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Is Terrorism Eroding Agglomeration Economies in Central Business Districts? Lessons from the Office Real Estate Market in Downtown Chicago*

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Abstract

The attacks of September 11, 2001, and more recently the Madrid and London downtown train bombings, have raised concerns over both the safety of downtowns and the continuous efforts by terrorists to attack areas of such high density and significance. This article employs building-level data on vacancy rates to investigate the impact of an increased perception of terrorist risk after 9/11 on the office real estate market in downtown Chicago. Chicago provides the perfect laboratory to investigate the effects of an increase in the perceived level of terrorist risk in a major financial district. Unlike in New York, the 9/11 attacks did not restrict directly the available office space in downtown Chicago. Moreover, the 9/11 attacks induced a large increase in the perception of terrorist risk in the Chicago Central Business District, which includes the tallest building in the U.S. (the Sears Tower) and other landmark buildings which are potential targets of large-scale terrorist attacks. Our results show that, following the 9/11 attacks, vacancy rates experienced a much more pronounced increase in the three most distinctive Chicago landmark buildings (the Sears Tower, the Aon Center and the Hancock Center) and their vicinities than in other areas of the city of Chicago. Our results suggest that economic activity in Central Business Districts can be greatly affected by changes in the perceived level of terrorism.

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1. Introduction

In the wake of the 9/11 attacks, economists are devoting much effort to evaluating the impact of terrorism on economic outcomes and understanding the channels through which the enhanced risk of large-scale terrorism induced by the 9/11 attacks may affect economic activity. A partial list of scholarly works in this rapidly growing literature is Abadie and Gardeazabal (2003, 2005), Becker and Murphy (2001), Becker and Rubinstein (2004), Berrebi and Klor (2006), Chen and Siems (2004), Enders and Sandler (1991, 1996), Enders, Sandler, and Parise (1992), Frey (2004), Frey, Luechinger, and Stutzer (2004), Glaeser and Shapiro (2002), Pshisva and Suarez (2004), and Zussman, Zussman, and Nielsen (2006).

The increase in the perceived level of terrorist risk induced by the 9/11 attacks has placed particularly large pressures on major Central Business Districts, such as New York, London, and Chicago, which are considered to be preferred targets of terrorist attacks because of their high population density, economic significance, and because they contain symbolic targets such as landmark buildings or government facilities. The susceptibility of Central Business Districts to large-scale terrorist attacks (as well as their vulnerability, as demonstrated by recent events) is particularly unsettling given the crucial role that Central Business Districts play in economic activity. Quite surprisingly, however, there is very little work available on the effects of terrorism on Central Business Districts. This article aims to fill that void. For this purpose, we use building-level data from downtown Chicago, one of the most significant Central Business Districts in the U.S., to investigate the economic impact of an increase in the perception of risk after 9/11.

There are two main channels through which terrorism affects economic outcomes. First, terrorist attacks have a direct effect on the economy because they destroy productive capital (physical and human). Because the destruction caused by terrorist attacks represents only a small fraction of the total stock of productive capital, Becker and Murphy (2001) have argued that the relative importance of this effect is small in practice. Second, terrorism increases the level of fear and uncertainty, which may have large effects on the behavior of economic agents (see Abadie and Gardeazabal, 2005, and especially Becker and Rubinstein, 2004).

The Central Business District (CBD) of Chicago provides the perfect laboratory to investigate the effects of the post-9/11 increase in the perceived risk of terrorism on a major financial center. The city of Chicago was not directly affected by the destruction of the 9/11 attacks. However, the 9/11 attacks induced a large increase in the perception of terrorist risk in the Chicago Central Business District, which includes the tallest building in the U.S. (Sears Tower) and other landmark buildings. The case of Chicago is, therefore, of particular interest, because it allows us to separate the direct impact of terrorist attacks on available office space (absent in Chicago following the 9/11 events) from the impact caused by an increased perception of terrorism threat in Central Business Districts after 9/11.

A distinctive characteristic of this study is that it uses data disaggregated at the building level on a quarterly basis for a panel of Class A and Class B office buildings (as defined by CoStar Group, see below) in the downtown area of Chicago. To our knowledge, data analysis of the impact of terrorism on real estate markets has never been done at this breadth and scale.

To detect the impact of an increase in the perception of terrorist risk in Chicago as a result of 9/11, we compare the evolution of vacancy rates at the three main landmark buildings of Chicago (the Sears Tower, the Aon Center, and the Hancock Center) and other nearby office buildings within a "shadow" area of 0.3-mile around each landmark building to the evolution of vacancy rates of office buildings located outside the shadow areas of the three landmark buildings. We use panel data fixed-effects estimators to control for the presence of unmeasured characteristics of each individual building in our sample. Our dataset includes quarterly data for Class A and Class B office buildings in downtown Chicago during the period of 1996-2006.[1] We selected the Sears Tower, the Aon Center, and the Hancock Center as "anchor" buildings because of their landmark stature, which makes them preferred targets of terrorist attacks. We based our choice of a 0.3-mile radius for the shadow areas on the spread of the massive debris in New York City after the 9/11 attacks (Dermisi, 2006).

Our results show that office vacancy rates increased in downtown Chicago in the wake of the 9/11 attacks. Most importantly, office properties in the three main Chicago

[1] Office buildings are classified as Class A because of their amenities, design, location, building efficiency, management quality and other property characteristics which make them unique in the market and highly desirable for tenants who are willing to pay the highest market rents. Buildings are classified as Class B if they have good management and maintenance but do not feature the special or innovative characteristics, or the highly efficient floor plates that are often found in Class A buildings. Other "no-frills" lower-quality buildings are classified as Class C in the CoStar database. Class C buildings are appealing to a tenants' base with lower quality demands and more severe budgetary constraints than those who lease Class A or Class B properties. The exact CoStar definitions of Class A, B, and C are included in Appendix A.

landmark buildings and the surrounding areas experienced more severe increases in vacancy rates than office properties not located in the vicinities of landmark buildings. These results suggest that the higher perceived level of terrorist risk in Chicago after 9/11 induced centrifugal forces powerful enough to counteract the effects of agglomeration economies and knowledge spillovers. This is particularly disturbing given the crucial role of Central Business Districts in exploiting agglomeration economies and knowledge spillovers (Glaeser et al, 1992).

The rest of the article is organized as follows. Section 2 reviews the literature on the impact of terrorism in cities. Section 3 describes in detail our dataset and methodology. Section 4 presents and discusses our empirical results. Section 5 concludes.

2. Terrorism in Cities

Long before the events of 9/11, terrorism had inflicted a large number of human losses and severe physical destruction in major urban centers around the world, including London, Istanbul, and Jerusalem. As Savitch and Ardashev (2001) indicate, not only is terrorism more prevalent in cities than in rural areas, but also the number of incidents and the magnitude of the physical damage created by terrorism in urban areas has increased steadily in recent years. Savitch and Ardashev (2001) provide four main reasons that cities are selected by terrorists for their attacks. First, cities represent what in military terms are called “target-rich environments”. They contain a high density and a heterogeneous mix of valuable assets, including numerous human targets and large infrastructures. Second, global economic interdependence hinges on the role that cities play as communication nodes and command centers. Third, the high population density and heterogeneity that is characteristic of urban areas often implies that antagonistic groups are located in close geographic proximity. As a result, some cities have become nesting grounds for terrorist organizations. Savitch and Ardashev (2001) mention Beirut and Belfast among other examples of this phenomenon. Finally, cities have substantial symbolic value as terrorist targets.

In addition to the four explanations offered by Savitch and Ardashev (2001) for why cities are preferred targets for terrorism, it should be pointed out that cities might be particularly vulnerable to terrorist actions. The large number of individuals and goods traveling into cities often makes security measures too costly or impractical. In addition, cities allow terrorists to "hide in the crowd".

Although terrorism is not new to cities, the 9/11 attacks massively increased the perceived level of terrorist risk in Central Business Districts. The New York downtown office market was severely impacted on 9/11, with 44 percent of Manhattan's downtown Class A space destroyed by the attacks, according to the City of New York (2001). The Government Accounting Office (2002) estimated the effects of the 9/11 attacks on New York City at "about $83 billion in lost output, wages, business closings, and spending reductions," (Eisinger, 2004).

Surveys of building owners and managers provide direct evidence of an increased perception of terrorist risk in Central Business Districts as a result of the 9/11 attacks, which resulted in enhanced security measures.[2] The introduction of better or additional building security measures in response to 9/11 led to security spending increases. Buildings Owners and Manager's Association/International estimated that U.S. security spending by private office building owners/managers rose from 49 cents per square foot in 2001 to 55 cents per square foot in 2003, a 12-percent increase (Chapman, 2004). For certain trophy buildings, such as the Sears Tower, the increases were even more pronounced. Security costs at Chicago's Sears Tower increased from 39 cents per square foot per year immediately before 9/11 to 1.05 dollars per square foot per year afterwards.[3] In 2004 the security costs throughout the U.S. for Class A downtown buildings averaged to 71 cents per square foot per year for buildings with more than 600,000 square feet and at 59 cents per square foot per year regardless of the size of the building (BOMA, 2005). However, security costs were substantially lower for firms located outside major urban centers.[4]

It is therefore not surprising that after 9/11 many real estate market analysts expressed their concerns about the potential impact of an increase of terrorist risk in cities. In particular, Johnson and Kasarda (2003) indicated that "commercial real estate brokers and corporate relocation consultants report that since 9/11 an increasing number of their clients are

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[2] See BOMA (2003) and Laing (2003).

