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The Effect of Terrorism on Housing Rental Prices: Evidence from Jerusalem

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השפעת הטרור על מחירי השכירות בירושלים

נדב בן יצחק

מחקר זה בוחן את השפעתם של פיגועי טרור על מחירי השכירות לטווח ארוך. במהלך ספטמבר 2015 פרץ גל טרור חדש ונרחב בישראל. במרכזו של גל פיגועים זה עמדה העיר ירושלים, שנפגעה יותר מכל עיר אחרת. מחקר זה מתייחס לגל זה כשוק אקסוגני לשוק השכירות בירושלים, ובוחן את השפעותיו על מחירי השכירות בהשוואה לתל-אביב ובתוך ירושלים עצמה.

מן המחקר עולה כי, בהשוואה לתל-אביב, מחירי השכירות בירושלים צנחו מיד לאחר תחילתו של גל הטרור, והגיעו לירידה של בין 2% ל-3% תוך שנה. מניתוח פנימי של ירושלים עולה כי כל קירבה של קילומטר נוסף למוקדי איום, כגון הקו הירוק ושער שכם, הביאו לירידה של בין 0.3% ל-0.4% במחירי השכירות.

המחקר הוגש גם כעבודת MA במחלקה לכלכלה של האוניברסיטה העברית, בהנחיית פרופ׳ אסף זוסמן.

Abstract

This research investigates the effect of terrorism on housing rental prices. September 2015 was the beginning of a new large-scale terror wave in Israel, hitting Jerusalem more than any other major city. Considering this terror wave as an exogenous shock to the housing rental market in Jerusalem, this study analyzes its effect on rental prices compared to Tel-Aviv and within Jerusalem. Immediately after the beginning of the terror wave, rental prices in Jerusalem declined, compared to Tel-Aviv, reaching a 2%-3% decrease within a year. Within Jerusalem, the results indicate that proximity of an additional one kilometer to suspected origins of terror incidents, such as the Green Line and Damascus Gate, resulted in a 0.3%-0.4% decline in rental prices.

1 Introduction

September 2015 marked an escalation of violence in the Israeli-Palestinian conflict, partly as a result of the tensions on the Temple Mount. This period has become known by names such as the "Knife Intifada", due to the large proportion of stabbing attacks instigated by young Palestinians and Arab-Israelis against Israeli citizens and security forces.

The following two years saw an increase in Israeli casualties, reaching over 60 deaths and 186 stabbings by October 2017.[1] This period of violence is the most severe in the past seven years in terms of Israeli casualties. Combined with the new nature of attacks, being mainly "lone wolf" stabbings, this wave of terror is widely regarded as a surge of hostility and a source of fear in the streets (see Israel Security Agency, 2015a; 2015b; 2016). While attacks have occurred in many areas across the country, Jerusalem has been the most severely affected out of all the major Israeli cities. At its peak, the city has seen 13 terror attacks, with 38 casualties, in one month.

As the threat of terror attacks rises in major European and American cities in recent years, the question of its multifarious effects on countries and cities becomes increasingly important. Trying to estimate these effects would help to better understand how terrorism changes public opinion, individuals' decisions and more. The aggregation of public response to fear can be quantified by market prices. In that context, housing prices can be a good indicator of how fear of terrorism affects the demand for residence in cities. Therefore, it is important to see whether we can identify a decline in prices that can be associated with terror incidents. Such a finding would quantify how terror affects the demand for housing through the agency of fear.

This study investigates whether the escalation of terror and violence in Jerusalem had an effect on housing rental prices. To execute this research, I assembled an extensive dataset of house rental listings in Jerusalem and Tel-Aviv from 2013 to 2017, alongside a dataset of terror incident locations. My strategy of causal effect identification is based on the unanticipated nature of this terror wave and on spatial variation. Therefore, I regard this terror wave as a natural experiment. I use a difference-in-differences approach, comparing pre- and post-periods of violence escalation between Jerusalem and Tel-Aviv. I also a use a resembling technique to identify intra-city causal effects in Jerusalem, exploiting spatial differences of listings regarding proximity to geographical areas of threat. I define these areas of threat as suspected origins of potential terror incidents, such as the Green Line (1949 Armistice border) and Damascus Gate.

My analysis aims to address two questions concerning the effects of terror-related violence on housing rental prices. The first is: to what extent, if any, did the discussed

[1] As reported by the Israeli Ministry of Foreign Affairs (see www.goo.gl/tCZrfm, accessed November 1, 2017). For detailed information of attacks and casualties see the Israeli Prime Minister's Office website (www.goo.gl/Qh9uts , accessed November 1, 2017), and the Meir Amit Intelligence and Terrorism Information Center (ITIC) website (www.goo.gl/Nv2TL5, accessed November 1, 2017).

terror wave affect housing rental prices in Jerusalem? The second is: are there spatial attributes associated with enhanced threat during this period that affected rental housing prices?

I found that, compared to Tel-Aviv, rental housing prices in Jerusalem declined immediately after the beginning of the terror wave, reaching a 2%-3% decline within a year. For the intra-city analysis of Jerusalem I found that proximity of an additional one kilometer to areas of threat results in a decline of about 0.3%-0.4% in rental prices, though these results are less statistically robust.

My findings can be interpreted with a hedonic model, following Rosen (1974) and Roback (1982). The model suggests that an asset price is determined by a set of attributes, such as size, number of rooms and location. Gyourko, Kahn, and Tracy (1999) followed them and formulated a model with utility-maximizing workers, profit-maximizing firms, and cities with given amenities. In this model, wages and rents adjust in equilibrium, so that workers and firms are indifferent between cities. The model predicts that better city amenities result in higher rents, and any worsening of an amenity will result in the opposite.

Under the assumption that the terror wave was unanticipated, I can use this framework to analyze price dynamics in Jerusalem. A large-scale terror wave, hitting Jerusalem more than any other major city, should have an effect on how the public perceives the level of risk involved in living in Jerusalem. As a result, Jerusalem would be seen as riskier compared to less severely hit cities, and I can interpret these incidents as the worsening of an amenity in Jerusalem. Following this idea, we would expect a change in the rental prices equilibrium, driving rental prices in Jerusalem downward compared to other cities.

There has been ample research in the economic literature concerning the causal effects of terrorism and national conflicts. Such works include the effect on financial assets (see, among others, Willard, Guinnane, and Rosen, 1996; Abadie and Gardeazabal, 2003; Brown et al., 2004; Drakos, 2004; Eldor and Melnick, 2004; Zussman and Zussman, 2006; Guidolin and La Ferrara, 2007; Arin, Ciferri, and Spagnolo, 2008; Zussman, Zussman, and Nielsen, 2008; Berrebi and Klor, 2010; Kollias, Papadamou, and Stagiannis, 2011).

Other research focuses on the effect of terrorism and national conflicts on political opinions and voting patterns (see, for example, Berrebi and Klor, 2008; Montalvo, 2011; Getmansky and Zeitzoff, 2014), or on tourism (such as Enders and Sandler, 1991; Fleischer and Buccola, 2002; Araña and León, 2008).

From the urban economic perspective, works focus on a wide range of potential effects caused by terrorism. Glaeser and Shapiro (2002) investigated the effect of terrorism on urban form in the United States, while Rossi-Hansberg (2004) developed a framework to analyze the effect of terrorist attacks on the internal structure of cities, and suggested that terror incidents have only a temporary effect; Abadie and Dermisi (2008) examined the effect of the 9/11 attacks on vacancy rates in the office real estate sphere and found an increase in vacancy rates in Chicago landmark buildings; Besley and Mueller (2012) investigated the effect of political violence on house prices in Northern Ireland and Manelici (2017) found that after the 2005 attack on the London Tube, house prices closer to major transit hubs fell.

Four studies in particular are the most closely related to this research. Hazam and Felsenstein (2007) examined the housing market in Jerusalem during the years of the Second Intifada (1999 - 2004). They found that rental prices responded more severely to terror, compared to transaction prices, while the largest effect was imposed by terror incident types most associated with randomness.

