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NEW SPORTS FACILITIES AND RESIDENTIAL HOUSING MARKETS

Haifang Huang

Department of Economics, University of Alberta, 8-14 Tory, Edmonton, AB T6G 2H4, Canada. E-mail: haifang.huang@ualberta.ca

Brad R. Humphreys

Department of Economics, West Virginia University, College of Business & Economics, 1601 University Ave, PO Box 6025, Morgantown, WV 26506-6025. E-mail: brhumphreys@mail.wvu.edu

ABSTRACT. Using data from 56 professional sports facilities opened between 1995 and 2008, we find what at first appears to be a substantial effect of new sports facilities on housing markets. The opening of a new facility is associated with an increase in residential mortgage applications in nearby areas of about 20 percent. However, much of the differential is due to facility location. The new facilities locate in areas which grew faster even if they were not near a new facility. Based on regressions using census-tract level data, we find that conditioning on local income and poverty rates reduces the effect by more than a half, suggesting that characteristics of locations drive much the increase on mortgage applications associated with new sports facilities.

1. INTRODUCTION

North America experienced a boom in the construction of new professional sports stadiums and arenas over the past 20 years. Long (2012) reports that 104 new stadiums and arenas were built between 1990 and 2010, compared to just 130 new stadiums and arenas built from 1900 through 1989 and estimates that public financing accounted for about 59 percent of the spending on these new sports facilities, an estimated US$(2010)22.3 billion. Of course, much of the economic activity that takes place in these venues benefits the owners, players, and fans of the teams that play in the facilities.

What economic justification exists for this sizable public subsidy for a private economic activity? Up until the mid-1990s, tangible economic benefits, in the form of new jobs, increases in local income, and more tax revenues, represented the primary justification for these subsidies. However, a mounting body of scholarly evidence refuting the existence of tangible benefits eroded confidence in this justification (Coates, 2007). By the 2000s, subsidy proponents turned to a new justification: urban revitalization. Although sports facilities do not appear to generate new economic activity, they do concentrate existing economic activity, both spatially in and around the facility, and temporally, on the day of events in the facility. In the 2000s, new stadiums and arenas were trumpeted as the key centerpiece of downtown economic revitalization projects in cities like San Diego (Petco Park), Detroit (Ford Field), Pittsburgh (Heinz Field, PNC Park), and Columbus (Nationwide Arena). Rosentraub (2009) examines the role played by several of these facilities in the context of urban revitalization policy. In this paradigm, rather than create new economic activity, new sports facilities reverse consumer flight to the suburbs, bring consumers back to specific locations, typically downtown, on nights and weekends, and possibly induce some people to move back to the urban core. The economic activity at sports facilities generates spill over economic benefits, as new bars, restaurants, and

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shops co-locate with the sports facility. By proposing urban revitalization, and not tangible economic benefits, as the justification for subsidies, subsidy proponents shifted the debate away from the discredited trinity of "new jobs, higher income, and more tax revenues," to an area where little scholarly research existed, and benefits were more difficult to measure.

Economic research also began to focus on the relationship between professional sports facilities and less tangible, as well as intangible economic impacts. In one branch, researchers use the contingent valuation method (CVM) to assess the value of intangible benefits generated by sports facilities and mega-events using the stated preference approach (Johnson and Whitehead, 2000; Johnson, Groothuis, and Whitehead, 2001; Johnson, Mondello, and Whitehead, 2006; Fenn and Crooker, 2009). These papers generally report CVM estimates of the intangible benefits generated by professional sports teams and facilities smaller than subsidies. A second branch examines the effect of professional sports facilities on housing values and rents (Carlino and Coulson, 2004; Tu, 2005; Dehring, Depken, and Ward, 2007, 2008; Feng and Humphreys, 2012; Ahlfeldt and Maennig, 2009, 2010; Ahlfeldt and Kavetsos, 2011; Coates and Matheson, 2011). This literature contains mixed support for the hypothesis that professional sports facilities increase the price of nearby residential properties. Increasing property values near sports facilities can be interpreted as evidence supporting urban revitalization, although it could reflect other factors. We extend this literature by examining the relationship between the opening of a new sports facility and applications for residential mortgages in nearby areas, exploiting both the timing and location of new sports facilities to estimate a standard "difference-in-difference" model.

We investigate the relationship between new professional sports facilities opened in the U.S. between 1995 and 2008 and activity in nearby housing markets. A large number of new professional sports facilities opened over this period, providing considerable cross-sectional variation in both location and neighborhood characteristics. Using data on the location and opening date of new sports facilities, we examine the relationship between these openings and the volume of new residential mortgage applications for the purchase of a new or existing dwelling in census tracts within two or three miles of the new facility. We posit that a neighborhood revitalization effect can be reflected in increases in new residential mortgage applications, since these application reflect increased trading the the housing market. We find evidence of a substantial increase in residential mortgage applications near new sports facilities: the opening of a new sports facility is associated with a 20 percent increase in new residential mortgage applications in nearby census tracts, compared to applications in the rest of the metropolitan area. This result provides one explanation for why property values and rents increase in proximity to professional sports facilities: these facilities increase trading activity in the area. We also find that new facilities tended to be located in areas with lower household income, a higher fraction of renter occupied housing, and a larger fraction of the population living below the poverty line. This suggests the possibility that stadium location decisions were made in order to revitalize urban areas. We also show that similar areas that did not get new sports facilities also experienced higher than average growth in home mortgage applications, suggesting that some of the redevelopment around new sports facilities would have taken place in the absence of a new sports facility.

2. THE IMPORTANCE OF SPORTS FACILITIES FOR LOCAL REDEVELOPMENT

Much of the research on the relationship between the opening of new professional sports facilities and residential housing values estimates hedonic housing price models, and uses models of amenities (Roback, 1982) to motivate the empirical analysis. Recent research formally links urban amenities and urban growth. The literature on urban growth and redevelopment is vast. Cinyabuguma and McConnell (2013), Reynolds and Rohlin (2014) and Capello and Lenzi (2014) are recent examples in this literature. Professional sports facilities can be considered a type of two urban amenities identified by Glaeser, Kolko, and Saiz (2001) as drivers of urban growth: the availability of a wide variety of consumer goods and an aesthetically pleasing physical environment; major league baseball teams are identified as a welfare-enhancing consumption good found only in cities. Krupka (2009) links amenities to migration into urban areas. In the context of the spatial equilibrium models discussed by Glaeser and Gottleib (2008), professional sports facilities could generate agglomeration effects through the increased consumer presence on game days. Glaeser and Gottlieb (2006) pointed out the importance of the availability of variety in consumer services available in cities, including entertainment services, in explaining the resurgence of cities since about 1980. Glaeser et al. (2001) investigated the role played by consumer amenities in explaining urban growth since 1977, and identified the presence of live performance venues and restaurants as key consumer amenities. Professional sports facilities, and the co-located bars and restaurants around these facilities, are one type of consumer service that could drive urban revitalization in this context. Ahlfeldt (2011) links employment accessability, which could be affected by this co-location of businesses, to the residential land gradient. Clearly, the spatial equilibrium models that underly much of this research predict that increased demand for residential housing would follow the introduction of an urban amenity like a new sports facility in an area.

