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The Cycle of Violence? An Empirical Analysis of Fatalities in the Palestinian-Israeli Conflict

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Thomas C. Schelling's *The Strategy of Conflict* (1960) laid the groundwork for thinking about conflicts as non-zero-sum games, in which each side may choose to exercise or threaten violence in order to deter or incapacitate the opponent, or simply to exact revenge. It has been difficult, however, to test many of the predictions formulated by Schelling and others because of the lack of data on the strategic choices of the two sides engaged in a conflict, observed at a high enough frequency for statistical tests to have any power. This paper uses daily-frequency data to analyze the dynamics of violence during four years of the Second Intifada, the most recent outburst of the Palestinian-Israeli conflict.

Violence in the Second Intifada (also known as the "al-Aqsa" Intifada) claimed the lives of more than 4,100 Palestinians and more than 1,000 Israelis from its outbreak in September 2000 through May 2007. The conflict has often been characterized as a vicious cycle of vengeful violence from which it is impossible to escape. Violence by one side, however, may deter the opposite side from engaging in future violence, or could have an incapacitation effect, limiting the operational capability of the other side to carry out attacks. The question of whether military operations are effective and whether their timing is chosen strategically has been at the center of the public debate in Israel, but little serious and convincing evidence has been provided to settle the issue.

In this paper we explicitly address these issues by examining whether violence against Israelis and Palestinians affects the incidence and intensity of each side's reaction. We empirically test whether the pattern of violence in the conflict should indeed be characterized as a cycle, in which violence by one party causes violence by the other party, and vice versa, or whether causality is unidirectional. Using data on the daily number of deaths on both sides of the conflict from September 2000 to January 2005, we find that there is little evidence to suggest that both sides of the conflict react in a regular and predictable way to violence against them. Rather, we find that the direction of causality (in the sense of Clive W. J. Granger 1969) runs only from violence committed by Palestinians to violence committed by Israelis, and not vice versa. That is, we find that the incidence and levels of Palestinian fatalities can be predicted by the past incidence and levels of Israeli fatalities, while there is little evidence that there is a direct relationship between Palestinian fatalities and a lethal response. This finding is robust to the specification of the lag structure and the level of time aggregation.

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Our results suggest that the Palestinians may deliberately choose to randomize the timing of their response to Israeli violence, providing some of the first evidence supporting one of Schelling's main insights: namely, that it is possible for it to be optimal, even in non-zero-sum games, for one or both sides to act in a deliberately random manner in equilibrium.[1] Despite the central role played by mixed strategies in the games analyzed by Schelling and others in different economic contexts, there has been relatively little empirical evidence showing that players actually choose mixed strategies in nonexperimental settings.[2]

A small empirical literature has recently developed examining various aspects of the Palestinian-Israeli conflict, particularly terrorism. Zvi Eckstein and Daniel Tsiddon (2004) examine the effects of terrorism on macroeconomic aggregates, while Claude Berrebi and Esteban F. Klor (2006a) examine its effects on financial markets. Berrebi and Klor (2006b, 2008) model the interaction between Palestinian militant groups and the Israeli political system. Our paper is most closely related to the work of Edward H. Kaplan et al. (2005), which analyzes the effect of Israeli antiterrorism tactics on the recruitment of Palestinian terrorists. They find that arrests reduce the number of subsequent suicide bombing attempts, but that targeted killings tend to increase them. Jaeger and Paserman (2006) examine how Israel reacts differently to violence claimed by the different Palestinian factions. Asaf Zussman and Noam Zussman (2006) attempt to assess the effectiveness of Israel's policy of targeted killings of terrorist leaders by looking at the reaction of the Israeli stock market. Our paper contributes to this literature by looking directly at the dynamic pattern of violence in the Palestinian-Israeli conflict.

I. Data and Descriptive Statistics

To construct the data on the daily series of fatal casualties in the Palestinian-Israeli conflict since September 2000, we rely primarily on the Web site of B'Tselem (http://www.btselem.org), an Israeli human rights organization. Widely thought to be accurate and reliable, the data published by B'Tselem record in detail every fatality (excluding suicide bombers) on both sides of the conflict during the second Intifada. Most notable for our purposes, the data include the date on which the attack causing the casualty took place, even if the individual died some time after the attack took place. The main advantage of these data is their comprehensiveness and the symmetric treatment of fatalities on both sides of the conflict, something that is unavailable in the official statistics compiled by either side in the conflict.

Our sample period is from September 29, 2000, to January 15, 2005, when Mahmoud Abbas assumed the presidency of the Palestinian Authority. The Israeli fatality count includes all civilians and members of the security forces killed during this period, either in Israel (within its pre-1967 borders, i.e., the "Green Line") or in the Territories, as well as foreign civilians killed by Palestinians. The Palestinian fatality count includes all civilians and members of the security forces, as well as foreign civilians killed by Israeli security forces and civilians. The total number of Palestinian fatalities, 3,244, is more than three times the number of Israeli fatalities, 994.

Figure 1 shows the monthly number of fatalities over our sample period. We highlight seven different phases of the conflict. The Intifada began on September 29, 2000, and the events that mark the next six phases are: 1) the election of Ariel Sharon as prime minister on February 6,

[1] While Schelling's theoretical insights were most applicable to a situation in which there are two actors of roughly equal strength (e.g., the Cold War), his work on randomization and mixed strategies is directly applicable also to conflicts in which there are asymmetries in power, like the Palestinian-Israeli conflict.

