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Financial markets and terrorism

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Abstract

This paper uses daily data to analyze how stock and foreign exchange markets react to terror. The data distinguishes location, type of attack and target, number of casualties, and the number of attacks per day for 639 terror attacks between 1990 and 2003 in which 1212 people in Israel were killed and 5726 people were maimed or injured. Suicide attacks had a permanent effect on both the stock and foreign exchange market, as did the numbers of victims, while location of a terror attack had no effect on either market. Markets did not become desensitized to terror. Financial markets continued to function efficiently; past market liberalization policies ostensibly contributed to coping with the terror. The conclusions, although based on terror against the population of Israel, have broader implications that extend to western societies because of Israel's democratic regime, free markets, and well-developed financial markets.

JEL classification: F31; G14; G15
Keywords: Terror; Terrorism; Israel; Efficient markets; Stock markets; September 11

1. Introduction

The population of Israel has been subject to ongoing terror attacks. In particular, in 639 terror attacks in the period 1990 to 2003, terrorists killed 1212 people and left 5726 people maimed or injured (Jews were targeted, but the victims also included non-Jewish citizens of the state of Israel and foreign workers). Such ongoing terror can be expected

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to have had economic consequences reflected in financial markets.[1] In this paper, we use daily data to analyze how the terror affected stock market prices and exchange rates. The terror attacks are identified with respect to location, type of attack, type of target, the number of casualties and the number of attacks per day. The data are used to address the following questions:

(1) Did the terror at all affect stock and currency markets?
(2) If so, are the consequences of all terror attacks alike?
(3) Is the effect of a terror attack permanent or transitory?
(4) Does market sensitivity to terror diminish over time?

The answers have broader relevance for western society because of Israel's democratic regime, free markets, and well-developed financial markets, and also because terror may remain an ongoing threat to western society.[2]

The following section describes the data, which consists of constructed time series for 3515 daily observations. Section 3 provides background on the stock and the currency markets in Israel. The model and the econometric methodology are set out in Section 4. The hypotheses and the results are presented in Sections 5 and 6. Section 7 summarizes the conclusions.

2. The anatomy of terror attacks

Terrorism against the civilian Jewish population has been a feature of the Israeli existence, and occurred before the founding of the modern state of Israel in 1948. Terror has, however, particularly been an unfortunate part of the daily experience of the population of Israel in the decade since the Oslo Peace Process began, and more so since September 27, 2000 after which terror heightened. The terror attacks cannot be considered as sporadic events. Hence the economic consequences cannot be analyzed as an event study but rather, because of the continuous process, the study of the consequences of terror requires an econometric analysis of the time series type.

The aspects of the time-series dimension of terror in Israel between 1990 and 2003 are presented in Fig. 1. Fig. 1 indicates that the sample is naturally divided into two periods—before and after September 27, 2000. This date marks the rupture of the peace process and the beginning of massive terror attacks on Israel initiated by the Palestinians. The figure

[1] Abadie and Gardeazabal (2003) found that terrorism reduced per capita GDP in the Basque Country by some 10% relative to the synthetic control region and that spikes in terrorist activity widen this gap. They also studied the effect of a 1998 truce on stock prices of firms with a significant part of their business in the Basque Country and found positive relative performance as the truce became credible. Chen and Siems (2004; this issue) have studied the link between financial markets and 9/11. On terror in Israel, see Eckstein and Tsiddon (2004), who attribute a total 5% reduction in GDP over the years 2000–2003 to Palestinian terror, and Fleischer and Buccola (2002), who show how terror adversely affected tourism. Other effects of terror have also been investigated. See for example, Trajtenberg (2003) who analyzes the nature of the terrorist threat following 9/11 and derives implications for U.S. defense R&D policy. See also other papers in this issue.

[2] See Bernholz (2004, this issue).

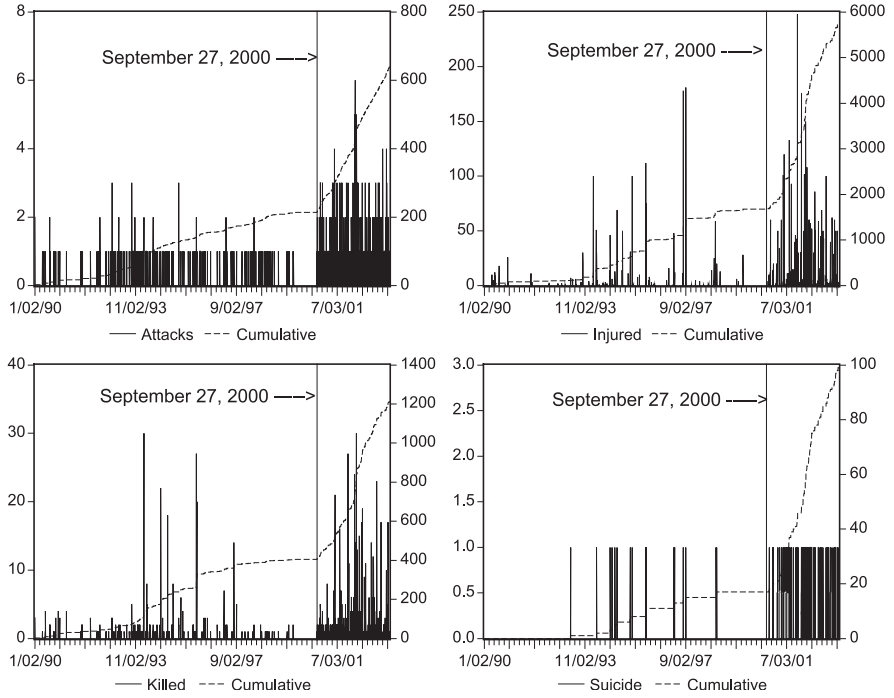

Fig. 1. Terror attacks, victim injured, victims killed and suicide attacks.

shows that the peace process was accompanied by a continuous progression of terrorism aimed at preventing a successful resolution of the Israeli Palestinian conflict. After September 27, 2000, the number of terror attacks and the brutality of the attacks intensified.

We constructed time series of the terror attacks and their characteristics: a summary of the data is presented in Table 1. The classification of the data is: by the geographical location—whether or not within the green line[3] and whether the terror attack took place in a major city, Haifa, Jerusalem, Tel Aviv, or elsewhere; by the target type[4]—transport, facilities, personnel, military, government and other; by the attack type—killing oneself to kill others (suicide), cold weapon, armed assault, bombing, kidnapping and other; by the total number of people injured and killed; by the number of attacks per day; and by the hour of the attack.