[3] The pre-9/11 figure is based on security costs in the Sears Tower for the period between January 1, 2001 and Sept. 11, 2001. The post-9/11 figure is based on security costs in the Sears Tower for the period 2002-2004. These figures were conveyed to us in personal communication with Carlos Villarreal, Vice President of National Security and Life Safety of Trizec Properties and former Director of Security of the Sears Tower.

[4] Kinum (2005) estimate that moving 15 to 20 miles outside the city can reduce security costs for a company by as much as 60 percent.

expressing an aversion to locating in so-called trophy properties ... and ‘run of the mill’ properties within the ‘shadow’ of such facilities, other large gathering venues, ... energy generating facilities, and infrastructure projects." Mills (2002) argued that the value of economies of agglomeration for Central Business Districts could erode as a result of the 9/11 attacks. Mills (2002) suggested also that rents on tall office buildings would be negatively affected. Moreover, a survey in Miller et al. (2003) showed that after 9/11 tenants were more concerned with the profile of their co-tenants and preferred to avoid companies or agencies that might be possible terrorist targets.

However, apart from documented increases in security costs after 9/11 and beyond the direct destruction that resulted from the attacks, to date empirical researchers have not yet detected evidence of a substantial impact of terrorism in cities. After analyzing historical data for cities affected by war or terrorism, Glaeser and Shapiro (2002) argued that while the effects of 9/11 on the lower Manhattan area are likely to be substantial, other urban areas in the U.S. may be largely unaffected. Miller et al. (2003) analyzed data for a sample of tall and trophy buildings in 10 U.S. cities. They failed to find significant evidence of an impact of the 9/11 attacks, with the exception of an increase in sublet activity for a small set of “truly famous” trophy buildings. However, the time data horizon of the regressions in Miller et al. (2003) does not go beyond the fourth quarter of 2001, only a few months after the 9/11 attacks. They caution the reader that “[t]his study is preliminary in that the lasting effects of 9/11 will not be known until much more time has elapsed.”[5]

There are two potential explanations for the limited amount of empirical evidence of the effect of terrorism in cities. First, appropriate data sources to analyze the effect of terrorism in cities (e.g., commercial real estate databases) are expensive and difficult to access, which limits the amount of research in this area. Second, given the pervasiveness of long-term leases in office markets, as pointed out by Miller et al. (2003) and Johnson and Kasarda (2004), the true magnitude of the impact of terrorism can only be detected after a prolonged adjustment period. In particular, Johnson and Kasarda (2004) suggested that the

[5] In a related literature, Davis and Weinstein (2002) provide evidence that the Allied bombing of Japanese cities during World War II had only a temporary effect on the growth of Japanese cities. Brakman, Garretsen, and Schramm (2004) obtain similar results for the effect of the bombing of German cities during World War II on the size of the cities in West Germany. These authors find, however, that the growth of East German cities was permanently affected by the Allied bombing. Miguel and Roland (2005) obtain similar results as Davis and Weinstein (2002) using district level data on the intensity of U.S. bombing in Vietnam during Vietnam War.

effect of the 9/11 attacks on business activity in cities would not be detectable until 2004 and maybe later, after many long-term commercial real estate leases begin to expire.

Notice, however, that it is not true that an increase in the perception of terrorist risk in densely occupied areas within Central Business Districts should necessarily reduce agglomeration or change the location decision of firms. The reason is that agglomeration economies in Central Business Districts may create substantial Ricardian rents. These rents may then act as a buffer when terrorist risk increases, so all the adjustment in the office real estate market may be done only through prices without any effect on vacancies. That is, if terrorists aim to maximize destruction, they will tend to attack large-agglomeration areas. However, large-agglomeration areas may be the most resilient to an increased perception of terrorist risk. Appendix B contains a simple model that illustrates this point.[6] The model suggests that only a large increase in the perceived risk of terrorism may affect the location of firms within cities.

In addition to the impact of terrorism on commercial real estate, terrorism may affect cities in ways that are not explored in this article. In particular, Gautier, Siegmann, and van Vuuren (2006) provided evidence that the prices of residential properties in Amsterdam neighborhoods with sizeable Muslim communities were adversely impacted as a result of the murder of Theo van Gogh in 2004. Moreover, the results in Becker and Rubinstein (2004) suggest that terrorist attacks on buses have affected transportation choices in Israeli cities.

3. Data Sources and Methodology

The data for this study come from the CoStar Group.[7] The CoStar Group database is the only nationwide commercial real estate database reporting panel data on rents and vacancy rates at the building level, along with other building characteristics like location and height.[8] The CoStar Group database provides a "comprehensive inventory of office and industrial

[6] Alternatively, as explained in Appendix B, rents created by agglomeration economies may allow building owners to offset increases in terrorist risk with increases in security spending, so the location of firms is not affected. Moreover, if firms' managers differ in their perception of terrorist risk or firms have different degrees of vulnerability to terrorism attacks, an increase in the risk of terrorism may induce a reallocation of firms within cities without changing the overall degree of agglomeration.

[7] Access to the CoStar Group database was provided to us by the Building Owners and Managers Association (BOMA) of Chicago.

[8] As discussed below, however, data on rents are limited in the CoStar database, because they include only asking rents for available office space.

properties in 50 U.S. markets" (CoStar Group, 2006a) with data reported on a quarterly frequency. For this study, we used the CoStar Group data for the city of Chicago.

We restrict our sample to Class A and Class B office buildings within the extended Central Business District of Chicago.[9] The sample period of the data used in our analysis spans from the second quarter of 1996 to the second quarter of 2006. We discarded from our dataset office buildings that were constructed, renovated, converted to condos, or demolished during our sample period or immediately before. We also discarded three additional buildings for other miscellaneous reasons.[10] Our final dataset is a balanced panel with a total of 242 individual buildings in downtown Chicago.

We classify each building in our dataset into one of two categories depending on whether or not the building is located in the "shadow areas" of the three main Chicago landmark buildings: the Aon Center, the Hancock Center, and the Sears Tower. Shadow areas are defined as the areas of 0.3-mile radius surrounding any of the three Chicago landmark buildings. Figure 1 shows the location of all Class A and Class B buildings in our dataset along with the three landmark building shadow areas.

The Sears Tower, the Aon Center and the Hancock Center are among the tallest buildings in the U.S. Two of them, the Sears Tower and the Aon Center, are almost exclusively office buildings with a small retail component. In contrast, the Hancock Center includes a significant residential component. The Sears Tower (1,451feet and 110 floors) is the tallest building in the U.S., the Aon Center (1,136 feet and 83 floors) is the third tallest in the U.S., and the Hancock Center (1,127 feet and 100 floors) is the fourth tallest in the U.S. The three buildings belong to different real estate submarkets within the downtown area of Chicago (as defined by the CoStar Group). More specifically, the Sears Tower is located in the West Loop submarket, the Aon Center is part of the East Loop submarket, and the Hancock Center is part of the Michigan Avenue submarket. Our study area, however, expands beyond these three submarkets and includes six additional CoStar Group

[9] More concretely, the study area focuses on the extended Central Business District (CBD) of Chicago with the following borders: Division Street (North), Ashland Avenue (West), Roosevelt Road (South) and the Lake Michigan (East).

[10] The first one of them seems to be totally vacant during most of the sample period due to litigations. The second one becomes owner-occupied during our sample period. Finally, the third of these three office buildings was converted to retail space in 2006.

submarkets: Central Loop, South Loop, LaSalle Street, River North, River West and Gold Coast.

The choice of a 0.3-mile radius to define the extent of the shadow areas was motivated by the extent of the debris fields caused by the collapse of the World Trade Center on 9/11.[11] The Sears Tower's shadow area includes 17 Class A buildings and 23 Class B buildings. The Aon Center's shadow area includes 7 Class A buildings and 4 Class B buildings. Finally, the Hancock Center's shadow area includes 5 Class A and 10 Class B buildings. Beyond the shadow areas of the three trophy buildings, our data set includes 23 Class A buildings and 153 Class B buildings. In total, our study uses data on 52 Class A buildings and 190 Class B buildings.

Our building dataset includes the following CoStar Group variables, among others: latitude, longitude, building height, rentable building area, submarket, vacancy rates, and gross rents. Gross rents are expressed in current values and they reflect asking rents for office space currently marketed for lease. We use the Harversine formula and data on the latitude and longitude of each building to calculate the distances between each of the buildings in our sample and the trophy buildings.