[2] Nonexperimental evidence of mixed strategies is mostly limited to the analysis of sports contests (Mark Walker and John Wooders 2001; Pierre-André Chiappori, Steven Levitt, and Timothy Groseclose 2002; Ignacio Palacios-Huerta 2003).

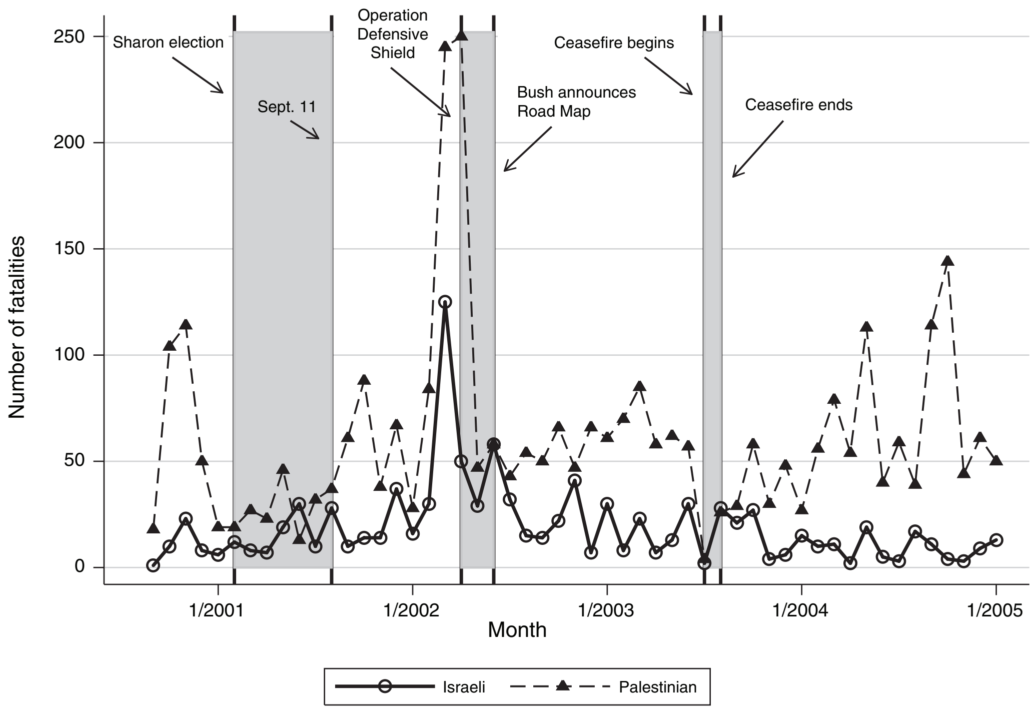

Figure 1. Monthly Number of Fatalities

Source: Authors' calculations from B'Tselem data, from 29 September 2000 to 31 January 2005.

2001; 2) the attacks on New York and Washington, DC, on September 11, 2001; 3) the beginning of Operation Defensive Shield on March 29, 2002; 4) the announcement of the "Road Map" by the Bush Administration on June 25, 2002; 5) the summer 2003 cease-fire, which was announced on June 29, 2003; and 6) the end of the cease-fire on August 22, 2003. Jaeger and Paserman (2005) present a more detailed discussion of this chronology.

II. Theoretical and Empirical Framework

We contend that three main factors may induce a dynamic link between violent incidents on the two sides of the conflict. First, violence by one side can have an *incapacitation* effect, if it limits the other side's capability to react. For example, Israeli targeted killings of key Palestinian leaders might reduce Palestinians' ability to carry out further attacks against Israel; this is the stated Israeli rationale for such actions. Second, violence can have a *deterrent* effect, when one side refrains from using violence in fear of the other side's reaction. Finally, violence by one side can lead to a reaction by the other side through a *vengeance* effect, to the extent that one side wishes to dispense retribution in response to the fatal casualties it suffers.

Solving for a full dynamic and game-theoretic equilibrium of violent behavior based on these three motives is beyond the scope of this paper. Instead, we posit the existence of *empirical reaction functions* for both sides, and employ a vector autoregression (VAR) framework using the daily data from B'Tselem. Our basic specification is

$$\begin{pmatrix} Pal_t \\ Isr_t \end{pmatrix} = \mathbf{A}_0 + \mathbf{A}_1 \begin{pmatrix} Pal_{t-1} \\ Isr_{t-1} \end{pmatrix} + \ldots + \mathbf{A}_p \begin{pmatrix} Pal_{t-p} \\ Isr_{t-p} \end{pmatrix} + \mathbf{B}\mathbf{X}_t + \boldsymbol{\varepsilon}_t,$$

where the $\mathbf{A}_j$'s and $\mathbf{B}$ are matrices of coefficients, $\mathbf{X}_t$ is a vector of exogenous variables that may shift the reaction function up or down, and $\boldsymbol{\varepsilon}_t$ is the vector error term. Note that the dependent variable is fatalities of the *opposite* group. That is, for the Israeli reaction function, the dependent variable is Palestinian fatalities, and vice versa. Our primary interest is the effect of "own" fatalities on fatalities of the opposite group. The signs of the coefficients on the "own" fatalities variables tell us whether the incapacitation and deterrence effects or the vengeance effect is dominant. We employ two different specifications of the VAR. In the first specification (the *incidence* specification), Pal_t and Isr_t are dummies for whether there were any Palestinian and Israeli fatalities on day t; in the second (the *levels* specification), Pal_t and Isr_t are the total number of fatalities in day t. All models are estimated equation by equation with ordinary least squares and heteroskedasticity-consistent standard errors. [3]

While the signs of the individual coefficients are of some interest, our primary focus is testing, overall, whether fatalities on one side of the conflict cause fatalities on the other side. That is, can we reasonably say that side A reacts to the actions of side B, and vice versa? Our main empirical tool for doing so is the Granger (1969) causality test. In a vector autoregression, a variable X is said not to Granger-cause Y if, conditional on lagged values of Y, lagged values of X have no predictive power for the current value of Y. In practice, the Granger test amounts to a test of the joint significance of the coefficients on lagged values of X in a regression of Y on lagged values of Y and lagged values of X.