Table 2 presents the damage rates.[5] The damage rate for attacks in Haifa is high but there were a small number of attacks in Haifa (only 5). The larger damage rates are for attacks in Tel Aviv, suicide attacks, attacks on facilities,[6] and attacks on Jerusalem.

[3] The green line was the armistice line from the creation of the modern state of Israel in 1948 until the 6-day war in June 1967.

[4] See definitions in Table 1.

[5] Defined as the number of victims people or injured per attack by category.

[6] This category includes for example attacks such as in Tel Aviv where young women waiting to enter a nightclub were targeted and on the Park hotel in Netanya where people gathering to celebrate the Passover holiday were targeted.

Table 1
Summary of terror attacks by categories (January 1990–June 2003)

		Total	Since September 27, 2000
Green line[a]	In	275	140
	Out	364	284
Large city[a]	Jerusalem	56	31
	Tel Aviv	18	11
	Haifa	5	5
Target type[a]	Transport[b]	162	120
	Facilities[c]	54	31
	Personnel[d]	231	137
	Military[e]	169	118
	Government[f]	5	4
Attack type[a]	Suicide	109	91
	Cold weapon	57	11
	Armed assault	379	272
	Bombing	69	46
	Kidnapping	19	3
Victims killed[g]		1212	807
Victims injured[g]		5726	4047
Number of attacks		639	424

[a] Qualitative categories treated as dummy variables in the econometric analysis.
[b] Aircraft, airport, bus, cargo transport, convoy, ship, train/railway, vehicle.
[c] Bank, beach/waterfront, building, bus stop, entertainment facility, garage, hotel, marketplace, office, place of worship, restaurant, school/university, shopping center, store.
[d] Businessperson, civilian, celebrity/personality, religious figure, student, tourist.
[e] Checkpoint/border crossing, military personnel, police facility/personnel.
[f] Diplomat, embassy, government building, government personnel, peacekeeping mission.
[g] Numerical variables treated as continuous variables in the econometric analysis.

Table 3 shows the proportion of victims killed, injured, and attacks by categories. These estimates can be interpreted as conditional probabilities. For example, conditional on a terror attack taking place, the probability that the attack was inside the green line is 0.43; conditional on people being killed in the attack, the probability that the attack is inside the green line is 0.61; and so on.

Before turning to the testing for the impact of terror attacks and their characteristics, we present, in the next section, a short description of the stock and the currency markets in Israel.

3. Financial markets in Israel

The characteristics of the financial markets affected by terror determine market responsiveness. In this section, we provide a brief background for the attributes of the stock and foreign exchange markets.

3.1. The stock market

The Tel Aviv Stock Exchange (TASE) is the sole securities market in Israel. The market value of the stocks listed on the TASE is in general more than one half of

Table 2
The damage rate[a] of attacks by categories[b] (January 1990–June 2003)

		Killed	Injured
Green line	In	2.7	17.9
	Out	1.3	2.2
Large city	Jerusalem	3.5	30.3
	Tel Aviv	5.9	37.9
	Haifa	9.6	27.6
	Other	1.1	5.6
Target type	Transport	2.7	11.6
	Facilities	4.2	35.8
	Personnel	1.4	6.8
	Military	1.2	1.7
	Government	0.8	4.6
	Other	0.3	1.7
Attack type	Suicide	4.7	34.7
	Cold weapon	1.1	0.4
	Armed assault	1.4	3.5
	Bombing	1.1	9.0
	Kidnapping	1.1	0.0
	Other	0.8	0.5

[a] The damage rate is defined as the number of victims killed or injured per attack by category.
[b] See definitions in Table 1.

Israel's GDP. The TASE, which is an important market for financial intermediation and an important source of financing for the business sector, is quite sophisticated and includes derivatives such as stock index options (the trading volume of which relative

Table 3
Proportion[a] of people killed, injured and days of a terror attack by categories[b] (January 1990–June 2003)

		Killed	Injured	Day of attacks
Green line	In	0.58	0.70	0.45
	Out	0.42	0.30	0.55
Large city	Jerusalem	0.18	0.28	0.10
	Tel Aviv	0.09	0.12	0.03
	Haifa	0.05	0.05	0.01
	Other	0.68	0.55	0.85
Target type	Transport	0.33	0.30	0.25
	Facilities	0.16	0.26	0.09
	Personnel	0.30	0.30	0.36
	Military	0.20	0.11	0.26
	Government	0.00	0.00	0.01
	Other	0.01	0.02	0.03
Attack type	Suicide	0.38	0.51	0.18
	Cold weapon	0.07	0.03	0.10
	Armed assault	0.46	0.34	0.56
	Bombing	0.08	0.11	0.12
	Kidnapping	0.02	0.00	0.03
	Other	0.00	0.01	0.01

[a] The proportion can be interpreted as conditional probabilities.
[b] See definitions in Table 1.

to the underlying assets is the world's highest). Dual listing of stocks is possible (in 2004, 22 stocks in the 100 index were listed both on the TASE and on one of the US stock markets). The Tel Aviv 100 index (thereafter TA100) used in the paper is a value-weighted index composed of the largest 100 companies in terms of market value traded in the TASE.

Fig. 2 shows a sharp rise and a decline of the stock market in 1993 that has nothing to do with terror attacks but is due to a stock market bubble. The decline in 1993 seems stronger than the decline after the beginning of the terror attacks on Israel in September 27, 2000. The turning point in the TA100, in the year 2000, is identified at its peak level (544) in March 2000, which preceded the intensification of the terror attacks from September 27, 2000. There is a positive trend in the stock market that starts in February 2003, before the beginning of the war in Iraq and before the temporary break in terror attacks ("Hudna") during the summer months of 2003 (see also Orgler, 2002).

In Fig. 3, we observe that in the second half of the 1990s the Israeli stock market became closely related to the USA stock market, and that the turning points of the Israeli market appear to be related to the turning points in the USA market.

3.2. The foreign exchange market

The Israeli foreign exchange market is an active inter-bank market that trades continuously in relatively large volumes. Until recently, due to several restrictions imposed by the Central Bank, market participants were mainly corporations who use foreign exchange in their transactions. Due to liberalization of the foreign exchange market, implemented gradually during the last decade, there are no trade restrictions on the foreign exchange market. The banks act as "market makers" since all transactions go through them. Around 3 PM of each trading day, except Friday—around 1 PM, the central bank publishes a settlement (representative) exchange rate for each currency that is based on the quotes obtained from the major banks.