We use fixed effects estimators to study the impact of 9/11 on the shadow versus non-shadow areas of our study. Our basic regression specification is:

$$\text{vacancy rate}_{it} = \alpha(\text{shadow}_i \times \text{post-9/11}_t) + f_t + \eta_i + \varepsilon_{it} \qquad (1)$$

where vacancy rate_{it} is the vacancy rate in building i and quarter t, $\text{shadow}_i \times \text{post-9/11}_t$ is a dummy variable that takes value one if building i is located in the shadow area of a landmark building and the quarter of the observation, t, is after 9/11. In other words, $\text{shadow}_i \times \text{post-9/11}_t$ takes value one if the building is located in an area that experienced a large increase in the perceived risk of terrorism as a result of the 9/11 attacks and the time period is after 9/11. The variable f_t is a time effect, representing common shocks to the Chicago office markets. In particular, f_t tries to capture the overall economic and business

[11] Risk Management Solutions (2001) reports that the collapse of the World Trade Center created a massive debris area up to 1,300 feet (or 0.25 miles) from the World Trade Center, with thick airborne debris traveling up to 0.5 miles. Based on the particular characteristics of downtown Chicago, Dermisi (2006) estimates that the collapse of one of the three anchor buildings in downtown Chicago would produce massive debris up to a distance of 0.3 miles from the building.

trends in Chicago's office market during the sample period of our study. The variable η_i represents time-invariant building-specific characteristics for building i, which are potentially correlated with shadow$_i$ (such as building location or floor plan). Finally, ε_{it} represent building-specific transitory shocks. In our estimators, all observations are weighted using the buildings' rentable areas. The parameter α measures the difference between changes in vacancy rates experienced around 9/11 in shadow areas and changes in vacancy rates experienced around 9/11 in non-shadow areas.

Under the assumption that, in the absence of 9/11, shadow and non-shadow areas would have experienced similar office real estate market trends, α allows us to detect whether or not the 9/11 attacks impacted the office real estate market in downtown Chicago. More concretely, if the 9/11 attacks eroded agglomeration economies in downtown Chicago, then we expect that α is positive.

Notice, however, that although a non-zero α allows us to detect the influence of 9/11 on the Chicago office real estate market, the value of α does not necessarily identify the magnitude of such effect. The magnitude of α would be inflated relative to the effect of 9/11 in shadow areas if office tenants moved from shadow areas in Chicago to outside shadow areas in Chicago in response to the higher perception of terrorism threat after 9/11. However, such bias would only enhance the statistical power of our tests for the hypothesis of no effect. The reason is that, if there was substitution between shadow and non-shadow areas in Chicago after 9/11, the comparison of buildings inside and outside the shadow areas incorporates two potential effects of terrorism: the negative effects in the shadow areas and the positive effects through substitution outside the shadow areas. It is also possible, however, that α includes an attenuation bias relative to the effect of 9/11 in shadow areas. That would be the case if there was little or no substitution between shadow and non-shadow areas in Chicago in response to the 9/11 attacks, and if the terrorist attacks had a negative impact on the office real estate markets in non-shadow areas (e.g., because they affected the overall economic conditions). Then, α would under-estimate the impact of the 9/11 attacks on the office vacancy rates at the main three Chicago landmark buildings and other nearby Class A and Class B buildings. However, even if the 9/11 attacks had a negative impact on the office real estate markets in non-shadow areas (through their effects on the overall economic conditions), because the increase in the perception of terrorism was arguably higher in the landmark building shadow areas than in the rest of Chicago, our statistical tests preserve power to reject the null of no effect.

To further substantiate our results, we use a dose-response design in which the variable that represents a building's exposure to a high perceived risk of terrorism is constructed as the interaction between a post-9/11 dummy and the distance to the closest anchor building:

$$\text{vacancy rate}_{it} = \alpha(\text{distance to anchor}_i \times \text{post-9/11}_t) + f_t + \eta_i + \varepsilon_{it}\,, \qquad (2)$$

where distance to $\text{anchor}_i \times \text{post-9/11}_t$ is the interaction between the distance of building i and the closest of the Sears Tower, the Aon Center, and Hancock Center and a binary variable which takes the value one after 9/11.

Arguably, however, the distance to the non-shadow area may be more strongly related to the perceived level of terrorism at any particular location after 9/11 than the distance to the anchor buildings. That would be the case if the distance to the anchor buildings is an important factor determining the level of perceived risk within shadow areas, but the perceived risk of terrorism does not vary much once the building is located outside the shadow areas. This possibility motivates the following specification:

$$\text{vacancy rate}_{it} = \alpha(\text{distance to non-shadow area}_i \times \text{post-9/11}_t) + f_t + \eta_i + \varepsilon_{it}\,. \qquad (3)$$

Finally, because tall buildings are often viewed as preferred targets of terrorist attacks, we estimate an alternative dose-response design in which we use buildings' heights to measure the perceived level of terrorist risk:

$$\text{vacancy rate}_{it} = \alpha(\text{height}_i \times \text{post-9/11}_t) + f_t + \eta_i + \varepsilon_{it}\,. \qquad (4)$$

4. Data Analysis

4.1. Main results

Figure II shows average quarterly vacancy rates in Chicago shadow and non-shadow areas from the second quarter of 1996 to the second quarter of 2006. The plot of these two vacancy series reveals that vacancy rates in shadow and non-shadow areas evolved very similarly before 9/11, which suggests that both were affected by the same market trends. However, a radically different behavior arose in the wake of the 9/11 attacks. After 9/11, vacancy rates experienced a large increase inside shadow areas. Outside shadow areas, vacancy rates also experienced an increase during the year 2002, but they stabilized and even decreased slightly afterwards. Remarkably, while the two series followed each other very closely before 9/11, after 9/11 vacancy rates were consistently higher for offices in or nearby landmark buildings. The pattern of the series in Figure II is therefore consistent with the hypothesis of a more severe impact of 9/11 in those office properties in Chicago in or nearby landmark buildings.

Table I reports descriptive statistics for our sample of office buildings in downtown Chicago. Twenty-seven percent of the buildings in our sample are located inside one of the three shadow areas. Relative to office buildings outside shadow areas, office buildings inside shadow areas tend to be of higher quality, higher height, have more stories, and larger rentable areas. In the first quarter of 2001 the average vacancy rate was approximately 9 percent in shadow areas and 7 percent in non-shadow areas. However, the difference between these two vacancy rates was not significant at conventional test levels. In the first quarter of 2006, more than four years after 9/11, average vacancy rates had increased to 17.4 percent in shadow areas and to 12.3 percent in non-shadow areas. The difference in average vacancy rates between shadow areas and non-shadow areas in the first quarter of 2006 was of about 5 percentage points and statistically significant at the 5% level. These figures suggest a deterioration of the office real estate market in downtown Chicago during the period 2001-2006. This deterioration was, however, more pronounced for the three main Chicago landmark buildings and the buildings close to them. Table I also provides descriptive statistics for rents in our sample of office buildings. These data should be interpreted with caution because they reflect average asking rents for office space that was marketed for lease at the time of the observation.[12] With this qualification in mind, it is worth noticing that the difference in average rents per square foot between shadow area buildings and non-shadow area buildings narrowed considerably from $4.14 in the first quarter of 2001 to $2.31 in the first quarter to 2006. This variation is also consistent with a deterioration of the office real estate market in the shadow areas, relative to the non-shadow area.

In order to quantify the differences observed in Figure II for the office real estate market in shadow and non-shadow areas around 9/11, we estimate fixed-effects models that

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[12] As a result, data on rents are missing for the buildings where no office space became available for lease during the quarter of observation. Notice also that the quality and characteristics of available office space at a building in different time periods may potentially experience significant changes not measured in our data.

control for the effects of unmeasured building-specific characteristics. Table II reports the estimates for our basic specifications in equations (1) to (4), along with standard errors clustered at the building level. Column (1) reports that around 9/11 vacancy rate increases for office buildings in the shadow areas of landmark buildings were 3 percentage points higher than for buildings outside the shadow areas. The coefficient of the interaction $shadow_i$×post-$9/11_t$ indicates that after the 9/11 attacks the deterioration of the real estate market was more severe for office buildings located inside the shadow areas, that is in areas that experienced a higher increase in the perceived terrorist risk.

In columns (2) to (4) of Table II, we use alternative variables to identify the buildings that experienced a large increase in perceived terrorist risk as a result of 9/11. In column (2), we use the distance between the buildings and the closest of the Aon Center, Hancock Center, and Sears Tower as a measure of the magnitude of the change in perceived risk of terrorism as a result of 9/11. The coefficient on the interaction $(\text{distance to anchor})_i$×post-$9/11_t$ indicates that, after controlling for other building characteristics, an additional mile to the closest of the three anchor buildings was associated with a 6.17 percentage point lower change in the vacancy rate after the 9/11 attacks, on average.

As explained above, it can be argued that increases in the distance between a building and the closest of the anchor buildings are associated with reductions in terrorist risk only up to the point where the building is located at a safe enough distance from the anchor buildings. To reflect this possibility, in column (3) we use the interaction between distance to the non-shadow area (which is, of course, equal to zero for all the buildings located outside the shadow areas) and a post-9/11 indicator as a measure of the magnitude of the change in terrorist risk after 9/11. Consistent with the results in the previous columns, the coefficient on the interaction $(\text{distance to non-shadow area})_i$×post-$9/11_t$ is positive and significant. This coefficient indicates that for buildings inside shadow areas, an additional 0.1-mile to the closest anchor building was associated, on average, with a 2.3 percentage point lower increase in the vacancy rate after the 9/11 attacks, after controlling for other building characteristics.