The primary issue is whether the Granger test can be given a true causal interpretation. This is the standard exogeneity question: is the disturbance term in the equation for one side's fatalities correlated with past values of the opposite side's fatalities? While it is possible that there are factors that may induce a correlation between the regressors and the disturbance (e.g., an endogenous increase in Israeli preventive measures following an attack against Palestinians, an issue we discuss at length in Section IV), it is the nature of the type of violence in this conflict that many of the realized fatalities are due to random elements. For example, did the suicide bomber enter a crowded or empty bus? Did the intended target of an assassination attempt sit in the front or the back of his car? Given these random factors, we suspect that endogeneity bias is unlikely to be quantitatively important for our results.

It is possible that Granger causation runs in the opposite direction of true causation, especially with time series that reflect forward-looking behavior. Such forward-looking behavior would lead to reverse causation if the expected future level of violence on one side affected the other side's level of violence in the present. In the context of this conflict, it would be unreasonable to assume away any form of forward-looking behavior. We argue, however, that plausible forms of forward-looking behavior are likely to bias our estimates in a direction that is contrary to what we actually observe. For example, attempts by Palestinian radical groups to scuttle the peace process (Andrew Kydd and Barbara F. Walter 2002) would lead to a finding of Palestinian violence Granger-*reducing* Israeli violence, which is the opposite of what we observe in practice. Similarly, if Israelis preemptively struck the Palestinians in anticipation of future Palestinan violence, we would be biased toward finding evidence of Israeli violence Granger-causing a Palestinian response, which is also in contrast to what we actually observe. The potential for mistakenly interpreting Granger causation as true causation would exist if, for example, the Palestinians engaged in preemptive strikes in anticipation of an Israeli attack (leading us to find that Palestinian violence Granger-causes Israeli violence). Because of the large imbalance in the

[3] Estimating the model equation by equation is equivalent to assuming that the off-diagonal terms of $E(\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}_t')$ are equal to zero. Estimating the system jointly yields identical inferences. We have also estimated the models using a probit specification for the incidence regressions and zero-inflated Poisson specifications for the levels regressions reported below. This yielded no qualitative difference from the results presented here.

military and intelligence capabilities of the two sides, this scenario seems, to us, fairly implausible. Thus, we view the potential for our results to be a product of reverse causation to be very small indeed.

III. Results

A. *Empirical Impulse Response Functions*

Before estimating the regressions defined above, we first present nonparametric impulse response functions for both sides. We define the empirical Israeli and Palestinian response functions, respectively, as

$$IsrRF_t = \left(\frac{\sum_{s:I_s>0} I_s}{\sum_{s:I_s>0} 1}\right)^{-1} \left(\frac{\sum_{s:I_{s-t}>0} P_s}{\sum_{s:I_{s-t}>0} 1} - \frac{1}{T}\sum_s P_s\right), \quad \text{and}$$

$$PalRF_t = \left(\frac{\sum_{s:P_s>0} P_s}{\sum_{s:P_s>0} 1}\right)^{-1} \left(\frac{\sum_{s:P_{s-t}>0} I_s}{\sum_{s:P_{s-t}>0} 1} - \frac{1}{T}\sum_s I_s\right),$$

where P_s and I_s are the number of Palestinian and Israeli fatalities on day s. In words, to obtain the Israeli response function, we first calculate the average number of Palestinian fatalities exactly t days after a day in which there was at least one Israeli fatality, and subtract from this the overall mean of Palestinian fatalities. We then divide this number by the average number of Israeli fatalities on days with fatalities, so that the empirical Israeli response function can be interpreted as the excess number of Palestinian fatalities t days after a Palestinian attack, *per* Israeli fatality. The empirical Palestinian impulse response function is calculated analogously.

We present the empirical impulse response functions with 95 percent confidence bands in Figures 2A and 2B for the Israelis and Palestinians, respectively. The contrast between the two response functions is striking. The Israeli response function shows that the number of Palestinian fatalities is above the mean for the first 38 days after a day with Israeli fatalities, and that this difference is statistically significant for the first 10 of those days. The Palestinian response is never statistically significant, although it is positive for 26 out of the first 31 days. The magnitude of the Israeli response, on average, is about 17 times larger than the Palestinian response for the first 10 lags and about 15 times larger for all 60 lags shown in the figures.

B. *Regression Estimates of the Response Functions*

In Table 1 we present the coefficients of the Israeli and Palestinian reaction functions, estimated from a VAR model with 14 lags. We control for the day of the week and the seven periods of the conflict described earlier. We also control for the cumulative length of the separation barrier dividing the West Bank from Israel.[4] Columns 1 and 2 of Table 1 present the Israeli reaction function using the incidence and the number of Palestinian fatalities as the dependent variable, respectively. We are primarily interested in the coefficients on lagged Israeli fatalities, which

[4] This variable was constructed using detailed data on the dates of completed construction and the length of each segment of the separation barrier, provided by the Israeli Ministry of Defense. We have estimated all the models without the control variables, and the results are essentially identical (Jaeger and Paserman 2005).