Arbel et al. (2010) concentrated on the Gilo neighborhood in Jerusalem during the period of the Second Intifada. During that time, Gilo suffered from sporadic gunfire from a neighboring Palestinian village. Using a VAR estimation, they found a 12% value reduction for houses in Gilo. Furthermore, with a difference-in-differences approach they found a 10% persisting decline in front-line houses facing the Palestinian village, compared to non front-line houses in the same neighborhood.

An additional important paper is by Gautier, Siegmann, and Van Vuuren (2009). Following the murder of Theo van Gogh in 2004 in Amsterdam, they investigated listed prices across the city. Using a difference-in-differences approach, their results show that neighborhoods with a large presence of an ethnic minority from a Muslim country experienced a decrease of about 3% in listed prices, compared to other neighborhoods.

Finally, another research related to this paper was done by Elster, Zussman, and Zussman (2017). This work explores the effect of the massive rocket attack by Hezbollah against northern Israel during the Second Lebanon War in 2006. They identify this massive attack as a surprise, and compare severely hit localities to other northern Israeli localities. Using hedonic and repeat sales approaches, their results present a 6%-7% decline in house prices in these localities. Similar results are presented for rental prices.

This work contributes to the existing literature in two major ways. First, my extensive dataset of listings for house rentals allows a more thorough investigation of the effect of terrorism on rental prices. In that aspect, this study uses a much more detailed sample of housing rentals than is traditionally used in the literature. Secondly, and more specifically, I provide evidence for the causal effect of the 2015 terror wave on market prices in Israel.

The rest of this research proceeds as follows: Section 2 describes the datasets on terror incidents and housing rental listings, and analyzes the spatial determinants for a terror incident in Jerusalem; Section 3 presents my methodology; Section 4 presents and discusses the estimation results, and Section 5 concludes and summarizes.

2 Data

This research uses an extensive dataset of rental listings, as well as data on terror attacks that occurred in Jerusalem. In addition, this research uses Geographic Information System (GIS) layers of statistical areas from the GIS Center at the Hebrew University of Jerusalem. The statistical areas were defined by the Israeli Central Bureau of Statistics (CBS) in 2008, for the cities of both Tel-Aviv and Jerusalem. A statistical area is defined as a continuous unit of land, where between 3,000 and 5,000 residents are housed.

2.1 Terror incidents

I gathered data on terror attacks in Jerusalem from the terror wave period. This data relies on media reports, casualty reports in the Israel Prime Minister's Office and surveys conducted by the Meir Amit Intelligence and Terrorism Information Center (ITIC). It includes basic information about the time of the event, the estimated location coordinates and the number of casualties (injured and killed). I did not include the attacks with no casualties that occurred in Jerusalem, as they are not always accurately reported in the media. I added information on attacks in Tel-Aviv as a means of comparison between the two most populous cities in Israel.

Figures 1 and 2 plot this difference in the number of attacks with casualties and number of casualties, respectively, over time. Tel-Aviv suffered 5 terror attacks with casualties, with over 50 casualties in total, from September 2015 to June 2017. Over the same period, Jerusalem suffered over 35 attacks, with many more unsuccessful attempts, reaching 150 casualties in total. These facts are a possible source of evidence for the way the risk of living in Jerusalem was perceived. Furthermore, they help to establish the idea of using Tel-Aviv as a control group for Jerusalem.

In addition to the different intensity of "treatment" between the two cities, I examined possible factors of spatial variation inside Jerusalem that reflect vulnerability to terror attacks. Figure 3 suggests that proximity to the Green Line and the Old City of Jerusalem can increase vulnerability to terror-related violence. The Green Line separates the west side and the east side of the city, roughly drawing a line between Jewish populated neighbourhoods and Arab populated neighbourhoods, accordingly. The Old City in general, and, specifically, Damascus Gate (which allows entrance to the Old City through the Muslim Quarter), is widely perceived by the public as one of the roots for political violence. With the Temple Mount located inside it, the Old City experienced the highest intensity of violent events throughout the terror wave period, with over 20 terror attacks and dozens of casualties.

I further investigate the geographical explanatory variables for the occurrence and intensity of terror attacks within Jerusalem. Table 1 uses the number of terror incidents in a statistical area as a dependent variable. There, columns (1) and (2) describe estimations for the west side of the Green Line only, while columns (3)-(5) include all statistical areas in Jerusalem. I did not include an additional estimation with a continuous distance from the Green Line explanatory variable for all observations. The reason for this is that, unlike Damascus Gate, I do not consider the Green Line itself to be a potential origin of terror incidents. The Green Line serves as a proxy for proximity to Arab neighbourhoods, located mainly east of the Green Line. For that reason, while distance from the Green Line should potentially reduce risk for neighbourhoods west of the Green Line, it should not have the same effect on eastern neighbourhoods, possibly even increasing the risk.

This table shows that the number of attacks per statistical area decreases for any additional kilometer from the Green Line or from Damascus Gate by 0.2-0.5, while the number increases by 0.1 for statistical areas east of the Green Line. Nevertheless, these coefficients are not statistically significant. An exception is column (5), where all statistical areas are included. There, the coefficient is negative and highly significant, representing a 0.1 decrease in the number of terror incidents for any additional kilometer from Damascus Gate.

Table 2 is estimated by a linear probability model, and uses a binary indicator for the occurrence of at least one terror incident in a statistical area as a dependent variable. This table shows that the probability of suffering at least one terror attack in a statistical area declines by 0.8%-2.5% for any additional kilometer from the Green line or from Damascus Gate, while the probability increases by 2%-3% east of the Green Line. These coefficients are, again, not statistically significant. Column (5) shows a statistically significant 3% reduction in probability for any additional kilometer from Damascus Gate.

These findings might suggest that the public perceived some parts of Jerusalem as areas where it is more likely to encounter a terror attack, thus making them more dangerous and less desirable for living. In turn, we would expect proximity to these areas to be a negative attribute that drove rental prices downward after the beginning of the terror wave.

2.2 Housing rental listings

The source of my dataset for housing rental listings is the Bank of Israel (BOI). The dataset is a sample of all online listings featured in all major Israeli listing websites, and comprises properties located in Jerusalem and in Tel-Aviv. This covers the majority of the online listing service market share in Israel.

The start of the sample period is January 2013, and its end is June 2017. Observations were sampled on a daily basis. Each observation describes a property for rent listing, and includes many physical attributes of the property and the building in which it is located. These attributes are: area in square meters, floor number, number of rooms, address and other features, as well as initial date of uploading the listing and dates of update (by editing or "bumping"). I geocoded the given addresses and transformed them into a set of coordinates for later distance computations and for attribution to statistical areas. Each property is identified by a unique ID number; therefore, some properties can be identified as recurring, when having new initial dates.

The price for each observation is the requested monthly rent. For that reason, I cannot know the real rental prices that were eventually negotiated on the signed contract between the tenant and the landlord. Even though negotiation is theoretically possible, I assume that since demand for rental housing is very high, the requested price is roughly the final price. If this assumption is not true, we would expect to have a systematic measurement error. In this case, the bias of the estimation depends on the direction of the measurement error. It would be reasonable to assume that the requested price is the upper bound for the actual price. Thus, if a measurement error does exist, then the actual prices are typically lower than the requested prices. This will imply that the estimated coefficients are upward biased. If the terror wave had a negative effect on rental prices, we would expect the estimation of the effect to be lower than its real magnitude.

The raw dataset contains 230,587 observations in Jerusalem and 356,466 observations in Tel-Aviv. These figures incorporate repeated occurrences of the same listing over time, listings with no accurate address, irregular attributes and missing attributes. After filtering those observations, the dataset contains 28,723 unique listings in Jerusalem and 59,260 unique listings in Tel-Aviv, for 20,732 and 47,794 unique properties, respectively. I define "unique listings" as the first appearance of each listing for that period. "Unique properties" is the number of unique property IDs. Keep in mind that I allowed properties to be re-listed in different periods (for cases such as when a property owner re-lists the property after the end of a contract), so the number of unique listings should be higher than the number of actual unique properties. In addition, I created a second dataset for Jerusalem, this time keeping all appearances of the same listing. This will be used in later analysis, in order to identify price changes within a specific listing over the same period. This dataset contains 92,318 observations.

