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THE ECONOMIC IMPACTS OF THE SEPTEMBER 11, 2001, TERRORIST ATTACKS

Estimating the Macroeconomic Consequence of 9/11

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S. Brock Blomberg and Gregory D. Hess

Abstract

We perform an empirical investigation to estimate the macroeconomic cost of September 11 attacks on the United States economy. We estimate the impact of the attacks to be approximately a 0.50 percentage point decrease in GDP growth or $60 billion. Our upper bound estimate of the impact of September 11 is approximately twice that or $125 billion.

KEYWORDS: Growth, Conflict, Terrorism

1. Introduction

Nobel laureate Paul Samuelson once said "Science is a parasite: the greater the patient population the better the advance in physiology and pathology; and out of pathology arises therapy."[1] The year 2001 was a particularly difficult year marked with corporate scandals, the headwinds of a recession, and the tragedy of September 11. As a matter of economic curiosity, we wish to reexamine the episode with hindsight of seven years to better understand the economic consequence of that period. While our paper cannot hope to begin to gain an understanding or appreciation of the human tragedy of that time period, we do stand to gain some scientific understanding as a result of the alliterated therapy.

Unfortunately, estimating the consequence of September 11 using standard macroeconomic times series is not straightforward. For the United States, there were many macroeconomic shocks occurring simultaneously, leaving few degrees of freedom to estimate the separate impact of the attack on the World Trade Center. For example, there were the financial difficulties of the dot com bubble bursting as demonstrated by the drop in the Nasdaq which had peaked in March 2000 at 5,132 only to descend to 1,108 by October 2002. There were also significant corporate scandals epitomized by Enron's Chief Skilling leaving in August 2001. Contractionary Federal Reserve Policy also placed a drag on the economy as the federal funds rate was increased to 6.25 percent in December 2000, the highest rate since February of 1991.

The shocks were not all contractionary, however. Realizing the recession was a serious possibility, the Federal Reserve quickly changed to an expansionary policy by dropping the federal funds rate to its lowest point ever or 1 percent through June 2003. The federal government also responded by engaging in expansionary fiscal policy. The Bush tax cuts of 2001-3 have been estimated to be $188 billion or similar in magnitude to Reagan tax cuts.

Given these simultaneous shifts in the economic landscape, it is challenging to precisely estimate the macroeconomic consequence of September 11. So, rather than attempt a direct calculation from the United States experience during 2001, we adopt a different empirical strategy. We appeal to other country experiences and compare their histories to the United States to estimate the economic cost of September 11. Finally, as the impact of September 11 may be larger than has been typically seen, we employ an upper bound estimate using the results from across the globe.

To conduct our empirical investigation, we first begin by estimating the long-term effect of terrorism on our cross-section of countries. We do this, to ensure that the effects are not merely "washed-out" over time. Second, we

[1] Quoted from his Nobel address in 1985 at Trinity University.

estimate the short-term effects using panel regression techniques. Finally, we conduct a series of robustness checks using VARs, quantile regressions, and welfare simulations. In this way, we are able to see how consistent our estimates are and what would be our upper bound estimate.

This exercise follows a long tradition to try to understand the economic consequences of conflict and peace. For example, Garfinkel (1990), Grossman (1991), Skaperdas (1992), Hess and Orphanides (1995, 2001a,b), and Alesina and Spolaore (1997) have been responsible for investigating the importance of arms races, revolution, diversionary war, institutions, and the size of the nation-state.

The impact of terrorist, distinct from other forms of conflict, has become a topic of research more recently. Most notably, Blomberg, Hess and Orphanides (2004) show that terrorism is indeed a drag on the economy, though not as significant as civil or external war. Since then there have been several papers that have investigated the economic impact of terrorism, most recently summarized in Sandler, Enders and Arce (2009).

The results in this study concur with the previous one. However, our investigation also suggests that these results are more robust than we previously thought and slightly larger in magnitude if our upper bound estimates are to be taken seriously. We estimate the impact of the September 11 attacks to be approximately a 0.50 percentage point decrease in GDP growth or $60 billion. Our upper bound estimate of the impact of September 11 is approximately twice that or $125 billion.

2. The Data and Empirical Regularities

This section describes the empirical regularities of the data and their sources. The economic data is the Penn World Table data from Summers and Heston (1991). The conflict data is from ITERATE, Brecher, Wilkenfeld and Moser (1988), and Gurr et al (2003).

The "International Terrorism: Attributes of Terrorist Events" (ITERATE) data from Mickolus et. al. (2003) defines a transnational terrorist event: "the use, or threat of use, of anxiety-inducing, extra-normal violence for political purposes by any individual or group, whether acting for or in opposition to established governmental authority, when such action is intended to influence the attitudes and behavior of a target group wider than the immediate victims and when, through the nationality or foreign ties of its perpetrators, its location, the nature of its institutional or human victims, or the mechanics of its resolution, its ramifications transcend national boundaries." (Mickolus et. al., page 2.)

ITERATE provides over 14,000 incidents of terrorism across 177 countries from 1968 to 2003. The raw data is grouped into four broad categories that denote incident characteristics, terrorist characteristics, victim characteristics

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and finally, life and property losses. Since we cannot control for the significance of individual events or identify some of the underlying information that may be missing, we define a dummy variable which takes the value 1 if a terrorist event is recorded for a given country year and 0 otherwise.

The external conflict data are obtained from the most recent update to Brecher, Wilkenfeld and Moser (1988). External conflict is defined by Brecher, Wilkenfeld and Moser (1988) as: "a specific act, event or situational change which leads decision-makers to perceive a threat to basic values, time pressure for response and heightened probability of involvement in military hostilities. A trigger may be initiated by: an adversary state; a non-state actor; or a group of states (military alliance). It may be an environmental change; or it may be internally generated." (page 3)

The Internal war data, obtained from Gurr et al (2003), provides data that originates from four broader categories to include ethnic conflict, genocide, revolutionary conflict and regime change which does not include nonviolent transitions. As there may be some unintended overlap between the data coding and actual incidence of internal conflict and terrorism, we include both in our empirical investigation. On a cursory level, there is little evidence that the internal conflict data is merely an overlap of terrorism. The pair-wise correlation coefficient is quite small at about 0.06, once controlling for country effects, which gives us some comfort when considering measurement issues. As well, there could be strategic complementarities and/or substitutabilities among these types of conflict, which could either increase or lessen the effects of terrorism on economic activity.