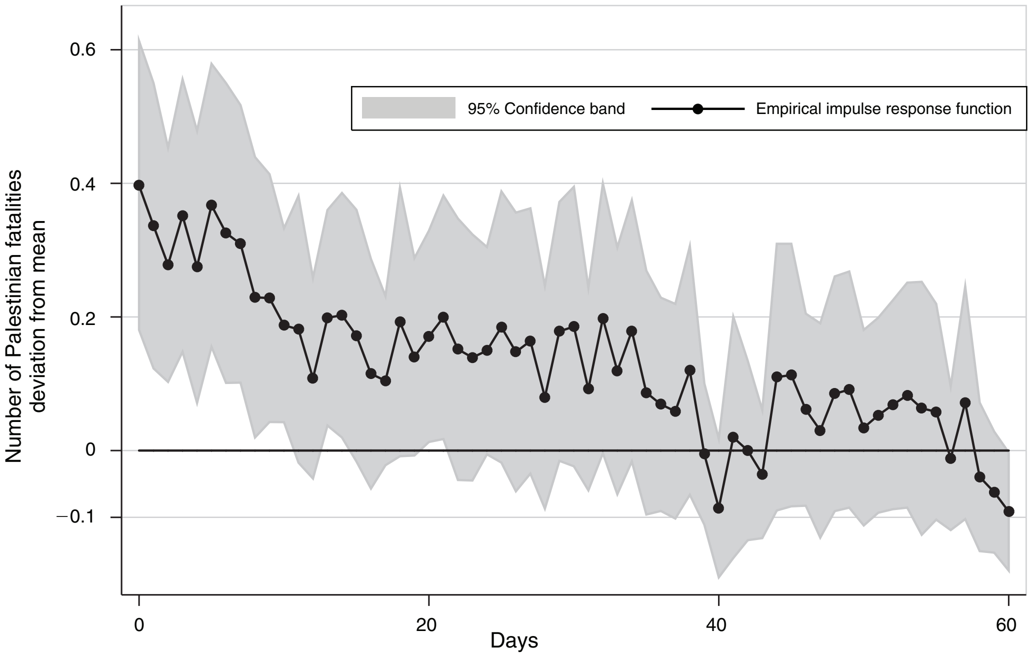

FIGURE 2A. EMPIRICAL ISRAELI RESPONSE FUNCTION

Source: Authors' calculations from B'Tselem data, from 29 September 2000 to 15 January 2005.

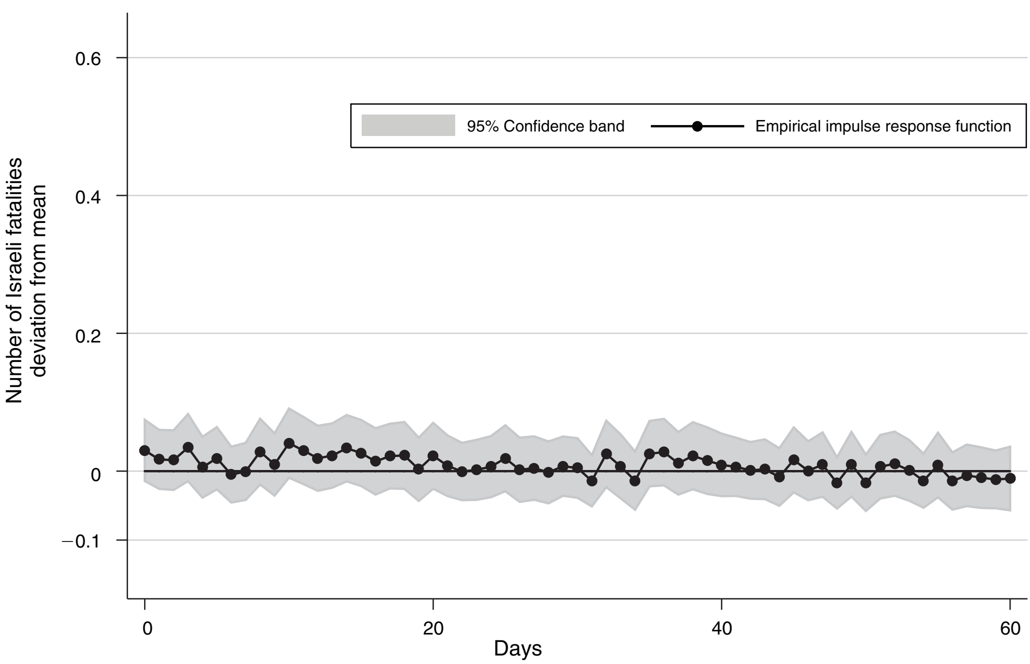

FIGURE 2B. EMPIRICAL PALESTINIAN RESPONSE FUNCTION

Source: Authors' calculations from B'Tselem data, from 29 September 2000 to 15 January 2005.

