. In fact, Evans (1987) finds that exogenous changes to various fiscal variables do not have significant effects on the yield of 10 year government bonds. Similarly, Plosser (1987) uses a vector autoregression and finds similar results to Evans (1987).

There is also a sector of the literature that treats lenders as forward looking agents. The previous studies employ current fiscal variables in their empirics, while studies like Elmendorf (1993) and Thorbecke (1993) both suggest that treating agents as having forward looking expectations can help clear up the empirical mess. Both papers come to the conclusion that increases in expected debt to GDP ratio can raise the long-term government bond yield.

Poghosyan (2014) explains that the traditional panel data studies use a fixed effects estimation, "where fiscal variables (most notably, the debt-to-GDP ratio) are introduced along with other control variables (including GDP growth) as long-run determinants of sovereign borrowing costs." Many of these studies treat short run and long run effects as one.

A few of the panel data studies yielded results similar to the vector autoregression approach. Kinoshita (2006) uses a panel of 19 developed economies to find that an increase in the debt-to-GDP ratio of 1 percentage point increases bond yields by 2-5 basis points.

The macroeconomic world was caught off guard when many advanced economies had very low bond yields right after the global financial crisis. Hauner et al. (2006) seeks to explain this phenomenon. Their findings suggest that the "upward pressures on government bond yields due to chronic weakening of budgetary positions were more than offset by foreign inflows triggered by 'safe-haven' considerations."

Lastly, Poghosyan (2014) uses a unique methodology to distinguish between long run variables and short run variables in an attempt to tease out the determinants of bond yields. By using a panel co-integration methodology, Poghosyan (2014) is able to isolate factors such as debt-to-GDP, potential growth, inflation, short-term rates, and other short run factors. Poghosyan (2014) finds strong results that yields increase 2 basis points for a 1 percentage point increase in the debt-to-GDP ration. Similarly, Poghosyan (2014) finds that a 1 percentage point increase in potential growth has a 45 basis point effect on bond yields.

II.2 Terrorism

After the events of September 11, 2001, there has been an increasing interest in the effect of terrorism on the global economy. Studies have been done on the political economy as well as the effect that terrorism has had on specific markets or groups of people.

Starting at a micro level, a natural question is whether terrorism has an effect on the day to day operation of markets. Because of readily available data, stock markets are often an accessible source. Drakos (2010) sampled 22 countries in an attempt to determine whether terrorism has an effect on stock markets. Drakos (2010) used an autoregressive conditional heteroskedastic model to show strong results indicating terrorism has a negative effect on returns the day of the attack. Drakos (2010) also found that the effect increased as the psychosocial effect of the attack increased.

Chesney et al. (2011) used a three step approach to expand on the approach used by Drakos (2010). The first was an event study, the second was a non-parametric model, and the third was a general autoregressive conditional heteroskedastic model. What makes the approach unique is that they compare the effect that the terrorist attacks have on the financial markets to other similar exogenous shocks like natural weather disasters. The non-parametric method is the most robust and provides implications for "portfolio diversification strategies against terrorism risk." (Chesney et al., 2011).

Similar to Drakos (2010), Arin et al. (2008) finds that terrorism can have a significant negative impact on stock markets. The two studies differed in that Arin et al. (2008) also found significant increases in volatility as a result of terror attacks and also found the effects of the attack to be larger for undeveloped economies.

Sticking with financial markets, Gries et al. (2013) looks at the reverse causality of terrorism in financial markets. That is, Gries et al. (2013) attempts to see whether banking crises can actually cause terrorism. Banking crises can result in a small increase in terrorism, but the estimation structure used leaves room to debate the causality of the findings (Gries et al., 2013). Similarly, the results only stood up for undeveloped economies.

On a separate note, Krieger et al. (2011) looks at the general determinants of terrorism, specifically focusing on transnational terrorism. Krieger et al. (2011) look at economic, political, institutional and demographic factors. These include poverty, inequality, infrastructure, etc...

Lastly, Enders et al. (2011) conduct a large overview of the Global Terrorism Database (used in this study). Specifically, they focus on the difference and dynamics between domestic versus transnational terrorism. Enders et al. (2011) "find a large cross correlation between domestic and transnational terrorist incidents that persists over a number of periods." They also find that domestic terrorism can have a significant effect on transnational terrorism, but not the reverse.

III Theory

This section explains the link between utility theory of consumer choice and the origins of risk. The objective is to produce a model that illustrates the decision of whether or not to engage in an investment as a function of the individual's original consumer preferences.

To start, take a simple model where a consumer has to choose to spend her wealth, W, on two goods, X and Y. Although the two-good world is a simplification, it is not far from reality as the decision to empirically model many consumer decisions is often based off the decision between purchasing a good, X, and all other possible goods, Y. Assume the individual gets utility in the manner below and chooses to spend all of their wealth on X and Y:

$$U = X^{\alpha} Y^{\beta}$$

$$W = P_x X + P_y Y$$

The consumer will optimize according to:

$$\max_{X,Y,\lambda} \; \Phi = X^{\alpha} Y^{\beta} - \lambda (P_x X + P_y Y - W)$$

The three first order conditions:

$$\frac{\partial \Phi}{\partial X} = \alpha X^{\alpha-1}Y^{\beta} - \lambda P_x = 0 \tag{1}$$
$$\frac{\partial \Phi}{\partial Y} = \beta X^{\alpha}Y^{\beta-1} - \lambda P_y = 0 \tag{2}$$
$$\frac{\partial \Phi}{\partial \lambda} = -P_x X - P_y Y + W = 0 \tag{3}$$

First order conditions 1 and 2 can be rearranged and simplified.

$$\frac{\lambda P_x}{\lambda P_y} = \frac{\alpha X^{\alpha-1}Y^{\beta}}{\beta X^{\alpha}Y^{\beta-1}}$$
$$\frac{P_x}{P_y} = \frac{\alpha Y}{\beta X}$$
$$Y = \frac{\beta P_x X}{\alpha P_y}$$
$$X = \frac{\alpha P_y Y}{\beta P_x}$$