2.1. The Geography of Terrorist Incidents

Let us return to a basic overview of the terrorism data.[2] Blomberg Hess and Weerapana (2003) have shown that the areas of the world with the most terrorism are in the Americas and Europe whereas there appears to be far less terrorism in Africa.[3]

This is usefully summarized by a map of the world (Figure 1). Each country has a graduated color with the darkest representing the countries with the most terrorist events and the lightest representing the countries with the least. The areas of the world that appear to be those with the most terrorism are the Americas and Europe whereas there appears to be far less terrorism in Africa.

This quick snapshot may suggest that terrorism is a rich democracies

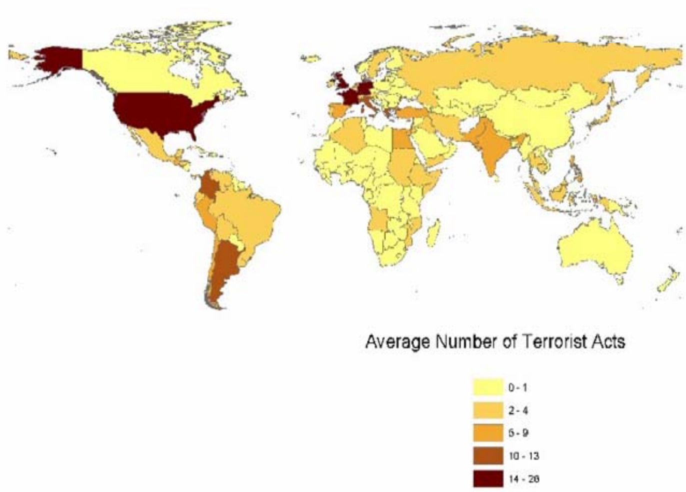
[2] Also see Blomberg, Hess and Weerapana (2003) for additional findings of terrorism and income, region and governance.
[3] When the terrorism data is adjusted for population, the Middle East is also found to have a high incidence of terrorism.

problem. However, countries neighboring to high terrorist incident states such as the United States and Germany do not share such high incidence rates. For example, regions such as Canada and Scandinavia have very little if any terrorism. Moreover, as income and democratization increased from 1995 to 2003, terrorism per country year actually fell.

Blomberg, Hess and Orphanides (2004) have provided more insight into the empirical regularities of transnational terrorism and the economy and other forms of conflict. They demonstrate that, at first glance, terrorism seems to resemble possibly less economically significant incidents of internal war. Terrorism is similar to internal war in its frequency the incidence of both is considerably higher than that of external conflict. However, terrorism appears to be positively correlated with income, while internal and external conflict are negatively correlated. A closer look reveals that much of this relationship is due to country fixed effects.

The greater incidence of terrorism in democracies and high income countries may be important when calculating the cost of 9/11 from the average impact. Hence, we will also consider quantile regression analysis that will allow us to examine the impact across the distribution of growth and income. In this way, we can examine whether the impact in the United States, a high income democracy, is significantly different from the average impact. As will be shown in subsequent subsections, the results are not sensitive to such specifications.

Figure 1: World Wide Acts of Terrorism (Shades of Brown Indicate Terrorism)



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3. Econometric Evidence

The purpose of this section is to provide our estimates employed to calculate the macroeconomic consequence of September 11. The section begins by first examining the long run implications of terrorism on growth to show that the effects are not "washed away" over time. Then, we estimate the average impact of terrorism on growth from panel growth regressions so that we can calculate the economic cost of September 11. Finally, we conduct a variety of robustness checks using quantile regression analysis, VARs, welfare analysis and estimate the over different economic variables.

We find that the incidence of terrorism in a country in a given year in the long run is associated with a reduction in per capita growth by less than one tenth of a percentage point, similar to the impact associated with internal conflict. And, while the impact of terrorism on growth is larger once controlling for time and fixed effects in panel regressions, the impact is smaller than either that of internal or external conflict. We estimate this impact of a terrorist event to be approximately a loss of 0.50 percentage points of growth for a given year. In addition, we provide evidence that terrorism is associated with a reallocation of income away from private investment spending and towards government spending. These estimates are not significantly different when viewed through the "lens" of welfare economics or quantile regression analysis.

3.1. Cross Country Growth Regressions

We begin these exercises by constructing our baseline model by appealing to the literature on economic growth. As in Blomberg, Hess and Orphanides (2004), we extend the standard Solow model to include a few select factors that have been shown to be important in determining growth. Our specification is consistent with previous research (see Levine and Renault (1992) for example) that shows many of the factors included in growth regressions are not statistically significant once other factors are introduced. So, once a researcher includes the relevant information, many theoretical results are not supported by the underlying data. Researchers who have then attempted to include geography or policy variables such as openness or institutional variables such as democracy or rule of law, have therefore been unable to establish a strong empirical relationship.

Our baseline model includes investment as a share of GDP (I/Y), the log of initial GDP ($\ln y_{0i}$),, a dummy for Africa (AFRICA) and a dummy variable for non-oil commodity exporters (COM) found to be robust in other research [see Easterly and Kraay (2001)].

$$\Delta y_i = \beta_0 + \beta_1 COM_i + \beta_2 AFRICA_i + \beta_3 \ln y_{0i} + \beta_4 I/Y_i + \beta_5 T_i + \beta_6 I_i + \beta_7 E_i + \varepsilon_i. \quad (1)$$

To control for possible reverse causality, we followed the suggestion in De La Croix and Doepke (2003) and employing initial values of the investment share as instruments.