Humphreys and Zhou (2012) develop a model of the effect of a new sports facility on an urban economy taking into account the location of the facility, agglomeration effects in the form of co-location of other service producers like bars and restaurants, the presence of other service producing firms, and locational decisions made by residents of the city. This model predicts that some consumers will move to the area near the sports facility in order to take advantage of the increased variety of service producing firms that co-locate with the sports facility.

Both the spatial equilibrium models in the new urban growth literature, and the agglomeration effects model developed by Humphreys and Zhou (2012), predict that the opening of a new sports facility could increase both demand for residential housing near a facility and residential property values. The driving force behind the increase in demand for residential housing is the attractiveness of the urban amenity, the sports facility in this case, and the other related service producers that co-locate with the facility.

The proponents of sports facility subsidies often simply assert that a new facility will revitalize the local area. Unlike previous claims about the effect of new sports facilities on metropolitan employment and income that were backed up with evidence from regional input-output models, claims about urban revitalization are more difficult to assess for several reasons. First, the claimed benefits are local, and not spread over the entire metropolitan area. Empirically assessing claims of sports facility led urban revitalization requires data at the submetropolitan level. The standard regional accounts data, like the Regional Economic Information System published by the U.S. Department of Commerce, Bureau of Economic Analysis, are not available for geographical units smaller than the county, which is probably too large to identify revitalization in a specific neighborhood. Second, urban revitalization is a difficult concept to quantify, when compared to previous claims about tangible economic benefits that often took the form "a new stadium will create X thousand new jobs in the city."

As empirical analysis of the ability of a new sports facility to revitalize a specific urban area must use data available at a relatively disaggregated spatial level that can also be plausibly linked to urban redevelopment. The literature on property values mentioned above represents one possible avenue of research. Previous research in this area has used data on the assessed or market value of individual residential properties, or housing values at the census block group. However, analysis of housing data requires detailed information often available for only one city or urban area and also entails accounting for spatial autocorrelation. Most of the studies cited above are case studies of a single city and sports facility, and most do not account for spatial autocorrelation.

We take a different, but related approach and analyze the determinants of residential mortgage applications. The residential mortgage application data were collected as part of the Home Mortgage Disclosure Act (HMDA), which requires mortgage lending institutions to report on the characteristics of residential mortgages they originate or purchase. Since 1990, detailed information about the location of the properties, the characteristics of the applicants, and the disposition of applications have been reported and disseminated. Annual data on residential mortgage applications are available at the census tract level for most U.S. cities. HDMA also has extensive coverage, mandating reports from a large number of lenders. Avery, Brevoort, and Canner (2007) suggested that these lenders together account for about 80 percent of home lending nationwide. Recent research using HMDA mortgage application data include Munnell et al. (1996), Mian and Sufi (2009), Goodman and Smith (2010), and Hanson, Schnier, and Turnbull (2012). HDMA data are available for census tracts in all U.S. cities, so analysis of these data is not limited to a specific metropolitan area, generating considerable cross-sectional variation.

We posit that the number of home-purchase mortgage applications in an urban area reflects urban revitalization, as it indicates interest in purchasing residential property in the area. A revitalized neighborhood may include construction of new residential housing, and new retail establishments, bars and restaurants, and other amenities may attract new residents to the area. Home-purchase loans can be used either for newly constructed residences or for existing units. The HMDA reports do not provide information to differentiate the two. These reports also do not include information on housing prices. But a rising volume of applications for mortgages to purchase either new or existing residential units would indicate an improving housing market, as there is a well-documented positive relationship between the intensity of trading activity and dwelling prices. Stein (1995) developed a model of the decision to buy and sell a residence that predicts a positive relationship between trading volume in housing markets and house prices. Berkovec and Goodman (1996) and Clayton, Miller, and Peng (2010) report evidence that trading volume in housing markets are associated with higher dwelling prices.

We also attempt to disentangle the potential revitalization effect of new sports facilities from an alternative explanation based on the increased availability of mortgage credit to residents of low-income neighborhoods. The new facilities in our sample tend to locate in poorer and more densely populated urban areas that have large minority populations. Such areas coincidentally experienced increases in mortgage availability over much of the sample period. One manifestation of the phenomenon was the subprime mortgage expansion leading to the 2007 housing crisis. But significant policy tools were used to increase the provision of mortgage credit to low-income borrowers since the mid-1990s.[1] Low-income and minority populations appear to have gained a better accesses to mortgage credit over this period. According to a report by the *New York Times* based on home ownership statistics from the Census Bureau, the U.S. home ownership rate increased from 64 percent in 1994 to near 68 percent in 2001, with black and Hispanic home ownership

[1]In 1996, the U.S. Department of Housing and Urban Development gave Fannie Mae and Freddie Mac an explicit target on how much of their mortgage financing had to serve low and moderate income borrowers. The target was raised twice in later years. See Mian, Sufi, and Trebbi (2010) for a discussion on U.S. public policy and subprime mortgages.

rising faster than the country as a whole.[2] The phenomenon became more prominent in the peak of the subprime boom. As reported in Mian and Sufi (2009), *subprime* ZIP Codes, defined as those in the top quartile of the distribution in terms of the fraction of borrowers with a low credit score in 1996, experienced a growth in mortgage credit more than twice as high as that in *prime* ZIP Codes (those in the bottom quartile). Huang and Tang (2012) found that the mortgage rejection rate in 1996 was a significant predictor of later housing price booms, and subsequent busts, in cities with a more limited supply capacity of residential housing. In summary, new sports facilities tend to locate in poorer areas, and these areas gained better access to mortgage credit over a majority of the sample period. This gives rise to a possible spurious correlation between new sports facility openings and increases in mortgage applications. Our analysis uses a regression approach to take into account the nonrandomness of facility location.

3. EMPIRICAL ANALYSIS OF NEW RESIDENTIAL MORTGAGE APPLICATIONS

Our empirical approach is based on a standard difference-in-difference model. We ask whether the area surrounding a new sports facility experienced greater increases in mortgage applications relative to more distant parts of the same metropolitan area over the same period. We divide metropolitan areas into two groups. The first group, which we call the treatment area, include census tracts whose population centroid is within a short distance, two or three miles, of a new sports facility. The second group, which we call the control area, includes census tracts in the rest of the metropolitan area. After identifying the treatment and control areas from the exact latitude and longitude of new sports facilities and the centroid of census tracts, we compare them in terms of changes in residential mortgage applications three years before the opening of the facility to three years after the opening. We ask whether there is a positive effect of new sports facilities in the treatment area. Do applications for residential mortgages in the treatment area increase by more than those in the control area in the period after the opening of a new sports facility?