In column (4), building height is used as a proxy for the increase in terrorist risk after 9/11. Regardless of their location relative to other potential targets, tall buildings are often perceived to be preferred targets for terrorist attracts, given the high density of personnel that concentrates in them. Moreover, average evacuation times are long for tall buildings, and therefore terrorist attacks pose a particularly severe threat for them. The coefficient on the interaction between height and a post-9/11 dummy is positive and significant, indicating that in the wake of the 9/11 attacks taller buildings experienced higher increases in vacancy rates. An increase of 1,000 feet in building height is associated with a 5.2 percentage point higher change in the vacancy rate around 9/11.

On the whole, the results in Table II indicate that, in the wake of the 9/11 attacks, buildings with characteristics that caused them to be perceived as prone or vulnerable to terrorist attacks experienced a particularly severe deterioration in real estate market outcomes. These results suggest that economic activity in Central Business Districts can be greatly affected by changes in the perceived level of terrorism.

4.2. Robustness analysis

In this section, we assess the validity of the results of the previous section using a variety of methods.

First, given the long term nature of lease contracts in office real estate markets and the complexities involved in corporate relocation decisions, if changes in the perceived levels of terrorism after 9/11 affected the location decision of office tenants in downtown Chicago, this effect could not be instantaneous but cumulative in time (see, e.g., Johnson and Kasarda, 2003). Table III tests this hypothesis. The first column of Table III reports the estimated coefficients for the following fixed-effects model:

$$\begin{aligned} \text{vacancy rate}_{it} = {} & \alpha(\text{shadow}_i \times \text{post-9/11}_t) \\ & + \delta(\text{shadow}_i \times \text{quarters since 9/11}_t) + f_t + \eta_i + \varepsilon_{it}. \end{aligned} \tag{5}$$

The coefficient on the interaction between the shadow area dummy and the number of quarters since 9/11 is positive and significant. However, once the interaction between the shadow area dummy and the number of quarters since 9/11 is included in the model, the coefficient on $\text{shadow}_i \times \text{post-9/11}_t$ becomes small in absolute value and statistically non-significant at conventional test levels. This result is consistent with our expectation that any real estate market reaction to an increase in the level of terrorism could not be instantaneous but cumulative in time.

The models in columns (2) to (4) are analogous to equation (5) but use the distance to the closest anchor building, the distance to the non-shadow area, and the height of the building, respectively, in place of the shadow area dummy. Again, for all these variables we obtain the same qualitative result as in column (1).

Table IV provides a more detailed description of evolution of vacancy rates after 9/11 for buildings with different degrees of exposure to terrorist risk. Column (1) reports the estimated coefficients on the interactions between a shadow area dummy and time dummies for the years 2002 to 2006, along with clustered standard errors. Columns (2) to (4) report analogous statistics for the cases in which distance to the closest anchor building, distance to the non-shadow area, and height of the building, respectively, are used as a proxy of exposure to terrorist risk after 9/11. The coefficients in Table IV shows that the gap in vacancy rates between buildings with different exposures to terrorist risk after 9/11 increased monotonically during the period 2002-2005. With the exception of the last column, where building height is used as a measure of exposure to terrorist risk after 9/11, Table IV indicates a narrowing of the gap in vacancy rates in 2006, something that can be observed also in Figure II.

As argued in more generality in Abadie (2006), the identification conditions behind equations (1) to (4) imply that in the absence of the 9/11 attacks, average vacancy rate trends in Chicago would not have differed depending on the location of the buildings relative to the three main landmark building or on their height. Although this assumption is not directly testable, it is easy to test the hypothesis that, previous to the 9/11 attacks, changes in trends in the average vacancy rates did not depend on building locations with respect to the three anchor buildings or on the building height. To test this hypothesis, we reproduced the analysis of Table II using pre-9/11 data only. We divided the pre-9/11 sample into two roughly equal periods depending on whether the observation is before or after the last quarter of 1998. Then we proceeded as in Table II but using an after-1998 dummy in place of the post-9/11 dummy. We report the result in Table V. None of the coefficients in Table V is statistically significant at conventional test levels. Table V provides evidence in favor of the hypothesis that, at least previous to 9/11, trends in vacancy rates did not depend on our proxy variables for the severity of the increase in terrorist risk at the building level after 9/11.[13]

As an additional robustness check, we applied a simple permutation test of significance of the coefficients in Table II. To implement this test, we produced 10,000 random permutations of the values of our measures of post-9/11 exposure to terrorism and recomputed the estimators of Table II for each permutation. We then compared the coefficients obtained in Table II to their permutation distribution. This inferential procedure produces exact test levels regardless of the sample size and the covariance structure of the regression errors, ε_{it}.[14] Figure III shows the permutation distributions of the coefficients on the interactions between our four proxies of the severity of terrorist risk after 9/11 and a post-9/11 dummy, along with one-sided p-values. Figure III demonstrates that there is only a small probability (p-value) of obtaining results like those in Table II, if we permute at random our proxy measures of exposure to terrorist risk after 9/11 among the buildings in the sample.

As a further empirical check of the meaning of our empirical results we plot in Figure IV, the total rentable building area in shadow and non-shadow areas during our sample period.[15] Some of the results of this article could have arisen artificially if the post-9/11 period happened to coincide with a larger increase in the supply of office space in shadow areas than in non-shadow areas. On the contrary, Figure IV shows that in the post-9/11 period non-shadow areas experienced a higher increase in total rentable building area than shadow areas.

4.3. Could our results be explained by differential responses to a recessionary period?

So far, our results indicate that buildings in Chicago with characteristics that made them be perceived as particularly exposed to a terrorist attack after 9/11 experienced larger average increases in vacancy rates following the 9/11 attacks. We interpret these results as evidence that the 9/11 attacks influenced the location decisions of office tenants in downtown Chicago.

[13] Notice that we do not fail to reject significance of the coefficients in Table V because of a large loss of statistical power relative to Table II. In fact, the standard errors are very similar in both tables. The coefficients of Table V, however, are small relative to the corresponding coefficients in Table II.
[14] In particular, this test is robust to the presence of spatial correlation between the regression errors.
[15] We computed total rentable areas for shadow and non-shadow areas using all the office buildings in the CoStar database of Class A and Class B office buildings in the extended Chicago downtown area (as defined above).

Alternatively, our results could be explained by differences in how the various office real estate market segments in Chicago were affected by the recessionary events of the early 2000's. In our sample, office buildings located inside the shadow areas tend to be taller and of higher quality than buildings located outside the shadow areas (see Table I). Moreover, as explained in section 3, the CoStar database defines nine real estate submarkets in downtown Chicago, which are not equally represented inside and outside the three landmark building shadow areas. Therefore, if the 2001 recession had a more pronounced effect on tall buildings, which are more prevalent in the shadow areas of the main Chicago landmark buildings, that by itself could generate a gap like the one observed in Figure II. Similarly, the gap in Figure I could be explained, without invoking the impact of the 9/11 attacks, if the 2001 recession had a more pronounced effect on top-end office buildings (Class A buildings) or on those real estate submarkets within the city of Chicago that overlap considerably with the three main landmark building shadow areas. As we show next, however, these alternative explanations are not supported by the data.

The most apparent reason why it would be difficult to explain the gap in Figure I in terms of differential effects of the 2001 recession is that the 2001 recessionary period ended in November of 2001 (as dated by the NBER Business Cycle Dating Committee, see NBER, 2003), while the gap in Figure II opens rapidly during 2003 to mid-2005, which was a period of substantial output growth.

As a further check of the hypothesis that our results could be driven by differential responses to the 2001 recession, we performed a battery of empirical tests. First, in order to reduce heterogeneity in the quality of the buildings we excluded Class B buildings from our sample and repeated our fixed-effect regressions. Table VI reports the estimated coefficients on the interactions between variables measuring post-9/11 exposure to terrorism and time dummies for the years 2002 to 2006, along with clustered standard errors. The coefficient estimates for a sample of Class A buildings only in Table VI, are similar to those previously reported in Table IV for the entire sample. All four building-level variables that we use to proxy for high increase in the perception of risk of terrorism after 9/11 produce significant coefficients of the hypothesized sign when interacted with post-9/11 year dummies. The coefficients on the interactions of $shadow_i$, distance to $anchor_i$, and distance to non-shadow $area_i$ with the 2004 and 2005 year dummies as well as the coefficient on the interaction of

$height_i$ with the 2006 year dummy are all significant at the 5% level, while the coefficient on the interaction of distance to non-shadow $area_i$ with the 2006 year dummy is significant at the 10% level. These results hold despite substantial increases in the standard errors of most estimated coefficients, caused in part by a reduced sample size. Restricting the sample to Class A building only, reduces the sample size to 2,132 observations (52 buildings times 41 quarters), which is a large decrease relative to the 9,922 observations (242 buildings times 41 quarters) of the entire sample.

In Table VII, we report estimates for a subsample of high-rise buildings. Following a common industry definition, we classify a building as a high-rise if it is at least 115 feet or 12 floor high.[16] The results for this subsample of high-rise buildings are, if anything, stronger than those for the entire sample, in Table IV. Relative to Table IV, the magnitudes of almost all regression coefficients increase. Despite the widespread increase in standard errors most coefficients became significant at conventional levels.