Table 3 depicts all the property attributes used in this study, while Figure 4 shows concentrations of listings per statistical area. This figure represents how many unique listings were posted in each statistical area in Jerusalem for the entire sample period. It is clearly visible that most of the east side of Jerusalem is not observable through the dataset, most likely because residents of Arab ethnicity do not use the same online listing services as Jewish residents (most of them do not have a web page in Arabic). Other west side neighbourhoods with no presence in the dataset are, in most cases, ultra-Orthodox Jewish neighbourhoods, where residents typically do not own computers or have an Internet connection.

3 Empirical strategy

To identify the effect of the wave of terror on housing rental prices, I use a difference-in-differences technique. My identification relies on the assumption that this wave of terror was unanticipated, therefore making it an exogenous event and a natural experiment. Moreover, it relies on variations in the intensity of violent events. As shown in Section 2.1, Jerusalem suffered greatly during this wave, while the number of terror attacks in Tel-Aviv was much lower.

Theoretically, we might expect this fact to influence public perception of the risk involved in living in each city, and influence its expectations regarding future attacks. The difference-in-differences strategy compares pre- and post-"treatment" trends in prices between "treatment" and "control" groups. In this matter, I consider Tel-Aviv to be a low intensity treatment group, that would be used as a control for the high intensity treatment group that consists of observations located in Jerusalem.

Following Rosen (1974), my theoretical framework is a hedonic model. According to this, a property has many varying attributes, and its price is determined by the equation $P(Z) = P(z_1, z_2, ..., z_k)$, where Z is a property, and $z_1, ..., z_k$ are its attributes. Such attributes can be: size of property, number of rooms, neighborhood and building characteristics. We do not observe the value of each attribute, but do observe market prices for properties. Within this framework, an exogenous shock such as many terror incidents occurring in a city, or proximity to terror incidents, might be considered by the tenants market as a negative attribute that would drive rental prices downward. I use the following formulation as a general setup:

$$log(p_{ist}) = \alpha + \beta' X_i + \lambda_t + \delta_s + Treatment_s + \gamma \lambda_t * Treatment_s + \epsilon_{ist} \tag{1}$$

where p_{ist} is the asking monthly rental price for property i in statistical area s at time t, X_i is a vector of property attributes stated in the listing[2], λ_t is a year-month fixed effect, δ_s is a statistical area fixed effect, $Treatment_s$ is a dummy indicator for properties located in the high intensity treatment group (i.e., Jerusalem), and ϵ_{ist} is a residual term for property i in statistical area s at time t. γ is the coefficient of interest, expressing the monthly price change associated with treatment in Jerusalem. We would expect this coefficient to be negative, meaning renting in Jerusalem has become less desirable compared to Tel-Aviv, ceteris paribus, due to the large amount of terror attacks since the beginning of the terror wave.

A complementary analysis would be to investigate the intra-city price changes of Jerusalem. This analysis is aimed at examining the determinants of variations in price changes between different parts of the city. Based on the assumption that residents

[2] See full list of attributes used in Table 3.

update their expectations according to the locations of terror incidents, we would expect properties with proximity to perceived areas of threat to be considered more risky and less desirable to live in. I use the geographical determinants investigated in Tables 1 and 2 as intensity of treatment variables after the beginning of the terror wave. The inclusion of such variables rests on the assumption that the public does not necessarily respond only to immediate threats, such as terror incidents in their own neighborhood, but concludes that larger spatial factors, such as distance from Arab neighborhoods or Damascus Gate, can predict better whether they are putting themselves at a higher risk. Under this assumption, terror incidents tend to occur at a minimum travelling distance for the terrorist, and so neighborhoods at the same distance from the Green Line, for example, have a perceived equal chance of suffering from an attack. The formulation is as follows:

$$log(p_{ist}) = \alpha + \beta' X_i + \lambda_t + \delta_s + \theta Distance_i + \gamma Distance_i * Post_t + \epsilon_{ist} \qquad (2)$$

where, as before, p_{ist} is the asking monthly rental price for property i in statistical area s at time t, X_i is a vector of property attributes stated in the listing. λ_t is a year-month fixed effect, δ_s is a statistical area fixed effect, $Distance_i$ is the distance from spatial determinants of intensity of terror incidents, $Post_t$ is a dummy indicator that equals 1 when time t is later than the terror wave's start date (defined as mid September 2015), and ϵ_{ist} is a residual term for property i in statistical area s at time t. The coefficient of interest in this specification is γ, which represents the interaction between distance from risky locations and post-beginning of treatment. This coefficient embodies the monthly price change associated with distance from risky locations after the beginning of the terror wave. We would expect this coefficient to be positive, meaning distance from these locations after the start of the terror wave has become an important factor for potential tenants, and proximity to them is a negative attribute of property.

4 Main results

This section presents the estimation results using the equations in Section 3. I began by estimating specification (1), and moved on to focusing on specification (2) with modifications when needed.

Figure 5 compares the development of rental prices from 2013 to mid-2017 in Jerusalem and Tel-Aviv. The vertical line indicates August 2015, a month prior the beginning of the terror wave. This figure is evidence that rental prices in Jerusalem and Tel-Aviv had common trends before the rise of terror incidents. These trends deviate from each other almost instantly after that. The assumption of common trends is important in the implementation of the difference-in-differences method, and is crucial for the identification of causal effects.

Figure 6 illustrates the value of γ from the estimation of equation (1). August 2015 is, again, set as the month prior to the start of the terror wave, and is thus used as the basis for comparison. This figure shows that throughout the period of 2013 up to August 2015, the difference between Jerusalem and Tel-Aviv is negligible, while it is clearly evident after that. This figure is supplementary confirmation for the identification of a causal effect.

Table 4 shows the results from the estimation of equation (1). The time fixed effects were modified to year-quarter fixed effects. The third quarter of 2015 and its interaction with treatment were excluded; therefore, they are used as the basis for comparison.[3] Prior to the terror wave, there is no statistically significant difference between Jerusalem and Tel-Aviv. However, all coefficients after the start of the treatment period are negative and highly significant, suggesting that this period shifted the common trends of the two groups, reaching a 2%-3% decrease within a year from the beginning of the terror wave, and a 5% decrease by the second quarter of 2017.

Clearly, there could be alternative explanations for this. For instance, one can argue that other major national conflicts in prior years had affected the perception of safety in each city differently. This argument is dubious in my opinion. All major military operations in earlier years (Operation Cast Lead in 2008, Operation Pillar of Defense in 2012 and Operation Protective Edge in 2014) resulted in missiles fired at Israeli cities, but Jerusalem and Tel-Aviv were not among the cities targeted the most. It is possible that Jerusalem suffered from terror incidents more than Tel-Aviv prior to the terror wave, but the rental price trend in both cities did not seem to be changing before that.

Another drawback for the identification would be to find other significant changes, for example, regulatory, that affected only one of the cities. It is also possible that residents in one of the cities anticipated a new municipal regulation and updated their expectations accordingly. To the best of my knowledge there have been no new regulations imposed on the rental market specifically in Tel-Aviv or Jerusalem, nor are there immediate expectations for one.