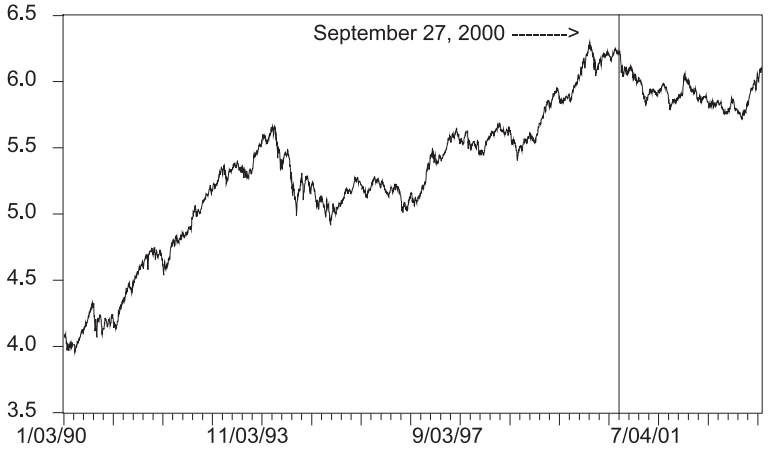

Fig. 2. The Tel Aviv 100 stocks market index January 1990–June 2003 (log).

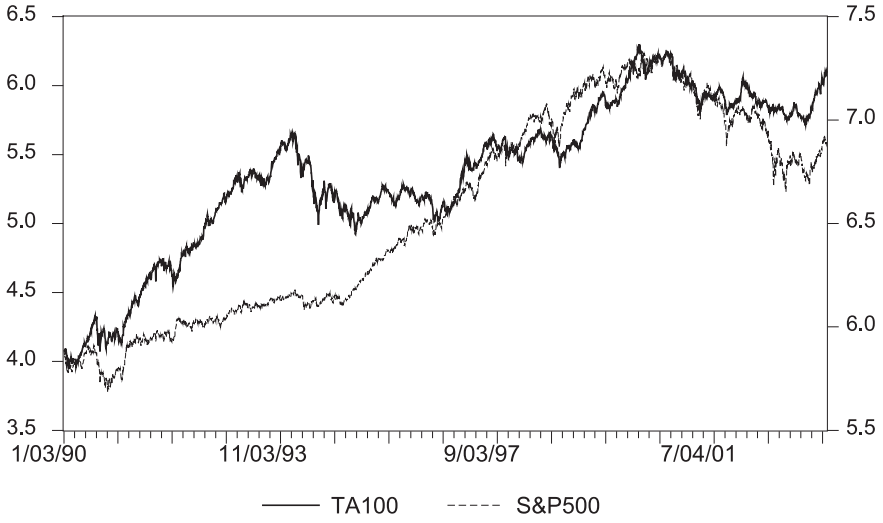

Fig. 3. The Tel Aviv 100 and the S&P500 indices January 1990–June 2003 (logs).

After a stabilization program in 1985, there was a fixed exchange rate. Over time, the exchange rate regime become more flexible and a horizontal exchange rate band, around a basket of five currencies reflecting the average international trade between Israel and the "basket" economies, was adopted. In the 1990s, the horizontal band was transformed into a narrow diagonal band. Further flexibility was applied by widening the band (see Fig. 4). The central bank is committed to intervene only when the band is breached.

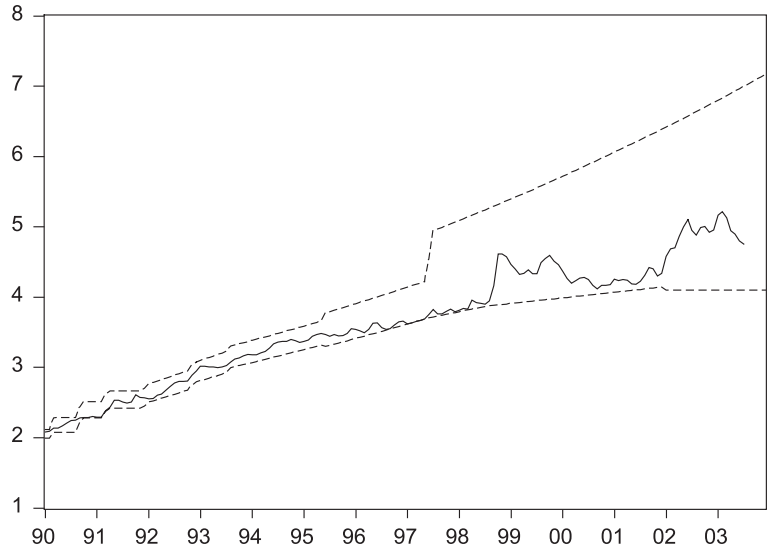

Fig. 4. The basket of currencies exchange rate and the exchange rate band January 1990–July 2003.

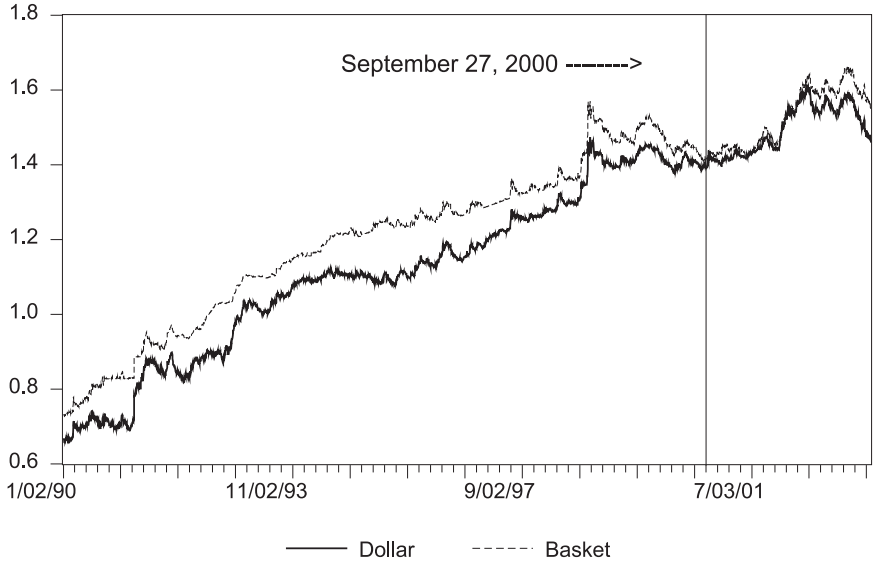

Fig. 5. The dollar and basket of currencies exchange rate January 1990–June 2003, (logs).

Apart from the changes in the slope and the width of the band, the trading regime changed several times during the 1990s.

