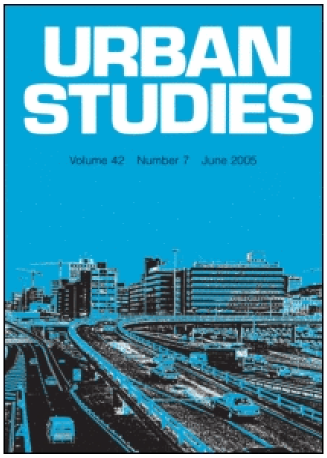

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Terror, Fear and Behaviour in the Jerusalem Housing Market

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Terror, Fear and Behaviour in the Jerusalem Housing Market

Shlomie Hazam and Daniel Felsenstein

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Summary. This paper tests the hypothesis that fear is a central factor in understanding human behaviour in the face of terror. This claim is addressed in the context of behaviour in the Jerusalem housing market over the terror-stricken years in the city, 1999–2004. Using a unique data source and the tools of spatial data analysis, the paper provides support for this hypothesis in three respects. First, patterns of terror in the city are shown to be increasingly deconcentrated over the period studied. Secondly, the types of terror having the sharpest effect on residential property prices are those most associated with randomness. Thirdly, the effect of terror is less on purchasing prices than on rental prices. The former represent revealed long-term behaviour less affected by fear and the latter, short-term behaviour more likely to be influenced by such disutility. The paper concludes with some of the policy implications arising from these findings.

1. Introduction

As terror becomes an endemic state that the developed world struggles to address, social and behavioural scientists are increasingly examining the effects of this phenomenon on human behaviour. In the extreme, when faced with atrocities and terrifying incidents, individuals are faced with the choices of either ‘coping’ or ‘avoiding’ (Sharkansky, 2003; Hargan, 2005). Whatever the choice, the attempt to deal with terror alters the individual’s behaviour in comparison with the counter-factual ‘no terror’ case. In addition, the ability to cope with or handle a situation of terror differs across sub-groups in a given population. Some will be able to alter their behaviour in order to deal with the presence of terror and will find substitutes that allow them to accommodate their pre-terror behaviour as much as possible. Others will have no choice. They will be forced to continue as normal, coping with the new situation and internalising any desire to change their behaviour to the changed circumstances.

In aggregate, terror induces high discount rates. The value of the future is more heavily discounted than the present because of the uncertainty that terror injects into human behaviour. This uncertainty has a variety of sources. In a recent paper, dealing with the response of individuals to terror events, Becker and Rubinstein (2004) outline some of these in proposing the ‘fear hypothesis’. Their argument is that human behaviour is modified by two forces. The first is the ‘risk’ factor associated with terror. This is assessed by the individual as the objective, numerical probability of running into danger. The second element is ‘fear’. This is borne of

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anxiety and subjectivity and differs across individuals. Hence, it has greater potential for modifying human behaviour. Furthermore, individuals are more likely to overvalue subjective probabilities than objective probabilities and thus fear is more likely to alter behaviour than risk.

In the absence of any real fear factor, human behaviour can be invariant to even relatively high levels of risk. For example, despite the risk of being involved in a car accident, the fear associated with driving is not enough to discourage people from using their cars. On the other hand, an infectious disease (such as avian flu, foot and mouth or mad cow) may only have a very small numerical probability of contagion, yet this is sufficient to modify human travel patterns and consumption habits.[1]

This paper seeks to test this fear hypothesis in the urban context. We focus specifically on the effect of terror events on behaviour in the Jerusalem housing market over the period 1999–2004. The housing market is a particularly good barometer of individuals' revealed preferences. These are capitalised in property prices and the willingness to pay for residential goods, both purchased and rented. The paper proceeds as follows. First, we review the strands of literature that fuse the effect of terror on urban development and human behaviour. We then go on to describe the context of the empirical application, the data and the method that serve the analysis. Throughout the empirics, we distinguish between behaviour in the purchase and rental markets, with the former taken to illustrate longer-term strategic behaviour and the latter, shorter-term *ad-hoc* solutions to immediate needs. Our descriptive and analytical findings identify the existence of a 'fear' factor and uphold the basic hypothesis. We conclude with some policy ramifications arising from the results and discuss their likely impact on Jerusalem's urban development.

2. Terror and Behaviour in an Urban Context

The events of 9/11 served to underscore the vulnerability of large cities to pre-meditated and ideologically driven threats. While historically cities have always been easy prey to external natural shocks (such as earthquakes) or even man-generated shocks such as contagious diseases or fires, the idea of a deliberate attack on a city as the means of inflicting maximum damage on a maximum number of civilians exposes the soft underbelly of urban agglomeration. This is not to say that cities cannot withstand these shocks. Recent empirical evidence shows cities to be remarkably resilient to perhaps the ultimate man-made shocks such as war-induced destruction of catastrophic proportions (Davis and Weinstein, 2002; Brakman *et al.*, 2004). Interim analysis of the mega-terror event at the World Trade Center also suggests that New York has been able to muster an economic recovery far more quickly than originally anticipated (Bram, 2003).

All of the above illustrate the ability of the city to rebound after a large catalytic event. However, much of the terror affecting cities is characterised by events of greater frequency and lower intensity. These interrupt the fabric and rhythm of urban life. Even if their physical and economic footprint on the city is somewhat contained, they still have an invidious effect on the personal behaviour patterns of its citizens. While some commentators have predicted significant effects of terror on the physical structure of cities, building densities and the demand for high-rise living (Mills, 2002; Cutter *et al.*, 2003; Graham, 2004), simulated and empirical evidence does not seem to support these contentions (Glaeser and Shapiro, 2002; Rossi-Hansberg, 2004).

What does seem to emerge is an emphasis on terror as disrupting human behaviour in the short term and the differential effects of this disruption contingent on the individual's ability to pay the costs of overcoming fear. This theme has become the subject of some interest in recent years and the effect of terror has been documented in many empirical studies related to consumption and production-driven activity.

On the consumption side, Becker and Rubinstein (2004) show how terror can change behaviour in areas such as demand for public transport, international travel and entertainment venues such as coffee shops. On the production side, they show considerable effects of terror on the supply of security guards and on the monetary compensation for bus drivers and airline pilots. In all these cases, those populations able to find alternative outlets for consumption, such as private instead of public transport, are able to internalise their feelings of fear.

Similar effects have been shown to exist in the Israeli tourism market. Studies by Fleischer and Buccola (2002), Krakover (2002) and Eckstein and Tsiddon (2004) show that the effects of terror events on tourism demand are short-term and will differentially affect individuals' demand depending on their alternative consumption possibilities. For tourism, foreign demand can be met at other tourism locations while for domestic tourists, many of whom live in urban settings that have experienced terror, a tourism venue away from the city may offer a lower effective cost for avoiding fear.