Note that we adopt the terminology from standard difference-in-difference analysis but recognize that this application differs from the assumptions underlying difference-in-difference analysis in an important way: in this case, the treatment is clearly *not* based on random assignment. Planners and other economic decision makers in metropolitan areas do not randomly locate new sports facilities; they locate them where a large enough parcel of land can be assembled in proximity to the transportation assets required to get fans in and out of the facilities. We do not attribute increases in residential mortgage applications in nearby census tracts after a new facility opens to a causal relationship. We use this terminology, where census tracts containing a new sports facility and located within two or three miles are called the "treatment" area and census tracts farther away from the facility but in the same metropolitan area are called the "control" area, as a matter of convenience. As stated earlier, we also recognize that the estimates of the magnitude of the treatment will be affected by the characteristics of the area where the new facility is located. In particular, we recognize that the estimated effect in the treatment area will be biased up if new facilities are located in areas that would have experienced higher than average growth in residential mortgage applications absent the new facility and biased down if new facilities are located in areas that would have experienced lower than average growth. To address this problem, we perform a regression analysis that takes into

[2]The *New York Times*, "Building Flawed American Dreams" By David Streitfeld and Gretchen Morgenson, October 18, 2008.

account the characteristics of the areas where new facilities were built, which will allow us to assess the impact of these factors on the estimated effect of new sports facilities in the treatment area. But we do not have an instrument that would completely solve this econometric problem. Throughout the paper, we strive to point out the appropriate caveats associated with this issue. Despite this problem, we believe that this analysis can tell us something interesting and important about the relationship between new sports facilities neighborhood turnover, which might reflect urban redevelopment.

The analysis proceeds in two steps. First, we perform a difference-in-difference analysis of residential mortgage applications in the treatment and control areas. Second, we undertake a regression analysis to determine the extent to which the treatment areas in the sample reflect selection on unobservables. New sports facilities are not located randomly in metropolitan areas. In addition, neighborhoods suitable for new sports facilities might also have characteristics that would lead to increases in residential mortgage applications over time even if the new facility was not located there. For example, access to residential mortgages increased over most of our sample period among low income and minority borrowers, so areas with many low income and minority residents would have experienced increases in residential mortgage application no matter what treatment occurred in the area. A failure to take this into account will bias the estimated effect in the treatment area up. We use a regression model to assess the effect of census tract characteristics on the estimated effect in the treatment area. Specifically, we assess the extent of this bias by comparing the estimated effects before and after controlling for census tract-specific socioeconomic information.

Data Description

More than 100 new sports facilities opened in North America from 1990 to 2010. Seventy-two of these facilities opened in the 1995 to 2008 period that makes up our sample period. Twenty-one were home to only a National Football League (NFL) team, 16 were home to only a Major League Baseball (MLB) team, 11 were home to only a National Hockey League (NHL) team, and 12 were home to only a National Basketball Association (NBA) team. The rest housed multiple teams. For each of these facilities, we determined the longitude and latitude of their locations and the dates of opening. Our analysis uses data from stadiums and arenas that opened between 1995 and 2008 in the U.S., because we need mortgage application data three years before and three years after the opening for the econometric analysis. The mortgage data sample begins in 1992 and ends in 2010.[3] We omitted all facilities opened in Canada and those that were home to a Major League Soccer (MLS) team.[4] Table 1 lists the 56 facilities in the sample, the teams that played in the facility, the metropolitan area, and the year the facility opened.

Home-purchase mortgage applications by census tract come from the annual reports submitted by mortgage lenders under the HMDA. Home-purchase loans can be used for

[3]The 1990 and 1991 HMDA reports are available as well. But 1992 is the year when the HMDA adopted the census tract definition used in the 1990 Census. The 1990 and 1991 HMDA reports contain the census tract ID, but the total number of tracts in 1991 is 10 percent smaller than those in the 1992 report. In addition, the correlation coefficient between the 1991 mortgage applications by census tract and the 1992 numbers is 0.58, while that between the 1992 and the 1993 reports is 0.92. It is thus clear that 1992 is the beginning of a consistent area definition in the data. For this reason, we begin our mortgage application data in 1992. The year 2010, on the other hand, is the latest available as of early 2012.

[4]Note that EverBank Field, the NFL stadium in Jacksonville, appears in the sample. Technically, this stadium contains some parts of the Gator Bowl, which was built in 1982. But the renovations to this facility that took place before the arrival of the Jacksonville Jaguars was extensive, and we treat this as a new facility.

TABLE 1: Sports Facilities in Sample

Facility	Team (Sport)	Metro Area	Year Opened
TD Garden	Celtics (NBA)	Boston-Worcester-Lawrence, MA-NH-ME-CT	1995
	Bruins (NHL)		
Coors Field	Rockies (MLB)	Denver-Boulder-Greeley, CO	1995
EverBank Field	Jaguars (NFL)	Jacksonville, FL	1995
Rose Garden	Trail Blazers (NBA)	Portland-Salem, OR-WA	1995
Edward Jones Dome	Rams (NFL)	St. Louis, MO-IL	1995
HSBC Arena	Sabres (NHL)	Buffalo-Niagara Falls, NY	1996
Bank of America Stadium	Panthers (NFL)	Charlotte-Gastonia-Rock Hill, NC-SC	1996
Bridgestone Arena	Predators (NHL)	Nashville, TN	1996
Wells Fargo Center	76ers (NBA)	Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	1996
	Flyers (NHL)		
St. Pete Times Forum	Lightening (NHL)	Tampa-St. Petersburg-Clearwater, FL	1996
Turner Field	Braves (MLB)	Atlanta, GA	1997
Oracle Arena	Warriors (NBA)	San Francisco-Oakland-San Jose, CA	1997
FedEx Field	Redskins (NFL)	Washington-Baltimore, DC-MD-VA-WV	1997
Verizon Center	Wizards (NBA)	Washington-Baltimore, DC-MD-VA-WV	1997
	Capitals (NHL)		
M&T Bank Stadium	Ravens (NFL)	Washington-Baltimore, DC-MD-VA-WV	1998
BankAtlantic Center	Panthers (NHL)	Miami-Fort Lauderdale, FL	1998
Chase Field	Diamondbacks (MLB)	Phoenix-Mesa, AZ	1998
Raymond James Stadium	Buccaneers (NFL)	Tampa-St. Petersburg-Clearwater, FL	1998
Philips Arena	Hawks (NBA)	Atlanta, GA	1999
	Thrashers (NHL)		
Cleveland Browns Stadium	Browns (NFL)	Cleveland-Akron, OH	1999
Pepsi Center	Nuggets (NBA)	Denver-Boulder-Greeley, CO	1999
	Avalanche (NHL)		
Conseco Fieldhouse	Pacers (NBA)	Indianapolis, IN	1999
Staples Center	Lakers,Clippers (NBA)	Los Angeles-Riverside-Orange County, CA	1999
	Kings (NHL)		
American Airlines Arena	Heat (NBA)	Miami-Fort Lauderdale, FL	1999
LP Field	Titans (NFL)	Nashville, TN	1999
RBC Center	Hurricanes (NHL)	Raleigh-Durham-Chapel Hill, NC	1999