Return to the third first order condition to solve for Y as a function of only exogenous variables (wealth and prices).

$$-P_x X - P_y Y + W = 0$$
$$P_x X + P_y Y = W$$
$$P_x \frac{\alpha P_y Y}{\beta P_x} + P_y Y = W$$
$$Y(\frac{\alpha P_y}{\beta} + P_y) = W$$
$$\frac{W}{\frac{\alpha P_y}{\beta} + P_y} = Y$$
$$\frac{W}{P_y(\frac{\alpha}{\beta} + 1)} = Y$$

Repeating the above for X:

$$
\begin{aligned}
P_x X + P_y Y &= W \\
P_x X + P_y \frac{\beta P_x X}{\alpha P_y} &= W \\
X(P_x + \frac{\beta P_x}{\alpha}) &= W \\
\frac{W}{P_x + \frac{\beta P_x}{\alpha}} &= X \\
\frac{W}{P_x(1 + \frac{\beta}{\alpha})} &= X
\end{aligned}
$$

Return to the original utility function and solve in terms of wealth and prices.

$$
\begin{aligned}
U &= X^\alpha Y^\beta \\
U &= \left(\frac{W}{P_x(1+\frac{\beta}{\alpha})}\right)^\alpha \left(\frac{W}{P_y(\frac{\alpha}{\beta}+1)}\right)^\beta \\
U &= \frac{W^{\alpha+\beta}}{\left(P_x(1+\frac{\beta}{\alpha})\right)^\alpha \left(P_y(\frac{\alpha}{\beta}+1)\right)^\beta} \\
\text{Let } \Pi &= \frac{1}{\left(P_x(1+\frac{\beta}{\alpha})\right)^\alpha \left(P_y(\frac{\alpha}{\beta}+1)\right)^\beta} \\
U &= \frac{1}{\Pi} W^{\alpha+\beta}
\end{aligned}
$$

Take an individual who has savings S and is deciding whether to invest I in a bond yield that has expected return R and a probability ψ of default. Assume the individual is rational and will choose the option that has the highest expected utility. Expected utility can be modeled as:

$$
\text{Expected Utility} = \psi \frac{1}{\Pi}(S-I)^{\alpha+\beta} + (1-\psi)\frac{1}{\Pi}(S+R)^{\alpha+\beta}
$$

If the expected utility of investing in the bond yield is greater than the individual's current utility, then the individual should invest in the bond yield. If the two are equal, she should be indifferent. If the current level of utility is larger than the expected utility, then she should not invest in the bond.

$$\begin{aligned}
\text{Purchase Bond: } & \frac{1}{\Pi}S^{\alpha+\beta} < \psi\frac{1}{\Pi}(S-I)^{\alpha+\beta} + (1-\psi)\frac{1}{\Pi}(S+R)^{\alpha+\beta} \\
\text{Indifferent: } & \frac{1}{\Pi}S^{\alpha+\beta} = \psi\frac{1}{\Pi}(S-I)^{\alpha+\beta} + (1-\psi)\frac{1}{\Pi}(S+R)^{\alpha+\beta} \\
\text{Do Not Purchase Bond: } & \frac{1}{\Pi}S^{\alpha+\beta} > \psi\frac{1}{\Pi}(S-I)^{\alpha+\beta} + (1-\psi)\frac{1}{\Pi}(S+R)^{\alpha+\beta}
\end{aligned}$$

We now have expressions for the individual's bond purchasing decision as a function of her original preferences. The original parameters α and β are most important. If $\alpha + \beta > 1$, the individual will make all investments with positive or 0 expected value, and may be willing to make some investments of negative expected value. If $\alpha + \beta = 1$ the individual will only make investments of positive expected value and will be indifferent to investments of 0 expected value. If $\alpha + \beta < 1$ the individual will only make investments of some (large) positive expected value.

The empirical section that follows will use the above framework to determine whether or not the reaction to terrorist attacks truly changes the aggregate individual's α and β. That is, are there notable changes in the market for bond yields (do investors see recently attacked countries as riskier) in the period after terrorist attacks?

IV Summary Statistics

The data come from two main sources: the International Monetary Fund's International Financial Statistics (IFS) database and University of Maryland's Global Terrorism Database (GTD). The overlap between the IFS and GTD is 1970 - 2012. That yields a total of 12,986 observations across the European countries. The IFS data is monthly, while the GTD logs the date of each event. The GTD will be collapsed for estimation.

In order to be considered an act of terror (and logged into the GTD), the event must be intentional, violent (or threat of violence), and the actor cannot be a government. Also, the act must have a political, social, religious, or economic goal.

The GTD is an open source database hosted by the University of Maryland's START initiative. The project now has over 125,000 entries and includes domestic, transnational, and international terrorism. The GTD logs the date of the event, the location, the group responsible, the target of the attack, the type of attack, the effectiveness of the attack, the number of people wounded and killed, and the group responsible (when the information is available). Information is gathered from open source media reports and is only added to the GTD if the sources are believed to be credible.

From 1970 - 2012 there are 8,088 observations of successful terrorist attacks in the European nations. Of those, 1,959 attacks resulted in the death of at least one person. There are 16 observations of suicide attacks. A summary of the attacks by country are given in Table 1.

Spain, Italy, France, Greece, and Germany were the most dangerous countries between 1970 and 2012. Spain topped the lethality scoreboard with 2,809 attacks. resulting in the death of 1,266 Spanish citizens and the wounding of 4,847. The country with the next most civilians killed during the same period was Great Britain with 532 deaths and 2,965 individuals wounded.

On the opposite end of the spectrum were Romania, Slovenia, Finland, Lithuania, and the Czech Republic. Luxembourg was the safest nation in the EU with 0 deaths and 14 wounded citizens spread over 14 successful attacks.

In the Main Results and Robustness section of the paper, the effect of different measures of terrorist activity will be estimated. Many of the functional forms will be used in order to weight the relative severity of the attack. The 20 deadliest attacks in the EU from 1970 - 2012 are given in Table 2.