Until July 1994, foreign exchange trade was conducted only between the central bank and commercial banks. In July 1994, inter-bank foreign exchange trading was allowed. In addition, until February 1996, the central bank intervened continuously in the foreign exchange market to keep the exchange rate close to the center of the band, since the exchange rate was used as the anchor to the price level. Central bank intervention ceased in February 1996,[7] with a move to an inflation-targeting regime with a flexible exchange rate.[8]

In Fig. 5, we observe sharp changes, typically upward shocks, of the exchange rate that are closely associated with exogenous shocks unrelated to terror attacks. In the early 1990s, we observe sharp fluctuations in the exchange rate due to speculative attacks on the domestic currency related to expected changes in the location of the exchange rate band. In 1998, we observe a sharp rise in the exchange rate related to the Asian crises, and the sharp rise in 2002 is associated with the unexpected cut of 200 basis points of the interest rate set by the Bank of Israel. It is clearly seen that the foreign currency market was not profoundly disturbed when the terror attacks started in September 27, 2000. The trends after the beginning of the terror attacks seem a natural continuation of the trends before the attack.

[7] Brenner et al. (2001) show that, at that time, the use of currency options become popular in Israel.

[8] The central bank continues to be committed to the exchange rate band but given that the band is widening, over time, the system is converging to a floating regime.

This short description of financial markets indicates that the impact of terror attacks is not obviously identified without econometric investigation.

Before turning to the econometric analysis, it should be noted that the terror attacks were accompanied by a process of liberalization in both the capital and foreign currency markets, and that at no time did trading in either market cease because of an attack. The markets functioned properly and became more competitive over time. It can be suggested, although we do not prove here, that the financial liberalization assisted the economy in coping with the uncertainties due to terror attacks.

4. The theoretical model and the econometric methodology

The basic model is given in Eq. (1). x_t is a non-stationary $I(1)$ variable with a possible drift f_t, and u_t is a white noise innovation:

$$x_t = f_t + x_{t-1} + u_t. \tag{1}$$

In our case, x_t represents either the log of the exchange rate (the dollar or the basket of currencies) or the log of stock market index (TA100). In Table 4, we present the empirical evidence, augmented Dickey Fuller tests for unit roots, using daily Israeli data from January 1, 1990 until June 30, 2003, which strongly support this specification. The presence of a unit root cannot be rejected for the log levels and is strongly rejected for the first differences.

A central question concerns the specification of f_t. In a rational expectations competitive environment, it is natural to specify the fundamental market influences f_t for the exchange rate model by the interest rate spread, domestic minus foreign interest rates. This assumption implies interest rate parity and the absence of arbitrage in the currency market. The specification is justified by the liberalization of the foreign exchange market and by the foreign exchange regime that is very close and converging, over time, to a pure floating regime.

For the stock market model, f_t is specified by the log difference of the S&P500 index. This is justified by the liberalization of the domestic capital markets, the openness of the Israeli economy to free capital movements, and the relative large number of stocks that are

Table 4
Testing for unit roots (January 1990–June 2003)

	ADF	1% critical level	5% critical level
Level—TA100[a]	−0.63	−3.97	−3.41
First difference—TA100[b]	−27.98	−3.44	−2.86
Level—dollar[a]	−1.67	−3.97	−3.41
First difference—dollar[b]	−26.75	−3.44	−2.86
Level—basket[a]	−2.10	−3.97	−3.41
First difference—basket[b]	−26.91	−3.44	−2.86

[a] In log including constant and trend.
[b] Log differences including constant.

Table 5
Granger causality tests (six lags) (January 1990–June 2003)

Null hypothesis	*F*-statistic	Probability
Dlog(TA100) does not Granger Cause Dlog(S&P500)	0.65418	0.68681
Dlog(S&P500) does not Granger Cause Dlog(TA100)	21.6941	0.00000

traded simultaneously in the Israeli and the USA markets. To support this specification we present, in Table 5, Granger causality tests that indicate strong Granger causality from the S&P500 index to the TA100 index.

The residual u_t is a white noise innovation. Denoting by D the first difference operator, Eq. (1) can be transformed into,

$$Dx_t = f_t + u_t. \tag{2}$$

The first natural hypothesis is a test for a structural change in f_t at the beginning of the massive terror attacks that commenced on September 27, 2000. A structural change at that date reflects the effect of the intensification of the terror attacks.

In the second hypothesis we ask: Are all terror attacks alike? We answer this question by estimating the informational content, the news, of a terror attack. To do that we decompose the u_t innovation into two components,

$$u_t = \varphi_t + \varepsilon_t, \tag{3}$$

where φ_t is the innovation associated with the terror attack and ε_t is pure noise.

The basic regression model to estimate φ_t is:

$$Dx_t = \alpha + \beta f_t + \gamma T_t + \varepsilon_t, \tag{4}$$

where $\varphi_t = \gamma T_t$, γ is a vector of parameters and T_t represents either the occurrence of a terror attack or a set of dummy variables describing the characteristic of the terror attacks.[9]

5. The hypotheses

Estimates of the fundamental equations (Eq. (2)) are presented in Table 6.[10]

For the stock market equation, we obtain a positive and highly significant coefficient of 0.22 for the daily effect of the USA stock market on the Israeli market. The constant is 0.042, indicating an average annual drift of 16.1 percent. The Chow test on September 27, 2000 indicates a significant structural change; this result can be interpreted as the general effect of the terror attacks on the stock market. Because two major causes are in general identified for

[9] For each terror characteristic, we define a dummy variable that equals 1 if it the attack belongs to the characteristic and 0 otherwise.

[10] The fundamental equations include the lagged dependent variable to account for serial correlation due to the use of index data in the stock market equation and possibly lagged adjustments in the foreign exchange market.

Table 6
The fundamental regressions[a] (January 1990–June 2003, 3515 daily observations)

Dependent variable	Constant	Fundamental[b]	Lag[c]	R^2[b]	LM[d]	Chow[e]
Dlog(TA100)	0.042 (0.064)	0.215 (0.001)	0.079 (0.001)	0.040	0.76 (0.47)	5.39 (0.001)
Dlog(Dollar)	0.066 (0.003)	−0.006 (0.040)	0.037 (0.027)	0.003	1.10 (0.58)	2.29 (0.076)
Dlog(Basket)	0.067 (0.001)	−0.007 (0.011)	0.033 (0.049)	0.003	1.14 (0.56)	1.61 (0.186)

[a] p values in parenthesis.
[b] Dlog(S&P500) in NIS terms for the stock exchange equation and corresponding interest rate spread for the exchange rate equations.
[c] Lag-dependent variable.
[d] Breuch–Godfrey serial correlation LM Test.
[e] Chow test at September 27, 2000.

the downturn[11] in the Israeli economy that started in October 2000, terror and the end of the high-tech boom,[12] it could be argued that our interpretation of the structural change in this equation is biased. We reject this possibility because our fundamental equation includes the S&P500 index that is a reflection of the USA and world recession. Therefore, the second source of the Israeli recession is included in the equation.