TABLE 1— DAILY REACTION FUNCTIONS, INCIDENCE, AND NUMBER OF FATALITIES

	Israeli reaction function				Palestinian reaction function			
	(1) Incidence		(2) Number		(3) Incidence		(4) Number	
	Coef.	z	Coef.	z	Coef.	z	Coef.	z
Israeli fatalities								
$t-1$	0.071	2.36	0.128	1.94	0.055	2.00	0.072	2.18
$t-2$	−0.001	−0.04	0.066	1.29	0.046	1.71	−0.012	−0.59
$t-3$	0.044	1.44	0.096	2.11	0.014	0.54	0.008	0.39
$t-4$	0.060	1.99	0.051	0.75	0.009	0.35	0.026	0.60
$t-5$	0.078	2.58	0.223	1.73	0.047	1.66	−0.013	−0.80
$t-6$	−0.010	−0.33	0.050	1.12	0.026	0.96	−0.021	−0.79
$t-7$	0.014	0.45	0.054	1.18	0.030	1.06	−0.013	−0.46
$t-8$	0.047	1.53	0.138	1.03	0.015	0.57	−0.024	−1.51
$t-9$	0.072	2.40	−0.023	−0.49	−0.015	−0.56	−0.006	−0.25
$t-10$	0.054	1.79	0.049	1.32	0.058	2.09	0.010	0.40
$t-11$	0.031	1.00	−0.070	−1.65	0.019	0.73	−0.001	−0.05
$t-12$	−0.004	−0.13	0.002	0.05	0.022	0.83	−0.007	−0.41
$t-13$	0.008	0.25	0.024	0.65	−0.000	−0.01	0.046	1.04
$t-14$	0.006	0.18	0.008	0.24	0.025	0.91	0.002	0.06
Palestinian fatalities								
$t-1$	0.026	0.98	0.164	3.31	−0.009	−0.42	0.026	1.33
$t-2$	0.045	1.72	0.010	3.21	0.022	1.06	0.027	1.08
$t-3$	−0.041	−1.58	0.140	1.27	0.006	0.28	0.000	0.01
$t-4$	0.039	1.49	0.020	0.41	−0.023	−1.01	−0.009	−0.55
$t-5$	0.045	1.70	0.043	1.25	0.031	1.49	0.014	0.47
$t-6$	0.026	0.96	−0.005	−0.13	−0.027	−1.28	−0.011	−0.54
$t-7$	−0.022	−0.85	0.009	0.26	−0.020	−0.98	−0.029	−1.81
$t-8$	−0.007	−0.28	−0.024	−0.73	0.012	0.56	0.064	2.73
$t-9$	0.034	1.31	−0.050	−1.65	−0.009	−0.41	0.005	0.24
$t-10$	0.022	0.84	−0.019	−0.73	0.004	0.21	0.009	0.44
$t-11$	−0.004	−0.14	0.035	1.51	0.008	0.41	0.012	0.69
$t-12$	0.038	1.48	0.011	0.37	−0.014	−0.69	−0.026	−1.96
$t-13$	−0.006	−0.24	−0.027	−1.14	0.006	0.28	−0.020	−1.14
$t-14$	−0.020	−0.78	0.001	0.05	0.016	0.79	0.027	1.13
Periods								
Barak-Sharon	ref.		ref.		ref.		ref.	
Sharon-9/11	−0.151	−2.75	−0.964	−3.35	−0.021	−0.43	0.256	1.48
9/12-ODS	−0.034	−0.65	−0.162	−0.46	0.053	1.07	0.617	2.92
ODS-roadmap	0.066	1.12	−0.156	−0.27	0.053	0.83	1.168	2.68
Roadmap-ceasefire	−0.001	−0.03	−0.586	−1.97	−0.042	−0.97	0.333	1.96
Ceasefire	−0.437	−4.21	−2.406	−4.23	−0.155	−1.77	0.619	1.19
Post-ceasefire	−0.063	−0.42	−2.741	−2.91	−0.187	−1.67	1.390	1.32
Length of separation barrier (100 km)	0.042	0.51	1.500	2.76	0.058	0.94	−0.803	−1.38
Constant	0.397	5.67	0.587	1.62	0.092	1.56	−0.082	−0.51
χ^2 for joint sig. of own fatalities (p-value)	43.50 (<0.001)		24.30 (0.042)		7.80 (0.899)		17.50 (0.230)	
R^2	0.102		0.233		0.074		0.064	

Notes: Dependent variable is an indicator for any Palestinian fatalities in column 1; the number of Palestinian fatalities in column 2; any Israeli fatalities in column 3; and the number of Israeli fatalities in column 4. The right-hand-side variables are indicators for whether there were any Palestinian/Israeli fatalities in days $t-1$ to $t-14$ (columns 1 and 3), and counts of Palestinian/Israeli fatalities in days $t-1$ to $t-14$ (columns 2 and 4). All regressions also include day-of-week indicator variables. Heteroskedasticity-consistent standard errors.

Source: Authors' tabulations of daily data from B'Tselem, from 29 September 2000 to 15 January 2005.

are boxed. Both the incidence and levels specification indicate that Israel reacts in a statistically significant and regular way after fatal Palestinian attacks. Overwhelmingly, the coefficients are positive, and many of them are statistically different from zero. The lack of any negative and statistically significant coefficients suggests that Palestinian attacks do not have a net deterrent or incapacitation effect. The period dummies generally reflect the pattern of Israeli violence against Palestinians shown in Figure 1. While the pattern of reaction is of some interest, our primary focus is on the test of Granger causality, reported in the penultimate line of the table. We find clear evidence that fatal Palestinian attacks Granger-cause an Israeli response leading to the death of Palestinians.