Figure 1 gives a summary of terrorist activity in the European Union in the time range of interest. Similarly, Figure 2 tracks the average lethality of an attack. Both total activity and fatalities per event fell slightly, on average, between 1970 - 2012.

Table 3 summarizes the IFS data on 10 year government bond yields for European countries between 1970 - 2012. It should be noted that the number of observations are not equal across countries. Many countries currently in the EU were communist at the beginning of the period (and hence don't have bond yield data).

The Czech Republic, Malta, Slovak Republic, and Lithuania were fairly consistent in having the lowest bond yields (though most of these countries have only more recent data). The Czech Republic had the lowest average bond yield, 4.18, during the period of interest. Meanwhile, Italy, Portugal, Greece, Bulgaria, and Slovenia had the largest yields. Slovenia had the largest average bond yield, 26.24.

Malta, Hungary, Cyprus, the Czech Republic, and the Slovak Republic all had the least variable bond yields. Denmark, Portugal, Greece, Bulgaria, and Slovenia had the most variable bond yields.

V Analysis

V.1 Main Results

Instead of estimating a complicated bond yield determinant function that is plagued by estimation issues, this technique will seek to use predetermined values of bond yields to explain away the variation in bond yield due to traditionally implemented long run and short run macroeconomic indicators. These include money market rates, debt to GDP ratio, measures of prices, exchange rates, and other variables for which exogeneity is often an unrealistic assumption.

There are both advantages and disadvantages to a panel style analysis. Determinants of bond yields are often unique to each individual country. For example, negative economic news that traditionally increases bond yields can end up decreasing yields in global economic powers like the US due to liquidity traps. Immediately after the attacks of September 11, 2001 many expected the US bond yield would rise, but it did not. The theory is that the attack signaled a more dangerous world, and in a dangerous world the US is the safest place to store money. Not only does a panel style analysis allow for a larger dataset (compared to estimating within a country), but it also allows controls for time invariant characteristics across countries that may affect the long run mean of a series.

Consider the autoregressive function:

$$b_{it} = \alpha_0 + \boldsymbol{\gamma}_j b_{it-j} + \boldsymbol{\beta}_k t_{it-k} + \varepsilon_{it}$$

Where the *it* notation denotes each panel unit (countries), i, in year/month t. The variable b is the 10 year government bond yield, in percent per annum, and t is some measure of terrorist activity. A few different measures of activity will be estimated in this section. $\boldsymbol{\gamma}_j$ and $\boldsymbol{\beta}_k$ are the following vectors of parameters.

$$\boldsymbol{\gamma}_j = \begin{bmatrix} \gamma_{t-1} \\ \gamma_{t-2} \\ \gamma_{t-3} \\ \vdots \\ \gamma_{t-j} \end{bmatrix} \qquad \boldsymbol{\beta}_k = \begin{bmatrix} \beta_{t-1} \\ \beta_{t-2} \\ \beta_{t-3} \\ \vdots \\ \beta_{t-k} \end{bmatrix}$$

The benefit of estimating in time series is that the identification of the lag structure is straightforward and easily testable. Panel data is a great deal more complicated. There is no real reason to believe that the lag structure is homogenous across countries. Two different lag structures need to be identified.

First, it must be understood how many of the previous periods bond yields' affect the current periods'. Next, shocks due to terrorist attacks may dissipate in a heterogeneous pattern across countries. Great Britain's economy may take only 2 months to recover from a terrorist attack, but Spain's may take 8 months. Estimating with a panel style does not allow for heterogeneity across lag structure.

Tests designed to identify unit roots in panel data can be flawed when the number of panel units is large. The Fisher tests for unit roots use traditional time series unit root tests and aggregate the test statistics for the panel units. Here are results from 12 Fisher tests using an Augmented Dickey Fuller on the bond yield data. The lag structure is varied for each test. The null hypothesis is that all panels contain unit roots.

Lags	P Value	Lags	P Value
1	0.0007	7	0.0456
2	0.0000	8	0.0000
3	0.6044	9	0.1259
4	0.0273	10	0.0973
5	0.0006	11	0.2541
6	0.0944	12	0.0003

The Fisher test does not do quite well enough to insist that all panel units are stationary. The standard deviation of the P values depending on the lag structure is large, and it is important to remember the test hypothesis. The very low P values lead one to accept the alternate hypothesis that states "at least one panel is stationary." Therefore, it cannot be concluded that all panels are stationary.

That being said, demeaning the data makes a big difference. Running the same test on the demeaned data returns a P value of 0.0000 for all 12 different lag structures. Therefore, in the main results section the function will be estimated assuming no unit root and with a demeaned structure. The validity of this assumption will be tested in the robustness section.

Demeaning the data in a autoregressive environment is a bit different than running a traditional fixed effects regression. Fixed effects would demean the terror attacks and the bond yields (not just the bonds). Because in an autoregressive format the left hand variable appears on the right, the whole variable will be demeaned in order to keep the units unchanged across time periods.

Again, identifying the proper lag structure can be difficult in a panel environment. To do this, partial autocorrelation functions were produced by country and observed. Most countries had lags 1-3 significant, and a few had up to 6, but never more. Therefore, the function will be estimated lag structures up to 6 to ensure that the errors are independently distributed of one another.

The next step before estimation is to test what type of demeaning is appropriate. It is clear that sweeping out the means of each country will be helpful, but what about getting rid of variation across years to account for changes in the European economies? It is possible that years are significantly different from one another with respect to European bond yield performance.

$$b_{it} = \alpha_0 + \boldsymbol{\gamma}_j b_{it-j} + \boldsymbol{\beta}_k t_{it-k} + \varepsilon_{it} \tag{4}$$

$$b_{it} = \alpha_0 + \boldsymbol{\gamma}_j b_{it-j} + \boldsymbol{\beta}_k t_{it-k} + \phi_1 Y1970 + \phi_2 Y1971 + ... + \phi_{42} Y2012 + \varepsilon_{it} \tag{5}$$

Upon estimating equations 4 and 5, a test of joint significance on the year dummies returns a test statistics of $F(44, 9199) = 3.78$ and a $P = 0.000$. The year dummies are jointly significant. Similarly a Hausman test on the coefficients of equations 4 and 5 returns a $P = 0.000$. It is again safe to conclude that the variation across years is significant.