Another area of interest relates to the effect of terror on behaviour in financial markets such as the stock market and foreign currency markets (Eldor and Melnick, 2004). In this case, terror again causes heavy discounting of the future in terms of firms' future performance and profits. Relating stock and currency prices to terror incidents, Eldor and Melnick find differential effects of types of attacks and their targets. Thus, terror attacks on public transport (target) via suicide bombing (type) have a permanent effect on stock market prices. These factors are less significant in the case of the foreign currency market. Interestingly, the location of an attack (Jerusalem, Tel-Aviv or Haifa) is not found to have any significant effect.

These findings notwithstanding, a parallel body of knowledge has emerged that emphasises the conditions so attractive for terror activity but plays less attention to the influence of terror on individual behaviour. In what has become a 'prophetic' paper, Savitch and Ardashev (2001) outline the main contours of the uncomfortable symbiosis between terror and urban agglomeration, presenting the 'rationale' for cities as venues for terror incidents, ranking cities by these incidents and suggesting a classification that explains this ranking. The classic features of urban agglomeration, such as population density, high public visibility and global linkages, all serve to expose the large city. In a further paper that analyses the patterns of terror in Jerusalem, Savitch (2005) makes the case that terror can paradoxically 'shrink' the urban agglomeration that it targets. Faced with terror, city authorities often react in the form of enhanced security, partitioning and greater surveillance thereby undermining the size of the potential area in which terror seeks to operate. Parhan *et al.* (2005) go one stage further, specifying those particular factors that have made Jerusalem a prime venue for terror attacks. They identify three factors that serve to exacerbate the potential for terror in the city. First, Jerusalem's physical location, surrounded on three sides by Arab population, serves to expose the urban area. Secondly, the symbolic status of the city as the national capital adds to its attractiveness as a terror target. Finally, the 'Islamisation' of the Israeli–Palestinian conflict further contributes, with attacks on Jerusalem taking on a religious and not just national meaning.

In sum, two parallel strands in the literature co-exist but do not co-relate. The body of knowledge on the effect of terror on human behaviour tends to ignore the urban context. Conversely, the literature emphasising terror patterns in an urban context seems to downplay the impact on human behaviour. This paper draws on insights from both bodies of knowledge, fusing them in an empirical study of behaviour in the Jerusalem housing market. It attempts to bridge the gap between these two lines of research by showing consistency in outcomes independent of scale. While on the one hand we underscore the role that fear plays in an individual's behaviour pattern, on the other hand we also highlight the aggregate house price patterns arising from these individual choices. Thus, we diffuse some of the theoretical concern that has been voiced concerning the existence of a 'modifiable areal unit problem'

(Fotheringham *et al.*, 2002), where the results of the analysis are expected to change with change in the scale of investigation. Our aggregate empirics presented here are consistent with our (micro) theoretical expectations and do not seem to be scale-contingent.

3. The Setting: The Jerusalem Housing Market

In an economy characterised by periodic and destabilising 'shocks' such as mass immigration and wars, the housing market has traditionally been considered a rock of financial stability. While the construction sector has often been perceived as the barometer of the Israeli economy, the housing market has served to yield solid returns to investment over a sustained period, making homeownership a popular hedge against inflation and a safe haven against recessions. Indeed, a study comparing investment in both dwellings and financial assets over the period 1990–2000 confirms this perception (Ben-Shahar, 2004). While returns to the latter were found to be higher over the study period, the embedded risk in the former was far lower.

The housing market is also important due to the high level of public involvement in this field (Bar-Nathan *et al.*, 1998). Government controls the supply of housing through its regulation of available building land and by actively supporting private building contractors through buy-back agreements and other subsidies. On the demand side, government promotes first-time homeownership through subsidised mortgages to young couples, new immigrants and so on. The result is that nearly 74 per cent of the housing stock in Israel is characterised by owner-occupation (Ministry of Housing, 2000). The rental market comprises 20 per cent of the housing stock and government influences the supply side of this market as well through recognising rental income for tax relief. The remainder of the housing stock (about 6 per cent) comprises public housing (Table 1).

Historically, real house prices (adjusted by the consumer price index) have risen over time especially coinciding with waves of immigration. Over the course of the 1990s, the effect of the immigration of former USSR citizens pulled the housing market out of the hyper-inflation-induced recession of the 1980s. However, the second *intifada* (Palestinian uprising) at the end of the 1990s caused a reversal in this trend. Over our study period (1999–2004), real house prices fell nationally by nearly 15 per cent. In contrast, real monthly rents were on average 4 per cent higher at the end of the period than in the beginning, but this conceals a large measure of volatility (a rise and decline of some 13 per cent) that took place over the period (CBS, selected years).

Against this background, the situation in Jerusalem closely reflects national trends. The composition of the housing stock in Jerusalem deviates slightly from the national picture due to a larger rental market (Ministry of Housing 2000) and a smaller owner-occupation sector. Owner-occupation in the city comprises 70 per cent of the housing stock, the rental market comprises a further 24 per cent and the public housing sector 6 per cent. For comparison, the composition

Table 1. Housing stock composition and price changes in housing markets in major Israeli cities

	National shares	Jerusalem	Tel-Aviv	Haifa
Housing stock composition (percentage of total)[a]				
Owner-occupied	73	70	73	74
Rental	20	24	25	20
Public housing	7	6	2	6
House price change 1999–2004 (percentage)[b]	−15	−16	−21	−17
Monthly rental change 1999–2004 (percentage)[b]	+3.5	+4.0	+7.0	0.0

[a]*Source*: Ministry of Housing (2000).

[b]*Source*: CBS (selected years).

of the housing stock in other large cities in Israel is somewhat different. Tel-Aviv and Haifa both have shares of owner-occupancy close to the national share (73 and 74 per cent respectively). In the rental sector, Tel-Aviv is closer to Jerusalem with a 25 per cent share and a very small public housing stock (2 per cent), while Haifa is closer to the national average of 20 per cent (Table 1).

In the purchasing market, the gross average price changes as presented in Table 1 can be misleading as they smokescreen the influences of price changes in different size categories of dwellings. Properties need to be disaggregated by size. Over the period 1999–2004, the purchase price of mid-sized dwellings (3.5–4.0 rooms) in Jerusalem fell by nearly 14 per cent. In comparison, the decline in price of this size category in Tel-Aviv was 11 per cent and in Haifa 14 per cent. Smaller dwellings (1.5–2.0 rooms) in Jerusalem declined by 12 per cent—the same rate as the national average. In Tel-Aviv, they fell by 14 per cent and in Haifa by 17 per cent (CBS, selected years).