I further investigated the effect of terror incidents on rental prices by focusing on Jerusalem, and examined whether such incidents affect prices differently across the city. I began by various estimations of Equation (2). The results are presented in Table 5. Columns (1) and (2) display results from observations west of the Green Line only, while columns (3)-(5) include the entire sample for Jerusalem: east and west. Estimations include statistical area and year-month fixed effects. August 2015 was excluded, setting it as the basis for comparison. When estimating for all of Jerusalem, I introduce a dummy variable for east side observations in columns (3) and (4), while allowing for a continuous distance from Damascus Gate for all observations in column (5). An estimation with a

[3] Estimations of the property attributes coefficients are available in Table A1 in the appendix.

continuous distance from the Green Line for all observations was, again, not included, for reasons mentioned above. These estimations use the unique listings dataset, as discussed in Section 2.2 (i.e., observations are first appearances only of each listing).

As discussed earlier, the use of spatial variables, such as distance from the Green Line, distance from Damascus Gate and location east of the Green Line, share the assumption that the public perception of threat is based on common spatial factors. For this reason, not only neighborhoods that suffered from terror incidents would be considered more risky, but so would all places with the same distance from areas of threat. Observations that share the same spatial quality would be equally less desirable after the beginning of the terror wave. I assume that Damascus Gate is widely considered this kind of area, while the Green Line serves as a proxy for distance from this kind of area.

The results presented suggest that the coefficients for distance variables get the expected positive sign. Therefore, to move away from these locations is a positive attribute after the start of the terror wave, and increases the desirability of property. An exception is the coefficient of the dummy variable for the east side of the Green Line, that was expected to be negative. However, none of the coefficients estimated here are statistically significant.

I investigated these explanatory variables more by altering the specification used above. For this purpose, I used a dataset with recurring observations of the same listing, as mentioned in Section 2.2. That is, I allowed listings in this dataset to be observable continuously over time. A typical listing will have at least a couple of separate observations, all showing the same offer and representing different days when the listing was still available. This dataset is larger than the one used before. It allows for analysis of price dynamics within each listing, like a modification of a price upwards or downwards. For this analysis, I altered Equation (2) and used the following:

$$log(p_{ist}) = \alpha + \lambda_t + \mu_i + \gamma Distance_i * Post_t + \epsilon_{ist} \tag{3}$$

where p_{ist}, λ_t, $Distance_i$, $Post_t$ and ϵ_{ist} are as defined above. μ_i is a property fixed effect. This specification excludes all physical and geographical attributes, since they are already included in the property fixed effect.

The results are presented in Table 6. They are similar to the ones presented in Table 5 in terms of the sign of the coefficients and magnitude. However, since specific property fixed effects were introduced, standard errors were reduced and, therefore, the results are highly statistically significant here. Estimations suggest that a distancing of one kilometer away from the Green Line or Damascus Gate results in a 0.3%-0.4% increase in price.

I performed a number of robustness checks for the estimations in Table 6. Since my identification in this specification relies on in-listing dynamics, it is crucial that a large enough amount of properties will be observed in the dataset at least once before the beginning of the terror wave, as well as at least once after that. A concern may arise if the numbers for this would be low, and, therefore, the identification would rely on a very small sample and would not be valid. These checks reveal the following: out of 4,310 unique properties in East Jerusalem, 654 were observed at least once before and once after the terror wave. Out of 16,422 unique properties in West Jerusalem, 2,072 were observed at least once before and once after the terror wave. In total, this sums up to 2,726 unique properties observed before and after the treatment, out of 20,732 unique properties in Jerusalem. I consider these figures to be high enough in order to validate the identification.

I next proceeded to another analysis of price dynamics within Jerusalem. Instead of assuming an equal effect on prices for all listings within the same distance from areas of threat, I investigated the effect of terror incidents in a statistical area using temporal variations. To conduct this, I marked observations as part of the treatment group if listings were uploaded in a given time window after a terror incident in their statistical area. The formulation for this analysis is as follows:

$$log(p_{ist}) = \alpha + \beta' X_i + \lambda_t + \delta_s + \gamma Treatment_{st} + \epsilon_{ist} \quad (4)$$

where $Treatment_{st}$ is a binary indicator that equals 1 when a terror incident occurred in statistical area s no later than given time window from time t. Here, γ is the coefficient of interest, signifying price changes in a statistical area as a response to a terror attack in it.

Table 7 presents results for the estimation of specification (4). The columns vary with the number of days after a terror incident to be considered still in the treatment period for a statistical area, ranging from 30 days to 180 days. While the coefficient's sign is as expected - a terror incident negatively affects rental prices nearby - it is not statistically significant in any given time window.

The most probable explanation for this is that the definition of the treatment group is strict, keeping very few observations in total compared to the control group. The numbers go from 30 observations in the treatment group for a 30 day window period, to 125 observations for a 180 day window period. There are numerous reasons for the small treatment group sample. First, the number of terror incidents is relatively small, and they are concentrated in only a few statistical areas. Only 14 statistical areas were affected out of 228 statistical areas in Jerusalem in total. Second, many of the affected statistical areas do not contain many listings, if at all. This is due to the fact that many affected statistical areas are not populated by residential properties, or are located outside of the scope of online listings. For this reason, these results are less indicative than the ones presented earlier.

I conducted robustness checks on these results. switching to a specification where the time windows refer to the occurrence of a terror incident within one and two kilometer radii. This specification includes more observations in the treatment group since it is not restricted to a specific statistical area. This specification is also more in line with the assumption that listings are affected by distance from areas of threat. The results in these checks are very similar in coefficient magnitude and statistical significance to the ones presented in Table 7.

The combination of the results presented in this section implies that the terror wave had an effect on rental prices in Jerusalem. The comparison between Jerusalem and Tel-Aviv at the beginning of this section suggests that Jerusalem was considered more risky as a whole, and, therefore, demand for properties declined after the beginning of the terror wave. This proposition is also in line with the theoretical framework of Gyourko. Kahn, and Tracy (1999). All in all, this comparison displays similar results to former works in this field, as presented in Section 1. While the results for the estimations within Jerusalem are less robust, they suggest that different parts of the city were affected differently. That is, proximity to areas of threat caused an additional decline in rental prices after the beginning of the terror wave. These findings imply that residents did not see terror incident locations as completely random, and responded accordingly by considering proximity to areas of threat as a negative attribute.

5 Conclusion

In this study I investigated the effect of terror on housing rental prices. I utilized a natural experiment in the form of an unanticipated, large-scale terror wave in Jerusalem. The research uses an extensive dataset of all online housing rental listings in Jerusalem and Tel-Aviv from 2013 to mid-2017. I relied on spatial and temporal variations of the rental listings and the terror incidents, and conducted a difference-in-differences method in order to compare price dynamics before and after the beginning of the terror wave. I began by comparing the two most populous cities in Israel: Jerusalem and Tel-Aviv. The former endured dozens of terror incidents during this period, while the latter considerably fewer. I proceeded by utilizing spatial and temporal variations within Jerusalem. Using distances from areas of threat, I explored differential effects on rental housing prices within the city.

I found that housing rental prices declined in Jerusalem, compared to Tel-Aviv, immediately after the start of the terror wave. This decline reached 2%-3% within a year from the beginning of the terror wave. When estimating the in-city specifications for Jerusalem, I found that proximity of an additional one kilometer to areas of threat results in a 0.3%-0.4% decline in price, though these findings are less robust to modifications.

The results suggest that Jerusalem was considered more risky as a whole, compared to Tel-Aviv. Thus, the intensity of terror incidents in Jerusalem was perceived by the public as a disamenity, and drove prices downwards. Within Jerusalem, the results imply that residents did not see the locations of terror incidents as completely random, and, therefore, proximity to areas of threat was regarded as a negative attribute that decreased rental prices.

Future research could investigate the long term effect of this wave of terror. It could also be interesting to compare the effects of the terror wave discussed in this paper on housing rental prices, with those of possible future conflicts.