This is based on the reasoning that as predetermined variables which would be known at time t and would not have an independent impact outside of its contemporaneous effect. Hence, we also employ initial values as instruments. We adopt their approach in selecting instruments as initial values have intuitive appeal as being predetermined and we do not wish to turn this paper into an exercise on optimal instrument selection.

Table 1 reports the results from the purely cross-sectional regressions. Column 1 is the base case following the growth literature. Columns 2 and 3 sequentially include terrorism (T) and internal conflict (I). Columns 4 and 5 include external conflict separate and then together with other forms of conflict to demonstrate how the different types of conflict influence growth. Columns 6 through 10 repeat the same regressions with one change - IV/GMM is employed to instrument for the endogeneity of investment.

Column 1 shows that investment has a positive impact and initial income, Africa and commodity exporters have a negative impact on growth. The sign of these effects are all quite similar to what was found in Blomberg, Hess and Orphanides (2004)

Column 2 provides our estimate on the impact of terrorism which is negative and statistically significant. An economic interpretation of the coefficient is that if a country were to experience a terrorist event in each year in the sample, per capita growth would drop by about 1.7 percent. To estimate the impact of one conflict for a given year, we must divide the coefficient by 35. Column 4 shows external conflict appears to have a large and negative impact, though it is insignificant in the long run. Columns 6 through 10 show these results are not biased due to joint causality issues. The general results hold on the impacts on growth using the IV/GMM specification.

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Table 1: Cross Sectional Regression: Terrorism and Growth

Model	1	2	3	4	5	6	7	8	9	10
Specification	Base	& T	& I	& E	& T,I,E	Base	& T	& I	& E	& T,I,E
Estimation	OLS	OLS	OLS	OLS	OLS	IV	IV	IV	IV	IV
COM	-1.175***	-1.284***	-1.254***	-1.181***	-1.303***	-1.217***	-1.334***	-1.271***	-1.221***	-1.341***
	[0.350]	[0.349]	[0.346]	[0.347]	[0.348]	[0.405]	[0.412]	[0.400]	[0.402]	[0.408]
AFRICA	-1.118***	-1.518***	-1.242***	-1.174***	-1.483***	-0.754	-1.161**	-0.889*	-0.808*	-1.162**
	[0.352]	[0.355]	[0.342]	[0.355]	[0.361]	[0.458]	[0.488]	[0.459]	[0.465]	[0.488]
ln$y$0	-0.506***	-0.464***	-0.615***	-0.530***	-0.550***	-0.910***	-0.881***	-0.944***	-0.919***	-0.897***
	[0.165]	[0.159]	[0.161]	[0.163]	[0.164]	[0.300]	[0.292]	[0.276]	[0.298]	[0.283]
I/Y	1.120***	1.114***	1.035***	1.107***	1.060***	2.484***	2.522***	2.264**	2.439***	2.436***
	[0.303]	[0.277]	[0.281]	[0.295]	[0.271]	[0.877]	[0.833]	[0.877]	[0.880]	[0.885]
T		-1.679***			-1.175*		-1.733***			-1.531*
		[0.528]			[0.687]		[0.640]			[0.834]
I			-0.784***		-0.514*			-0.584*		-0.227
			[0.246]		[0.282]			[0.334]		[0.388]
E				-3.614	-0.225				-2.896	0.244
				[2.978]	[2.621]				[4.044]	[3.841]
Observations	112	112	112	112	112	110	110	110	110	110
R-squared	0.41	0.45	0.44	0.41	0.46	0.23	0.26	0.3	0.25	0.29

Notes: Robust standard errors are presented in square brackets. $*$, $**$ and $***$ represent statistical significance at the .10, .05 and .01 levels, respectively. Models (1) through (10) are different specifications of cross country growth regressions. Models (1) through (5) are the basic OLS model adding separately the different forms of conflict, i.e. terrorism (T), internal conflict (I), home (H) and away (A) wars and their sum, external wars (E). Models (6) through (10) repeat the exercises but estimate the model as IV/GMM with initial investment as a percent of GDP (I/Y) as the instrument. Included in each regression is a dummy for non-oil exporting commodity countries (com), Africa (afr), initial GDP per capita (lny0) and average investment as a percent of GDP (I/Y). The R-squared measure excludes the contribution from the individual fixed effects.

In Table 2, we reexamine the evidence presented in Table 1 in terms of panel regressions. The main differences are that we control for time and fixed effects in the regressions; we are able to examine other sub-samples because we have sufficient observations; and we include one more statistically significant covariate—log of openness (lnop)—as it appears to be highly statistically significant and of the expected theoretical sign, namely.[4]

$$\Delta y_{it} = \gamma_0 + \gamma_1 lnop_{it-1} + \gamma_3 ln y_{it-1} + \gamma_4 I/Y_{it-1} + \gamma_5 T_{it} + \gamma_6 I_{it} + \gamma_7 E_{it} + \phi Z + \varepsilon_{it} \quad (2)$$

where Z is a set of time and country fixed effects.[5]

Column 1 shows that I/Y and lagged GDP per capita continue to be statistically significant with the theoretically predicted sign. The sign associated with Openness, lnop, is also consistent with theory. In columns 1 through 4 we present the coefficient on terrorism which we estimate to be larger than in the cross-section and we find that terrorism reduces growth by about 0.5 percent in a given year. Columns 5 through 10 provide the results for other sub-samples and the results are broadly consistent across the different categories.

As a robustness check, we also consider the results using an alternative definition for terrorism, the number of incidents per capita. The results were not sensitive to such an extension. Moreover since researchers may be tempted to construct measures that will support their conjectures a priori, it is more objective to employ our agnostic approach regarding data construction which is done in all other tables. And, since the point of the paper is to investigate the impact of terrorism as compared to other types of conflict, redefining terrorism in per capita, unlike the other types of conflict, terms or by intensity of conflict may be giving it special treatment relative to the other forms of conflict.

The results tell a consistent story. Terrorism appears to have a statistically strong negative impact on growth. This remains true even when considering other types of conflict and endogeneity concerns.