Real rental prices over this period behaved somewhat differently. In Jerusalem, monthly rentals for mid-sized properties (3.5–4.0 rooms) were unchanged at the beginning and end of the study period (but with some within-period volatility). In contrast, rents on small properties (1.5–2.0 rooms) increased by 4 per cent. In Tel-Aviv, this pattern was reversed with smaller units showing no change and rents on larger units increasing by 4 per cent. Monthly rents in Haifa, in both size groups, were broadly stagnant. In sum, over the study period, the Jerusalem housing market displayed rather different attributes from both the national market and those of the other large cities—both in terms of composition and price behaviour.

4. Method and Data

4.1 Method

We assume that house prices reflect individuals' revealed preferences in the housing market.[2] Conceptually, we expect these preferences to be influenced by four distinct vectors of characteristics. First, there are macroeconomic influences such as interest rates that can affect prices in the housing market (Poterba, 1984). On the supply side, high interest rates produce a downward effect on housing supply. McGibany and Nourzad (2004) suggest that with a given level of supply, as interest rates rise, demand will fall tending to lower prices. The level of permanent income is another influence. However, as interest rates are spatially invariant and income levels can be indirectly addressed, we effectively ignore the macro effects.

In common with hedonic pricing studies, we concentrate on two further main vectors of attributes that affect housing prices (Tse, 2002; Sirmans *et al.*, 2005). The first relates to structural property characteristics (age, condition and quality of the housing stock) and the second to neighbourhood characteristics (location, environment, accessibility). Finally, in line with our major hypothesis, we introduce a vector of terror characteristics (magnitude, intensity, proximity) as a further factor in understanding the (purchasing and rental) prices of residential properties.

Operationally, this means estimating a basic model as follows

$$P_i = \alpha_i + \beta X_i - \lambda T_i + \varepsilon_i \qquad (1)$$

where, P refers to the purchase price or rental price of the dwelling (per square metre); $\mathbf{X}$ is a vector of exogenous dwelling-related and neighbourhood-related controls; $\mathbf{T}$ is a vector of terror incidence attributes; the label i refers to the spatial unit of analysis (neighborhood, statistical area, etc.); and ε_i denotes the residual error with variance σ^2.

Equation (1) implies that the expected price of dwellings in place i is

$$E(P_i) = \text{Exp}\left\{\alpha_i + X\beta_i - \lambda_i + \frac{1}{2}\sigma_i^2\right\} \qquad (2)$$

Equation (2) shows that housing prices are derived from several sources. First, they vary directly with the change in α, which captures the national-level effects on price of factors such as interest rates and earnings levels. These are not expected to be contingent on the characteristics of place i. Secondly, prices are directly related to the change in β, which captures the change in the returns to property or neighbourhood characteristics, such as improvements to a dwelling or changes in the demographic composition of the neighbourhood. Thirdly, expected price change is inversely related to λ, the terror attributes of area i, such as number of incidents, their intensity and distance of the area from terror sources. Finally, if the unexplained variance in prices increases then expected price changes will be larger.

Having estimated equation (1), its parameters may in principle be substituted into equation (2) in standard OLS fashion. However, given the spatial nature of the data (continuous statistical areas), hedonic price models need to be augmented by an appropriate spatial econometric specification that takes into account the lack of spatial independence between the units of analysis (Dubin, 1998; Mikelbank, 2004). The spatial nature of property and neighbourhood characteristics in hedonic estimation makes this dependence almost inevitable (Fik *et al.*, 2003). Thus, in addition to the relationships hypothesised earlier, we can also posit that average house prices in a given spatial area will be directly related to those in neighbouring areas. To avoid spatial mis-specification, we re-estimate equation (1) as a spatial lag model. This reduces the biases, inconsistencies and inefficient parameter estimates of OLS in the presence of simultaneity induced by spatial lags (Anselin, 1988). Equation (3) presents the model for estimation

$$P_i = \alpha_i + \beta X_i - \lambda T_i + \rho WP_i + \varepsilon_i \qquad (3)$$

where, WP is a vector of spatial lags for the dependent variable; and ρ is the spatial autoregressive coefficient. The weight matrix used here (W) follows Garrett *et al.* (2005) in using the distance between statistical area centroids as the weighting measure.[3] As in most spatial regression models, we are concerned with 'neighborhood' or spatial dependence (WP) while controlling for the effect of the standard hedonic predictors. We use the IV (instrumental variable) approach to estimating the spatial lag model in which instruments are correlated with the predictors but uncorrelated with the errors. Our instruments are first-order spatially lagged exogenous variables.[4]

4.2 Data

We estimate equations (2) and (3) for two time-periods, 2000 and 2004.[5] The spatial unit of analysis, i, is the statistical area (SA). This is an administrative unit defined by the Israeli Central Bureau of Statistics. Over 200 SAs are included within the municipal boundaries of Jerusalem over the period of study.

The dependent variable log P_i represents the (log) average housing cost per square metre in SA i. Data for this variable come from a commercial monthly real estate publication (the Yizhak Levi Guide). This lists current house prices (purchase and rents) per street in Jerusalem, distinguishing between different sizes of dwellings. This is the appraised value data (and not the actual transaction value) and relates to prices ranging from 2-room to 5-room dwellings.[6]

In line with the hedonic pricing literature, we expect property characteristics to be positively related to dwelling prices (Sirmans *et al.*, 2005). We measure these using two leading variables, describing the physical attributes of the property and quality of the physical stock. The first relates to the extent of sub-standard or dilapidated structures in the SA and the second to the average housing conditions in the SA proxied by the amount of living space available to the individual. These variables were collected for 1999 and 2004 from the Jerusalem city property tax registry. Following the literature, we also expect neighbourhood conditions to be positively related to prices (Tse, 2002). These can reflect the socioeconomic level of a neighbourhood as measured by level of property taxes collected per square metre of taxable property and by average population density per SA which in our case is taken to reflect land prices. The source for both these indicators is the Jerusalem city property tax registry.

Terror was measured using three indicators. In general, we expect to find an inverse relationship between the incidence of terror and dwelling prices (Eckstein and Tsidddon, 2004; Eldor and Melnick, 2004). Specifically, we expect both the magnitude of terror attacks and their intensity to exert such an effect. Accessibility to terror as measured by distance from a perceived boundary is also expected to be inversely related to prices. The further the distance from the boundary, the less the impact on prices.