See Table 4 for the main results. The lag structure for the bond yields was held constant based on partial autocorrelation functions, but the lag structure on the terrorist attacks was variable. Here, the measure of terrorism used was number of successful attacks in each month. The results were very consistent across different specifications.

The addition of the terrorism variables added very little explanatory power to the model. The R^2 was constant out to three decimal places for lags $1-6$. That can either be because all of the value was in the first lag, or because the terrorist attacks are not a strong contributor to the variability in bond yields. That being said, every single coefficient on the terrorist attacks was positive and statistically insignificant. The fact that all coefficients were positive is telling, but no strong conclusions about terrorism causing increases in bond yields can be drawn.

Table 5 estimates the same regression except the terrorism variable is now how many people were killed in each month. The results are nearly the exact same. The R^2 values stay consistent and the terrorism coefficients are all positive but insignificant.

Table 6 regresses the standard bond yields (not demeaned) on the lags of the demeaned bond yields and the number of fatalities due to terrorist attacks in the previous months. The results are significantly stronger than the previous structures. The coefficients on fatalities from the previous month are all significant at the 95% confidence interval. In fact, the conclusion drawn from all lag structures are the same. An increase in one fatality from the previous month will increase a country's bond yield by .02 in the current month. The R^2 value remains constant across lag structures. The model explains roughly 70% of the variation in bond yields.

The residuals from Table 4 are compared to the residuals from Table 6 in Figure 3. Clearly, both are heteroskedastic (confirmed by the Park test), and robust standard errors are reported for all regression results. What's also apparent is the strong variation in residuals across country, which again makes the case for the demeaned bond yields. The terrorist attacks, however, appear to be exogenous shocks, and the fixed effects remove significant variation across country.

V.2 Robustness

The goal of this section will be to see if the results from the previous section stand up to changes in specification. Differenced specifications, lag length changes, loss of year dummies, and different combinations of demeaned yields will be regressed on (as well as combinations of the above) in this section.

The first change will be to estimate the model in Table 6 with standard (and not demeaned) bond yields on both the left and the right as opposed to just the left. This is actually the regression structure recommended by the Fisher test for stationarity in panel data. The test statistic suggested that the data are stationary. The estimates in the previous section were demeaned as a precaution, but the estimates in Table 7 are not.

The results in Table 7 look more like the main results table. The lags on the fatalities are all positive, but they are jointly insignificant. Changing the bond structure from demeaned to standard on the right hand side causes the coefficients to drop in both magnitude and significance.

This result can be adjusted by generating a 4 month moving average of fatalities as in 8. After observing the residuals from the "pseudo" fixed effects regression (demeaned bond yields but standard terrorism measures) it becomes clear that there are strong differences in bond yields across countries. The demeaned bonds capture significant variation. Once the moving average is applied, the standard error shrinks to slightly below the coefficient size for a more convincing result.

Removing the year dummies is another test of the coefficients sensitivity to specification. The results of the removal are given in 9. The removal of the between effects actually strengthens the coefficients on fatalities in both magnitude and significance. The model explains about 67% of the variation in the standard bond yields.

The coefficients are similar across lag structures. A one unit increase in fatalities due to terror in the previous month causes a jump in bond yields of 0.028 in the current month.

The results from the standard fixed effects are similar to those shown in Table 6.

A natural specification check is to vary the lags on the bond yields. The maximum lag significance on the partial autocorrelation values from each country was 6, but most countries did not have lag significance greater than 3. Therefore, it makes sense to estimate with fewer lags and see if any estimable efficiency is gained. The results from Table 6 will be replicated but the lag length on fatalities will be held constant and the lags on the demeaned bond yields will be adjusted.

The adjustment of the demeaned bond lags reveal interesting results in Table 10. The coefficients on fatalities for bond lag structures 1 and 2 are large in magnitude but insignificant. This is a result that has not yet been encountered. Up to this point the terrorism coefficients have either been large and significant or small and insignificant.

As lags are added to the bond yields the coefficients on fatalities become more significant. The regression in column 5 of Table 10 has powerful fatality coefficients and lagged bond yields. In fact, every coefficient when bond yield lags are 3 or larger is significant. The estimated effect of an extra fatality on the bond yield is between .018 - .024.

Although the Fisher test for stationarity returned a P value of 0.0000, it is not possible to conclude that all panels are stationary. A possible specification is to difference the data to ensure that potential unit roots are not causing biases in the estimates.

The regressions on the differenced data in Table 11 continue to provide strong results. Specifications with 2 and 3 lagged months of fatalities provide strong and statistically significant coefficients. Both estimate an increase in bond yields of 0.025 for a 1-unit increase in the number of fatalities in the previous month. Also of note is that the effect of the fatalities does not diminish as the lags go back. Meaning a fatality 3 months ago has close to the same effect as a fatality from last month.

A final robustness check is to rerun the regression in 6 except use number of successful attacks instead of fatalities. The results are given in Table 12. The coefficients remain positive, large, and statistically significant. When attacks are lagged only once, an increase in attacks in the previous month by 1 would increase the bond yield in the current month by 0.07, a result that is significant at the 0.01 level. Similarly, adding a second lag brings the coefficient from the first lag down to 0.045, but the second lag coefficient takes on the value of 0.042 which adds up to roughly the same total effect as the result with only one lag. Again, both of these are significant at the 0.01 level. Lastly, a third lag yields very similar result. The coefficients on the lags are 0.036, 0.027, and 0.034. None, however, are significant at the 0.01 level, but they are all at least significant at the 0.1 level. Oddly, the strength of the effect does not diminish month as the time from the attack increases.