Finally, in Table VIII, we report regression results for specifications with submarket-specific trends. Because Figure II suggests that temporal trends in vacancy rates could be highly nonlinear, we report results for a variety of flexible specifications of the submarket-specific temporal trends. Columns (1) to (3) report the results for regression specifications including submarket-specific trends as fourth, fifth and sixth order polynomials, respectively. Column (4) reports regression results for specifications that include a full set of submarket times period dummies. The magnitudes of the estimated regression coefficients tend to increase as we increase the flexibility in the specification of the submarket-level trends, going from column (1) to (4). The specification in column (4) is the most flexible, but also the most demanding for the data, because requires the inclusion of many submarket times period dummies, most of them without significant coefficients, which increases the standard errors of the coefficients of interest, as is apparent in Table VIII. In spite of the increase in standard errors, most coefficients of interest remain significant, with magnitudes that are close to those estimated for our basic specification in Table II.

5. Conclusion

The results of this study suggest that the 9/11 attacks created centrifugal forces that

[16] See Emporis (2007).

influenced the location decision of high-end office tenants in downtown Chicago. We use the panel data structure of our dataset to eliminate the potential confounding effects that unmeasured building characteristics and common shocks to the Chicago office real estate market may have had in our analysis. We show that vacancy rates increased in Class A and B office buildings in Chicago after the 9/11 attacks. Moreover, we show that these increases were more severe for office properties located in or nearby landmark buildings that are considered preferred targets for terrorist attacks. In addition, we demonstrate that our results are remarkably robust to an extensive set of alternative specifications.

The results of this article are particularly unsettling, given the critical role that the economic literature assigns to agglomeration economies in cities as a motor of economic growth. On the bright side, our analysis focuses on a period during which the perceived threat of terrorism in Central Business Districts has been particularly elevated. The results in Davis and Weinstein (2002), Glaeser and Shapiro (2002), Brakman, Garretsen, and Schramm (2004) and Miguel and Roland (2005) suggest that if the perception of terrorist risk in cities were to return to the pre-9/11 levels, the long-run growth of cities would not be affected by the 9/11 attacks.

Appendix A: Building Class Definitions in the CoStar Database (CoStar, 2006b)

Class A: A classification used to describe buildings that generally qualify as extremely desirable investment-grade properties and command the highest rents or sale prices compared to other buildings in the same market. Such buildings are well located and provide efficient tenant layouts as well as high quality, and in some buildings, one-of-a-kind floor plans. They can be an architectural or historical landmark designed by prominent architects. These buildings contain a modern mechanical system, and have above-average maintenance and management as well as the best quality materials and workmanship in their trim and interior fittings. They are generally the most attractive and eagerly sought by investors willing to pay a premium for quality.

Class B: A classification used to describe buildings that generally qualify as a more speculative investment, and as such, command lower rents or sale prices compared to Class A properties. Such buildings offer utilitarian space without special attractions, and have ordinary design, if new or fairly new; good to excellent design if an older non-landmark building. These buildings typically have average to good maintenance, management and tenants. They are less appealing to tenants than Class A properties, and may be deficient in a number of respects including floor plans, condition and facilities. They lack prestige and must depend chiefly on a lower price to attract tenants and investors.

Class C: A classification used to describe buildings that generally qualify as no-frills, older buildings that offer basic space and command lower rents or sale prices compared to other buildings in the same market. Such buildings typically have below-average maintenance and management, and could have mixed or low tenant prestige, inferior elevators, and/or mechanical/electrical systems. These buildings lack prestige and must depend chiefly on a lower price to attract tenants and investors.

Appendix B: Terrorism in a Simple Ricardian Model of Agglomeration

Suppose there is a continuum of firms with mass equal to one. Firms choose location, x, on the real line. The density of firms at location x is denoted by $f(x)$. Location x has maximum capacity $\overline{f}(x)$, so $f(x) \leq \overline{f}(x)$. The envelope function $\overline{f}(x)$ is positive, symmetric, unimodal, quasi-concave, and $\int \overline{f}(x)\,dx > 1$. Without loss of generality, assume that $\overline{f}(x)$ has mode equal to zero (otherwise transform location to $x-\mu$, where μ is the mode of $\overline{f}(x)$). Let

$$A(x, f) = \int_{\mathbb{R}} K(z)\, f(x-z)\,dz$$

measure the agglomeration of firms around location x when the density of firms is given by $f(x)$. We assume that K is positive, quasi-concave, symmetric around its mode at zero, and $\int_{\mathbb{R}} K(z)\,dz = 1$. Firms' production function is $y(x, f) = g(A(x, f))$, with $g' > 0$. That is, a firm's output increases with the agglomeration of firms around its location. Firms pay real estate rents $r(x)$. There is a minimum rent, r_0, given by occupancy costs, so $r(x) \geq r_0$.[17] Firms maximize profits and building owners maximize rents. In the absence of terrorism, profits for a firm located at x are given by

$$\pi(x) = g(A(x, f)) - r(x).$$

Let m be such that $\int_{-m}^{m} \overline{f}(x)\,dx = 1$. Consider the maximum agglomeration configuration, f^*, where all firms concentrate in the interval $[-m, m]$, as close as possible to the point of maximal capacity. Let $r^*(x) = r_0 + (g(A(x, f^*)) - g(A(m, f^*)))$. Assume that $g(A(m, f^*)) - r_0 \geq 0$. Then, the pair (f^*, r^*) constitutes an equilibrium: no firm or building owner benefits from deviation. Owners of buildings located in the interval $[-m, m]$ receive Ricardian rents equal to $r^*(x) - r_0 = g(A(x, f^*)) - g(A(m, f^*))$: the difference between the

[17] In a more realistic dynamic setting, occupancy costs can be substantial as they incorporate the continuation values of vacancies in an environment with long-term contracts under uncertainty.

real estate rents and the minimum rent necessary to elicit supply of building space. Figure A.I portrays this equilibrium.

We now introduce terrorism into this model. To simplify the exposition, we assume that a terrorist attack imposes a cost c to all firms in and area of radius h around the location of the attack. We assume that $h < m$, so a terrorist attack cannot affect all firms in the maximum agglomeration equilibrium. Terrorists can produce one attack with probability equal to λ. We assume that terrorists maximize the costs induced by their attacks.

Consider the conditions under which the maximum agglomeration configuration can be maintained in equilibrium. If firms are located following the maximum agglomeration configuration (and in the absence of location-specific security measures), then terrorists will always attack the center of the distribution of firms. The maximum agglomeration configuration can be sustained in equilibrium if there exists a rent structure, $r(x) \geq r_0$, such that for all $x \in [-h,h]$ and all $z \notin [-m,m]$:

$$g(A(x, f^*)) - r(x) - \lambda c \geq g(A(z, f^*)) - r(z).$$

In other words, to sustain the maximum agglomeration equilibrium, we need a rent structure under which firms located in the interval of $\mathbb{R}$ potentially affected by a terrorist attack would not benefit from moving. It is easy to see that if the maximum agglomeration configuration can be sustained in equilibrium, then it can be sustained in an equilibrium with $r(x) = r_0$ for all $x \notin [-m,m]$. In addition, notice that $A(m, f^*) > A(z, f^*)$, for all $z \notin [-m,m]$. Therefore, the maximum agglomeration configuration can sustained in equilibrium if there exists a rent structure, $r(x) \geq r_0$, such that for all $x \in [-h,h]$:

$$g(A(x, f^*)) - r(x) - \lambda c \geq g(A(m, f^*)) - r_0.$$

Therefore:

$$\begin{aligned} r(x) &\leq r_0 + \left(g(A(x, f^*)) - g(A(m, f^*))\right) - \lambda c \\ &= r^*(x) - \lambda c. \end{aligned}$$

That is, building owners have to *completely* compensate tenants for the expected loss due to terrorism, λc, in order to preserve the equilibrium. This compensation is possible as long as it does not violate the participation constraint of building owners, $r(x) \geq r_0$. The maximum agglomeration configuration can be preserved in equilibrium if

$$\lambda c \leq g(A(x, f^*)) - g(A(m, f^*)),$$

for all $x \in [-h, h]$. That is, the maximum agglomeration configuration can be preserved in equilibrium if the terrorism threat is small relative to the difference in the gain from agglomeration economies between the firms that are threatened by terrorism and the marginal firms located at the periphery, m. This simple model suggests that a small increase in the perception of terrorism in Central Business Districts may only affect rents, without an increase in vacancies. In this model, vacancies may be affected only when the increase in the perception of terrorism is large.

Moreover, the real estate market may react to an increased threat of terrorism in ways different than a reduction in rents and still preserve the maximum agglomeration equilibrium. In particular, building owners may decide to invest in security if λ or c can be reduced by security spending, s. If the product λc is a decreasing and convex function of s, terrorism will increase security spending up to the point where the derivative of λc with respect to s is equal to minus one. If it is possible to induce a large reduction in λc via security spending before the derivative of λc with respect to s becomes larger than minus one, terrorism may not have a large effect on real estate market rents. Alternatively, if different firm managers have different perceptions of the probability of a terrorist attack, λ, or if there is heterogeneity across firms in the costs that a terrorist attack imposes, c, firm locations may be reassigned without altering the maximum agglomeration configuration.