Terror events data were collected directly from two sources. The primary source was the activity diaries of the Sabotage Department at the Israel National Police Headquarters. These data record each incident by type of the attack, date, geographical co-ordinates, number of casualties and technical engineering data on explosive devices, etc. All incidents, even those resulting in zero casualties and damage (such as devices that do not explode), are recorded. Hence, these records would seem to be more complete than data hitherto reported. For example, over the years 2000–2004, this data source reports 1592 casualties from 179 terror incidents with 86 per cent of casualties caused by explosive devices (in the main suicide bombings).[7]

Terror intensity was measured using these incidence data combined with data from a secondary source on monetary damage provided by the Jerusalem office of the Israeli income tax authority (charged with providing compensation for terror-induced property loss).[8] These data are only available for the three years, 2001–03. Over this period, over 1100 claims were made to the tax authority for compensation assessed at 38 million shekels (nearly US$8.5 million). Of this, over 70 per cent of claims and over 80 per cent of value were for terror damage in the city centre, indicating the magnitude of monetary damage inflicted at this location. The remainder was incurred in the outer neighbourhoods.

Accessibility to terror was measured using the log of the straight-line distance from the centroid of each SA to the 'seam line'. This is represented by the north–south Route 1 that straddles the former border between the east and west parts of the city. Figure 1 shows all the terror incidents for the period 1999–2003, along with incidents for two base years 1990 and 1995. A trend in the westward drift of terror events from the vicinity of the seam line is readily apparent.

Finally, to represent visually and to manipulate the data, we used GIS data layers made available by the Hebrew University GIS centre. These related to coverage of streets, buildings and the borders defining the statistical areas.

5. Findings

We report both descriptive and analytical findings. As every element in our data has a spatial assignment, GIS-based description allows us to derive three key insights concerning the impact of terror and fear on behaviour in the housing market. These relate to the overall pattern of terror attacks and the changing centre of gravity of the attacks, the increasing spatial randomness in their overall distribution and the relationship between different forms of terror incidents and house prices. Together, these insights lend descriptive support to the disutility of fear hypothesis. Additionally, this premise is tested analytically in a spatial regression model that attempts to observe the role of terror alongside structural and neighbourhood characteristics in determining house prices.

5.1 Descriptive Results

Creating a geo-referenced dataset of terror events and dwellings prices required a certain amount of standard spatial data manipulation. The first stage involved importing the alphanumeric house price data (provided at the street level) into a GIS streets layer. This procedure was repeated four times: for purchasing prices and rental prices and for the years 2000 and 2004 respectively. Those fields that could not be matched through the import process were manually adjusted (roughly 25 per cent). The second

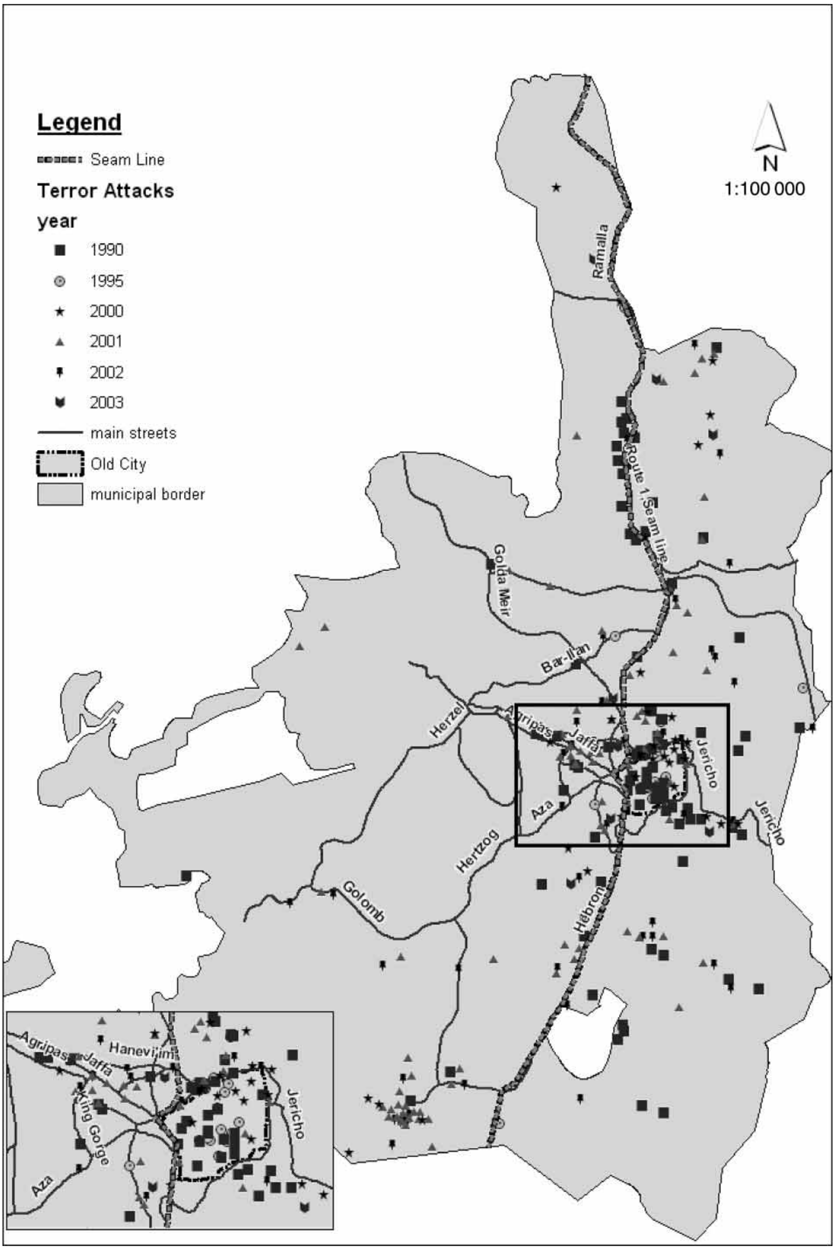

Figure 1. Distribution of terror incidents, 1990, 1995, 1999–2003.

stage involved joining the dwelling price data by street to a GIS buildings cover for all the streets, on the same basis.

The basic distribution of house prices over the study period can be seen in Figure 2. This shows average purchase prices (per square metre) in Jerusalem for 2000 and 2004. The darker shading represent the more expensive areas in the city, located in the west and centre, and the lighter shading shows the cheaper areas located in the vicinity of the seam line and in the outer neighbourhoods. As noted earlier, due to local and global recessions, real price levels were

Figure 2. Average purchase prices, Jerusalem 2000 (left) and 2004 (right).

lower in 2004 than in 2000. This change was felt most acutely in the outer neighbourhoods where prices dropped further, while in the city centre price levels remained relatively high.