Continued

TABLE 1: Continued

Facility	Team (Sport)	Metro Area	Year Opened
SafeCo Field	Mariners (MLB)	Seattle-Tacoma-Bremerton, WA	1999
Paul Brown Stadium	Bengals (NFL)	Cincinnati-Hamilton, OH-KY-IN	2000
Nationwide Arena	Blue Jackets (NHL)	Columbus, OH	2000
Comerica Park	Tigers (MLB)	Detroit-Ann Arbor-Flint, MI	2000
Minute Maid Park	Astros (MLB)	Houston-Galveston-Brazoria, TX	2000
Xcel Energy Center	Wild (NHL)	Minneapolis-St. Paul, MN-WI	2000
AT&T Park	Giants (MLB)	San Francisco-Oakland-San Jose, CA	2000
American Airlines Center	Mavericks (NBA)	Dallas-Fort Worth, TX	2001
	Stars (NHL)		
Sports Authority Field	Broncos (NFL)	Denver-Boulder-Greeley, CO	2001
Miller Park	Brewers (MLB)	Milwaukee-Racine, WI	2001
PNC Park	Pirates (MLB)	Pittsburgh, PA	2001
Heinz Field	Steelers (NFL)	Pittsburgh, PA	2001
Gillette Stadium	Patriots (NFL)	Boston-Worcester-Lawrence, MA-NH-ME-CT	2002
Ford Field	Lions (NFL)	Detroit-Ann Arbor-Flint, MI	2002
Reliant Stadium	Texans (NFL)	Houston-Galveston-Brazoria, TX	2002
AT&T Center	Spurs (NBA)	San Antonio, TX	2002
CenturyLink Field	Seahawks (NFL)	Seattle-Tacoma-Bremerton, WA	2002
Great American Ballpark	Reds (MLB)	Cincinnati-Hamilton, OH-KY-IN	2003
Toyota Center	Rockets (NBA)	Houston-Galveston-Brazoria, TX	2003
Lincoln Financial Field	Eagles (NFL)	Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	2003
Jobing.com Arena	Coyotes (NHL)	Phoenix-Mesa, AZ	2003
FedEx Forum	Grizzlies (NBA)	Memphis, TN-AR-MS	2004
Citizens Bank Park	Phillies (MLB)	Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	2004
Petco Park	Padres (MLB)	San Diego, CA	2004
Time Warner Cable Arena	Bobcats (NBA)	Charlotte-Gastonia-Rock Hill, NC-SC	2005
U. of Phoenix Stadium	Cardinals (NFL)	Phoenix-Mesa, AZ	2006
Busch Stadium	Cardinals (MLB)	St. Louis, MO-IL	2006
Prudential Center	Devils (NHL)	New York, Northern New Jersey, Long Island, NY-NJ-CT-PA	2007
Lucas Oil Stadium	Colts (NFL)	Indianapolis, IN	2008
Nationals Park	Nationals (MLB)	Washington-Baltimore, DC-MD-VA-WV	2008

newly constructed or existing residences; the residences include single family homes, multifamily dwellings, and individual condominium or cooperative units in multi-unit structures.[5] We include applications for loans insured by government agencies, such as the Federal Housing Administration (FHA) and Veterans Administration (VA), as well as loans that are not insured by the government. The HMDA reports are publicly available.[6]

Census tracts are "small, relatively permanent geographic entities within counties ... [generally having] between 2,500 and 8,000 residents" (Geographic Areas Reference Manual, U.S. Census Bureau). We use the population centroid of each census tract to determine if a property is located near a new sports facility. For this purpose, we calculate the distance between stadiums and census tracts using longitude and latitude information. The Census Bureau provides an estimate of population centroid online based on the Census-2000 population counts. We use a two-mile radius from the stadium, and a three-mile radius as a robustness check, to allocate census tracts into a treatment area and a control area: those that have a population centroid within the two or three mile radius belong to the treatment area; those outside the two or three mile radius belong to the control area. Table 2 shows the total number of census tracts in each metropolitan area and the number in the treatment group for each radius. Note that only four of the facilities, the BankAtlantic Center (NHL Florida Panthers), the RBC Center (NHL Carolina Hurricanes), Gillette Stadium (NFL New England Patriots), and the University of Phoenix Stadium (NFL Arizona Cardinals) have fewer than 10 census tracts within three miles. Overall, the average number of census tracts in a metropolitan area in the sample is 819, an average of 24 census tracts are within a two-mile radius, and an average of 49 within a three-mile radius. If we define the treatment area with a two-mile radius, the average treatment area includes about three percent of the census tracts in the metropolitan area. The three-mile radius treatment area contains about 6 percent of the census tracts.

The Census Bureau updates census tract area definitions between censuses to reflect population dynamics; the revision "often involve[s] the subdivision of an existing census tract (or census tracts) into two or more new units." Our mortgage data covers the period from 1992 to 2010 and thus encompasses one revision in the census tract area definitions. The Census Bureau provides a between-census geographic relationship crosswalk file covering the entire universe of census tracts. We use the relationship file to reconstruct, when necessary, the population centroid and mortgage counts to the 1990-Census definition (see Appendix). We use the 1990 definition because most of our mortgage data (those between 1992 and 2002) are based on this definition. We use the Census-2000 resident population as weights in the reconstruction process, because that year is roughly the midpoint of the sample period for our mortgage data (from 1992 to 2010).

The following example illustrates the construction of the data set. Lincoln Financial Field (located at lat 39°54′3″ N, long 75°10′3″ W), home of the Philadelphia Eagles of the NFL, opened in 2003. The facility is located in the Philadelphia-Wilmington-Atlantic City Combined Metropolitan Statistical Area (CMSA) in the 2000 Census. For each individual census tract in this CMSA, we calculated the straight-line distance

[5]We use what the HMDA calls "one-to-four-family dwellings," which actually includes not just one-to-four-family dwellings, but also individual condominium or cooperative units "even if the unit is located in a structure that houses five or more families" (see for example page 27 of the 2003 *A Guide to HMDA Reporting: Getting It Right!*).