We can approximate the impact of terror attacks on the stock market by the difference of the actual TA100 index after September 27, 2000, with a simulation of the index using the actual value of the S&P500 index in an equation estimated with data until that date. This simulation is presented in Fig. 6.[13] In the absence of the terror attacks, the value of the TA100 index on June 30, 2003 would have been 604 compared with an actual value of 449, that is, 30% lower.

Further analyzing the source of the structural change of the equation, we find that the only coefficient that changes significantly is that of the S&P500 index,[14] indicating a decline in the transmission effect between the two markets due to the deterioration of the Israeli economy. We tested for a further change after 9/11, and we found no effect.

For the exchange rate equations, we obtain a negative and significant effect for the interest rate spread on the exchange rate. The very low R^2 could be due to the fact that the interest rate spread is measured at the monthly frequency only. Contrary to the stock market equation, the exchange rate equation is stable after September 27, 2000. We do not find a statistically significant general effect of the intensification of the terror attacks on the foreign currency market. It seems that the relatively comfortable balance of payments position[15] at the time of the terror attacks prevented a general deterioration of the shekel. It is possible that the impact of terror attacks was reflected in the interest rate spread, leaving the interest parity equation unaffected. However, we reject this interpretation, since the average interest rate spread diminished after September 27, 2000.[16]

[11] See business cycles dates obtained by the "Melnick" index (Melnick, 2002).
[12] See annual report of the Bank of Israel for 2001.
[13] The constant of the equation is corrected for the lower inflation rate in this period.
[14] See Appendix A.
[15] Low current account deficit, large amount of foreign exchange reserves and low and diminishing net foreign debt.
[16] The average interest rate spread for the dollar and the basket of currencies before September 27 was 7.2% and 6.8%, and after September 27, 4.4% and 4.3%, respectively.

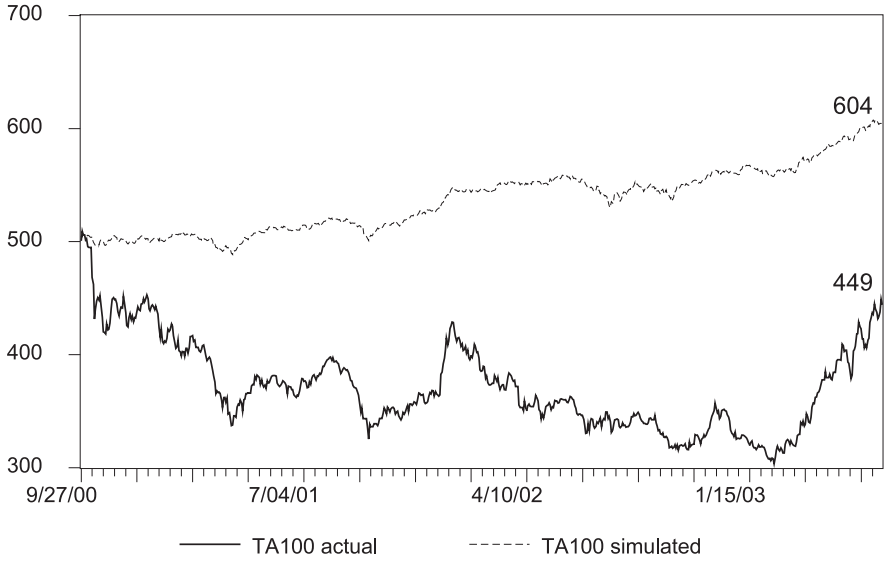

Fig. 6. Tel Aviv 100 index—actual and simulated with the pre-September 27, 2000 fundamental equation September 2000–June 2003.

We turn now to the estimation of the informational content—the news—of a terror attack. The first null hypothesis we test is a simple informational hypothesis:

$$H_0: \gamma = 0. \tag{5}$$

Rejection of H_0 will be interpreted as a significant informational content of the terror attack or the terror attack characteristics. For the exchange rate model, we expect $\gamma>0$, that is, a terror attack weakens the domestic currency (a devaluation of the currency), and for the stock market model we expect $\gamma<0$, that is, a decline in the value of stocks.

Since we use daily Israeli data, we have to address the problem of the timing of the terror attack and the measures of the exchange rate and the stock market. Clearly, a terror attack can occur at any time[17] but the exchange rate and the stock market data are measured at discrete intervals. The representative exchange rate published by the Bank of Israel is announced at 3 PM, so the impact of a terror attack early in the day will possibly affect the exchange rate the same day but an attack after 3 PM will be captured only the day after. This is also true for the stock market data; we have used closing trade data so that for the stock market model the critical time is 5 PM. Another problem is that no exchange rate is announced on Saturdays and Sundays and no trade takes place in the stock market on Fridays and Saturdays. So the response to a terror attack that occurs between Friday afternoon and Monday before 3 PM will be captured in the change of the exchange between Friday and Monday. For the stock market, a terror

[17] The terror attacks are evenly distributed among the days of the week.

Table 7
Interpreting the news of a terror attack

Interpretation	Coefficient[a]			
	γ_0	γ_1	γ_2	$\gamma_0+\gamma_1+\gamma_2$
No information	−	−	−	−
Transitory information and efficient market	+	+	−	−
Permanent information and efficient market	+	+	−	+
Transitory information with lagged effects[b]	+	+	+	−
Permanent information with lagged effects[b]	+	+	+	+

[a] The + sign means coefficient statistically different from zero, the − sign otherwise.
[b] This could indicate market inefficiency.

attack that occurs between Thursday after 5 PM and Sunday before 5 PM will be captured in the stock market change between Thursday and Sunday. The terror attacks data was organized in two sets. For the exchange rate model, we constructed a 5-day week starting on Monday and ending on Friday and for the stock market model a 5-day week starting on Sunday and ending on Thursday.[18]

Although we collected the time of the attack data, given the discrete nature of the dependent variable, the impact of a terror attack could be incorporated in prices either on the same day of the attack or the day after without violating market efficiency. To overcome this problem, we included in all the regressions the date of the attack and its first lag. H_0 is tested for both coefficients.