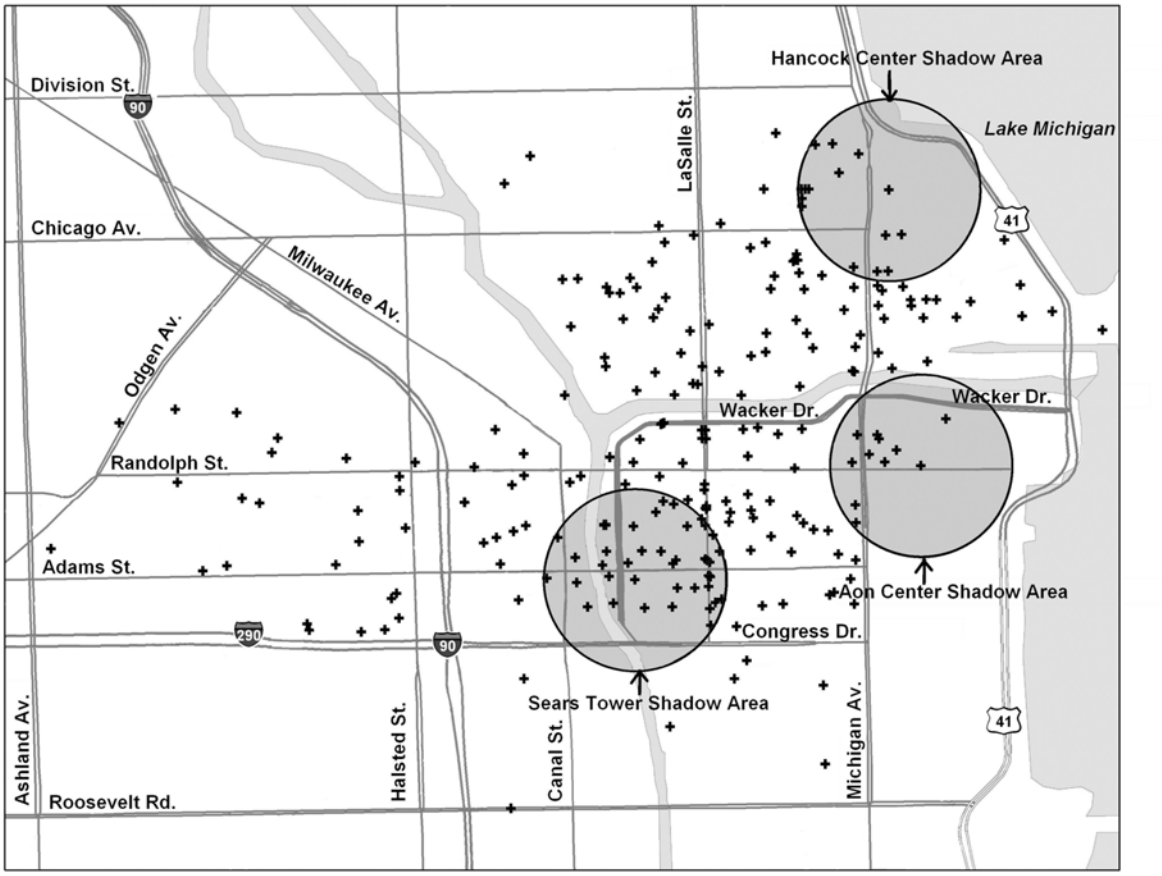

FIGURE I

Chicago's Central Business District Office Buildings and Shadow Areas

Crosses represent all Class A and Class B office buildings in Chicago's Central Business District. Shaded circles represent 0.3-mile radius "shadow areas" surrounding the three main Chicago landmark buildings: the Aon Center, the Hancock Center, and the Sears Tower.