[6]For the years after 2003, we aggregate the application counts to census tract using the *HMDA Loan Application Register* (LAR), a loan-level database. For the years between 1992 and 2002, we used already-aggregated statistics from the *HMDA Aggregate Tables Print Image Files*. Some of the recent HMDA data are available online. The rest is available from the National Technical Information Service, U.S. Department of Commerce.

TABLE 2: Number of Census Tracts in Metro Area and in Treatment Groups

Facility	Total	Within Two miles	Within Three miles
TD Garden	1,177	54	108
Coors Field	580	29	52
EverBank Field	168	11	22
Rose Garden	393	31	55
Edward Jones Dome (Trans World)	450	15	35
HSBC Arena	290	17	34
Bank of America Stadium (Ericsson)	263	17	33
Bridgestone Arena	202	21	38
Wells Fargo Center	1,522	13	43
St. Pete Times Forum (Ice Palace)	409	14	26
Turner Field	495	28	55
Oracle Arena (Oakland Arena)	1,376	18	46
FedEx Field	1,545	11	22
Verizon Center (MCI)	1,545	60	99
M&T Bank Stadium (PSInet)	1,544	47	99
Bank Atlantic Center	427	1	2
Chase Field (Bank One Ballpark)	490	15	24
Raymond James Stadium	409	10	24
Philips Arena	495	33	56
Cleveland Browns Stadium	855	27	60
Pepsi Center	579	23	55
Conseco Fieldhouse	330	20	41
Staples Center	2,552	50	100
American Airlines Arena	427	17	32
LP Field (Adelphia Coliseum)	202	18	33
RBC Center (Raleigh Sports Arena)	196	2	9
SafeCo Field	615	19	35
Paul Brown Stadium	436	39	66
Nationwide Arena	343	25	51
Comerica Park	1392	31	58
Minute Maid Park (Enron Field)	793	19	43
Xcel Energy Center	648	30	50
AT&T Park (Pacific Bell Park)	1,372	35	72
American Airlines Center	866	21	44
Sports Authority Field at Mile High	575	21	53
Miller Park	429	37	93
PNC Park	760	50	98
Heinz Field (Rooney)	760	46	98
Gillette Stadium (CMGI)	1,159	1	4
Ford Field	1,392	31	58
Reliant Stadium	791	10	25
AT&T Center (SBC Center)	249	9	21
CenturyLink Field (Qwest Field)	614	21	35
Great American Ballpark	435	41	69
Toyota Center	791	22	45
Lincoln Financial Field	1,519	14	43
Jobing.com Arena	490	3	10
FedEx Forum	225	22	40
Citizens Bank Park	1,522	19	49
Petco Park	437	22	40
Time Warner Cable (TWC) Arena	265	19	34

Continued

TABLE 2: Continued

Facility	Total	Within Two miles	Within Three miles
University of Phoenix Stadium	490	2	9
Busch Stadium III	464	14	35
Prudential Center	5,099	71	123
Lucas Oil Stadium	330	16	36
Nationals Park	1,654	36	82
Average	818.5	24.07	48.61

between its population centroid and Lincoln Financial Field. We then use the distance information to allocate census tracts to the treatment and control areas. The treatment area includes 14 census tracts within a two-mile radius, and 43 census tracts within a three-mile radius, of the facility. The control area includes the rest of the 1,519 census tracts in the CMSA. The stadium was opened in 2003; we use the average annual volume of residential mortgage applications over 2000 to 2002 as the before-opening application volume. The after-opening volume is the average over 2003 to 2005. We repeat the procedure for all other facilities in the sample.

Difference-in-Difference Analysis

We first examine the changes in residential mortgage applications before and after the opening of a new facility in each metropolitan area in the sample based on a standard difference-in-difference approach. Using the notation in Imbens and Wooldridge (2009), we have data for $i = 1, 2 \ldots N$ groups of census tracts. Building a new sports facility in or near a neighborhood represents the treatment in this case. Let G_i identify groups of census tracts where $G_i = 1$ identifies those that receive the treatment and $G_i = 0$ those that did not. The housing-market outcomes, in terms of the number of residential mortgage applications, are observed two time periods, $T_i \epsilon (0, 1)$ where $T_i = 0$ is the pretreatment period and $T_i = 1$ the posttreatment period. The outcome in the absence of the treatment is $Y_i(0)$ and, under the assumption of an additive treatment, the outcome in areas in the treatment group is $Y_i(1) = Y_i(0) + \tau_{did}$, where τ_{did} is the effect of the treatment on the outcome. Imbens and Wooldridge (2009) show that the estimator for this set-up is

$$\tau_{did} = (E[Y_i|G_i = 1, T_i = 1] - E[Y_i|G_i = 1, T_i = 0]) \\ - (E[Y_i|G_i = 0, T_i = 1] - E[Y_i|G_i = 0, T_i = 0]).$$

In other words, the effect in the treatment area can be estimated by comparing the average difference in the outcome over time in the treatment group to the average difference in the outcome over time in the control group. This procedure removes any bias in the estimate of the effect in the treatment area associated with a common trend over time that is not associated with the treatment. For a sample of data, the estimator is

$$\hat{\tau}_{did} = (\overline{Y}_{11} - \overline{Y}_{10}) - (\overline{Y}_{01} - \overline{Y}_{00}), \tag{1}$$

where $\overline{Y}_{gt}$ is the average outcome in group g in period t. This approach assesses housing market outcomes for each new facility, while still controlling for local housing market trends common to the control and treatment areas.

Table 3 contains estimates of the average effect of a new sports facility in each treatment area using Equation (1). The table shows the the level and percent change of residential mortgage applications in the two-mile treatment area and control areas for

TABLE 3: Increase in Mortgage Applications, Control Census Tracts and Two-mile Radius Treatment Area Census Tracts