The next stage consisted of joining the terror incidence data to the house price data. For describing terror incidence, we used the digitised street and housing covers in order to locate the sites of the attacks. We generated a layer of terror points (incidents) and joined this information to the GIS layers. Finally, total compensations claims and number of claims per attack were added to the layer attributes. Thus for any given point we had a terror history for the period 2000–04 relating to total injuries, fatalities and number of claims and assessed monetary damages in order to measure a composite index of terror.

The basic spatial distribution of attacks by type during 2000–04 (including historical benchmarks for 1990–95) can be seen in Figure 3. The most salient feature of this map, apart from the westward movement of incidents noted earlier, is the increasing intensity of types of attack. Thus, while the early and mid 1990s were characterised by attacks

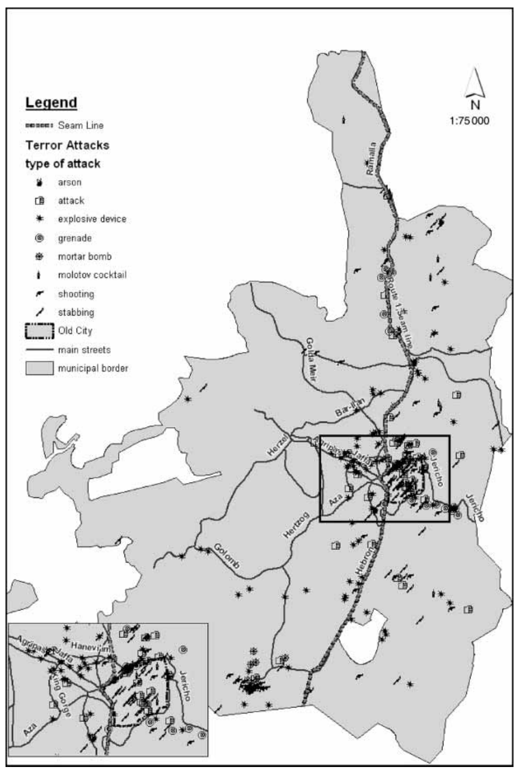

Figure 3. Distribution of attacks by type, 2000–03.

that took place in the vicinity of the Old City and close to the seam line and consisted in the main of physical assault, stabbings, arson and some use of explosive devices, by the end of the decade this picture had changed. The attacks were increasingly dispersed and involved much more use of explosive devices, shootings, mortar bombs and molotov cocktail bombs.

The changing centre of gravity of terror attacks. What are the implications of the general diffusion of the pattern of terror on the role of fear in influencing behaviour? One insight that can be gained relates to observing the change in the centre of gravity of the terror attacks. A movement in the centre of gravity would seem to indicate an overall randomness in the pattern of terror and, by implication, an increase in the potency of the fear element.

Figure 4 plots the geographical centres of terror attacks for each year. The square symbols represent the geographical centre of recorded attacks for a given year and the triangles indicate the weighted average for each year. For the weighting factor, we use the number of casualties. The weighted mean centre of a cluster of points is calculated as follows

$$\bar{x}_{wc} = \frac{\sum f_i x_i}{\sum f_i}$$

$$\bar{y}_{wc} = \frac{\sum f_i y_i}{\sum f_i}$$

where, wc = weighted centre; and f = frequency (or weighting factor).

The geographical centre of the terror attacks in both cases is the city centre and the vicinity of the seam line. The movement of the mean centre over time is in a general north–south direction. The area with the highest number of casualties per area unit is the city centre which is relatively low in residential areas but still very crowded.

While the weighted mean centre indicates the city centre as the place that suffered most of the injuries and fatalities over the years, another way to compute terror intensity is by analysing the ‘neighbourhood effect’ of terror incidence. This does not look at the event in isolation but relates it to other incidents in the (user-defined) vicinity. The neighbourhood statistics GIS function computes an output raster where the value at each location is a function of the input cells in some specified neighbourhood of the location. For each cell in the input raster, the neighbourhood function computes a statistic based on the value of the processing cell and the value of the cells within a specified neighbourhood and then sends this value to the corresponding cell location on the output raster. We computed the sum of the casualties in a radius of 500 metres from each terror point (Figure 5). We note that the city centre and seam line areas suffered the most with nearly 200–400 casualties per square km. Other significant areas were peripheral neighbourhoods such as Neve Ya’akov, French Hill and Gilo

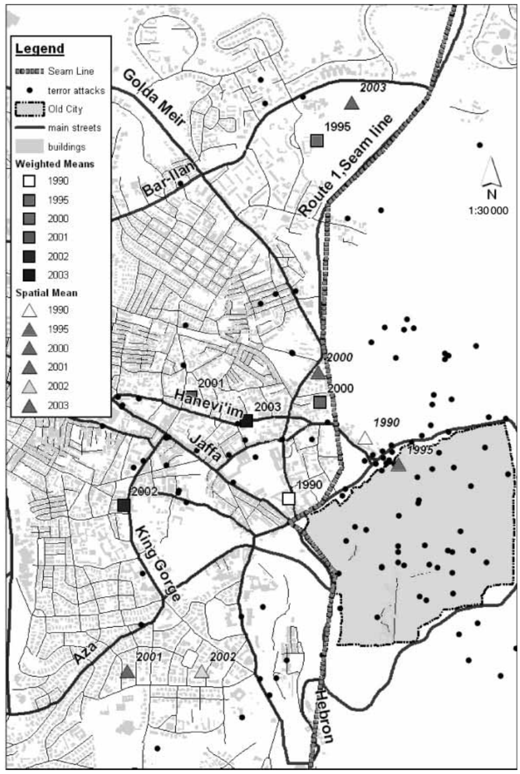

Figure 4. The centre of gravity of terror, 1999–2003: spatial and weighted means.