We present estimates of the Palestinian reaction function in column 3 (incidence) and column 4 (levels). While we find some degree of serial correlation in the Palestinians' attacks on Israelis, we find no support for the hypothesis that Israel's actions cause a Palestinian response: the p-values in the Granger tests are well above conventional significance levels, and the coefficients on lagged Palestinian fatalities, boxed in the table, are generally small and not statistically significant. That we estimate no negative and significant coefficients indicates that Israeli attacks against Palestinians do not have a net short-term deterrent or incapacitation effect. We also find that the separation barrier has little effect on the probability and magnitude of deadly Palestinian attacks against Israelis.[5] We are cautious about interpreting this finding as conclusive regarding the effectiveness of the barrier, however, as the barrier may be effective only when it is complete. More geographic detail on the location of the barrier and of Israeli fatalities might also affect our conclusions.

Overall, we find strong evidence that the Israelis react in a significant and predictable way to Palestinian violence against them, but no evidence that the Palestinians react to Israeli violence. This stands in contrast to the popular notion that the Israelis and Palestinians are engaged in a "tit-for-tat" cycle of violence.

C. *Robustness Checks*

Previous research (James H. Stock and Mark W. Watson 1989) has shown that conclusions about Granger causality may be sensitive to the choice of the lag structure for the independent variables, as well as the lagged values of the dependent variable. To examine this issue, we estimated the incidence and levels regressions that include the day-of-week and period indicators, as well as the length of the separation barrier for a variety of combinations of 4-, 7-, 14-, and 21-day lag structures. We present the χ^2 statistics for the tests of Granger causality in these models in Table 2. We find no evidence that our conclusions regarding the lack of a Palestinian response to Israeli violence are sensitive to the choice of lag structure. We continue to find that Palestinian violence Granger-causes an Israeli response in all of the incidence specifications and in the levels specifications with 14 lags or fewer. Although we cannot reject the null hypothesis of no Granger causality in the specifications with 21 lags, it is well known that adding lags can reduce the power of the Granger test.[6]

Using daily data may mask some broader features of the reaction functions, particularly for the Palestinians, and our results could be sensitive to the frequency at which we aggregate fatalities. The decentralized and factional nature of the Palestinian side may dictate longer or less regular response times that may not be captured at a daily frequency. To explore this possibility, in Table 3 we present Granger causality statistics from the Israeli and Palestinian reaction

[5] The coefficient on the separation barrier is negative and statistically significant in both the incidence and levels regression when we do not include the period dummy variables.

[6] In these specifications, the first 14 lags are always jointly significantly different from zero.

Table 2—Granger Causality Tests for Different Lag Structures
(χ^2 *statistics, p-values in parentheses*)

Lag structure (own, opposite)	Israeli reaction function		Palestinian reaction function	
	Incidence	Number	Incidence	Number
(4, 4)	19.69 (0.001)	9.95 (0.041)	2.77 (0.598)	3.04 (0.552)
(7, 4)	29.34 (<0.001)	15.32 (0.032)	7.62 (0.367)	3.67 (0.817)
(14, 4)	53.15 (<0.001)	23.22 (0.057)	9.77 (0.779)	17.54 (0.229)
(21, 4)	73.58 (<0.001)	27.92 (0.142)	16.58 (0.680)	20.40 (0.496)
(7, 7)	27.21 (<0.001)	15.32 (0.032)	6.54 (0.478)	4.91 (0.670)
(14, 7)	47.21 (<0.001)	23.62 (0.051)	8.54 (0.859)	18.29 (0.194)
(21, 7)	66.07 (<0.001)	27.57 (0.153)	15.68 (0.736)	21.01 (0.459)
(14, 14)	43.50 (<0.001)	24.30 (0.042)	7.80 (0.899)	17.50 (0.230)
(21, 14)	58.72 (<0.001)	27.69 (0.149)	14.43 (0.808)	20.98 (0.460)
(21, 21)	57.38 (<0.001)	26.16 (0.200)	14.48 (0.805)	20.56 (0.486)

Note: The entries in the table are the test statistics and *p*-values for the joint hypothesis that all lags of own fatalities are equal to zero. All models include period and day-of-week indicators, as well as the length of separation barrier as regressors.

Source: Authors' tabulations of daily data from B'Tselem, from 29 September 2000 to 15 January 2005.

functions estimated at weekly, bi-weekly, and monthly frequencies. Because there is very little variation in incidence at these frequencies, we present only results for regressions using levels. We do not find a significant response by the Palestinians at any frequency, lending weight to our finding that Israeli violence does not Granger-cause a Palestinian response. Using weekly data, we continue to find that Palestinian violence Granger-causes an Israeli response using models with both two weeks and four weeks of lags, although the model with two lags is significant only at the 10.1 percent level. While not shown in the table, the coefficient on the first week's lag is always substantially larger than the coefficient on the other week(s). At the bi-weekly frequency, we do not find a significant Israeli response, while we do find a significant response at the monthly frequency. [7]

[7] Our results are not sensitive to disaggregation by civilian status, by location, or by time period. See Jaeger and Paserman (2005). Jaeger and Paserman (2007) examine the dynamics of suicide attacks and targeted killings and find similar results.

IV. Israeli Preventive Measures

One potential explanation for our finding that Palestinian violence cannot be predicted by past Israeli violence is that the Palestinians do try to react, but are unable to do so effectively because of Israeli countermeasures. For example, Israel, anticipating a Palestinian reaction, may step up its preventive measures to thwart any possible Palestinian response. These can take the form of more frequent roadblocks, tighter restrictions on the movement of Palestinians within the Occupied Territories and from the Territories into Israel, increased presence and alertness of the Israeli security forces in crowded areas, as well as arrests of suspected Palestinian militants. This scenario would imply that an important explanatory variable is omitted from the equation specifying Palestinian violence. To counter this concern, we now introduce into our regressions direct measures of Israeli vigilance, based on data on restrictions to movement of Palestinian civilians through Israeli checkpoints in the Occupied Territories.