To calculate the economic impact of such an effect we merely interact the coefficient with the dollar value of GDP in 2006 our base year. As the impact is not statistically relevant in previous or future years, we only calculate the impact of 9/11 for the year 2001. In this case, we estimate the economic cost to be $60 billion.

[4] As in the earlier case, we considered various institutional and policy variables with little statistical impact and do not show them here. As well, using instruments for investment and openness provided broadly similar results.

[5] Estimating the model using a random effects estimator instead of a fixed effects estimator does not provide any qualitative change to what is reported in Tables 4 and 5.

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However, this presumes the average impact of an international terrorist event is the same as the impact in the United States in 2001. There are many reasons to presume this assumption is restrictive. First, the severity of the attack was surely larger for 9/11 than for other attacks. Using casualties as a metric, 2,976 died during the attack on September 11. For many of other terrorist attacks, there were no casualties. Second, as the incidence of terrorism is higher in high income democracies such as the United States, it is also possible that the impact in these areas is not the same as the average impact.

One way (albeit a crude way) to estimate the impact in the United States is to use the upper bound confidence interval from the average estimate. In this case, a two standard deviation estimate from the average estimate is $125 billion. There are, of course, other ways to explore how different the impact was during the 9/11 attacks. These ways are analyzed in the following subsection.

Table 2: Panel Regression: Terrorism and Growth

Model	1	2	3	4	5	6	7	8	9
Specification	& T	& I	& E	& T,I, E	& T,I, E	& T,I, E	& T,I, E	& T,I, E	& T,I, E
Sample	FULL	FULL	FULL	FULL	NONDEMO	OECD	AFRICA	MIDEAST	ASIA
$lnop_{it-1}$	3.275***	3.114***	3.200***	3.067***	3.117***	0.451	2.644**	5.506***	1.056
	[0.516]	[0.517]	[0.516]	[0.516]	[0.569]	[0.871]	[1.102]	[1.949]	[0.851]
lny_{it-1}	-5.406***	-5.558***	-5.372***	-5.561***	-5.793***	-7.293***	-6.903***	-14.866***	-5.165***
	[0.577]	[0.572]	[0.575]	[0.569]	[0.633]	[1.157]	[1.096]	[2.729]	[1.011]
I/Y_{it-1}	0.120***	0.117***	0.121***	0.116***	0.115***	0.300***	0.071	0.266***	0.269***
	[0.030]	[0.030]	[0.030]	[0.030]	[0.034]	[0.037]	[0.058]	[0.094]	[0.046]
T	-0.553**			-0.418*	-0.482*	-0.123	-1.212*	0.041	-0.487
	[0.222]			[0.221]	[0.285]	[0.188]	[0.706]	[0.736]	[0.370]
I		-1.249***		-1.157***	-1.126***	0.496	-2.047***	1.137	-0.482
		[0.330]		[0.326]	[0.334]	[0.844]	[0.698]	[0.909]	[0.387]
E			-3.832***	-3.588**	-5.000**	0.883	-0.178	-0.43	-5.116**
			[1.478]	[1.451]	[1.963]	[0.673]	[3.790]	[1.624]	[2.336]
Observations	4439	4439	4439	4439	3386	980	1374	290	597
R-squared	0.09	0.09	0.09	0.1	0.1	0.37	0.11	0.37	0.21

Notes: robust standard errors are presented in parentheses. $*$, $**$ and $***$ represent statistical significance at the .10, .05 and .01 levels, respectively. All specifications include time and individual fixed effects. Models (1) through (9) are different specifications of panel growth regressions. Models (1) through (4) are the basic OLS model adding separately the different forms of conflict, i.e. terrorism (T), internal conflict (I), and external wars (E). Models (6) through (9) repeat the exercises but estimate the model over sub-samples: Non-democracies (NONDEMO), OECD countries, AFRICA, Middle East (MIDEAST) and (ASIA). Included in each regression is ln((exports+imports)/GDP) ($lnop_{it-1}$), lagged GDP per capita (lny_{it-1}) and average investment as a percent of GDP $(I/Y)_{it-1}$.

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3.2. Robustness Checks

In this subsection, we consider four different methodologies to see if the results from the previous section are fragile. First, we re-estimate the model analyzing different parts of the cross-national income or growth distribution. Second, we calculate the cost with regards to lost utility rather than only lost GDP. Third, we calculate the loss to components of GDP rather than only GDP itself. Finally, we calculate the loss using a structural VAR. In summary, we find our results consistent with our earlier findings that September 11 resulted in lost GDP of $60 billion. The upper bound estimate continues to be a loss of $125 billion.

3.2.1. Quantile Regressions

In this subsection, we provide the results using quantile regression analysis. Quantile estimation is a type of regression when to estimate of the various quantiles (such as the median) of a population. Since the macroeconomic impact of terrorism may be different on 9/11 than the average impact, we consider techniques that allow us to estimate the impact on different parts of the distribution.

One advantage of using quantile regression to estimate the median, rather than the mean, is that quantile regression will be more robust in response to large outliers. More importantly for our purposes, we can consider other parts of the distribution a well. Since U.S. growth in 2001 was in the 70th percentile, we can consider the impact, estimating the model using absolute deviations at the 70th fractile. Or, if one believes that 9/11 was an extreme event, we can estimate the model at the 90th fractile.

Table 3 reports the results from this exercise. The model estimated is a slight extension of the model estimated in Table 2, excluding openness in some cases due to data limitations and including regional dummy variables in others due to estimation limitations that do not allow the inclusion of country fixed effects. Column 1 and 2 provide the baseline OLS results including contemporaneous terrorism and lagged terrorism in the regression. As reported previously, only contemporaneous terrorism is statistically significant with approximately a negative 0.5 percentage point impact on GDP per capita growth. Column 3 estimates the model using quantile regression techniques estimated at the median or Q = .5. Columns 4 - 7, then consider various points along the distribution of growth, from Q = .1, .75, .9, .95. The impact of terrorism on growth is negative and statistically significant at each point, though the magnitude rises significantly for Q = .9, .95.