Tables and figures

Table 1: Terror attacks targeting:

	Dependent variable:				
	Number of attacks per statistical area				
	West Jerusalem only		East and West Jerusalem		
	(1)	(2)	(3)	(4)	(5)
West x Dist(GL)	−0.047		−0.047		
	(0.070)		(0.091)		
West x Dist(DG)		−0.017		−0.017	
		(0.030)		(0.040)	
Dist(DG)					−0.095***
					(0.028)
East			0.130	0.131	
			(0.171)	(0.188)	
Observations	131	131	228	228	228
R^2	0.004	0.002	0.012	0.012	0.049

*p<0.1; **p<0.05; ***p<0.01

Notes: West is a dummy variable for west side of the Green Line. Dist is the shortest aerial distance of statistical area centroid to point of interest (measured in kilometers). East is a dummy variable for east side of the Green Line. GL refers to the Green Line. DG refers to Damascus Gate. Columns (1)-(2) describe estimations for west side of the Green Line only. Columns (3)-(5) describe estimations for all of Jerusalem. Estimated by OLS.
Sources: Statistical areas are from the GIS Center at the Hebrew University of Jerusalem. Terror attack locations are from media and governmental reports.

Table 2: Terror attacks targeting:

	Dependent variable:				
	Binary variable for at least one attack in a statistical area				
	West Jerusalem only		East and West Jerusalem		
	(1)	(2)	(3)	(4)	(5)
West x Dist(GL)	−0.025		−0.025		
	(0.019)		(0.024)		
West x Dist(DG)		−0.008		−0.008	
		(0.008)		(0.010)	
Dist(DG)					−0.029***
					(0.007)
East			0.022	0.027	
			(0.045)	(0.050)	
Observations	131	131	228	228	228
R^2	0.013	0.007	0.017	0.015	0.067

*p<0.1; **p<0.05; ***p<0.01

Notes: West is a dummy variable for west side of the Green Line. Dist is the shortest aerial distance of statistical area centroid to point of interest (measured in kilometers). East is a dummy variable for east side of the Green Line. GL refers to the Green Line. DG refers to Damascus Gate. Columns (1)-(2) describe estimations for west side of the Green Line only. Columns (3)-(5) describe estimations for all of Jerusalem. Estimated by linear probability model. *Sources*: Statistical areas are from the GIS Center at the Hebrew University of Jerusalem. Terror attack locations are from media and governmental reports.

Table 3: Descriptive statistics

	City	
	Jerusalem	Tel Aviv
Variable	N = 28,723	N = 59,260
Price	4137 (1372)	5282 (1991)
Cottage	0.064 (0.244)	0.028 (0.166)
Floors	3.438 (1.966)	3.917 (2.312)
Floor	1.768 (1.641)	2.164 (1.997)
Lift	0.172 (0.377)	0.305 (0.460)
0.5-1 Rooms	0.026 (0.158)	0.047 (0.212)
1.5-2 Rooms	0.257 (0.437)	0.301 (0.459)
2.5-3 Rooms	0.424 (0.494)	0.449 (0.497)
3.5-4 Rooms	0.229 (0.420)	0.164 (0.370)
4.5-5 Rooms	0.063 (0.243)	0.038 (0.192)
Square Meter	67.949 (24.507)	69.268 (24.274)
Yard	0.029 (0.166)	0.002 (0.043)
AC	0.221 (0.415)	0.485 (0.500)
Solar Water Heating	0.487 (0.500)	0.059 (0.235)
Parking	0.024 (0.154)	0.019 (0.137)
Accessibility	0.123 (0.328)	0.159 (0.366)
Balcony	0.284 (0.451)	0.221 (0.415)
Security Room	0.101 (0.301)	0.110 (0.313)

Notes: Price is requested monthly rent; Floors is number of floors in building; Floor is the floor the property is on; Square Meter is number of square meters in a property; all other variables are binary indicators for existence of attribute. Presenting means; Standard deviations in parentheses. *Sources*: Listings data is from Bank of Israel.

Table 4: Effect of terror incidents on housing rental prices: Jerusalem vs. Tel-Aviv

	Dependent variable:
	log(Rental Price)
2013 Q1 x Treatment	−0.003
	(0.010)
2013 Q2 x Treatment	−0.006
	(0.008)
2013 Q3 x Treatment	0.009
	(0.008)
2013 Q4 x Treatment	−0.005
	(0.010)
2014 Q1 x Treatment	0.015
	(0.010)
2014 Q2 x Treatment	−0.008
	(0.009)
2014 Q3 x Treatment	0.015*
	(0.008)
2014 Q4 x Treatment	0.003
	(0.009)
2015 Q1 x Treatment	−0.002
	(0.009)
2015 Q2 x Treatment	−0.004
	(0.008)
2015 Q4 x Treatment	−0.018**
	(0.008)
2016 Q1 x Treatment	−0.016**
	(0.008)
2016 Q2 x Treatment	−0.037***
	(0.008)
2016 Q3 x Treatment	−0.027***
	(0.007)
2016 Q4 x Treatment	−0.025***
	(0.008)
2017 Q1 x Treatment	−0.033***
	(0.008)
2017 Q2 x Treatment	−0.050***
	(0.008)
Year-Quarter FE	Yes
Statistical Area FE	Yes
Property FE	No
Property Attributes	Yes
Observations	87,844
R^2	0.677

*p<0.1; **p<0.05; ***p<0.01

Notes: Treatment is a binary indicator for treatment group (i.e., Jerusalem). Third quarter of 2015 is excluded, thus set as the basis for comparison. Property attributes are all attributes included in Table A1 in the appendix. Estimated by OLS. *Sources*: Listings data is from Bank of Israel.

Table 5: Effect of terror incidents within Jerusalem: hedonic approach

	Dependent variable:				
	log(Rental Price)				
	West Jerusalem only		East and West Jerusalem		
	(1)	(2)	(3)	(4)	(5)
West x Dist(GL) x Post	0.005*		0.004		
	(0.003)		(0.003)		
West x Dist(DG) x Post		0.001		0.001	
		(0.001)		(0.001)	
Dist(DG) x Post					0.001
					(0.001)
East x Post			0.010	0.010	
			(0.016)	(0.016)	
Year-Month FE	Yes	Yes	Yes	Yes	Yes
Statistical Area FE	Yes	Yes	Yes	Yes	Yes
Property FE	No	No	No	No	No
Property Attributes	Yes	Yes	Yes	Yes	Yes
Observations	22,371	22,371	28,673	28,673	28,673
R^2	0.670	0.670	0.674	0.674	0.674

*p<0.1; **p<0.05; ***p<0.01

Notes: West is a binary indicator for west side of the Green Line. Post is a binary indicator for time later than beginning of treatment period (i.e., mid-September 2015). East is a binary indicator for east side of the Green Line. Dist is the shortest aerial distance from observation to point of interest (measured in kilometers). GL refers to the Green Line. DG refers to Damascus Gate. Columns (1)-(2) describe estimations for west side of the green line only. Columns (3)-(5) describe estimations for all of Jerusalem. Controls for property attributes and fixed effects for statistical areas and year-month are included. Estimated by OLS. *Sources*: Listings data is from Bank of Israel.

Table 6: Effect of terror incidents within Jerusalem: properties fixed effects

	Dependent variable:				
	log(Rental Price)				
	West Jerusalem only		East and West Jerusalem		
	(1)	(2)	(3)	(4)	(5)
West x Dist(GL) x Post	0.004***		0.004***		
	(0.001)		(0.001)		
West x Dist(DG) x Post		0.003***		0.003***	
		(0.001)		(0.001)	
Dist(DG) x Post					0.003***
					(0.001)
East x Post			0.012***	0.017***	
			(0.003)	(0.003)	
Year-Month FE	Yes	Yes	Yes	Yes	Yes
Statistical Area FE	No	No	No	No	No
Property FE	Yes	Yes	Yes	Yes	Yes
Property Attributes	No	No	No	No	No
Observations	71,635	71,635	92,318	92,318	92,318
R^2	0.973	0.973	0.972	0.972	0.972

*p<0.1; **p<0.05; ***p<0.01

Notes: West is a binary indicator for west side of the Green Line. Post is a binary indicator for time later than beginning of treatment period (i.e., mid September 2015). East is a binary indicator for east side of the Green Line. Dist is the shortest aerial distance from observation to point of interest (measured in kilometers). GL refers to the Green Line. DG refers to Damascus Gate. Columns (1)-(2) describe estimations for west side of the green line only. Columns (3)-(5) describe estimations for all of Jerusalem. Property and year-month fixed effects are included. Estimated by OLS. *Sources*: Listings data is from Bank of Israel.