Table 3—Effect of Time Aggregation on Granger Causality Tests: Number of Fatalities
(χ^2 *statistics, p-values in parentheses*)

Frequency of data	Israeli reaction function	Palestinian reaction function
Weekly		
2 Lags	4.58	2.48
	(0.101)	(0.289)
4 Lags	9.19	2.74
	(0.056)	(0.602)
Biweekly		
1 Lag	0.04	1.42
	(0.838)	(0.492)
2 Lags	1.96	3.10
	(0.162)	(0.212)
Monthly		
1 Lag	3.83	1.04
	(0.050)	(0.309)

Note: The entries in the table are the test statistics and *p*-values for the joint hypothesis that all lags of own fatalities are equal to zero. All models include period and day-of-week indicators, as well as the length of separation barrier as regressors.

Source: Authors' tabulations of data from B'Tselem, from 29 September 2000 to 15 January 2005.

The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) has compiled a series of reports on restrictions to movement of Palestinians within the Occupied Territories and between the Occupied Territories and Israel.[8] OCHA records whether there were any restrictions to the movement of Palestinians at each of 88 checkpoints in the West Bank and Gaza from 1 October 2003 to the end of our sample period. Using these reports, we assigned a daily value to each checkpoint, ranging from 1 (completely closed) to 5 (completely open).[9] We then calculated for each day the fraction of checkpoints that were completely closed, and used that as our measure of Israeli vigilance. We note that often a checkpoint was completely closed because of a "hot" security warning, leading us to believe that the measure we use is indeed a good proxy for Israeli vigilance and for the level of Palestinian violence anticipated by the Israeli security forces. The average percentage of checkpoints that were completely closed was 15.6 percent, with a standard deviation of 5.6 percent.

In regressions reported in online Appendix Table I.2 (available at http://www.aeaweb.org/articles.php?doi=10.1257/aer.98.4.1591), we find that checkpoint closings are positively associated

[8] These are available at http://www.ochaopt.org//index.php?module=displaysection&section_id=104&static=0&format=html&period=50:YEAR (last seen 12 June 2007).

[9] In online Appendix Table I.1, we give some examples of how we transformed the verbal descriptions in the OCHA reports into a numeric scale. We excluded checkpoints that appear in the OCHA reports for a total of less than 365 days, leaving a total of 45 checkpoints in our sample. These are presumably the most important checkpoints in the Occupied Territories. Our results are not sensitive to using all 88 checkpoints, or only checkpoints in the West Bank, or only checkpoints on the border between the Territories and Israel.

with lagged Palestinian fatalities, meaning that Israel does impose tighter restrictions on the movement of Palestinians after it has inflicted a high number of Palestinian fatalities. This suggests that our constructed measure of border closings is a reasonable proxy for Israeli vigilance. We also find that lagged Israeli fatalities are strongly positively associated with closings, suggesting that to some extent Israel uses closings as a retaliatory measure against Palestinian violence.

In Table 4, we assess whether controlling for Israeli preventive measures affects the estimates of the Palestinian reaction function. The top panel presents the incidence specification: to make the results more easily interpretable, we use the number of days from $t-1$ to $t-7$ and from $t-8$ to $t-14$ with Palestinian and Israeli fatalities as the right-hand-side regressors. The bottom panel presents the levels specification with the total number of Palestinian and Israeli fatalities in days $t-1$ to $t-7$ and in $t-8$ to $t-14$ as regressors. Column 1 reproduces the estimates of the Palestinian reaction functions from Table 1 with this parsimonious specification, with essentially identical results. Column 2 presents the estimates of these same specifications, for the period from 1 October 2003 to 15 January 2005, where we have data on checkpoint closings. None of the coefficients on lagged Palestinian fatalities is individually or jointly statistically significant in either the incidence or levels regressions. In column 3 we add the closure variable to these regressions. In the incidence regressions we find that the closure variable is not statistically significant, while in the levels regression it is, with more border closings somewhat surprisingly leading to more Israeli fatalities.[10] Our conclusion regarding the lack of Granger causality is not altered in any way, however, in either specification. While our border closing variable may not be a perfect measure of Israeli vigilance, we suspect that any potential endogeneity bias in our results is quite small—and cannot account for the lack of an estimated Palestinian response to Israeli violence in our general specifications.

To this point, all of our analysis has been based on realized levels of violence, measured by fatalities. Our focus on realized violence may miss many nonlethal activities by the Palestinians and induce considerable bias in our estimates of the reaction functions. This may remove the appearance of tit-for-tat actions by the Palestinians when they are, in fact, following that strategy. Numerous attempted Palestinian attacks have been thwarted by Israeli Defense Forces (IDF) intelligence operations, which have led to arrests of terror suspects and *en route* interceptions of suicide bombers. In online Appendix II, we estimate a series of Palestinian reaction functions, where the dependent variables are different measures of intended Palestinian violence, such as the total number of planned attacks (both those that resulted in Israeli fatalities and those that were thwarted by the IDF), or the total number of terror warnings received by the Israeli security forces.[11] Whether measured using successful (fatal) attacks, unsuccessful attacks, total attacks, or the number of terror warnings, we continue to find no effect of lagged Palestinian fatalities on the level of Palestinian violence.