		Treatment CTs			Control CTs			
Facility	Year Opened	Before	After	% Change	Before	After	% Change	% $\Delta_{\text{Treatment}}$ − % Δ_{Control}
TD Garden	1995	1,406	2,299	64	55,625	74,021	33	30
Coors Field	1995	990	1,499	51	51,604	64,641	25	26
EverBank Field	1995	181	330	82	15,331	25,020	63	19
Rose Garden	1995	791	1,152	46	32,209	43,868	36	9
Edward Jones Dome (Trans World)	1995	128	195	53	38,343	50,598	32	21
HSBC Arena	1996	167	146	−12	12,494	12,507	0	−13
Bank of America Stadium (Ericsson)	1996	452	848	88	25,825	43,828	70	18
Bridgestone Arena	1996	282	379	35	21,781	30,882	42	−7
Wells Fargo Center	1996	588	711	21	72,506	89,600	24	−3
St. Pete Times Forum (Ice Palace)	1996	299	468	56	39,865	56,311	41	15
Turner Field	1997	483	1,040	115	79,458	1,15,119	45	70
Oracle Arena (Oakland Arena)	1997	649	1,017	57	88,453	1,43,017	62	−5
FedEx Field	1997	466	446	−4	1,09,567	1,56,977	43	−48
Verizon Center (MCI)	1997	1,765	3,333	89	1,08,268	1,54,090	42	46
M&T Bank Stadium (PSInet)	1998	953	2,005	110	1,16,050	1,75,772	51	59
Bank Atlantic Center	1998	581	860	48	71,801	99,542	39	9
Chase Field (Bank One Ballpark)	1998	436	715	64	77,303	1,09,600	42	22
Raymond James Stadium	1998	477	648	36	48,312	68,563	42	−6
Philips Arena	1999	950	2,124	124	1,01,895	1,27,462	25	98
Cleveland Browns Stadium	1999	151	205	35	49,886	56,685	14	21
Pepsi Center	1999	1,712	2,380	39	74,616	94,561	27	12
Conseco Fieldhouse	1999	497	805	62	33,893	41,630	23	39
Staples Center	1999	588	817	39	2,46,640	3,35,670	36	3
American Airlines Arena	1999	939	1,670	78	80,831	1,05,649	31	47
LP Field (Adelphia Coliseum)	1999	383	530	38	30,878	33,971	10	28
RBC Center (Raleigh Sports Arena)	1999	209	191	−9	37,145	39,988	8	−16
SafeCo Field	1999	1,123	1,279	14	77,394	91,103	18	−4
Paul Brown Stadium	2000	1,035	1,034	0	41,628	43,098	4	−4
Nationwide Arena	2000	788	892	13	33,605	37,677	12	1
Comerica Park	2000	200	236	18	1,28,164	1,30,430	2	17
Minute Maid Park (Enron Field)	2000	577	1,016	76	1,09,749	1,18,341	8	68

Continued

TABLE 3: Continued

		Treatment CTs			Control CTs			
Facility	Year Opened	Before	After	% Change	Before	After	% Change	% $\Delta_{\text{Treatment}}$ − % Δ_{Control}
Xcel Energy Center	2000	1,227	1,435	17	69,454	77,508	12	5
AT&T Park (Pacific Bell Park)	2000	1,639	1,721	5	1,42,401	1,47,031	3	2
American Airlines Center	2001	1,283	1,480	15	1,47,197	1,49,896	2	14
Sports Authority Field at Mile High	2001	2,138	2,102	−2	92,972	88,314	−5	3
Miller Park	2001	1,137	1,429	26	28,307	30,710	8	17
PNC Park	2001	657	645	−2	34,007	33,646	−1	−1
Heinz Field (Rooney)	2001	600	588	−2	34,064	33,702	−1	−1
Gillette Stadium (CMGI)	2002	89	98	9	1,03,015	1,16,258	13	−4
Ford Field	2002	217	317	46	1,38,506	1,29,230	−7	53
Reliant Stadium	2002	929	1,162	25	1,19,350	1,37,098	15	10
AT&T Center (SBC Center)	2002	385	375	−3	36,621	38,869	6	−9
CenturyLink Field (Qwest Field)	2002	1,455	1,818	25	90,926	1,07,754	19	6
Great American Ballpark	2003	1,079	1,395	29	43,053	50,733	18	11
Toyota Center	2003	1,616	2,500	55	1,17,741	1,60,681	36	18
Lincoln Financial Field	2003	1,207	1,607	33	1,12,018	1,39,024	24	9
Jobing.com Arena	2003	809	1,649	104	1,16,955	2,03,736	74	30
FedEx Forum	2004	305	638	109	26,337	38,844	47	62
Citizens Bank Park	2004	1,504	2,391	59	1,14,850	1,46,616	28	31
Petco Park	2004	1,799	3,671	104	73,654	88,737	20	84
TimeWarner Cable (TWC) Arena	2005	1,427	2,454	72	49,576	69,474	40	32
University of Phoenix Stadium	2006	1,558	821	−47	2,03,827	1,38,619	−32	−15
Busch Stadium III	2006	855	957	12	72,998	58,859	−19	31
Prudential Center	2007	3,861	1,510	−61	4,09,100	2,19,537	−46	−15
Lucas Oil Stadium	2008	916	281	−69	50,938	24,539	−52	−17
Nationals Park	2008	2,828	1,499	−47	2,68,111	1,11,015	−59	12
Average				36.4			19.5	16.8
Standard Deviation				43			27.1	26.9
Minimum				−69			−59	−48
Maximum				124			74	98

each facility in the sample. Since the facilities were home to sports teams in different leagues with different schedules and seasons, these results allow for heterogenous facilities and teams to affect new mortgage applications differently. For each of the 56 new facilities, we aggregate the number of residential mortgage applications at the census-tract level to the level of control and treatment areas and calculate the percentage change in the aggregate area-wide applications from the three years before each facility opened to the three years after. The columns headed "Before" reports the average annual number of residential mortgage applications over the three-year period before the opening of a new facility. The columns headed "After" reports the annual average in the three-year period after the opening. The columns headed "% change" shows the percent change in residential mortgage applications in that area, which simply scales $\overline{Y}_{g1} - \overline{Y}_{g0}$ in Equation (1) by $\frac{100}{\overline{Y}_{g0}}$. The column headed "% $\Delta_{\text{Treatment}}$ − % Δ_{Control}" reports the difference, in percentage points, between the percent change in the two areas. Note that the control area is much larger in terms of absolute volume of residential mortgage applications, as the control area contains the rest of the metropolitan area. Our interest is in the treatment-control difference in the percent change in residential mortgage applications; a positive value indicates that residential mortgage applications in the treatment area increased by more than in the control are in the years around the opening of a new sports facility. Table 4 reports the same set of estimates for the larger three-mile treatment area. Our preferred definition of neighboring areas are the ones defined by the two-mile radius. The treatment area under this definition contains 3 percent of census tracts. The larger radius doubles the size of the treatment area. We use the three-mile radius as a robustness test. Estimates of $\hat{\tau}_{did}$, scaled to percent changes, can be found at the bottom of Tables 3 and 4 and on Figures 1 and 2 as the sample average.

From the top line, in the three years before the TD Garden, home of the NBA Celtics and NHL Bruins, opened there were an average of 1,406 new residential mortgage applications per year in the 54 census tracts within two miles, and in the three years after the opening there were an average of 2,299 new residential mortgage applications per year, an increase of 64 percent. In the 1,123 census tracts more than two miles from the facility in the Boston-Worcester-Lawrence metropolitan area over that period, there were an average of 55,625 new residential mortgage applications per year, and in the three years after the new stadium opened, there were an average of 74,021 new residential mortgage applications, an increase of 33 percent. From the last column, new residential mortgage applications grew by 30 percentage points more in the treatment area than in the control area during the later period. We estimate growth differences for all other facilities in a similar manner.