Table 7: Effect of terror incidents within Jerusalem: varying time windows

	Dependent variable:			
	log(Rental Price)			
	30 days	60 days	90 days	180 days
	(1)	(2)	(3)	(4)
Treatment	−0.015	−0.027	−0.014	−0.012
	(0.033)	(0.026)	(0.023)	(0.019)
Year-Month FE	Yes	Yes	Yes	Yes
Statistical Area FE	Yes	Yes	Yes	Yes
Property FE	No	No	No	No
Property Attributes	Yes	Yes	Yes	Yes
Observations	28,673	28,673	28,673	28,673
R^2	0.674	0.674	0.674	0.674

*p<0.1; **p<0.05; ***p<0.01

Notes: Treatment is a binary indicator that equals 1 when a terror incident occurred in a given time window prior to listing being uploaded. Columns (1)-(4) differ from each other with the number of given days. Controls for property attributes and fixed effects for statistical areas and year-month are included. Estimated by OLS. *Sources*: Listings data is from Bank of Israel.

Figure 1: Number of attacks with casualties

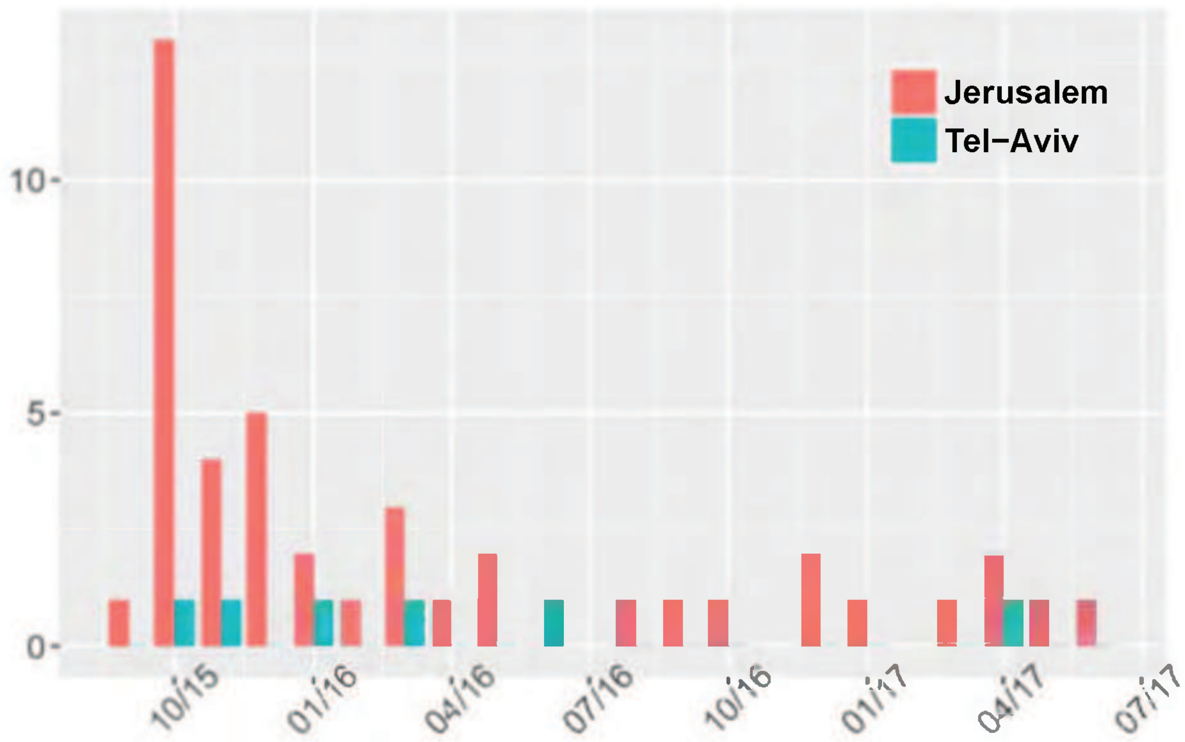


Figure 2: Number of casualties

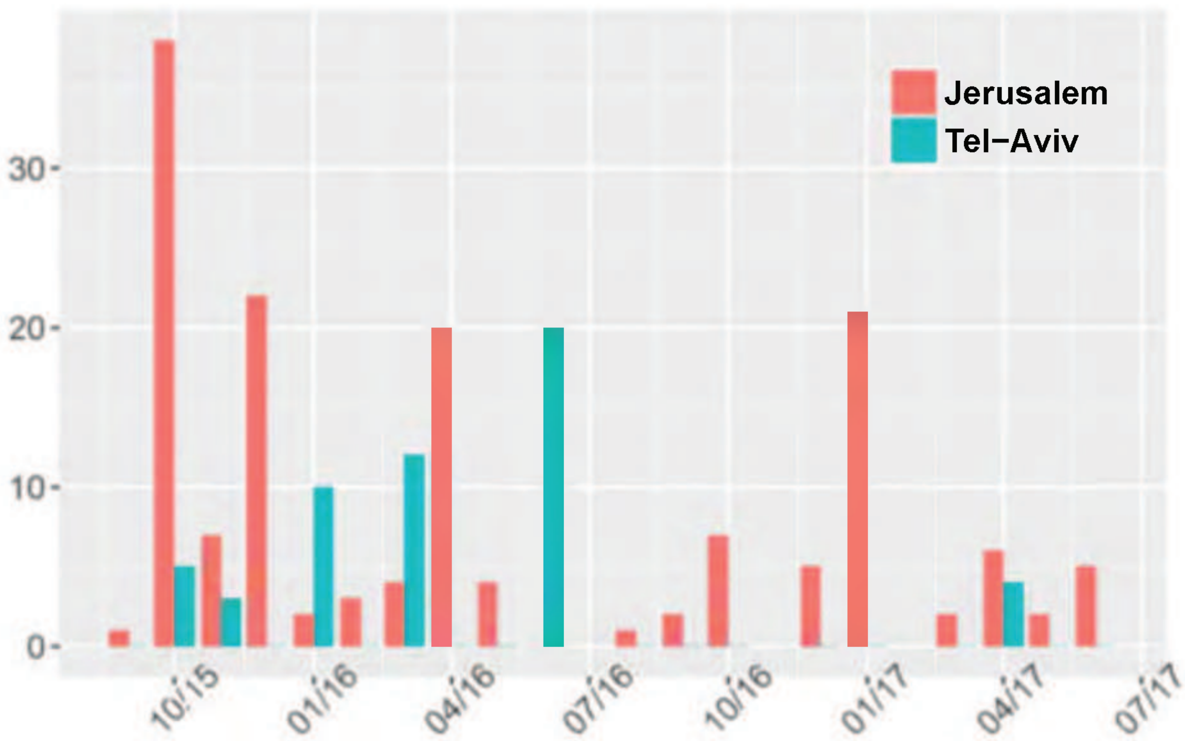


Figure 3: Terror attacks in Jerusalem by statistical area

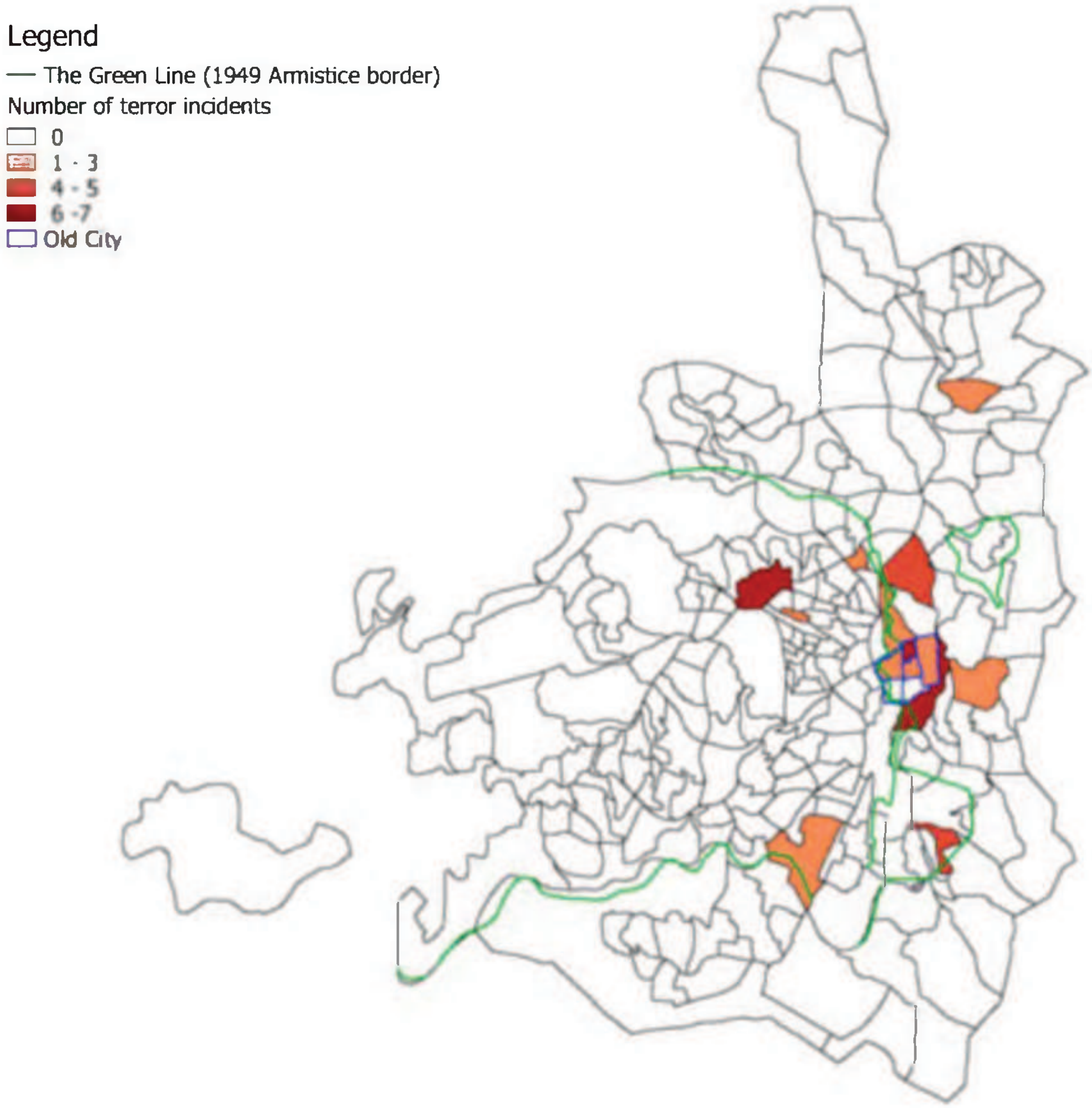
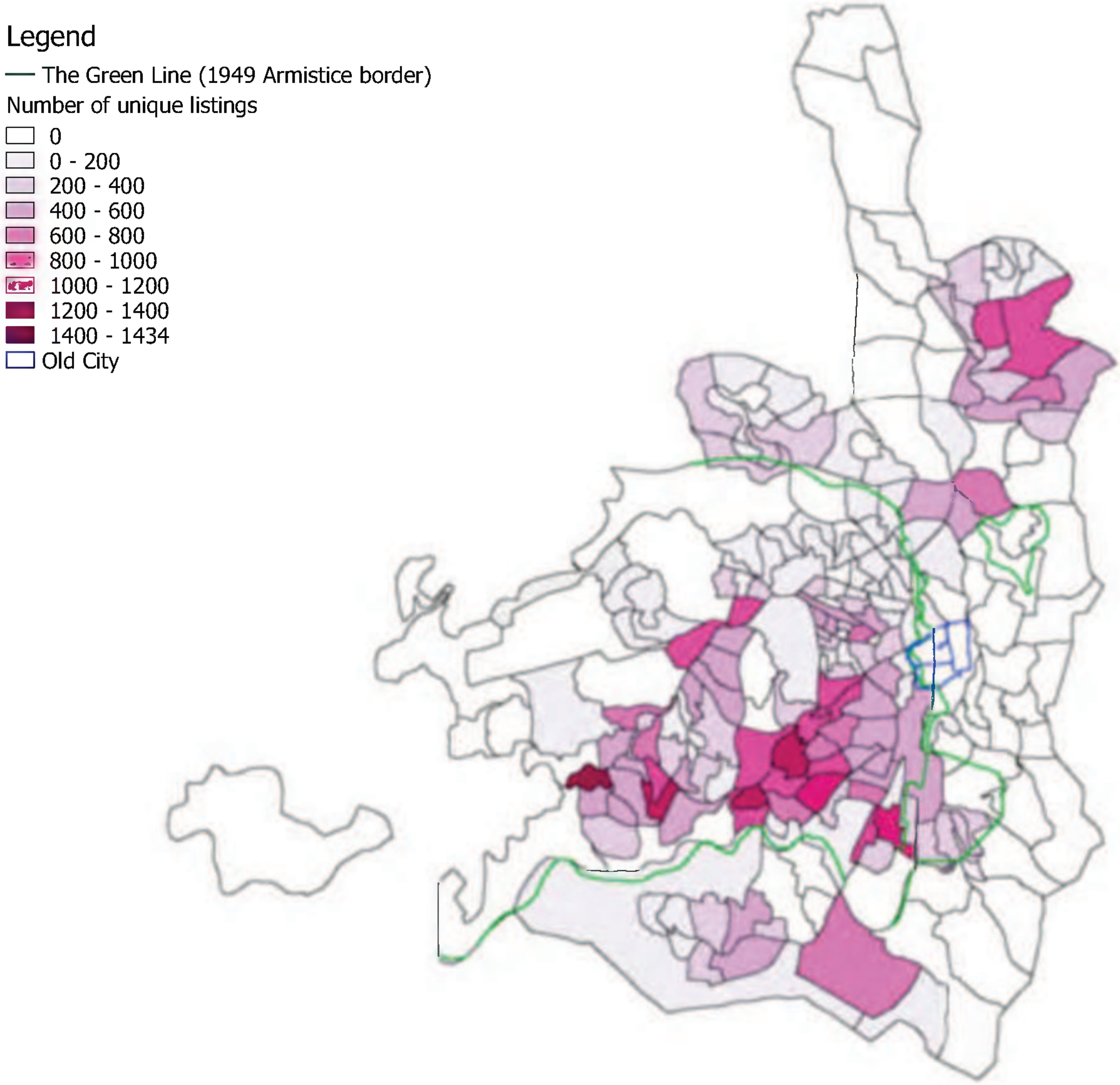
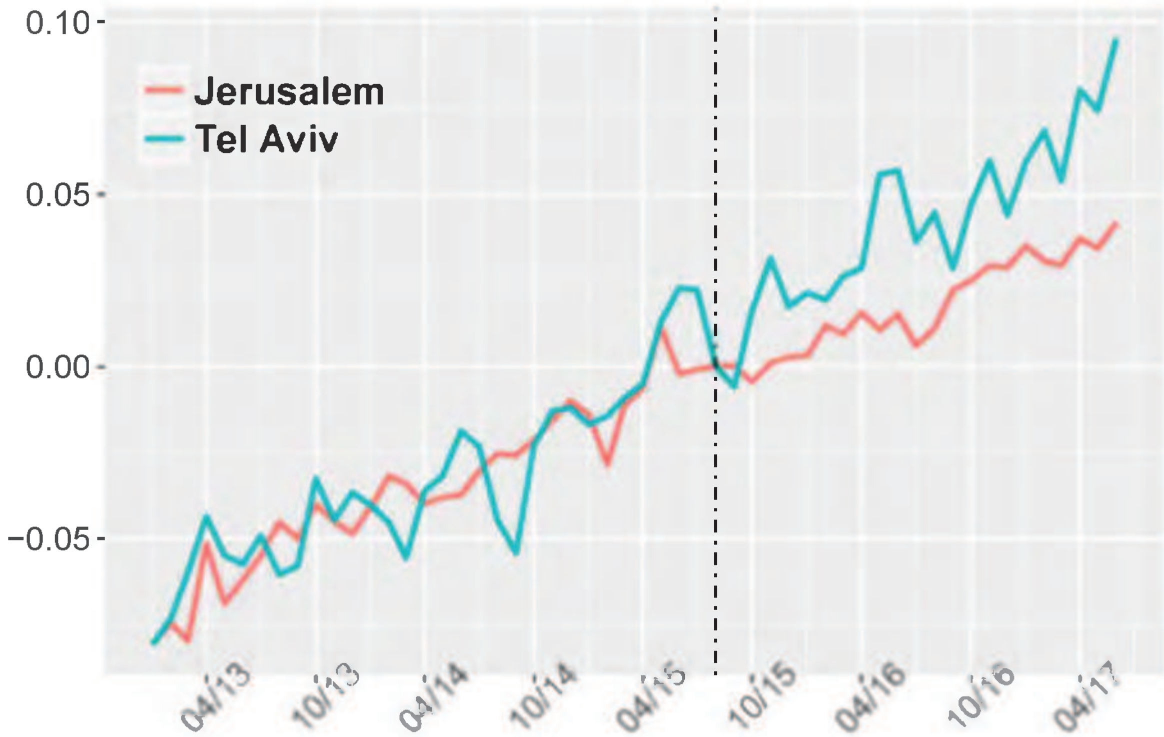