V. Discussion

What accounts for the differences in the estimated reaction functions of Israelis and Palestinians? There is obviously a marked asymmetry between the two sides in terms of their decision-making processes and the technology at their disposal. The IDF is highly organized and centrally commanded, meaning that Israel has the organizational, logistic, and technological capabilities to inflict fatalities on the Palestinian side when it wishes. This can explain our

[10] This finding reinforces the notion that border closings may be a proxy for anticipated Palestinian violence, some of which is eventually realized.

[11] The measures of intended Palestinian violence are drawn from unpublished B'Tselem data on successful and unsuccessful suicide attacks, as well as data from the IDF regarding successful and thwarted attacks.

TABLE 4—THE EFFECT OF BORDER CLOSINGS ON THE PALESTINIAN REACTION FUNCTION

	Time period					
	(1) 29 Sep. 2000– 15 Jan. 2005		(2) 1 Oct. 2003– 15 Jan. 2005		(3) 1 Oct. 2003– 15 Jan. 2005	
	Coef.	*z*	Coef.	*z*	Coef.	*z*
Dependent variable: Incidence of Israeli fatalities						
Number of days with Palestinian fatalities in days:						
$t-1$ to $t-7$	−0.003	−0.36	0.012	1.06	0.010	0.90
$t-8$ to $t-14$	0.003	0.37	0.015	1.28	0.014	1.21
Fraction checkpoints closed	—		—		0.374	1.33
χ^2 for joint sig. of Palestinian fatalities (p-value)	0.25 (0.881)		2.78 (0.249)		2.25 (0.325)	
R^2	0.064		0.025		0.029	
Dependent variable: Number of Israeli fatalities						
Number of Palestinian fatalities in days:						
t−1 to $t-7$	0.004	0.80	0.001	0.17	−0.001	−0.15
$t-8$ to $t-14$	0.006	1.33	−0.002	−0.77	−0.005	−1.50
Fraction checkpoints closed	—		—		2.946	2.69
χ^2 for joint sig. of Palestinian fatalities (p-value)	2.56 (0.278)		0.68 (0.713)		3.08 (0.214)	
R^2	0.041		0.021		0.029	

Note: All models estimated with ordinary least squares and include day-of-week and period indicators as well as the length of the separation barrier as regressors. Heteroskedasticity-consistent standard errors.

Source: Authors' tabulations of daily data from B'Tselem.

finding that Israel reacts predictably to Palestinian violence, even though in most of our specifications we find no evidence of a short-term net deterrent effect of Israeli actions.

In contrast, it appears that Palestinian violence is difficult to predict with past Israeli actions. Part of this can probably be attributed to the technology available—the Palestinians have limited means, and carrying out attacks against Israel may require long planning and complex logistics. In addition, the ability of the Palestinians to respond in an organized, timely, and predictable way is hampered by the decentralized nature of the various groups (Hamas, Islamic Jihad, al-Aqsa Martyr Brigades, etc.) who engage in attacks against Israelis.

It is also possible that the Palestinians choose to act in a deliberately unpredictable way. Given Israel's intelligence capabilities and the various measures it can adopt to prevent Palestinian attacks, it is likely that a systematic Palestinian response could be easily thwarted. Therefore, it is probably optimal for the Palestinians to randomize the timing of their response if they wish to increase the likelihood of inflicting costs on Israel. The effectiveness of terror attacks in disrupting day-to-day Israeli life is, almost by definition, greater if these attacks are unpredictable. Moreover, as Schelling (1960, chap. 8) noted, it may be optimal for one side in a conflict to act randomly (i.e., in a manner that is out of its control) until certain demands are met. Given our evidence, it seems possible that the Palestinian Authority under Yasser Arafat followed this strategy as it did relatively little to rein in Hamas and Palestinian Islamic Jihad: these groups were essentially acting randomly and out of its control.

Finally, it is possible to quantify the overall, long-term effect of violence by one side on the other side's reaction. To do so, we calculate the simple impulse-response function implied by the regressions in levels presented in Table 1, and then compute the cumulative number of fatalities on one side of the conflict due to one fatality on the opposite side.[12] At 60 days after a fatality, each of the cumulative impulse response functions reaches a nearly steady state. We find that one Palestinian fatality raises the cumulative number of Israeli fatalities by 0.25 (standard error 0.15) in the long run. In contrast, one Israeli fatality raises the number of Palestinian fatalities by 2.19 (standard error 1.15), nearly a factor of ten greater than those caused by a Palestinian fatality. Moreover, while the cumulative number of Palestinian fatalities is statistically different from zero at every horizon, we cannot reject the null hypothesis that Palestinian fatalities inflicted by Israel have no effect on the cumulative level of violence. The 95 percent confidence band of the Palestinian reaction function indicates that one Palestinian fatality would induce at most 0.53 Israeli fatalities in the long run. Overall, there is little evidence in the data to suggest that the conflict can be characterized as a self-perpetuating cycle of violence.

VI. Conclusion

Despite the popular perception that Palestinians and Israelis are engaged in "tit-for-tat" violence, there is no evidence to support that notion. Rather, the Israelis react in a predictable and statistically significant way to Palestinian violence against them, while Palestinian actions appear not to be related to Israeli violence, either through revenge or deterrence.

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[12] The simple impulse response function assumes that, in the vector moving average (VMA) representation of the system of equations, there is no immediate (contemporaneous) response by either of the two sides to an exogenous shock to violence by the opposite side. Given that we are using daily data, we view this assumption as reasonable. We have also calculated an orthogonalized impulse response function that assumes that Israel may respond simultaneously to Palestinian violence, but not vice versa, and the results are essentially unchanged.

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