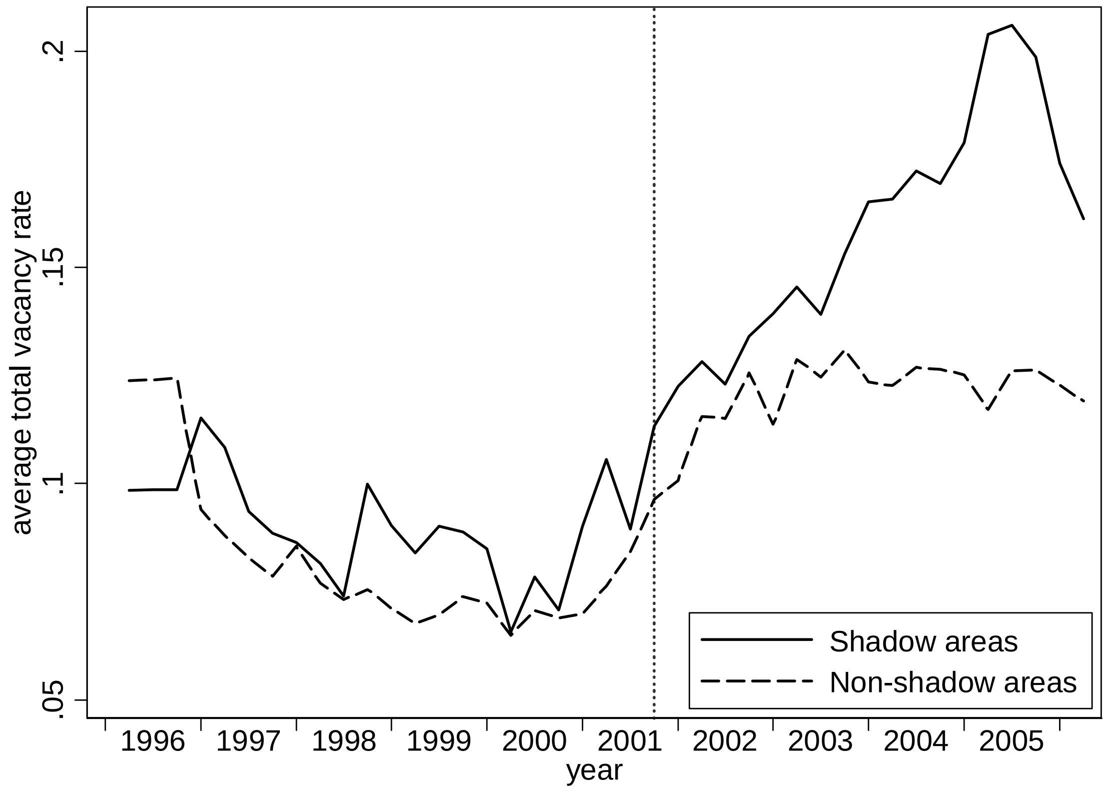

FIGURE II

Average Vacancy Rates in Shadow and Non-shadow Areas

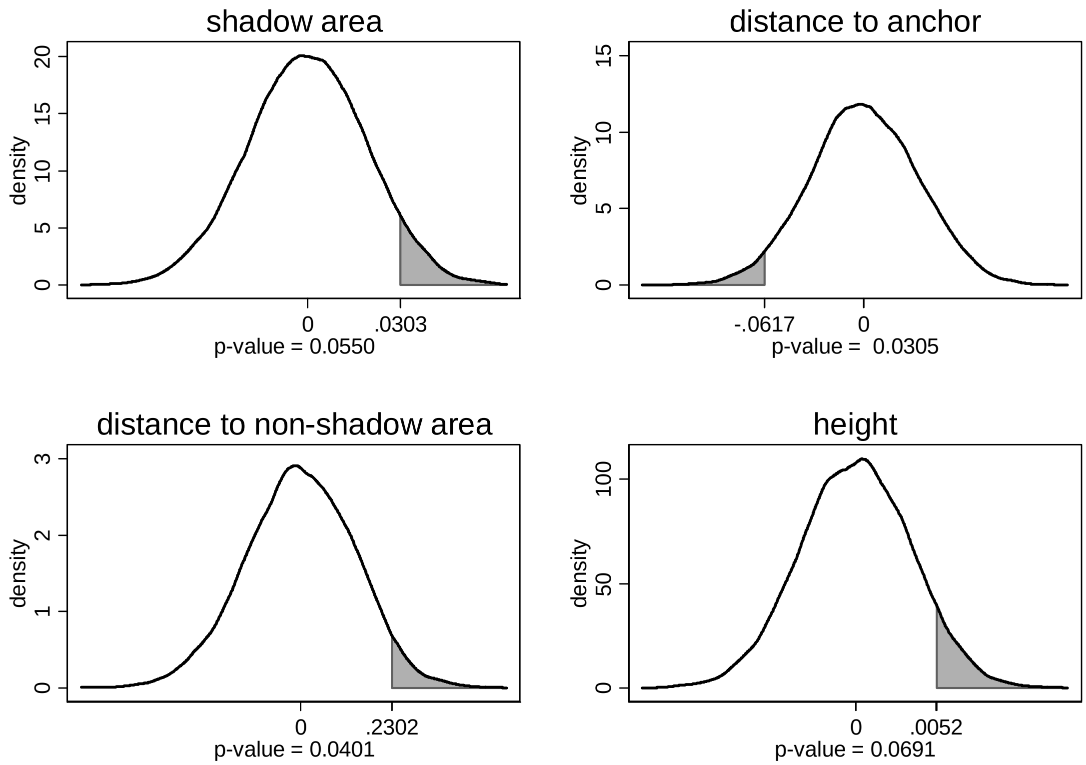

FIGURE III

Permutation Distributions and p-Values

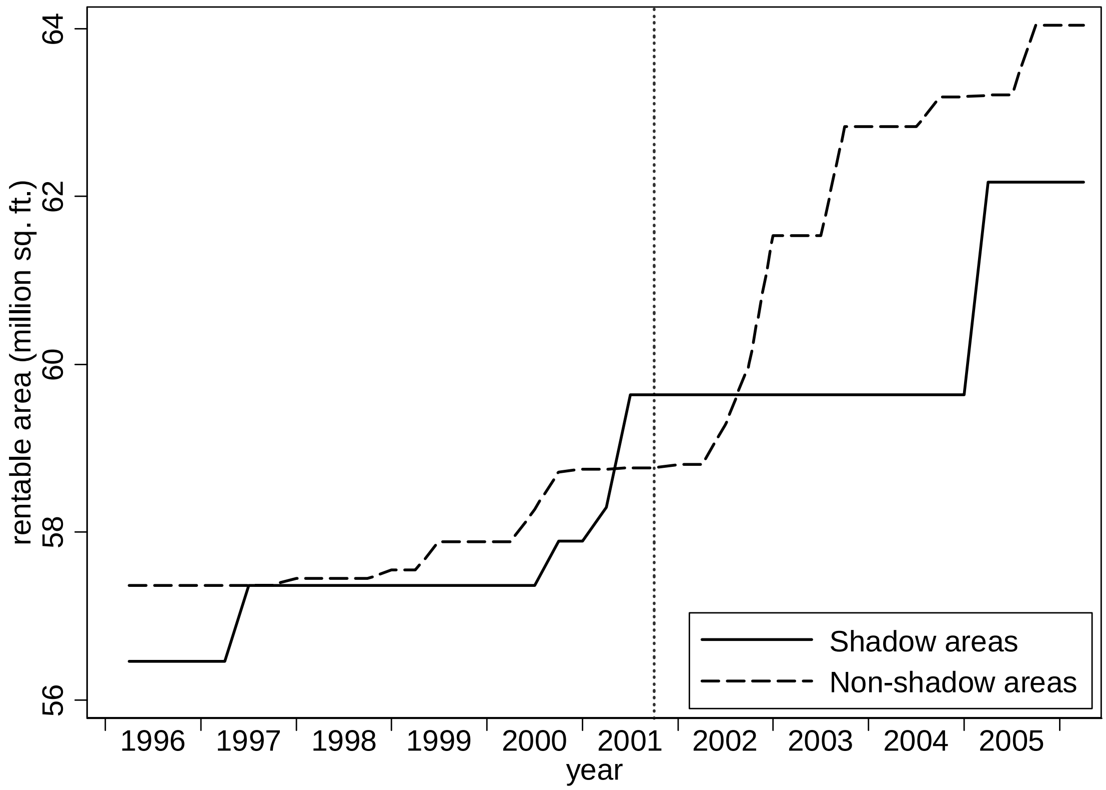

FIGURE IV

Total Rentable Areas in Shadow and Non-shadow Areas

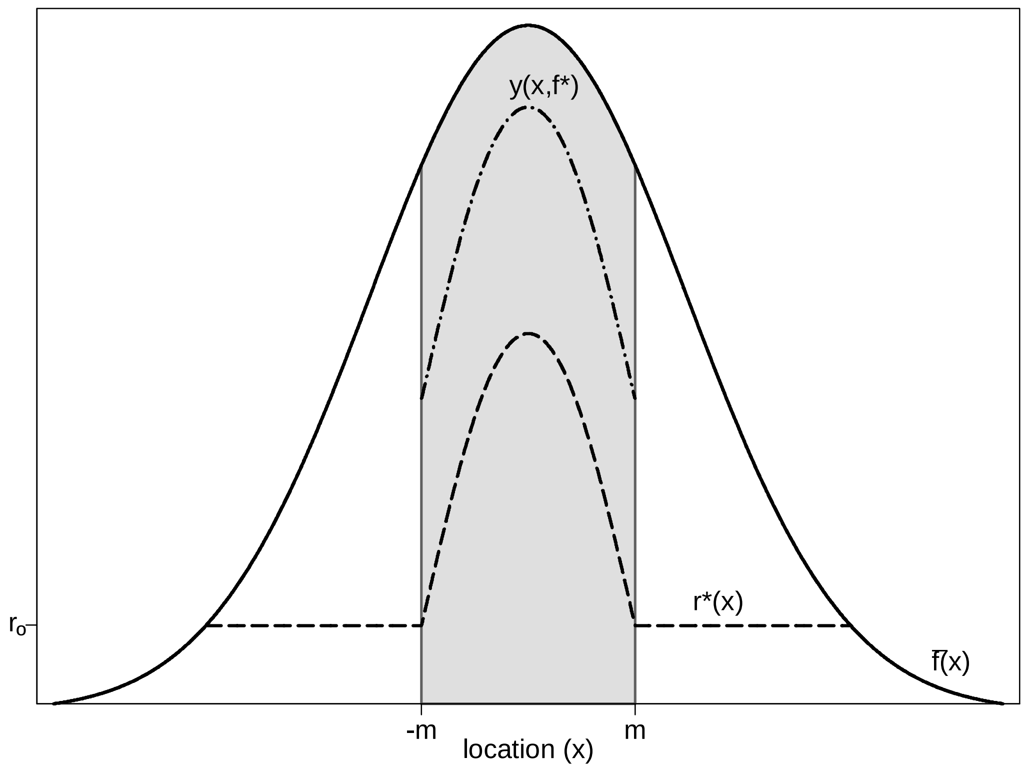

FIGURE A.I

A Simple Ricardian Model of Agglomeration

TABLE I

DESCRIPTIVE STATISTICS – MEANS AND STANDARD DEVIATIONS
(Class A and B office buildings in downtown Chicago)

	(1) Entire sample	(2) Inside shadow areas	(3) Outside shadow areas	(4) Diff. (2)-(3) (s.e.)
Characteristics of the buildings:				
shadow (= 1 if in shadow area, = 0 otherwise)	.27			
	[.45]			
Class A (=1 if Class A building, =0 if Class B building)	.21	.44	.13	.31**
	[.41]	[.50]	[.34]	(.07)
distance to anchor (miles)	.46	.19	.56	-.38**
	[.26]	[.08]	[.24]	(.02)
height (hundred feet)	2.76	4.43	2.14	2.29**
	[2.46]	[2.90]	[1.94]	(.39)
number of stories	19.77	32.59	14.96	17.63**
	[18.80]	[21.67]	[15.08]	(2.90)
rentable building area (sq. feet)	353,683	665,705	236,675	429,031**
	[499,847]	[604,842]	[397,123]	(80,243)
Vacancy rates (fraction):				
First quarter of 2001	.0803	.0901	.0699	.0202
	[.0949]	[.0903]	[.0989]	(.0174)
First quarter of 2006	.1491	.1740	.1228	.0512**
	[.1306]	[.1302]	[.1266]	(.0248)
Rent per square foot (current USD):				
First quarter of 2001	30.40	32.22	28.08	4.14**
	[5.43]	[5.59]	[4.25]	(1.23)
First quarter of 2006	28.08	29.09	26.78	2.31*
	[5.97]	[5.30]	[6.54]	(1.28)
Number of buildings in the sample	242	66	176	

Note: Columns (1) to (3) report sample means, with the standard deviations in brackets. Column (4) reports the difference between columns (2) and (3), along with the standard deviation for the difference in parentheses. The sample is a balanced panel of Class A and Class B office buildings in the extended Chicago Central Business District between the second quarter of 1996 and the second quarter of 2006. See text of the article for the exact limits of the area of the City of Chicago included in our sample. Vacancy rates and rents are weighted by the rentable area of the buildings. Rent figures reflect asking rents for office building space available at the time of the survey. Data on rents for the first quarter of 2001 are available for 54 buildings inside the shadow areas and 80 buildings outside the shadow areas. Data on rents for the first quarter of 2006 are available for 55 buildings inside the shadow areas and 97 buildings outside the shadow areas.
* indicates statistical significance at the 10% level.
** indicates statistical significance at the 5% level.

TABLE II

9/11 AND VACANCY RATES IN DOWNTOWN CHICAGO OFFICE BUILDINGS
(Fixed-effects estimates with clustered standard errors, 1996-2006)

Dependent variable: Building vacancy rate

	(1)	(2)	(3)	(4)
shadow area×post-9/11	.0303*			
	(.0166)			
distance to anchor×post-9/11		-.0617*		
		(.0362)		
distance to non-shadow area×post-9/11			.2302**	
			(.0633)	
height×post-9/11				.0052**
				(.0022)
R-squared	.39	.39	.39	.39
Number of observations	9,922	9,922	9,922	9,922

Note: The sample is a quarterly panel of Class A and Class B office buildings in the extended Chicago Central Business District between the second quarter of 1996 and the second quarter of 2006. See text of the article for the exact limits of the area of the City of Chicago included in our sample. Observations are weighted by the rentable area of the buildings. All specifications include building fixed effects and a full set of year×quarter dummies. Standard errors (in parentheses) are clustered at the building level.
* indicates statistical significance at the 10% level.
** indicates statistical significance at the 5% level.