This may be better seen in Figure 2 which depicts the estimated impact of terrorism on growth across the entire distribution. The solid green line depicts the

Table 3: Quantile Regressions: Lost GDP Due to Transnational Terrorism Attacks

	OLS	OLS	Q=.5	Q=.1	Q=.75	Q=.9	Q=.95
T_{it}	-.446**	-0.444**	-0.357***	-0.14	-0.440**	-0.698***	- [illegible]
	[0.218]	[0.212]	[0.107]	[0.348]	[0.173]	[0.229]	[0.351]
T_{2001}	- .054						
	[0.663]						
T_{it_1}		-0.071					
		[0.212]					
lny_{it_1}	-4.382***	-4.391***	-0.606***	-0.223	-0.862***	-1.184***	- [illegible]
	[0.369]	[0.369]	[0.059]	[0.190]	[0.095]	[0.136]	[0.218]
I/Y_{it_1}	0.60***	0.060***	0.081***	0.067**	0.071***	0.072***	0.069***
	[0.017]	[0.017]	[0.006]	[0.026]	[0.010]	[0.014]	[0.023]
SSAFR			-1.469***	-1.617***	-0.689**	-0.301	-0.119
			[0.160]	[0.492]	[0.269]	[0.350]	[0.551]
LAT			-1.187***	-1.301***	-0.974***	-0.673**	-1.184**
			[0.154]	[0.493]	[0.250]	[0.343]	[0.504]
EASIA			-0.037	-1.096*	0.218	0.009	-0.173
			[0.182]	[0.601]	[0.297]	[0.400]	[0.643]
MIDEAST			-1.280***	-4.909***	-1.055***	0.677*	1.929***
			[0.182]	[0.594]	[0.296]	[0.403]	[0.580]
POOR			-1.636***	-2.089***	-2.573***	-3.379***	- [illegible]
			[0.162]	[0.516]	[0.255]	[0.341]	[0.539]
RICH			0.242	1.383***	0.027	-0.519	-0.786
			[0.178]	[0.524]	[0.295]	[0.409]	[0.609]
NAMER			0.004	0.052	-0.389	-0.48	-1.055
			[0.404]	[1.317]	[0.654]	[0.831]	[1.262]
OCEANIA			-0.675*	-0.19	-0.954*	-1.18	-1.805**
			[0.360]	[1.134]	[0.559]	[0.720]	[0.868]
Observation	4709	4709	4744	4744	4744	4744	4744

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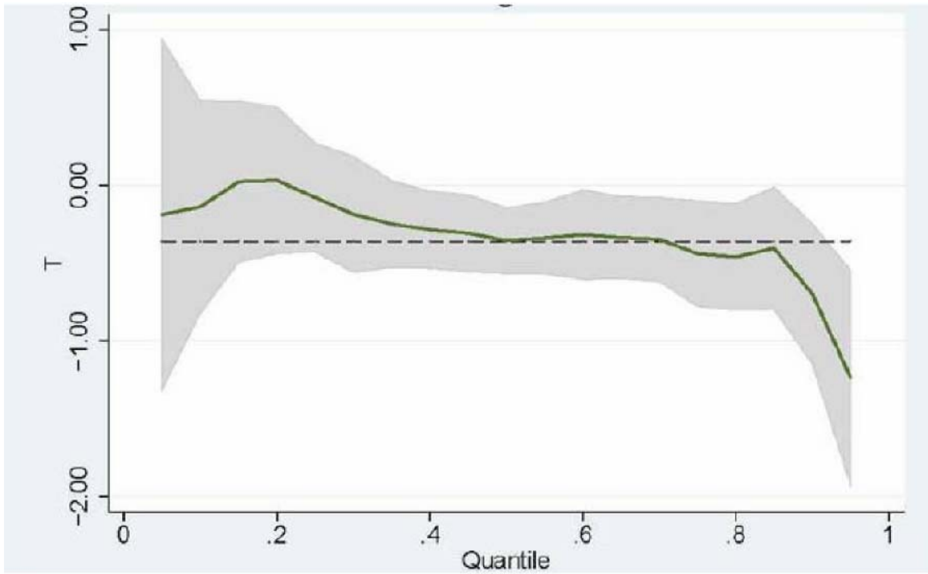
FIGURE 2: IMPACT OF TERRORISM ON GDP GROWTH ACROSS DISTRIBUTION



estimate at each fractile and the graph line depicts the confidence interval. The dotted line is the OLS estimate. Notice that the impact of terrorism is negative in most of the fractiles and statistically significant once the distribution is around Q = .3. The slope becomes only becomes steeper around Q = .9. This means that OLS estimates are not that different from quantile estimates for most of the distribution. Figure 2 also shows the point at which the United States is in the distribution. It is almost exactly where the OLS estimate equals the quantile estimate again providing more evidence that the earlier results are not fragile.

As the United States is in the Q = .7 portion of the distribution, one might argue that the impact of 9/11 is somewhere in between Q = .5 and Q = .75 which is similar to the OLS estimate. In this case, the economic consequence of 9/11 would be estimated to be approximately $60 billion. However, if one believes that 9/11 had a significant deleterious impact on growth, one might chose the upper bound estimate at Q = .9 or Q = .95. In this case, the impact would be similar to the upper bound OLS estimate of $125 billion. In summary, the results from the earlier section are robust to quantile regression techniques.

3.2.2. Welfare Calculations

This section provides utility measures in estimating the consequence of September 11th following Lucas (1987). The methodology is adapted from Blomberg (2009).