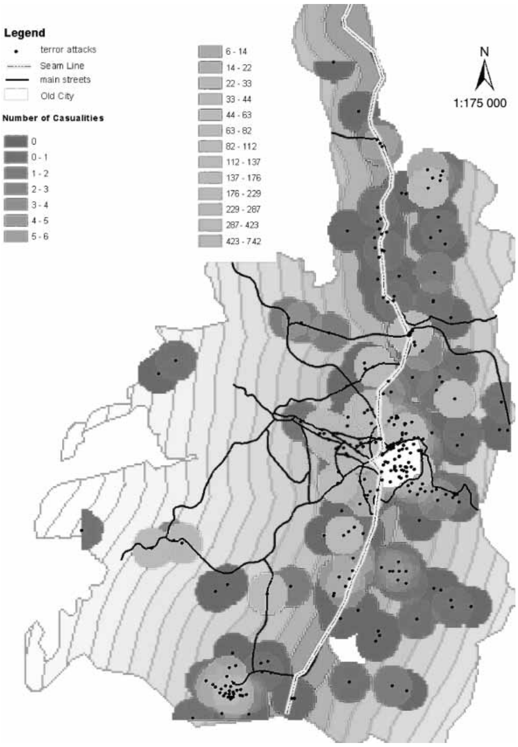

Figure 5. The ‘neighbourhood effect’ of terror: number of casualties within a 500 metre radius.

which suffered up to 100 casualties per square km. Together, these patterns show gross patterns of ‘neighbourhoods’ rather than individual points where fear is likely to be a prevailing factor.

The increasing randomisation of terror. Increasing spatial randomisation of terror over time is another indication of the existence of a fear factor. To this end, we investigate the issue of local clustering/dispersion using the local G-statistic (Getis and Ord, 1992). The $G(d)$ statistic is a multiplicative measure of overall spatial association of values which fall within a given distance of each other. A $G(d)$ value higher than the expected $G(d)$ indicates a clustering of high values and a $G(d)$ lower than the expected $G(d)$ indicates a clustering of low values. The variance of $G(d)$ and a Z-value are calculated to determine the level of significance (Chen and Getis, 1998).

For a chosen critical distance d, $G(d)$ is

$$G(d) = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} \omega_{ij}(d) x_i x_j}{\sum_{i=1}^{N}\sum_{j=1}^{N} x_i x_j}, \quad j \neq i$$

where, x_i is the value of the ith point and $\omega_{ij}(d)$ is the weight for point i and j for distance d. This tool calculates the high/low G value (observed and expected) and the associated Z-score for a given input feature class. The Z-score value indicates whether the G value could be the result of random chance or is statistically significant.

We input the data of total terror attacks per statistical area, for each year in order to calculate the G-statistic (Table 2). The general trend over the years is towards an increasingly random pattern. Values of G decrease over time, indicating less local clustering. The attacks over the period 1995–2000 occurred mainly in the vicinity of the Old City, while for 2000–04 the western part of the city and the peripheral neighbourhoods came under attack as well. Thus as terror events proceed over time to cover wider areas and become more random, we can surmise that this is likely to heighten the fear element embodied in these incidents.[9]

Type of terror attack and effect on house prices. In order to establish a connection between the distribution of terror attacks and that of house prices, we need to create a continuous surface of house prices and overlay on this data layer, the surface of terror incidents created earlier. Using the input point locations that we have for house prices 1999–2004, we

Table 2. Spatial randomness, 1990–2003

Year	Observed G	Z-score
1990	0.000491	4.888852
1995	0.001463	0.000330
2000	0.000472	2.870340
2001	0.000379	1.275824
2002	0.000345	0.400215
2003	0.000365	0.451158

Note: Expected G = 0.000330.

can interpolate predicted values for the whole surface using the Kriging technique.[10] This is based on the notion that the distance or direction between sample points shows spatial correlation that helps to describe the surface. The assumption is that nearby dwelling price points have similar values. Kriging builds an incremental surface based on ever-increasing radii until a homogeneous level in the distribution of prices is achieved.

The result is an interpolated grid of the dwelling prices. Figure 6 shows a 3D version of the difference in dwelling prices 2000–04 over background buffers from the seam line. The terror attacks are the black points. The darker zones are the areas where prices were lower in 2004. These are the peripheral neighbourhoods, which suffered most of the terror attacks. Viewing in 3D provides insights not readily apparent from a planimetric map of the same data. The 'height' in the 3D figure represents the Z-values of the difference in house (purchasing) prices between the years 2000–04. The steep 'mountains' are the peripheral neighbourhoods while the valleys represent those areas where house prices have fallen less dramatically.

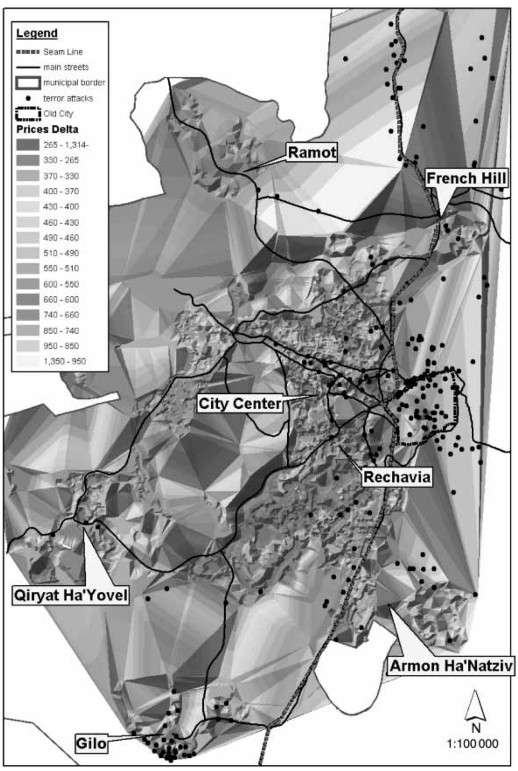

Figure 6. Three-dimensional representation of differences in dwelling prices, 2000–04.

We observe the relationship between the type of terror attack and the change in housing prices using the grid of the change (delta) in interpolated house prices, 2000–04. To do this, we utilise the zonal overlay GIS function which takes a value raster as input and for each cell and calculates a function using the value for that cell and all cells belonging to the same zone. Zonal functions quantify the characteristics of the geometry of the input zones. The result displayed in Table 3 shows the effect of different types of terror attack on average dwelling purchase prices (per square metre). As can be seen, shooting and mortar bombs have the largest effect on prices. This can be interpreted as further support for the fear hypotheses. While these forms of violence may not be the most intense, they are the most sporadic and can cover extensive areas. This could account for the significant drop in prices in peripheral neighbourhoods such as Gilo that suffered low-intensity shooting attacks for a protracted period of time.