To conclude, the results are not very sensitive to specification. The coefficients remain positive, strong, and significant through most model variations. That being said, adjusting the variable used to control for the bond yields (demeaned vs. standard) did cause the coefficients to lose a large amount of significance. Leaving the bond yields in standard form was the only change that caused the results to lose significance.

VI Conclusion

Previous studies on bond yields have sought to explain the yield rate as a function of long run macroeconomic variables. Newer studies have brought short run determinants into the model. The preceding empirical section attempts to take predetermined values of bond yields as exogenous and sufficient explanatory variables in order to allow for the time path of a third variable, terrorist shocks, to transfer an effect to the bond yield. In a way, the results support the notion that the macro economy is complicated, and the traditional indicator variables do not sufficiently explain away all of the variation in bond yields.

This estimation is done via a transfer function. A transfer function is almost a mix between an autoregressive and intervention (structural break) approach. The transfer function allows for lagged dependent variables on the right hand side, but also predetermined values of a continuous shock variable (terrorist attacks, in this example) on the right. The key moment restriction for a transfer function is that the shock variable is a leading indicator and not the other way around. In other words, terrorist attacks can be used to predict bond yields, but if bond yields can be used to predict attacks, then the consistency of the estimator breaks down. The data fit this assumption and do not provide any reason to believe that lagged values of bond yields can be predictive of future terrorist attacks. The results support the efficient-market hypothesis in that the market is responding to information received after an attack.

The issue with estimating in a panel is the lack of ability to control for heterogeneous characteristics across countries that are time variant (a property that can be controlled for in a single country time series setting). The benefit to the panel is the larger observations available for inference. The results presented in the empirical section point two different ways. No matter what specification is used, the coefficients on terrorist attacks were positive. That being said, using homogenous bond structure estimation yielded small and insignificant coefficients. Estimating with a dual structure allowed for large and significant results. The results were consistent in suggesting that a one unit increase in fatalities from terrorism in the previous month leads to about a .2 increase in basis points of the bond yield.

Directions for future research may include estimating a transfer function with different types of exogenous shocks. For example, one could repeat the analysis above using natural catastrophes, changes to crime rates, or political instability.

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Table 1: Terrorist Activity in European Union Countries

Country	Successful Attacks	Suicide Attacks	Total Wounded	Total Killed
Austria	83	0	124	28
Belgium	115	0	235	37
Bulgaria	42	1	35	28
Croatia	52	1	72	247
Cyprus	95	0	41	45
Czech Republic	10	0	27	4
Denmark	30	1	23	3
Estonia	14	0	11	2
Finland	6	1	3	9
France	1015	1	1420	223
Germany	514	1	484	45
Great Britain	421	5	2965	532
Greece	983	2	711	255
Hungary	38	1	15	6
Ireland	110	0	24	115
Italy	1361	1	1169	406
Latvia	12	0	36	2
Lithuania	7	0	2	1
Luxembourg	14	0	6	0
Malta	18	0	12	6
Netherlands	104	0	55	42
Poland	30	0	30	7
Portugal	129	0	95	32
Romania	4	0	9	4
Slovak Republic	14	0	10	7
Slovenia	6	0	2	1
Spain	2809	0	4847	1266
Sweden	52	1	42	13

Table 2: Deadliest Terror Attacks in the European Union

Country	Date	Type	Target	Fatalities
Great Britain	12/21/88	Bombing	Airport/Aircraft	270
Croatia	7/28/91	Armed Assault	Police	180
Greece	9/8/74	Bombing	Airport/Aircraft	88
Italy	8/2/80	Bombing	Transportation	76
Spain	3/11/04	Bombing	Transportation	73
Spain	3/11/04	Bombing	Transportation	62
Greece	11/23/85	Hijacking	Airport/Aircraft	60
Croatia	11/19/91	Armed Assault	Educational Institution	41
Great Britain	8/16/80	Infrastructure Attack	Business	37
Spain	3/11/04	Bombing	Transportation	37
Italy	12/17/73	Hijacking	Airport/Aircraft	31
Italy	12/17/73	Hostage Taking	Airport/Aircraft	30
Great Britain	7/7/05	Bombing	Transportation	27
Ireland	5/17/74	Bombing	Private Property	26
Spain	3/11/04	Bombing	Transportation	19
Spain	4/12/85	Bombing	Business	18
Cyprus	2/18/78	Assassination	Journalists	16
Italy	12/27/85	Bombing	Airport/Aircraft	16
Italy	12/23/84	Bombing	Transportation	15
Spain	6/19/87	Bombing	Business	15

Table 3: Summary of Bond Yields by Country
10 Year Government Bond (1970 - 2012)

Country	Mean Yield	Std. Dev.	Minimum Yield	Maximum Yield
Austria	6.48	2.28	1.62	11.44
Belgium	7.15	2.92	1.40	13.88
Bulgaria	16.78	36.12	3.12	449.95
Cyprus	5.70	1.23	3.96	7.71
Czech Republic	4.18	1.29	1.49	7.59
Denmark	8.88	4.94	1.07	21.65
Estonia	7.85	3.07	3.5	15.27
Finland	6.13	3.43	1.18	13.74
France	7.47	3.49	1.41	17.05
Germany	6.12	2.28	1.20	10.68
Great Britain	8.37	3.77	1.64	17.18
Greece	10.59	6.65	3.30	29.24
Hungary	7.32	1.12	4.33	11.65
Ireland	9.42	4.56	2.71	21.07
Italy	9.49	4.69	2.63	21.44
Latvia	5.97	2.57	2.74	13.76
Lithuania	5.67	2.72	2.61	14.50
Luxembourg	6.21	2.30	1.41	10.84
Malta	4.63	0.08	2.78	6.30
Netherlands	6.40	2.41	1.20	12.30
Poland	6.02	1.66	3.28	11.86
Portugal	10.05	5.43	3.19	22.80
Romania	6.72	1.83	1.93	11.46
Slovak Republic	4.85	1.45	2.45	8.36
Slovenia	26.24	195.12	-3.50	2649.10
Spain	8.99	4.63	2.41	18.11
Sweden	7.79	3.52	1.33	13.78