Formally, we begin with a representative individual who lives in country i with lifetime utility described by the following equation:

$$U_{it} = E_t\left\{\sum_{s=t}^{\infty}(1+\theta)^{-(s-t)}\left[\frac{C_{is}^{1-\rho}}{1-\rho}\right]\right\}, \tag{3}$$

where $C_s = (1+\mu_i)^{s-t}\overline{C}\exp^{[\varepsilon_{is}-\frac{1}{2}\sigma^2_{\varepsilon_i}]}$, $\Delta\varepsilon_{is} = \upsilon_{is}$ is a normal, i.i.d. mean-zero shock with variance $\sigma^2_{\varepsilon_i}$, and μ_i is the growth rate of consumption. Using the fact that $\exp[1-\rho]\varepsilon_{is}$ is log-normally distributed, we can then obtain:

$$E_t\{C_{is}^{1-\rho}\} = (1+\mu_i)^{(1-\rho)(s-t)}\overline{C_i}^{1-\rho}\exp\left[-\left\{(1-\rho)\rho\sigma_i^2/2\right\}(s-t)\right] \tag{4}$$

where σ_i^2 denotes the variance of $\upsilon_{is} = \Delta\varepsilon_{is}$. Assuming that the following holds for all i countries,

$$\Phi_i \equiv (1+\theta)^{-1}(1+\mu_i)^{1-\rho}\exp-\left\{(1-\rho)\rho\sigma_i^2/2\right\} < 1 \tag{5}$$

and substituting (4) into (3), we obtain expected utility as:

$$U_{it} = \left[\frac{\overline{C_i}^{1-\rho}}{1-\rho}\right]\left[1-\Phi_i\right]^{-1}. \tag{6}$$

Instead of a world without consumption uncertainty, as Lucas (1987) proposed for his measure of the welfare costs of business cycles, we propose comparing the expected welfare from each country remaining in its realized path of consumption, to another synthetic path of consumption where there is no state of transnational terrorism.

Formally, to ``price'' the amount that a representative household in each country would pay in order to obtain the peaceful path of consumption, we return to Lucas' methodology.[6.] In other words, we now solve for the amount of current consumption, τ_i^*, that equates the expected welfare of remaining on the current path of consumption to one where consumption is devoid of conflict, namely:

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[6]We now denote the mean and variance of the log-change of per-capita consumption in a peaceful world as μ_i^* and σ_i^{2*}, respectively.

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$$\left[\frac{((1+\tau_i^*)\overline{C_i})^{1-\rho}/(1-\rho)}{1-\Phi_i}\right]=\left[\frac{\overline{C_i^*}^{1-\rho}/(1-\rho)}{1-\Phi_i^*}\right] \tag{7}$$

where $\Phi_i^* \equiv (1+\theta)^{-1}(1+\mu_i^*)^{1-\rho}\exp-\left\{(1-\rho)\rho\sigma_i^{2*}/2\right\}$.

Solving for τ_i^* and assuming that $\overline{C_i}=\overline{C_i^*}$, we have:

$$\tau_i^* = \left[\frac{1-\Phi_i}{1-\Phi_i^*}\right]^{\frac{1}{1-\rho}} - 1. \tag{8}$$

To understand how potentially enhanced consumption growth and reduced consumption volatility can effect the economic welfare costs of conflict, first, define $\Delta\sigma_i^2 \equiv \sigma_i^{2*} - \sigma_i^2$ and $\Delta\mu_i \equiv \mu_i^* - \mu_i$. A log-linear approximation of expression (8) in the neighborhood of $\Delta\mu_i = \Delta\sigma_i^2 = 0$ yields:

$$\tau_i^* \approx \left[\frac{\Phi_i}{1-\Phi_i}\right]\cdot\left[-(\rho/2)\Delta\sigma_i^2 + (1+\mu_i)^{-1}\Delta\mu_i\right] \tag{9}$$

Ceteris paribus, if a more peaceful world can deliver more growth and less volatility, each of these factors will raise the amount that a representative individual would pay in order to get rid of conflict.

In developing a baseline specification for a country's per-capita consumption growth, and how conflict might affect it, the simple permanent income hypothesis (PIH) provides a very reasonable starting point. Hence, the baseline specification we adopt is:

$$\Delta\dot{c} = \alpha_1 + \alpha_2 T_{it} + I_i + y_t + e_{it}, \tag{10}$$

where again $\Delta\dot{c}$ is the log-difference of per-capita consumption for country i at time t, I_i and y_t are estimated individual and time fixed effects, respectively and T is a terrorist event. As we do not have reliable consumption per capita data for the entire time sample, we employ GDP per capita data as a proxy assuming that the growth rate must be equated in the steady state. For the sample period 1968-2003, over 177 countries, we estimate $\alpha_2 = -.397$ and find it be significant at the

0.05 percent level. As our model is suggestive of a lower bound, we employ an estimate of $\alpha_2 = -.174$ or the original estimate plus one standard error.

From these results, one can construct a ``synthetic" growth rate were an economy to be perpetually at peace as follows. From the estimated, fitted values of equation (10), each country's ``peaceful" growth rate at time t is just $\dot{\hat{\mu}} \equiv cx = \hat{I}_i + \hat{y}_t + \hat{e}_{it}$. Averaging this yields each country's peaceful growth rate of per-capita consumption, $\dot{\hat{\mu}} = (1/T)\sum_{t=1}^{T} cx$.

The construction of a synthetic measure of the volatility (either standard deviation or variance) of consumption during peace involves two steps: estimating the mean squared growth in consumption during peace and the squared mean growth in consumption during peace. Fortunately, the latter has been calculated, $(\hat{\mu}_i^*)^2$. Hence, to insure that this volatility measure does not become negative, we adopt the following specification for the squared growth of per-capita consumption.

$$|cx|^2 = \exp\{2 \cdot [\delta_1 \cdot T_{it} I_i + y_t + u_{it}]\} \tag{11}$$

According to this exponential specification, the squared change in per-capita consumption growth will always be positive, and one can estimate the fixed individual and time effects and the effect of conflict on volatility using non-linear least squares. A more appealing approach, however, is to take natural logs of both sides of (11) so that one can estimate these same crucial parameters using OLS, namely:

$$log(|cx|) = \delta_1 T_{it} + I_i + y_t + u_{it} \tag{12}$$

Notice that one can come up with a reasonable measure of the effect of conflict on consumption volatility by estimating the parameters using OLS on the transformed dependent variable. For the sample period 1968-2003, over 177 countries, we estimate $\delta_1 = .31$ and find it be significant at the 0.05 percent level. As our model is suggestive of a lower bound, we employ an estimate of $\delta_1 = .145$ or the original estimate minus one standard error.