Before we discuss the growth differences in detail, note that the estimated difference in growth rates reported on Tables 3 and 4 represents a strictly same-area-same-period comparison. The difference-in-difference procedure removes all unobservable time invariant factors that affected residential mortgage applications in all census tracts, and all local trends in residential mortgage applications in a metropolitan area with a new sports facility. Such common elements include national or metropolitan area-wide business cycle effects, as well as common changes in mortgage interest rates, lending practices, and local housing market conditions. It also removes the substantial growth heterogeneity across metropolitan areas. For example, the greater Los Angeles metropolitan area over the period 1997–2001 (when the Staples Center opened) grew much faster than the Cleveland metropolitan area over the same period (when the Cleveland Browns Stadium opened). This difference in metropolitan area growth trends does not contribute to the difference in growth rates shown on Tables 3 and 4, as we subtract the trend growth in the Los Angeles control area from the Los Angeles treatment area, and the trend growth in the Cleveland

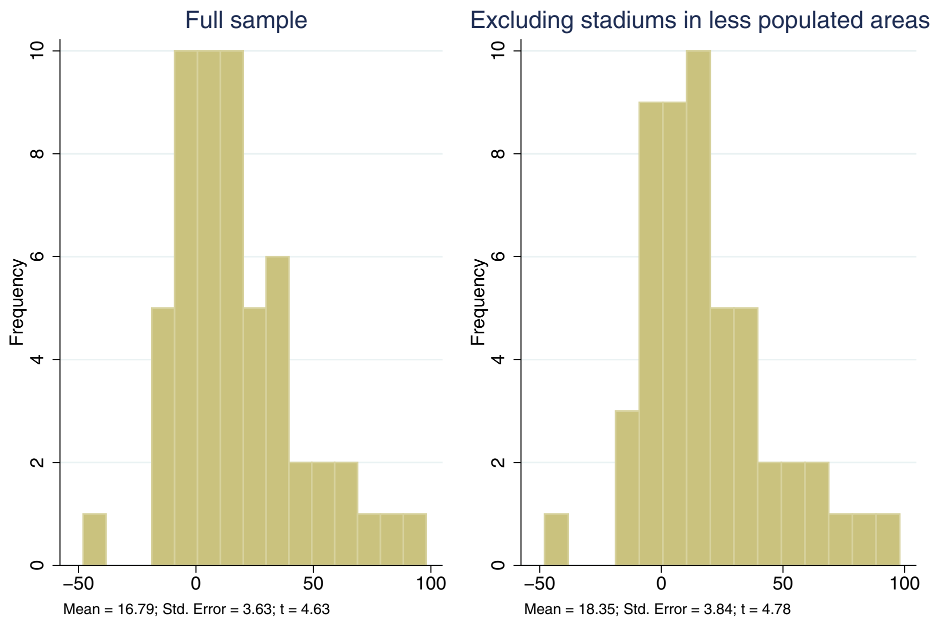
TABLE 4: Increase in Mortgage Applications, Control Census Tracts and Three-Mile Radius Treatment Area Census Tracts

		Treatment CTs			Control CTs			
Facility	Year Opened	Before	After	% Change	Before	After	% Change	% $\Delta_{\text{Treatment}}$ − % Δ_{Control}
TD Garden	1995	2,458	3,918	59	54,573	72,402	33	27
Coors Field	1995	2,370	3,218	36	50,223	62,922	25	10
EverBank Field	1995	435	747	72	15,077	24,603	63	8
Rose Garden	1995	2,288	2,959	29	30,713	42,061	37	−8
Edward Jones Dome (Trans World)	1995	296	475	60	38,175	50,318	32	29
HSBC Arena	1996	511	433	−15	12,150	12,220	1	−16
Bank of America Stadium (Ericsson)	1996	1,185	2,007	69	25,092	42,669	70	−1
Bridgestone Arena	1996	872	1,203	38	21,191	30,058	42	−4
Wells Fargo Center	1996	1,275	1,621	27	71,820	88,690	23	4
St. Pete Times Forum (Ice Palace)	1996	880	1,356	54	39,284	55,423	41	13
Turner Field	1997	1,270	2,598	105	78,671	1,13,561	44	60
Oracle Arena (Oakland Arena)	1997	1,936	3,200	65	87,166	1,40,835	62	4
FedEx Field	1997	1,389	1,361	−2	1,08,644	1,56,061	44	−46
Verizon Center (MCI)	1997	2,881	5,244	82	1,07,152	1,52,178	42	40
M&T Bank Stadium (PSInet)	1998	2,354	4,801	104	1,14,649	1,72,976	51	53
Bank Atlantic Center	1998	1,035	1,399	35	71,347	9,90,02	39	−4
Chase Field (Bank One Ballpark)	1998	881	1,287	46	76,858	1,09,028	42	4
Raymond James Stadium	1998	1,213	1,701	40	47,576	67,509	42	−2
Philips Arena	1999	2,292	4,258	86	1,00,553	125,328	25	61
Cleveland Browns Stadium	1999	552	710	29	4,94,86	56,180	14	15
Pepsi Center	1999	4,185	5,750	37	72,143	91,191	26	11
Conseco Fieldhouse	1999	1,265	2,040	61	33,125	40,396	22	39
Staples Center	1999	1,766	2,408	36	2,45,462	3,34,080	36	0
American Airlines Arena	1999	1,757	2,849	62	80,013	1,04,469	31	32
LP Field (Adelphia Coliseum)	1999	972	1,320	36	30,289	33,181	10	26
RBC Center (Raleigh Sports Arena)	1999	1,202	1,194	−1	36,152	38,985	8	−8
SafeCo Field	1999	2,737	3,217	18	75,779	89,164	18	0
Paul Brown Stadium	2000	2,072	2,112	2	40,591	42,020	4	−2
Nationwide Arena	2000	2,058	2,381	16	32,336	36,188	12	4
Comerica Park	2000	291	488	68	1,28,073	1,30,178	2	66
Minute Maid Park (Enron Field)	2000	1,999	2,788	39	1,08,326	1,16,569	8	32