In an efficient market, the information of a terror attack should be instantaneously incorporated in market prices. Theoretically, we could test the efficiency hypothesis by adding a second lag to the equation and testing whether the second lag coefficient is statistically different from zero:

$$Dx_t = \alpha + \beta f_t + \gamma_0 T_t + \gamma_1 T_{t-1} + \gamma_2 T_{t-2} + \varepsilon_t \tag{6}$$

In our case, this is not a clean test for efficiency for two main reasons. The first reason is technical. Assume that a terror attack has a transitory effect on the market, that is, an effect that will not be permanently incorporated in market prices. In this case, either γ_0 or γ_1 will be statistically significant from zero, but the transitory effect on the level of the market will be reversed by a significant γ_2 without violating efficiency. The second reason is more substantial. Assume that Israel retaliates or reacts in any way to the terror attack. This will introduce new information that will affect market prices, which could be captured in γ_2. In any case, the lag structure of the equation allows us to test for the hypothesis of transitory versus more permanent effects. If either γ_0 or γ_1 is statistically different from zero, we conclude that the terror attack has informational content. If $\gamma_0+\gamma_1+\gamma_2=0$, the effect is transitory. Otherwise, it is more permanent.

Table 7 summarizes the different hypotheses and offers an interpretation of the possible results.

[18] The Jewish holidays are determined according to the lunar calendar; in the estimation we do not address this.

The estimated equations presented in Tables 8, 8a, 9, and 10 indicate the following:

(1) All the significant effects have the expected signs, negative (a market drop) for the stock market equations and positive (a devaluation of the shekel) for the exchange rate equations.
(2) Attacks inside the green line are statistically significant in all the equations.
(3) With regard to the attack-type category, only suicide attacks are statistically significant in all the equations.

Table 8
Testing the impact of terror on the stock exchange[1,2] (January 1990–June 2003)

		γ_0	γ_1	γ_2	$\gamma_0+\gamma_1+\gamma_2$	Chow[3]	R^2	LM[4]
		Regressions with dummy variables						
Major city	Jerusalem	−0.091	−0.259	0.112	−0.238	2.396	0.043	0.674
		(0.619)	(0.162)	(0.544)	(0.446)	(0.011)*		(0.510)
	Haifa	−1.031	−0.396	−0.043	−1.470			
		(0.089)**	(0.513)	(0.943)	(0.161)			
	Tel Aviv	−0.098	−0.383	−0.061	−0.542			
		(0.757)	(0.228)	(0.848)	(0.327)			
	Green line	0.006	−0.271	0.072	−0.193	2.867	0.043	0.655
		(0.944)	(0.002*)	(0.414)	(0.167)	(0.009)*		(0.519)
Target type	Transport	0.021	−0.251	−0.044	−0.275	1.686	0.042	0.790
		(0.858)	(0.029*)	(0.702)	(0.141)	(0.047)*		(0.454)
	Facilities	0.125	−0.065	−0.017	0.044			
		(0.501)	(0.730)	(0.929)	(0.887)			
	Military	−0.098	0.025	−0.024	−0.097			
		(0.392)	(0.829)	(0.836)	(0.592)			
	Government	−0.527	−0.271	0.218	−0.580			
		(0.380)	(0.651)	(0.717)	(0.577)			
Attack type	Suicide	−0.013	−0.379	−0.159	−0.551	2.325	0.045	0.667
		(0.927)	(0.007*)	(0.252)	(0.009)*	(0.003)*		(0.516)
	C.[5] weapon	−0.061	−0.211	0.048	−0.225			
		(0.735)	(0.242)	(0.791)	(0.457)			
	Bomb	0.075	−0.212	0.178	0.041			
		(0.653)	(0.206)	(0.287)	(0.882)			
	Kidnap	−0.441	−0.013	0.016	−0.439			
		(0.152)	(0.965)	(0.959)	(0.396)			
		Regressions with quantitative variables						
	V.[5] killed	−0.015	−0.021	−0.019	−0.055	2.594	0.043	0.754
		(0.246)	(0.099)**	(0.128)	(0.004)*	(0.016)*		(0.471)
	V.[5] injured	−0.002	−0.004	−0.002	−0.008	2.613	0.042	0.787
		(0.295)	(0.055)**	(0.341)	(0.013)*	(0.016)*		(0.455)
	Attacks	0.019	−0.136	0.006	−0.111	3.129	0.043	0.816
		(0.677)	(0.003)*	(0.901)	(0.084)**	(0.005)*		(0.442)

[1] p values in parenthesis.
[2] Coefficients with gray cell are statistically different from zero, * at 5% and ** at 10%.
[3] Chow test at September 27, 2000.
[4] Breuch–Godfrey Serial correlation LM Test.
[5] C. = cold and V. = victims.

(4) The number of people injured and killed is statistically significant in all the equations.
(5) The numbers of terror attacks per day is statistically significant in all the equations.

In Table 8 we see that, even after adding the different terror dummies or quantitative characteristics, the stock market equations show a structural break in September 27, 2000.

Our interpretation of this break is that the general deterioration of the Israeli economy due to the intensification of terror attacks is reflected in the value of Israeli

Table 8a
Testing the impact of terror on the stock exchange[1,2] (January 1990–June 2003)

		γ_0	γ_1	γ_2	$\gamma_0+\gamma_1+\gamma_2$	Chow[3]	R^2	LM[4]
		Regressions with dummy variables						
Major city	Jerusalem	−0.071	−0.248	0.124	−0.195	0.890	0.046	1.416
		(0.699)	(0.182)	(0.504)	(0.536)	(0.557)		(0.243)
	Haifa	−1.029	−0.347	−0.101	−1.477			
		(0.089)**	(0.566)	(0.866)	(0.161)			
	Tel Aviv	−0.041	−0.359	−0.064	−0.464			
		(0.897)	(0.258)	(0.841)	(0.404)			
	Green line	0.026	−0.257	0.076	−0.155	0.710	0.047	1.381
		(0.771)	(0.004)*	(0.396)	(0.288)	(0.641)		(0.252)
Target type	Transport	0.036	−0.238	−0.049	−0.250	0.663	0.046	1.499
		(0.758)	(0.044)*	(0.679)	(0.216)	(0.821)		(0.224)
	Facilities	0.124	−0.080	−0.007	0.037			
		(0.507)	(0.669)	(0.972)	(0.906)			
	Military	−0.101	0.035	−0.021	−0.088			
		(0.384)	(0.763)	(0.855)	(0.649)			
	Government	−0.495	−0.243	0.262	−0.476			
		(0.409)	(0.685)	(0.662)	(0.648)			
Attack type	Suicide	−0.010	−0.366	−0.179	−0.555	0.842	0.049	1.322
		(0.943)	(0.011)*	(0.210)	(0.014)*	(0.631)		(0.267)
	C.[5] weapon	−0.072	−0.215	0.059	−0.228			
		(0.690)	(0.232)	(0.742)	(0.450)			
	Bomb	0.061	−0.211	0.174	0.025			
		(0.716)	(0.210)	(0.301)	(0.932)			
	Kidnap	−0.466	−0.027	0.043	−0.450			
		(0.130)	(0.929)	(0.888)	(0.383)			
		Regressions with quantitative variables						
	V.[5] killed	−0.014	−0.020	−0.019	−0.053	0.819	0.046	1.454
		(0.287)	(0.118)	(0.146)	(0.009)*	(0.556)		(0.234)
	V.[5] injured	−0.002	−0.004	−0.002	−0.008	0.628	0.046	1.523
		(0.355)	(0.061)	(0.380)	(0.024)*	(0.708)		(0.218)
	Attacks	0.021	−0.135	0.003	−0.110	1.176	0.046	1.542
		(0.659)	(0.006)*	(0.946)	(0.168)	(0.317)		(0.214)