TABLE III

TIME SINCE 9/11 AND VACANCY RATES IN DOWNTOWN CHICAGO OFFICE BUILDINGS
(Fixed-effects estimates with clustered standard errors, 1996-2006)

Dependent variable: Building vacancy rate

	(1)	(2)	(3)	(4)
shadow area×post-9/11	-.0046			
	(.0173)			
shadow area×quarters since 9/11	.0037**			
	(.0017)			
distance to anchor×post-9/11		.0156		
		(.0379)		
distance to anchor×quarters since 9/11		-.0081**		
		(.0039)		
distance to non-shadow area×post-9/11			.0614	
			(.0639)	
distance to non-shadow area×quarters since 9/11			.0178**	
			(.0060)	
height×post-9/11				-.0003
				(.0022)
height×quarters since 9/11				.0006**
				(.0002)
R-squared	.39	.39	.39	.39
Number of observations	9,922	9,922	9,922	9,922

Note: The sample is a quarterly panel of Class A and Class B office buildings in the extended Chicago Central Business District between the second quarter of 1996 and the second quarter of 2006. See text of the article for the exact limits of the area of the City of Chicago included in our sample. Observations are weighted by the rentable area of the buildings. All specifications include building fixed effects and a full set of year×quarter dummies. Standard errors (in parentheses) are clustered at the building level.
* indicates statistical significance at the 10% level.
** indicates statistical significance at the 5% level.

TABLE IV

POST-9/11 YEARS AND VACANCY RATES IN DOWNTOWN CHICAGO OFFICE BUILDINGS
(Fixed-effects estimates with clustered standard errors, 1996-2006)

Dependent variable: Building vacancy rate

	Post-9/11 Exposure to Terrorism			
	shadow area	distance to anchor	distance to non-shadow area	height
	(1)	(2)	(3)	(4)
exposure×year 2002	.0048	-.0125	.0966*	.0025
	(.0143)	(.0287)	(.0579)	(.0016)
exposure×year 2003	.0118	-.0153	.1602**	.0030
	(.0175)	(.0428)	(.0688)	(.0026)
exposure×year 2004	.0354*	-.0677	.2570**	.0033
	(.0208)	(.0463)	(.0799)	(.0030)
exposure×year 2005	.0652**	-.1360**	.3791**	.0091**
	(.0251)	(.0542)	(.0910)	(.0032)
exposure×year 2006	.0387	-.0924*	.2858**	.0114**
	(.0246)	(.0560)	(.1027)	(.0036)
R-squared	.39	.39	.39	.39
Number of observations	9,922	9,922	9,922	9,922

Note: The sample is a quarterly panel of Class A and Class B office buildings in the extended Chicago Central Business District between the second quarter of 1996 and the second quarter of 2006. See text of the article for the exact limits of the area of the City of Chicago included in our sample. Observations are weighted by the rentable area of the buildings. All specifications include building fixed effects and a full set of year×quarter dummies. Standard errors (in parentheses) are clustered at the building level.
* indicates statistical significance at the 10% level.
** indicates statistical significance at the 5% level.

TABLE V

REGRESSIONS USING PRE-9/11 DATA ONLY
(Fixed-effects estimates with clustered standard errors, 1996-2001)

Dependent variable: Building vacancy rate

	(1)	(2)	(3)	(4)
shadow area×after 1998	. 0120			
	(.0165)			
distance to anchor×after 1998		-.0313		
		(.0370)		
distance to non-shadow area×after 1998			.1017	
			(.0839)	
height×after 1998				.0026
				(.0025)
R-squared	.48	.48	.48	.48
Number of observations	5,324	5,324	5,324	5,324

Note: The sample is a quarterly panel of Class A and Class B office buildings in the extended Chicago Central Business District between the second quarter of 1996 and the third quarter of 2001. See text of the article for the exact limits of the area of the City of Chicago included in our sample. Observations are weighted by the rentable area of the buildings. All specifications include building fixed effects and a full set of year×quarter dummies. Standard errors (in parentheses) are clustered at the building level.
* indicates statistical significance at the 10% level.
** indicates statistical significance at the 5% level.

TABLE VI

POST-9/11 YEARS AND VACANCY RATES IN DOWNTOWN CHICAGO CLASS A OFFICE BUILDINGS
(Fixed-effects estimates with clustered standard errors, 1996-2006)

Dependent variable: Building vacancy rate

	Post-9/11 Exposure to Terrorism			
	shadow area	distance to anchor	distance to non-shadow area	height
	(1)	(2)	(3)	(4)
exposure×year 2002	.0043	-.0003	.0504	.0003
	(.0222)	(.0574)	(.0719)	(.0021)
exposure×year 2003	.0136	-.0471	.1215	.0018
	(.0236)	(.0639)	(.0744)	(.0037)
exposure×year 2004	.0510**	-.1545**	.2483**	.0024
	(.0237)	(.0548)	(.0768)	(.0045)
exposure×year 2005	.0760**	-.2298**	.3408**	.0087
	(.0309)	(.0615)	(.0900)	(.0054)
exposure×year 2006	.0267	-.1331	.2286*	.0110**
	(.0336)	(.0817)	(.1226)	(.0045)
R-squared	.42	.43	.43	.42
Number of observations	2,132	2,132	2,132	2,132

Note: The sample is a quarterly panel of Class A office buildings in the extended Chicago Central Business District between the second quarter of 1996 and the second quarter of 2006. See text of the article for the exact limits of the area of the City of Chicago included in our sample. Observations are weighted by the rentable area of the buildings. All specifications include building fixed effects and a full set of year×quarter dummies. Standard errors (in parentheses) are clustered at the building level.
* indicates statistical significance at the 10% level.
** indicates statistical significance at the 5% level.

TABLE VII

POST-9/11 YEARS AND VACANCY RATES IN DOWNTOWN CHICAGO TALL OFFICE BUILDINGS
(Fixed-effects estimates with clustered standard errors, 1996-2006)

Dependent variable: Building vacancy rate

	Post-9/11 Exposure to Terrorism			
	shadow area	distance to anchor	distance to non-shadow area	height
	(1)	(2)	(3)	(4)
exposure×year 2002	.0091	-.0274	.1148*	.0038**
	(.0151)	(.0365)	(.0598)	(.0017)
exposure×year 2003	.0215	-.0719	.1983**	.0052**
	(.0180)	(.0445)	(.0684)	(.0025)
exposure×year 2004	.0457**	-.1479**	.2932**	.0053
	(.0214)	(.0436)	(.0816)	(.0033)
exposure×year 2005	.0675**	-.2004**	.3805**	.0097**
	(.0259)	(.0550)	(.0932)	(.0037)
exposure×year 2006	.0376	-.1317**	.2777**	.0120**
	(.0259)	(.0587)	(.1070)	(.0041)
R-squared	.40	.40	.41	.40
Number of observations	5,207	5,207	5,207	5,207

Note: The sample is a quarterly panel of Class A and Class B high-rise office buildings in the extended Chicago Central Business District between the second quarter of 1996 and the second quarter of 2006. See text of the article for the exact limits of the area of the City of Chicago included in our sample. We follow a usual real estate convention a define tall buildings as those that are Observations are weighted by the rentable area of the buildings. All specifications include building fixed effects and a full set of year×quarter dummies. Standard errors (in parentheses) are clustered at the building level.
* indicates statistical significance at the 10% level.
** indicates statistical significance at the 5% level.

TABLE VIII

9/11 AND VACANCY RATES IN DOWNTOWN CHICAGO OFFICE BUILDINGS, SUBMARKET TRENDS INCLUDED

(Fixed-effects estimates with clustered standard errors, 1996-2006)

Dependent variable: Building vacancy rate

	Submarket Polynomial Trends			Submarket Time Dummies
	4th order	5th order	6th order	
	(1)	(2)	(3)	(4)
Panel A:	.0272*	.0282*	.0295*	.0292
shadow area×post-9/11	(.0158)	(.0164)	(.0169)	(.0195)
Panel B:	-.0388	-.0477	-.0516	-.1008**
distance to anchor×post-9/11	(.0316)	(.0331)	(.0344)	(.0475)
Panel C:	.2206**	.2302**	.2372**	.2450**
distance to non-shadow area×post-9/11	(.0682)	(.0698)	(.0705)	(.0779)
Panel D:	.0047**	.0050**	.0054**	.0060**
height×post-9/11	(.0019)	(.0020)	(.0020)	(.0027)

Note: The sample is a quarterly panel of Class A and Class B office buildings in the extended Chicago Central Business District between the second quarter of 1996 and the third quarter of 2001. See text of the article for the exact limits of the area of the City of Chicago included in our sample. Observations are weighted by the rentable area of the buildings. All specifications include building fixed effects. Standard errors (in parentheses) are clustered at the building level.

* indicates statistical significance at the 10% level.

** indicates statistical significance at the 5% level.

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