To implement the welfare calculations embodied in expression (8), we need to provide parameter values for the discount rate (θ) and the coefficient of relative risk aversion (ρ), in addition to the consumption growth and volatility measures calculated from above. Clearly, changes in θ and ρ will affect τ_i^*. Four important issues in the selection of these parameters should be kept in mind. First, the parameter values should be plausible. Second, the parameters should be

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such that $\Phi_i < 1$ and $\Phi_i^* < 1$ for all countries -- see expression (5). Third, the parameter values selected should be suggestive of a lower bound for τ_i^*. Fourth, the reader should get an indication of the robustness of τ_i^* to changes in the values chosen for θ and ρ. We provide results for the welfare measures using $\theta = .08$ and $\rho = 2$ which are standard in the literature. The general qualitative results are not sensitive to slight deviations in θ and ρ.

Once this exercise has been conducted, we can compare the synthetic path of no terrorism to the path with terrorism. This deviation is a measure of lost welfare due to terrorism. What does the analysis yield? Again, we find a result very similar to what was found using the OLS estimates. We find the lost welfare in dollar terms to be approximately $80 billion. While this number is slightly larger than the GDP lost measure of $60 billion, it is not significantly larger. Moreover, given that the utility-based measure attempts to take into account lost welfare due to uncertainty, it is remarkable to see that the original results continue to be supported.

3.3. Compositional Effects

The central finding from the results reported above is that economic activity appears to be impaired by conflict. Moreover, these results suggest that the macroeconomic impact of 9/11 was a loss of approximately $60 billion with an upper bound of $125 billion. In this section, we wish to analyze which GDP component the process may operate concentrating on investment and government spending.

The results in Table 4 show the results from these regressions. Our results show terrorism causes a reduction in investment as a percentage of GDP of approximately one half of a percentage point. Columns 1 to 4 show that the result is statistically significant across various specifications. The results in columns 5 through 8, show that terrorism has the opposite impact on government spending as a percentage of GDP causing the spending rate to rise by approximately 0.4 percentage points. Terrorism appears to cause government spending to crowd in while terrorism appears to cause investment spending to be crowded out, leaving the overall compositional effect relatively small.

3.4. A Structural VAR Model

In this section, we wish to trace out the dynamic effects of 9/11 using dynamic panel analyses using a Structural vector auto regression (VAR). This approach follows closely Blomberg, Hess and Orphanides (2004). Our abridged explanation here is to allow for the co-determination of the log-level of real GDP per-capita, as well as dummy variables for internal conflict, external

Table 4: Panel Regression: Terrorism and I/Y and G/Y

Model	1	2	3	4	5	6	7	8
Specification	T	I	E	T I E	T	I	E	T I E
Dep Var	I/Y	I/Y	I/Y	I/Y	G/Y	G/Y	G/Y	G/Y
$ln\text{op}_{it-1}$	2.938***	2.878***	2.929***	2.880***	3.196***	3.333***	3.223***	3.346***
	[0.317]	[0.317]	[0.317]	[0.318]	[0.399]	[0.400]	[0.400]	[0.400]
lny_{it-1}	0.531	0.493	0.553*	0.479	-1.923***	-1.808***	-1.951***	-1.798***
	[0.335]	[0.336]	[0.335]	[0.336]	[0.423]	[0.423]	[0.423]	[0.423]
T	-0.414**			-0.372**	0.491**			0.386*
	[0.182]			[0.183]	[0.230]			[0.231]
I		-0.433**		-0.393**		1.017***		0.964***
		[0.175]		[0.176]		[0.220]		[0.222]
E			-0.379	-0.293			1.352*	1.162
			[0.642]	[0.642]			[0.810]	[0.809]
Observations	4553	4553	4553	4553	4553	4553	4553	4553
R-squared	0.11	0.11	0.11	0.11	0.09	0.1	0.09	0.1

Notes: robust standard errors are presented in parentheses. $*$, $**$ and $***$ represent statistical significance at the .10, .05 and .01 levels, respectively. All specifications include time and individual fixed effects. Models (1) through (8) are the basic OLS model adding separately the different forms of conflict, i.e. terrorism (T), internal conflict (I), and external wars (E). Models (1) through (4) estimate the model with I/Y as a dependent variable. Models (5) through (8) estimate the model with G/Y as a dependent variable. Included in each regression is ln((exports+imports)/GDP) (lnop_{it-1}) and lagged GDP per capita (lny_{it-1}). The R-squared measure does not include excludes the contribution from the individual fixed effects.

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conflict and terrorism.[7] The reduced form errors, e_{Yt}, e_{Tt}, e_{Et}, e_{It} are taken from the output, terrorism, external conflict and internal conflict equations, respectively.

We incorporate these through equation (13) which shows that GDP responds to all of the other shocks in a given year.

$$e_{Y_t} = \alpha_1 \cdot \varepsilon_{T_t} + \alpha_2 \cdot \varepsilon_{E_t} + \alpha_3 \cdot \varepsilon_{I_t} + \varepsilon_{y_t} \qquad (13)$$

$$e_{T_t} = \alpha_4 \cdot \varepsilon_{I_t} + \varepsilon_{T_t} \qquad (14)$$

$$e_{E_t} = \alpha_5 \cdot \varepsilon_{I_t} + \varepsilon_{E_t} \qquad (15)$$

$$e_{I_t} = \varepsilon_{I_t} \qquad (16)$$

Table 5 provides the estimates of the Structural VAR described above. In addition to providing coefficient estimates and standard errors, the table yields the associated p-values from of over-identifying restrictions: p-value 1 is the p-value from the test of the restrictions in equations (13) to (16).[8] The remaining p-values have alternative restrictions.[9]

[7] The VAR also includes lagged investment and openness as exogenous right hand side variables. They are included to provide continuity with our panel regressions presented above. The VAR results are not affected by the exclusion of these variables from the analysis. The lag length for the VAR estimates is set at two and, as explained above, we also include fixed effects and time effects in the VAR. The results are robust to changing the lag length.