Table 4: Main Results
Regressions on Country Demeaned Bond Yields
Number of Attacks In The Previous Month

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Lag 1 - Demeaned Bond	1.086***	1.086***	1.086***	1.086***	1.086***	1.086***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Lag 2 - Demeaned Bond	-0.451***	-0.451***	-0.451***	-0.451***	-0.451***	-0.451***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Lag 3 - Demeaned Bond	0.336***	0.336***	0.336***	0.336***	0.336***	0.336***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Lag 4 - Demeaned Bond	-0.022***	-0.022***	-0.022***	-0.022***	-0.022***	-0.022***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lag 5 - Demeaned Bond	0.021***	0.021***	0.021***	0.021***	0.021***	0.021***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lag 6 - Demeaned Bond	0.026***	0.026***	0.026***	0.026***	0.026***	0.026***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lag 1 - Number of Successful Attacks	0.005	0.004	0.004	0.003	0.004	0.004
	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Lag 2 - Number of Successful Attacks		0.001	0.001	0.001	0.001	0.001
		(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
Lag 3 - Number of Successful Attacks			0.001	0.000	0.000	0.000
			(0.005)	(0.005)	(0.005)	(0.006)
Lag 4 - Number of Successful Attacks				0.001	0.002	0.002
				(0.005)	(0.005)	(0.006)
Lag 5 - Number of Successful Attacks					-0.002	-0.003
					(0.005)	(0.006)
Lag 6 - Number of Successful Attacks						0.001
						(0.005)
Constant	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	(0.130)	(0.130)	(0.130)	(0.130)	(0.130)	(0.130)
Observations	9,250	9,250	9,250	9,250	9,250	9,250
R-squared	0.965	0.965	0.965	0.965	0.965	0.965

Standard errors in parentheses - Year dummies included but not reported
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5: Fatalaties as an Explanatory
Regressions on Country Demeaned Bond Yields

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Lag 1 - Demeaned Bond	1.087***	1.086***	1.086***	1.086***	1.086***	1.086***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Lag 2 - Demeaned Bond	-0.452***	-0.452***	-0.452***	-0.452***	-0.452***	-0.452***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Lag 3 - Demeaned Bond	0.336***	0.336***	0.336***	0.336***	0.336***	0.336***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Lag 4 - Demeaned Bond	-0.022***	-0.022***	-0.022***	-0.022***	-0.022***	-0.022***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lag 5 - Demeaned Bond	0.021***	0.021***	0.021***	0.021***	0.021***	0.021***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lag 6 - Demeaned Bond	0.026***	0.026***	0.026***	0.026***	0.026***	0.026***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lag 1 - Number of Fatalities	0.001	0.001	0.001	0.001	0.001	0.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Lag 2 - Number of Fatalities		0.000	0.000	0.000	0.000	0.000
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Lag 3 - Number of Fatalities			0.002	0.002	0.002	0.002
			(0.003)	(0.003)	(0.003)	(0.003)
Lag 4 - Number of Fatalities				0.001	0.001	0.001
				(0.003)	(0.003)	(0.003)
Lag 5 - Number of Fatalities					0.001	0.001
					(0.003)	(0.003)
Lag 6 - Number of Fatalities						0.002
						(0.003)
Constant	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(0.130)	(0.130)	(0.130)	(0.130)	(0.130)	(0.130)
Observations	9,250	9,250	9,250	9,250	9,250	9,250
R-squared	0.965	0.965	0.965	0.965	0.965	0.965

Standard errors in parentheses - Year dummies included but not reported
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Dual Bond Structure
Regressions on Bond Yields
Number of Fatalities In The Previous Month

Variables	(1)	(2)	(3)
Lag 1 - Demeaned Bond	0.845***	0.845***	0.845***
	(0.024)	(0.024)	(0.024)
Lag 2 - Demeaned Bond	-0.273***	-0.273***	-0.273***
	(0.036)	(0.036)	(0.036)
Lag 3 - Demeaned Bond	0.035	0.035	0.035
	(0.023)	(0.023)	(0.023)
Lag 4 - Demeaned Bond	-0.007***	-0.007***	-0.007***
	(0.001)	(0.001)	(0.001)
Lag 5 - Demeaned Bond	0.025***	0.025***	0.025***
	(0.001)	(0.001)	(0.001)
Lag 6 - Demeaned Bond	0.035***	0.035***	0.035***
	(0.001)	(0.001)	(0.001)
Lag 1 - Number of Fatalities	0.020**	0.019**	0.018**
	(0.008)	(0.008)	(0.008)
Lag 2 - Number of Fatalities		0.019**	0.018**
		(0.008)	(0.008)
Lag 3 - Number of Fatalities			0.020**
			(0.008)
Constant	8.102***	8.103***	8.102***
	(0.375)	(0.375)	(0.375)
Observations	9,250	9,250	9,250
R-squared	0.694	0.695	0.695

Standard errors in parentheses - Year dummies included but not reported
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Standard Bond Structure
Regressions on Bond Yields
Number of Fatalities In The Previous Month

Variables	(1)	(2)	(3)
Lag 1 - Bond Yield	1.081***	1.081***	1.081***
	(0.008)	(0.008)	(0.008)
Lag 2 - Bond Yield	-0.448***	-0.448***	-0.448***
	(0.013)	(0.013)	(0.013)
Lag 3 - Bond Yield	0.329***	0.329***	0.329***
	(0.008)	(0.008)	(0.008)
Lag 4 - Bond Yield	-0.022***	-0.022***	-0.022***
	(0.000)	(0.000)	(0.000)
Lag 5 - Bond Yield	0.021***	0.021***	0.021***
	(0.000)	(0.000)	(0.000)
Lag 6 - Bond Yield	0.026***	0.026***	0.026***
	(0.000)	(0.000)	(0.000)
Lag 1 - Number of Fatalities	0.001	0.001	0.001
	(0.003)	(0.003)	(0.003)
Lag 2 - Number of Fatalities		0.001	0.001
		(0.003)	(0.003)
Lag 3 - Number of Fatalities			0.002
			(0.003)
Constant	0.106	0.106	0.107
	(0.132)	(0.132)	(0.132)
Observations	9,250	9,250	9,250
R-squared	0.963	0.963	0.963