5.2 *Analytical Findings*

In this section, we estimate some of the structural factors influencing behaviour in the Jerusalem housing market. More specifically,

Table 3. Distribution of mean dwelling price decline, by terror type

Terror type	Percentage mean price decline (per square metre)	Standard deviation
Shooting	−25.71	7.17
Mortar bomb	−25.65	2.20
Molotov cocktail	−25.45	6.39
Stabbing	−22.06	6.87
Grenade	−21.78	5.64
Explosive device	−21.41	7.44
Physical assault	−21.11	8.14
Arson	−15.32	8.32

we attempt to isolate the effect of terror alongside that of structural and neighbourhood characteristics in determining house prices.[11] As outlined earlier, we pay special attention to the role of spatial dependence in the data and estimate a spatial lag regression that takes account of the continuous nature of the units of analysis (Statistical Areas).

Our LHS variable is the log price of housing (per square metre) in both the purchasing and rental markets.[12] The former market is taken to represent the arena for longer-term strategic behaviour and to be less influenced by fear. The latter market is assumed to reflect shorter-term behaviour where personal utility is more susceptible to feelings of fear and anxiety. In the first instance, we estimate cross-section OLS models for the years 2000 and 2004 that span the period of the second Arab *intifada* (uprising).

From Table 4, it becomes immediately apparent that the magnitude of terror events (number of incidents) has an inverse relationship with house prices and that this effect is more significant in the rental market than in the purchasing market. However, it should be noted that in each market the size of the coefficients diminishes over time, perhaps suggesting an accommodation of sorts with the existence of terror events. In contrast, the intensity of terror is in the main insignificant in both markets.[13] In addition, the distance from the seam line displays the expected inverse relationship on house prices, although this is also not significant.

The variables representing both structural (housing conditions) and neighbourhood (population density) attributes are both directly related to house prices. The coefficients are larger and more significant for purchasing than rentals, as could be expected. Overall, the explanatory power of all the models is weak suggesting some underspecification. In addition, the Moran's I diagnostic test for spatial dependence is negative and significant for all models, suggesting global spatial dependence between the SAs.[14] The Lagrange multiplier tests indicate that a spatial lag model is more suitable than a spatial error model for dealing with the problem of spatial dependence.

The results of the spatial lag model are reported in Table 5. We use the IV (instrument variable) estimation procedure in SpaceStat. This is a robust alternative to using the more common maximum likelihood estimation and suitable for small datasets and non-normally distributed errors. The IV procedure includes the spatially lagged house prices as an explanatory variable (ρWY) and creates spatially lagged independent variables as instruments. As earlier, all spatial weighting is done using a matrix based on distances between the centroids of the SAs.

Overall, the inclusion of the autoregressive parameter certainly improves the explanatory power of the model. As in the OLS model, terror (incidence) has a negative effect on house prices that is more significant for rentals than for purchases. Housing stock conditions and neighbourhood characteristics are in the main directly related to house prices. As expected, these are more significant for purchasing prices than for rental prices. In addition, they tend to decline in strength over time perhaps suggesting a cumulative effect indirectly related to the negative impact of terror. The most surprising factor, however, is the significant inverse relationship that neighbouring prices have on house prices. This is more significant for rentals than for purchases and the strength of this relationship reduces marginally between 2000 and 2004. We would expect a positive effect on house price exerted by prices in adjacent SAs, but our results suggest the opposite. A technical explanation of this effect is that house prices in neighbouring SAs are picking up the negative effect of terror attacks in these areas. The negative spatial lag in house prices is simply a reflection of the (non-tested) negative spatial lag in terror incidence. A more intrinsic explanation may be grounded in the disjointed nature of the Jerusalem housing market. Much anecdotal evidence suggests that the Jerusalem housing market is comprised of a collection of adjacent but highly differentiated neighbourhoods with major price discontinuities between them (*Haaretz*, 2007; *Makor Rishon*, 2007). This mosaic lacks any form of social or economic continuum, with wealthy

Table 4. Factors influencing house prices: OLS results (dependent variable: log price per square metre)

	Purchase prices				Rental prices			
Variables	2000		2004		2000		2004	
Constant	1.946***		2.115***		0.562***		0.538***	
Terror magnitude (log)	−1.967**		−0.990**		−0.856***		−0.336***	
Terror intensity (log)	0.554		0.256**		0.227		0.080**	
Distance from the seam line (log)	−0.093		−0.119		−0.044		−0.028	
Population density	0.031***		0.021***		0.007***		0.004**	
Housing conditions	0.653***		0.721***		0.127***		0.160***	
Adjusted R^2	0.177		0.213		0.172		0.203	
Spatial dependence								
	MI/DF	Value	MI/DF	Value	MI/DF	Value	MI/DF	Value
Moran's I	−0.061***	−22.40	−0.019***	−5.956	−0.095***	−35.832	−0.018***	−5.572
Lagrange multiplier (error)	59.024		5.930		143.029		5.352	
Lagrange multiplier (lag)	60.162		22.384		113.627		21.533	

Notes: Prices per square metre are real prices—i.e. adjusted by the consumer price index.
**significant at the $p < 0.05$ level; ***significant at the $p < 0.001$ level.

Table 5. Spatial lag model for factors influencing house prices (dependent variable: log price per square metre)

	Purchase prices		Rental prices	
Variables	2000	2004	2000	2004
Constant	3.8993***	3.2024***	1.1656***	0.8199***
LAG prices (log)[a]	−0.0003960**	−0.0002537**	−0.0006088***	−0.0002691***
Terror incidence (log)	−1.5633**	−0.5104**	−0.6886***	−0.1953***
Population density	0.01987**	0.01228**	0.004155**	0.004**
Housing conditions	0.52835***	0.69140***	0.078621**	0.002187
Adjusted R^2	0.3879	0.3052	0.5028	0.2870

[a]Multiplied by the average distance of the weight matrix – 4700 metres.

Notes: Prices per square metre are real prices—i.e. adjusted by the consumer price index.

**significant at the $p < 0.05$ level; ***significant at the $p < 0.001$ level.

neighbourhoods located next to deprived areas. While more substantive work needs to be done to support this claim, it does seem to reflect the development path of many of the city's neighbourhoods.

6. Conclusions and Policy Implications

This paper has highlighted the role of fear in influencing both individual human behaviour and aggregate urban patterns of economic activity. We find terror to be a potent force in influencing behaviour irrespective of scale of analysis. The empirics presented here are not sufficient to provide conclusive answers to the question of the impact of terror on urban development. The time-frame considered is too short and the comparative static analysis presented insufficient for what is essentially a question of dynamics and cumulative effects. These issues remain a challenge for future work. However, our more limited findings do lead to some concrete policy prescriptions related to the urban economic development of Jerusalem. These are considered later in this section.