[1] Same specification as in Table 6 including a dummy for the post September 27 period and a dummy multiplied by the lag S&P500 log difference. p values in parenthesis.
[2] Coefficients with gray cell are statistically different from zero, * at 5% and ** at 10%.
[3] Chow test at January 1, 2002 for the post September 27 sample.
[4] Breuch–Godfrey serial correlation LM Test.
[5] C. = cold and V. = victims.

stocks. It is interesting that this effect is captured by the decline in the coefficient of the change in the S&P500 index and not as a significant reduction in the constant. To avoid possible biases in the interpretation of the direct effects of terror attacks, we estimated all the stock market equations by adding a dummy for September 27, 2000 and an interaction of the dummy with the change in the S&P500 index. The results are given in Table 8a.

Table 9
Testing the Impact of terror on the dollar exchange rate[1,2] (February 1996–June 2003)

		γ_0	γ_1	γ_2	$\gamma_0+\gamma_1+\gamma_2$	Chow[3]	R^2	LM[4]
		Regressions with dummy variables						
Major city	Jerusalem	−0.042	0.064	0.003	0.025	3.006	0.020	1.237
		(0.493)	(0.297)	(0.957)	(0.807)	(0.001)*		(0.290)
	Haifa	−0.061	−0.045	0.601	0.495			
		(0.741)	(0.808)	(0.001)*	(0.126)			
	Tel Aviv	0.221	0.318	−0.067	0.472			
		(0.032)*	(0.002)*	(0.518)	(0.009)*			
	Green line	−0.031	0.077	0.019	0.065	1.244	0.009	2.789
		(0.349)	(0.022)*	(0.561)	(0.223)	(0.281)		(0.062)
Target type	Transport	0.016	−0.002	0.034	0.048	2.567	0.009	0.258
		(0.687)	(0.960)	(0.404)	(0.467)	(0.002)*		(0.773)
	Facilities	0.031	0.123	−0.004	0.150			
		(0.638)	(0.060)**	(0.949)	(0.187)			
	Military	0.011	−0.037	0.018	−0.009			
		(0.790)	(0.361)	(0.659)	(0.896)			
	Government	0.012	−0.088	−0.023	−0.099			
		(0.952)	(0.670)	(0.909)	(0.782)			
Attack type	Suicide	0.093	0.057	0.060	0.210	2.650	0.015	1.484
		(0.040)*	(0.212)	(0.182)	(0.003)*	(0.001)*		(0.227)
	C.[5] weapon	−0.081	0.065	−0.204	−0.220			
		(0.361)	(0.463)	(0.018)*	(0.139)			
	Bomb	0.024	−0.020	−0.029	−0.025			
		(0.670)	(0.727)	(0.609)	(0.797)			
	Kidnap	0.104	0.036	0.004	0.144			
		(0.535)	(0.832)	(0.979)	(0.621)			
		Regressions with quantitative variables						
	V.[5] killed	0.006	−0.001	0.007	0.012	1.748	0.009	0.695
		(0.139)	(0.804)	(0.125)	(0.072)**	(0.106)		(0.498)
	V.[5] injured	0.001	0.001	0.001	0.003	1.471	0.009	2.001
		(0.206)	(0.088)**	(0.212)	(0.012)*	(0.184)		(0.135)
	Attacks	−0.011	0.013	0.028	0.029	1.535	0.008	1.551
		(0.469)	(0.410)	(0.075)**	(0.199)	(0.163)		(0.212)

[1] p values in parenthesis.
[2] Coefficients with gray cell are statistically different from zero, * at 5% and ** at 10%.
[3] Chow test on September 27, 2000.
[4] Breuch–Godfrey serial correlation LM Test.
[5] C. = cold and V. = victims.

Notice that γ_2 is not statistically different from zero. This is interpreted as efficiency of the stock market, i.e. new information of a terror attack is instantaneously incorporated in the value of stocks.

Suicide attacks have a permanent effect on the stock market prices. The same is true for the number of victims injured and the number of victims killed. Terror attacks with a transitory effect on the stock market level are attacks on transport (most usually buses), attacks inside the green line, and the number of attacks per day.

Table 10
Testing the impact of terror on the basket exchange rate[1,2] (February 1996–June 2003)