Standard errors in parentheses - Year dummies included but not reported
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Moving Average Fatalities
Regressions on Bond Yields
4 Month Moving Average

Variables	(1)
Lag 1 - Bond Yield	1.019***
	(0.003)
Lag 2 - Bond Yield	-0.030***
	(0.001)
Lag 3 - Bond Yield	-0.002***
	(0.001)
Lag 4 - Bond Yield	-0.009***
	(0.001)
4 Month Fatality Moving Average	0.009
	(0.008)
Constant	0.152***
	(0.028)
Observations	9,319
R-squared	0.920

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Dual Bond Structure Without Between Effects
Regressions on Bond Yields
Number of Fatalities In The Previous Month

Variables	(1)	(2)	(3)
Lag 1 - Demeaned Bond	0.916***	0.916***	0.915***
	(0.025)	(0.025)	(0.025)
Lag 2 - Demeaned Bond	-0.303***	-0.303***	-0.303***
	(0.037)	(0.037)	(0.037)
Lag 3 - Demeaned Bond	0.113***	0.113***	0.113***
	(0.024)	(0.024)	(0.024)
Lag 4 - Demeaned Bond	-0.009***	-0.009***	-0.009***
	(0.001)	(0.001)	(0.001)
Lag 5 - Demeaned Bond	0.026***	0.026***	0.026***
	(0.001)	(0.001)	(0.001)
Lag 6 - Demeaned Bond	0.035***	0.035***	0.035***
	(0.001)	(0.001)	(0.001)
Lag 1 - Number of Fatalities	0.028***	0.027***	0.026***
	(0.009)	(0.009)	(0.009)
Lag 2 - Number of Fatalities		0.026***	0.025***
		(0.009)	(0.009)
Lag 3 - Number of Fatalities			0.027***
			(0.009)
Constant	8.007***	7.999***	7.992***
	(0.033)	(0.033)	(0.033)
Observations	9,250	9,250	9,250
R-squared	0.669	0.669	0.669

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10: Dual Bond Structure With Varying Lag Length
Regressions on Bond Yields
Number of Fatalities In The Previous Month

Variables	(1)	(2)	(3)	(4)	(5)
Lag 1 - Demeaned Bond	0.053***	0.041***	0.053***	0.681***	1.106***
	(0.010)	(0.010)	(0.002)	(0.008)	(0.022)
Lag 2 - Demeaned Bond		0.073***	0.020***	-0.014***	-0.499***
		(0.010)	(0.002)	(0.001)	(0.023)
Lag 3 - Demeaned Bond			0.016***	0.004***	0.018***
			(0.002)	(0.001)	(0.001)
Lag 4 - Demeaned Bond				-0.005***	-0.004***
				(0.001)	(0.001)
Lag 5 - Demeaned Bond					0.028***
					(0.001)
Lag 1 - Number of Fatalities	0.018	0.015	0.024**	0.018**	0.018**
	(0.075)	(0.075)	(0.012)	(0.009)	(0.009)
Lag 2 - Number of Fatalities	0.015	0.015	0.023**	0.018*	0.018**
	(0.075)	(0.075)	(0.012)	(0.009)	(0.009)
Lag 3 - Number of Fatalities	0.016	0.017	0.025**	0.019**	0.020**
	(0.075)	(0.075)	(0.012)	(0.009)	(0.009)
Constant	8.386***	8.361***	8.371***	8.116***	8.100***
	(2.772)	(2.765)	(0.432)	(0.354)	(0.362)
Observations	9,410	9,380	9,355	9,319	9,284
R-squared	0.025	0.030	0.425	0.641	0.670

Standard errors in parentheses - Year dummies included but not reported
*** p<0.01, ** p<0.05, * p<0.1

Table 11: Differenced Dual Bond Structure
Regressions on Bond Yields
Number of Fatalities In The Previous Month

Variables	(1)	(2)	(3)
Lagged 1 Differenced - Demeaned Yield	0.152***	1.377***	1.376***
	(0.017)	(0.069)	(0.069)
Lagged 2 Differenced - Demeaned Yield	0.094***	-0.907***	-0.906***
	(0.018)	(0.074)	(0.074)
Lagged 3 Differenced - Demeaned Yield	0.186***	0.019	0.018
	(0.014)	(0.057)	(0.057)
Lagged 4 Differenced - Demeaned Yield	-0.140***	0.353***	0.353***
	(0.008)	(0.033)	(0.033)
Lagged 5 Differenced - Demeaned Yield	0.089***	-0.092***	-0.092***
	(0.003)	(0.013)	(0.013)
Lagged 6 Differenced - Demeaned Yield	-0.018***	0.010***	0.010***
	(0.001)	(0.002)	(0.002)
Lag 1 - Number of Fatalities	0.000	0.025**	0.024**
	(0.003)	(0.011)	(0.011)
Lag 2 - Number of Fatalities		0.025**	0.024**
		(0.011)	(0.011)
Lag 3 - Number of Fatalities			0.025**
			(0.011)
Constant	-0.022	8.402***	8.402***
	(0.132)	(0.540)	(0.540)
Observations	9,217	9,217	9,217
R-squared	0.614	0.470	0.470

Standard errors in parentheses - Year dummies included but not reported
*** p<0.01, ** p<0.05, * p<0.1

Table 12: Dual Bond Structure
Regressions on Bond Yields
Number of Successful Attacks In The Previous Month