This study presents some empirical basis for the hypothesis claiming that the disutility of fear changes behaviour patterns. Using GIS tools, our findings show that the centre of gravity of terror events has moved over the period studied, the spatial randomness of terror attacks has increased and those forms of terror most related to unpredictability have had the greatest impact on house prices. Taken together, these results would seem to provide implicit evidence of the growing potency of the fear element in housing market behaviour in Jerusalem. More explicit evidence is provided further in our formal modelling of the factors that have influenced house prices over the period 2000–04. We find terror incidence to have a significant and negative effect on house prices in the city, more so in the purchasing than the rental market. In the context of the fear hypothesis, we interpret this finding as showing that fear is more an issue in short-term than in long-term behaviour.

In terms of municipal policy significance, we can point to three implications arising from these findings. First, we find that terror intensity (measured by casualties and damage) has a smaller effect on prices than terror incidence (measured by the number of attacks). This result supports the case for preferential property tax zoning (or tax rebates) for areas with many attacks rather than for areas with many casualties. The public conception of 'hard-hit' terror areas are those that have suffered a few high-profile attacks, such as suicide bombings. Our findings seem to suggest that these high-intensity forms of terror have less of an effect on house prices than lower-profile incidents such as shootings.

Secondly, the results presented earlier reiterate the fact that terror has more significant effect on the rental than on the purchasing market.

In view of the importance of the rental market in Jerusalem, with its large student population and constant stream of long-term foreign visitors, this would seem to point to the case for subsidising rentals (rent rebates) on the demand side and tax breaks on rental gains on the supply side. Of course, interventions such as these are not solely a municipal issue and some are the province of central government.

Finally, despite the decline in house prices over the period studied, Jerusalem has fared no worse than the rest of the country and marginally better than some other large cities, all this despite being a focus for terror attacks. This relative price stability in the purchasing market can be used as a marketing tool by the city which has an overt policy of attracting foreign property investment.

Notes

1. In a similar spirit, Eckstein and Tsiddon (2004) consider a 'stress' factor as capable of modifying human behaviour in the face of terror. The difference between stress and fear is that the former results in the loss of human capital while the latter generates personal disutility.
2. We use the generic term 'house prices' or 'dwelling prices' to refer to both purchasing and rental prices.
3. We experimented with alternative weighting schemes such as the common border weighting, where element $\omega_{ij} = 1$, units i and j share a common border and $\omega_{ij} = 0$ is otherwise (Cliff and Ord, 1981), inverse distance weighting, i.e. $\omega_{ij} = 1/d_{ij}$ and exponential distance decay weighting, i.e. $\omega_{ij} = \exp(-d_{ij})$ (Dubin, 1998; Fik *et al.*, 2003). The most consistent results were yielded by centroid distances.
4. As we only test for the one-time effect of terror events and not their cumulative effects, we do not consider endogeneity an issue. However, it should be noted that a dynamic analysis would raise such an issue, as house prices could also be a function of earlier rounds of terror. We test for serial correlation via a residuals regression of purchasing and rental prices in 2004, on the same prices in 2000. The resulting coefficients are positive and highly significant ($\beta = 0.713$, $p < 0.001$ and $\beta = 0.553$, $p < 0.001$ respectively). In addition, regressing terror events in 2004 on terror events in 2000 also yields a significant result ($\beta = 1.096$, $p < 0.001$). Together, these tests are a cursory indication of the persistence of terror. However, they are not a substitute for substantive dynamic analysis that directly considers the endogeneity induced by cumulative events.
5. Strictly speaking, data refer to assessed house prices as of end of December 1999 and 2003. These are reflected in asking prices in 2000 and 2004. This spans the whole time-period of the second Arab *intifada* (uprising) in Jerusalem. We also provide historical benchmark data for 1990 and 1995 for some of the descriptive analysis.
6. The standard size categories are 2 rooms (50–75 square metres), 3 rooms (75–90 square metres), 4 rooms (90–110 square metres) and 5 rooms (110–135 square metres). Within each SA, the distribution of dwellings by size categories was normalised to reflect the average cost of housing per square metre (P_i) as follows

$$P_i = (P_2 * 65\text{m} + P_3 * 80\text{m} + P_4 * 100\text{m} + P_5 * 125\text{m})/370\text{m}$$

7. Other sources of data—for example, the ICT database (International Policy Institute for Counter Terrorism (used by Eckstein and Tsiddon, 2004; Eldor and Melnick, 2004; and Savitch, 2005) and the NSCC data (National Security Studies Centre at Haifa University (used by Parhan *et al.*, 2005)—report much lower numbers of incidents. These rely on media-reported events, police and security forces press releases and the Israel Defence Forces archive.
8. The combined total terror activity index (incidence and damage) was calculated as

$$\text{total incidence}^{0.8} * \text{total damage}^{0.2}$$

No significant statistical correlation between these two variables was observed; $r_{1999} = 0.102$ ($p < 0.333$) and $r_{2004} = 0.117$ ($p < 0.266$).
9. It should be noted that the G-statistic is used here as an aggregate measure for city-wide clustering/dispersion and as such is sensitive to scale. However, we have no grounds for assuming that we are overstating patterns of dispersal and that in larger cities, the patterns would reflect greater clustering. Rather, larger city size is likely further to dilute any pattern of clustering and exacerbate the pattern of randomisation.
10. We experimented with other interpolation methods such as spline smoothing and

constructing kernel densities (Bao and Wan, 2004). The best results were obtained using Kriging. The general interpolation formula is formed as a weighted sum of the data

$$\hat{Z}(s_0) = \sum_{i=1}^{N} \lambda_i z(s_i)$$

where, $\hat{Z}(s_0)$ is the measured value at the i location; λ_i is an unknown weight for the measured value at the i location; s_i is the prediction location; and N is the number of measured values.

11. Other attempts to isolate the effect of terror on Israel's macro economy (Eckstein and Tsiddon, 2004) and financial markets (Eldor and Melnick, 2004) may be similar in intent but use very different estimating procedures.
12. A Ramsey test, that looks for non-linear combinations in the predictor variables (Ramsey, 1969) does not suggest that this specification is inappropriate.
13. Note that an opposite effect exists for the impact of terror on financial markets (Eldor and Melnick, 2004)
14. Morans's I is defined as follows

$$\mathrm{MI} = N/S_0 \sum_i \sum_j w_{ij} * (x_i - \mu) * (x_j - \mu) \Big/ \sum_i (x_i - \mu)^2$$

where, $S_0 = \sum_i \sum_j w_{ij}$ (constant weight); N is the number of observations; w_{ij} are the spatial weights based on aerial distances between centroids of the SAs; and x_i and x_j are observations i, j with average value μ.

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