Figure 4: Unique listings in Jerusalem by statistical area



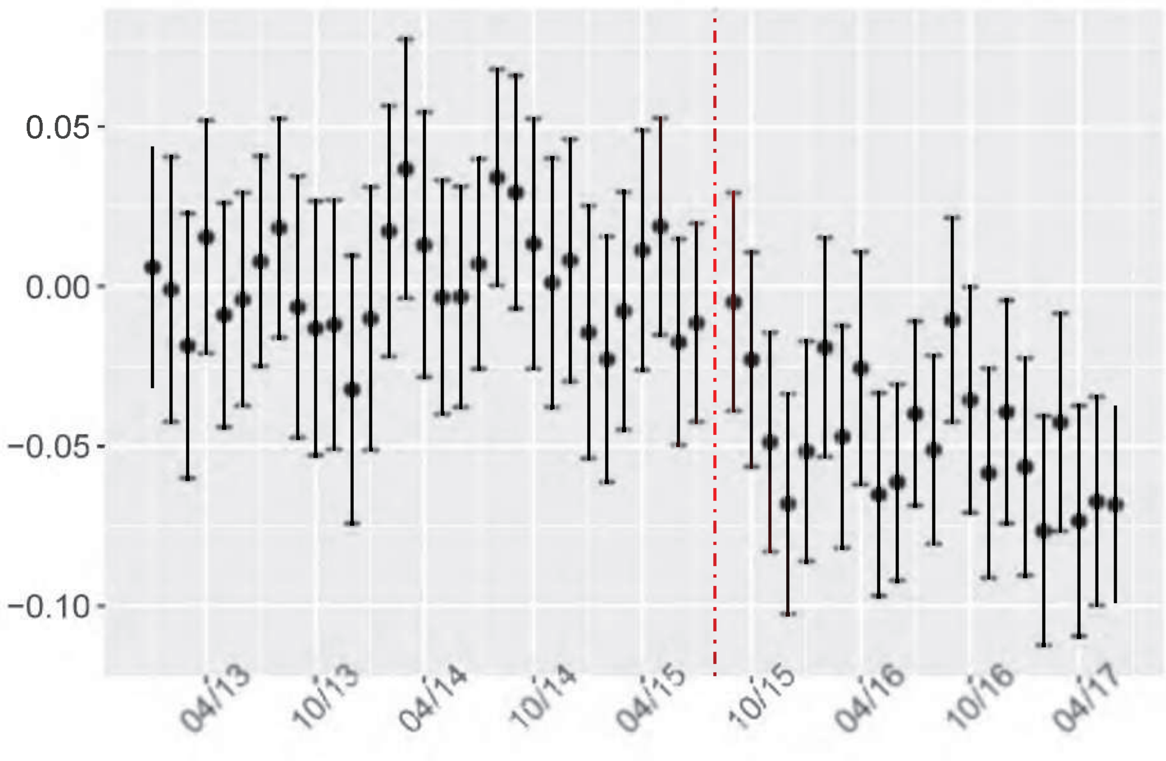
Note: Unique listings are defined as first appearance of each listing for that period. Figure presents number of unique listings over the entire sample period. *Sources*: Statistical areas layer is from the GIS Center at the Hebrew University of Jerusalem; Listings data is from Bank of Israel.

Figure 5: Rental price trends for Jerusalem and Tel-Aviv



Notes: The figure plots rental price changes for Jerusalem and Tel-Aviv separately. It is based on hedonic model regressions of log rental price on property attributes with statistical area and year-month fixed effects. Indices are normalized to zero in August 2015, a month prior to the beginning of the terror wave.
Sources: Listings data is from Bank of Israel.

Figure 6: Effect of the terror wave on rental prices: Jerusalem vs. Tel-Aviv



Notes: The figure plots the value of γ in equation (1) along 95% confidence intervals. August 2015 is excluded and set as the basis for comparison. *Sources*: Listings data is from Bank of Israel.

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Appendix

Table A1: Hedonic estimations

	Dependent variable:	
	log(Rental Price)	
	Tel Aviv	Jerusalem
	(1)	(2)
Cottage	0.085***	0.053***
	(0.006)	(0.004)
Floors	0.0002	0.001
	(0.001)	(0.001)
Floor	0.001	−0.009***
	(0.001)	(0.001)
Lift	0.071***	0.010*
	(0.004)	(0.005)
1.5-2 Rooms	0.167***	0.186***
	(0.005)	(0.007)
2.5-3 Rooms	0.268***	0.287***
	(0.005)	(0.007)
3.5-4 Rooms	0.299***	0.362***
	(0.006)	(0.008)
4.5-5 Rooms	0.318***	0.425***
	(0.008)	(0.010)
Square Meter	0.006***	0.005***
	(0.0001)	(0.0001)
Yard	−0.004	0.010
	(0.021)	(0.006)
AC	0.005*	0.027***
	(0.003)	(0.003)
Solar Water Heating	0.023***	0.009***
	(0.004)	(0.002)
Parking	0.046***	0.022***
	(0.007)	(0.007)
Accessibility	0.022***	0.009**
	(0.003)	(0.003)
Balcony	0.020***	0.021***
	(0.002)	(0.002)
Security Room	0.058***	0.026***
	(0.004)	(0.004)
Lift x Floor	0.007***	0.011***
	(0.001)	(0.001)
Constant	8.427***	7.431***
	(0.042)	(0.071)
Year-Month FE	Yes	Yes
Statistical Area FE	Yes	Yes
Property FE	No	No
Observations	59,171	28,673
R^2	0.640	0.674

*p<0.1; **p<0.05; ***p<0.01

Notes: Floors is number of floors in building; Floor is the floor the property is on; Square Meter is number of square meters in a property; all other variables are binary indicators for existence of attribute. Columns (1) and (2) present results of a basic hedonic estimation for each city separately. Fixed effects for year-month and statistical areas are included. Estimated by OLS. *Sources*: Listings data is from Bank of Israel.

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