Variables	(1)	(2)	(3)
Lag 1 - Demeaned Bond	0.844***	0.844***	0.844***
	(0.024)	(0.024)	(0.024)
Lag 2 - Demeaned Bond	-0.272***	-0.272***	-0.272***
	(0.036)	(0.036)	(0.036)
Lag 3 - Demeaned Bond	0.034	0.034	0.034
	(0.023)	(0.023)	(0.023)
Lag 4 - Demeaned Bond	-0.007***	-0.007***	-0.007***
	(0.001)	(0.001)	(0.001)
Lag 5 - Demeaned Bond	0.025***	0.025***	0.025***
	(0.001)	(0.001)	(0.001)
Lag 6 - Demeaned Bond	0.035***	0.035***	0.035***
	(0.001)	(0.001)	(0.001)
Lag 1 - Successful Attacks	0.070***	0.045***	0.036**
	(0.011)	(0.014)	(0.014)
Lag 2 - Successful Attacks		0.042***	0.027*
		(0.014)	(0.015)
Lag 3 - Successful Attacks			0.034**
			(0.014)
Constant	8.099***	8.098***	8.097***
	(0.374)	(0.374)	(0.374)
Observations	9,250	9,250	9,250
R-squared	0.695	0.696	0.696

Standard errors in parentheses - Year dummies included but not reported
*** p<0.01, ** p<0.05, * p<0.1

Figure 1: Terrorist Activity in European Union By Year

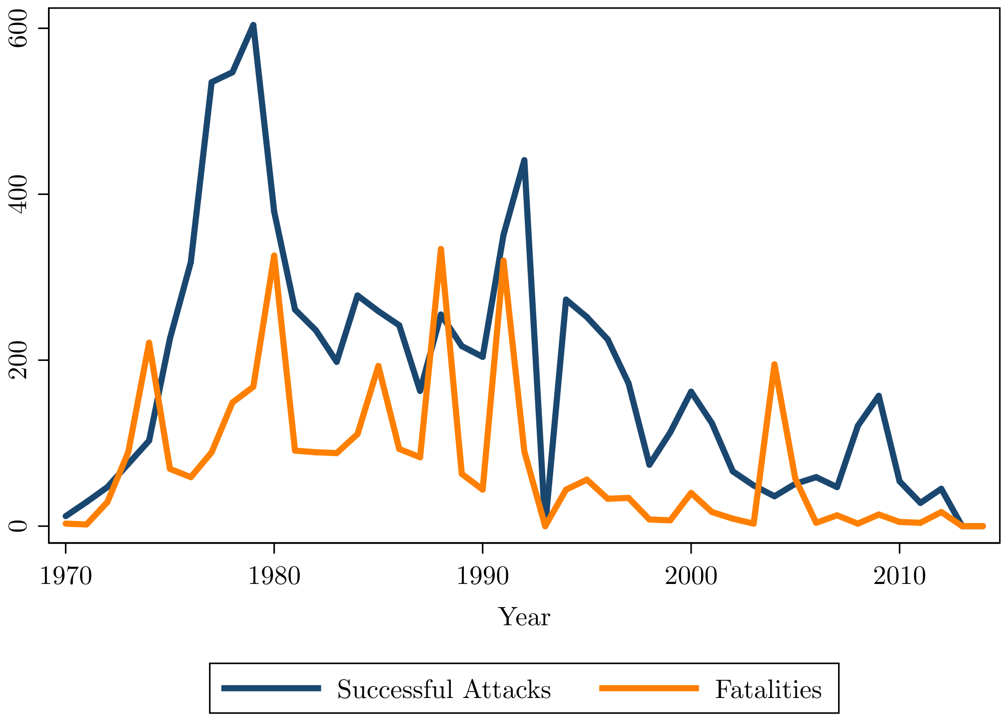

Figure 2: Average Number of Fatalities / Incident

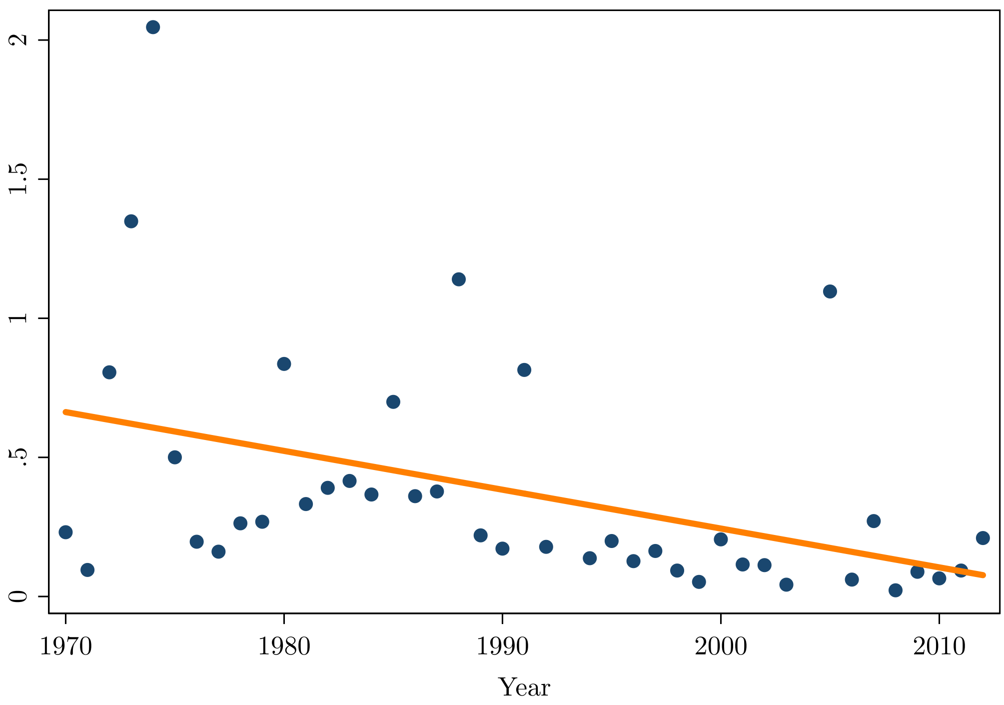

Figure 3: Structural Residual Comparison