		γ_0	γ_1	γ_2	$\gamma_0+\gamma_1+\gamma_2$	Chow[3]	R^2	LM[4]
		Regressions with dummy variables						
Major city	Jerusalem	–0.013	0.081	–0.021	0.047	2.271	0.016	0.131
		(0.849)	(0.234)	(0.754)	(0.684)	(0.016)*		(0.877)
	Haifa	–0.091	–0.096	0.724	0.537			
		(0.660)	(0.642)	(0.000)*	(0.136)			
	Tel Aviv	0.195	0.364	0.025)	0.584			
		(0.090)**	(0.002)*	(0.828)	(0.004)*			
	Green line	–0.018	0.089	0.041	0.112	0.800	0.006	1.537
		(0.619)	(0.017)*	(0.270)	(0.062)**	(0.570)		(0.215)
Target type	Transport	0.042	–0.027	0.027	0.041	2.302	0.007	0.276
		(0.345)	(0.542)	(0.554)	(0.573)	(0.007)*		(0.759)
	Facilities	0.025	0.143	0.034	0.202			
		(0.732)	(0.050)*	(0.635)	(0.110)			
	Military	0.029	0.009	0.007	0.046			
		(0.522)	(0.844)	(0.875)	(0.535)			
	Government	0.231	–0.143	0.013	0.101			
		(0.317)	(0.535)	(0.955)	(0.801)			
Attack type	Suicide	0.129	0.063	0.076	0.268	2.063	0.012	1.387
		(0.011)*	(0.215)	(0.131)	(0.001)*	(0.009)*		(0.250)
	C.[5] weapon	–0.093	0.053	–0.197	–0.237			
		(0.343)	(0.588)	(0.040)*	(0.152)			
	Bomb	0.038	0.025	–0.032	0.031			
		(0.537)	(0.689)	(0.613)	(0.769)			
	Kidnap	0.112	0.121	–0.085	0.148			
		(0.548)	(0.516)	(0.648)	(0.647)			
		Regressions with quantitative variables						
	V.[5] killed	0.008	0.004	0.006	0.018	1.219	0.005	0.372
		(0.098)**	(0.427)	(0.211)	(0.017)*	(0.294)		(0.689)
	V.[5] injured	0.001	0.002	0.001	0.004	0.812	0.007	1.587
		(0.192)	(0.017)*	(0.248)	(0.004)*	(0.561)		(0.205)
	Attacks	0.005	0.017	0.033	0.055	1.298	0.005	0.912
		(0.756)	(0.334)	(0.059)**	(0.034)*	(0.255)		(0.402)

[1] p values in parenthesis.
[2] Coefficients with gray cell are statistically different from zero, * at 5% and ** at 10%.
[3] Chow test on September 27, 2000.
[4] Breuch–Godfrey serial correlation LM Test.
[5] C. = cold and V. = victims.

The impact of terror attacks on the foreign currency market is presented in Tables 9 and 10. Since the Bank of Israel stopped its daily intervention in the currency market. In February 1996, we ran the regressions starting on that date. Most equations remain stable after September 27, 2000.[19] We therefore conclude that no general effect of terrorism is present in the currency market. As in the stock market case, none of the γ_2 coefficients is statistically significant from zero,[20] so indicating an efficient currency market. New information of a terror attack is instantaneously incorporated in the foreign currency market.

The results for the dollar and basket of exchange rates are similar. However, it seems that those for the basket of exchange rates are more reliable, since they represent more general trends in the value of the shekel. The dollar exchange rate was influenced by changes in the cross rates, which were particularly strong in recent years.

We estimate permanent effects on the level of the exchange rate of: suicide attacks, attacks inside the green line,[21] the number of victims injured, the number of victims killed and the number of attacks per day.[22]

6. Testing the diminishing effect hypothesis

In this section, we ask whether markets become insensitive to terror attacks over time. That is, do investors expect a particular number of terror attacks and do market prices internalize these expectations? To address this question, we used the sample after September 27, 2000 and tested two different hypotheses. The first hypothesis tests whether the first attack of its kind, i.e. the first attack on transport or the first suicide attack, had a significantly larger effect than the attacks that followed. For the second hypothesis, we introduce an interaction between a year dummy ($d_t = 1$ for year t and 0 otherwise) and a terror-attack characteristic to see whether the coefficient of the characteristic diminishes over time.

The results are sharp. The first-terror-attack-of-its-kind coefficient is not significantly different from zero, and thus the effect of the first attack type of its kind is not different from the terror attacks that follow, with the exception of the first kidnapping case. The kidnapping dummy was not statistically significant but the first case was highly significant.

None of the year interaction dummies is significantly different from zero, indicating that the news content of an additional terror attack does not diminish over time. Our

[19] From the relevant equations, that with a suicide attack is an exception. This is probably due to the small number of suicide attacks before September 27.

[20] Except for the Haifa location, ignored due to the small number of cases, and the cold weapon dummy that is significant but with the wrong sign.

[21] Only for the basket exchange rate.

[22] Only for the basket exchange rate.

results indicate that one cannot talk about a routine of terror attacks. The informational content of a terror attack is a factor for each and every attack and it does not diminish over time. The financial markets continued to incorporate efficiently the news of terror attacks as the attacks occurred.

7. Conclusions

This paper has analyzed the impact of Palestinian terror attacks on stock market prices and exchange rates in Israel using daily time series data from 1990 until 2003. Intensified Palestinian terror attacks after September 27, 2000 had a permanent negative effect on the stock market but not on the foreign currency market. The stock market decline indicates that, beyond the loss of life and personal injuries to victims, the terror attacks had real economic costs that reduced firms' expected profits. Given the position of the balance of payments, the terror did not affect the value of the shekel.

We have proposed a methodology for decomposing the innovations in the market into the news from a terror attack and other white noise. The results indicate that suicide attacks have a permanent effect on both markets; other types of attack do not. Terror attacks on transport have a transitory effect on the stock market and terror attacks on other targets do not. The target type does not affect the currency market. Terror attacks that took place within Israel's 1948–1967 armistice lines (the green line) had a transitory effect on both markets, while other attacks did not. Attacks on major cities have no special effect. The number of people injured and killed has a permanent effect on both markets. The number of attacks per day has a transitory effect on both markets.

We find that markets are efficient in incorporating the news of terror attacks and find no evidence that markets became desensitized to terror attack over time. Our principal conclusion is that financial markets continued to perform their economic functions in an efficient way.

Economic liberalization policies were not affected by the terror. The results about market efficiency suggest that the process of market liberalization contributed to the economy's coping with the terror.

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Appendix A. Exploring the source of the structural change in the fundamental stock market equation

Dependent Variable Dlog(TA100)
Included observations: 3515 after adjusting endpoints

Variable	Coefficient	S.E.	*t*-statistic	Probability
C	0.049476	0.025299	1.955664	0.0506
Sept. 27	− 0.060935	0.055743	− 1.093139	0.2744
Dlog(S&P500(− 1))	0.269688	0.025587	10.54024	0.0000
Sept 27* Dlog(S&P500(− 1))	− 0.151368	0.042993	− 3.520718	0.0004
Dlog(TA100(− 1))	0.084865	0.018108	4.686639	0.0000
Sept. 27* Dlog(TA100(− 1))	− 0.049713	0.046006	− 1.080579	0.2800
R^2	0.044628	Mean dependent var		0.057432
Adjusted R^2	0.043267	S.D. dependent var		1.361908
S.E. of regression	1.33212	Akaike info criterion		3.413125
Sum squared resid	6226.87	Schwarz criterion		3.423648
Log likelihood	− 5992.568	*F*-statistic		32.78303
Durbin–Watson stat	1.987415	Prob(*F*-statistic)		0.0000

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