[8] This p-value is derived from a χ^2 test with 1 degree of freedom.

[9] See Blomberg, Hess and Orphanides (2004).

TABLE 5. STRUCTURAL VAR EVIDENCE

Sample	Full	NONDEMO	OECD	AFRICA	MIDEAST	ASIA
a_1	-0.475*	-0.765**	-0.169	-1.524**	0.029	-0.316
	[0.247]	[0.379]	[0.219]	[0.723]	[0.754]	[0.372]
a_2	- 4.307***	- 6.094***	1.243	-1.966	-2.130	- 4.615***
	[0.895]	[1.282]	[1.430]	[2.327]	[1.800]	[1.365]
a_3	-1.267**	-1.531**	- 3.232***	- 2.933***	0.889	-0.567
	[0.525]	[0.659]	[1.170]	[1.130]	[1.617]	[0.694]
a_4	7.735**	1.928***	-14.303	19.646**	23.817*	-2.896
	[3.344]	[3.518]	[18.505]	[9.045]	[13.447]	[7.714]
a_5	4.188***	5.033***	-5.760**	12.163**	5.409	2.682
	[0.923]	[1.035]	[2.827]	[5.765]	[5.627]	[2.085]
p-value 1	.242	.376	.388	.567	.569	.542
p-value 2	.000	.000	.139	.023	.222	.539
p-value 3	.000	.000	.044	.038	.308	.195
p-value 4	.026	.001	.477	.033	.071	.684
p-value 5	.000	.000	.042	.035	.336	.199
p-value 6	.035	.005	.511	.080	.177	.774
NOBS	4019	2438	835	1267	252	592

Notes: See Table 4. The model is from a Structural VAR presented in the text, equations (13) - (16).

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Figure 3 depicts the impulse response function for our Structural VAR. The figure is arranged so with each column demonstrating the dynamic response of the row variables to a one standard deviation shock to the variable denoted at the top of the column. Starting from the upper most left corner, Figure 3 depicts a one standard deviation shock to GDP on GDP, T, E and I, respectively. Columns 2 through 4 continue the exercise with the shocks from T, E and I, respectively. Along with the dynamic response, the 90 percent confidence interval is also plotted using the technique pioneered by Sims and Zha (1999).

The impulse responses in Figure 3 continue to demonstrate the robustness of our findings—namely that terrorism has a negative and statistically significant impact on growth. More importantly, the impact of terrorism on growth is short-lived—lasting approximately one year.

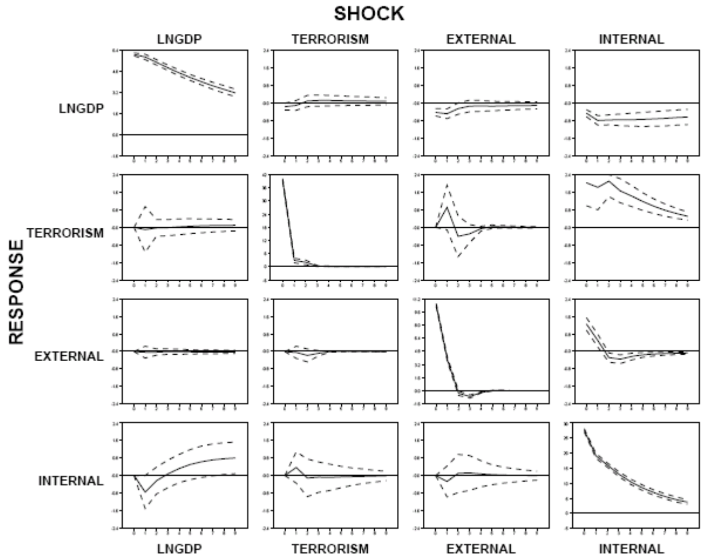
The implication is that the cost of 9/11 is most dramatic in the year of the shock. However, we find that the shock should subside quickly. This means that the cost in GDP terms should not be visible beyond one year in the future. In short, we find again the cost of 9/11 to be approximately $60 billion with an upper bound at $125 billion over the lifetime of the United States economy.

4. Conclusion

This study provides three contributions for our understanding of underlying macroeconomic consequences of terrorism. First, the study proposes to estimate the long run economic growth effects associated with terrorism. To accomplish this task, we construct a panel data set that incorporates the economic data on national income and growth, IMF data on financial conditions, data on domestic and international terrorism incidents, and data on external and internal conflict. Using this unique dataset, which spans 35 years for 177 countries, we examine the dynamic effects of terrorism on economic growth, consumption growth, as well as possible effects on capital accumulation and macroeconomic instability. The panel dimension of this data is particularly useful as it allows identification of the effects of terrorism on economic activity, growth and stability that may be evident in long-run trends that cannot be detected absent long-horizon cross-country comparisons. With these added degrees of freedom across the globe, we can then extract the impact on the United States economy. These results suggest that the economic consequence of 9/11 is $60 billion in 2006 terms.

Second, we explore the extent to which terrorism “crowds-in” and/or “crowds-out” alternative forms of domestic and international conflict and the potential differences in the macroeconomic consequences of these alternative forms of conflict. This is of particular interest because terrorist episodes are far

Figure 3: Impulse Responses and 90% Error Bands (Full Sample)



more frequent and persistent than are other forms of external and internal conflicts. While terrorism and more traditional forms of conflict are not typically considered as gross substitutes or complements for one another, the explicit consideration of this issue is essential for understanding the macroeconomic costs of terrorism per se, as opposed to the costs that might typically be identified with other forms of conflict. We find that there are indeed important complementarities between terrorism and other forms of conflict.

Finally, having established the empirical properties of how terrorism affects economic activity as well as the extent to which terrorism affects the nation-specific and world-wide frequency of domestic and international conflict, the paper concludes by ”pricing” the macroeconomic impact of terrorism. We do this by comparing the original estimate of $60 billion to other estimates, doing a variety of robustness checks such as quantile regression analysis, structural VAR estimation and welfare analysis. We find that our original estimates are robust to the various types of estimation techniques.

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