Continued

TABLE 4: Continued

		Treatment CTs			Control CTs			
Facility	Year Opened	Before	After	% Change	Before	After	% Change	% $\Delta_{\text{Treatment}}$ − % Δ_{Control}
Xcel Energy Center	2000	2,684	3,081	15	67,997	75,862	12	3
AT&T Park (Pacific Bell Park)	2000	3,773	3,574	−5	1,40,267	1,45,178	4	−9
American Airlines Center	2001	2,392	2,698	13	1,46,087	1,48,678	2	11
Sports Authority Field at Mile High	2001	5,852	5,456	−7	89,258	84,960	−5	−2
Miller Park	2001	3,003	3,526	17	26,442	28,614	8	9
PNC Park	2001	1,453	1,444	−1	33,211	32,847	−1	0
Heinz Field (Rooney)	2001	1,711	1,729	1	32,954	32,562	−1	2
Gillette Stadium (CMGI)	2002	304	331	9	1,02,800	1,16,024	13	−4
Ford Field	2002	439	717	63	1,38,284	1,28,830	−7	70
Reliant Stadium	2002	2,111	2,430	15	1,18,168	1,35,830	15	0
AT&T Center (SBC Center)	2002	775	762	−2	36,231	38,482	6	−8
CenturyLink Field (Qwest Field)	2002	3,096	3,768	22	89,286	1,05,804	19	3
Great American Ballpark	2003	2,225	2,833	27	41,908	49,295	18	10
Toyota Center	2003	3,184	4,649	46	1,16,173	1,58,533	36	10
Lincoln Financial Field	2003	2,522	3,567	41	1,10,703	1,37,064	24	18
Jobing.com Arena	2003	2,640	4,439	68	1,15,124	2,00,946	75	−6
FedEx Forum	2004	1,128	1,896	68	25,514	37,587	47	21
Citizens Bank Park	2004	3,053	5,216	71	1,13,301	1,43,791	27	44
Petco Park	2004	3,207	5,419	69	72,247	86,988	20	49
TimeWarner Cable (TWC) Arena	2005	2,805	4,362	56	48,198	67,565	40	15
University of Phoenix Stadium	2006	4,189	2,406	−43	2,01,196	1,37,034	−32	−11
Busch Stadium III	2006	1,763	1,717	−3	72,091	58,099	−19	17
Prudential Center	2007	8,505	3,333	−61	4,04,456	2,17,714	−46	−15
Lucas Oil Stadium	2008	2,324	569	−76	49,530	24,251	−51	−24
Nationals Park	2008	6,866	3,194	−53	2,64,073	1,09,320	−59	5
Average				31.1			19.5	11.7
Standard Deviation				38			27.1	23
Minimum				−76			−59	−46
Maximum				105			75	70



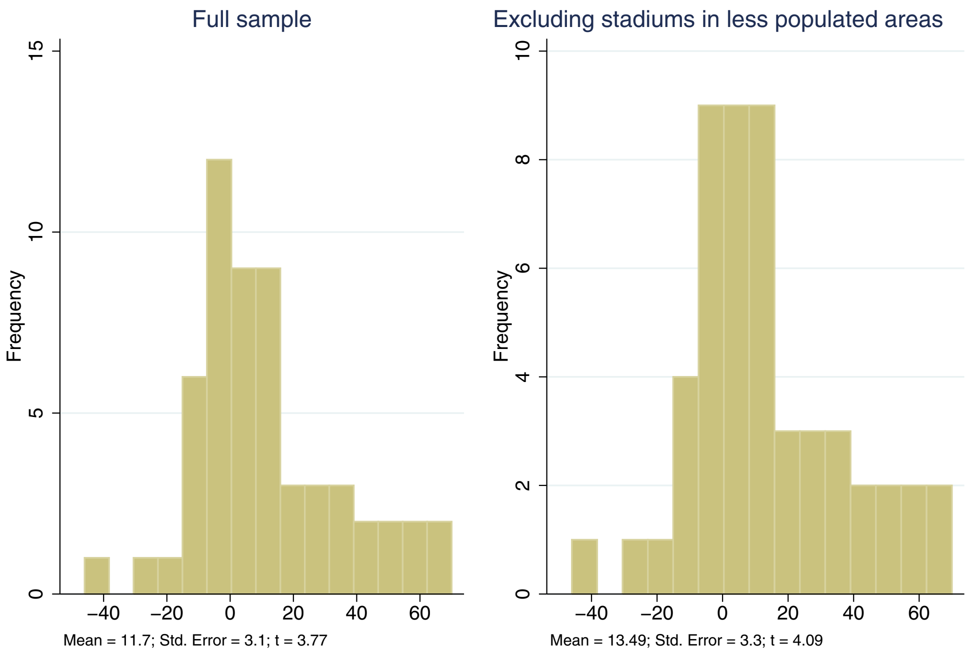
Source: Author's Calculation.

FIGURE 1: Difference in Application Growth with a Two-mile Radius.

control area from the Cleveland treatment area. The difference-in-difference procedure also removes heterogeneity across time within metropolitan areas. Consider the St. Louis metropolitan area over the period 1992–1997 (when the Edward Jones Dome opened) and the St. Louis metropolitan area from 2003 to 2008 (when Busch Stadium opened). The earlier period had an upward trend in the housing market; the latter period had a downward trend in this market. But we are not comparing St. Louis in 2006 to St. Louis in 1995 on Tables 3 and 4. Instead, we compare different local housing markets in St. Louis over the same periods (either around 1995 or around 2006).

Most of the increases in Table 3 are positive; the same is true for the alternative treatment area definition reported on Table 4. Figure 1 shows the histogram of the distribution of differences in growth rates pre and post facility opening. It clearly suggests a positive effect in the treatment area: neighborhoods with new sports facilities experienced higher growth in residential mortgage applications than the rest of the metropolitan area, on average after the new facility opened. The footnote for the histograms shows the estimated mean and standard error of the growth differential. In the default case of a two-mile radius, the average effect of a new facility in the treatment area (i.e., growth differential) is 16.8 percent; the standard error is 3.63 percent. The *t*-statistic is 4.63, so we can safely reject the null hypothesis that the two areas have the same rate of increase. Figure 2 reports the distribution based on the larger radius. The results are similar. The average effect falls to 11.7 percent, but we can still reject the null of equal rates of increase with a *t*-statistic of 3.77. We also note that removing five stadiums that are located in sparsely populated areas slightly increases the estimated effect in the treatment area, to 18.4 percent in the case of the two-mile radius and to 13.5 percent in the alternative case.[7]

[7]These five facilities are the BankAtlantic Center in Miami-Fort Lauderdale, FL, the RBC Center (Raleigh Sports Arena) in Raleigh-Durham-Chapel Hill, NC, Gillette Stadium (CMGI) in Boston-Worcester-



Source: Author's Calculation.

FIGURE 2: Difference in Application Growth with a Three-mile Radius.

The outcomes in these metropolitan areas provide context for recent research on the relationship between professional sports facilities and residential property values and rent. Carlino and Coulson (2004) examined the effect of new NFL stadiums in Baltimore (M&T Bank Stadium), Charlotte (Bank of America Stadium), Jacksonville (EverBank Field), Nashville (LP Field), and St. Louis (Edward Jones Dome) on rent in these cities and found rent was higher in these cities than in other large cities without new NFL stadiums. From Table 3, all five of these treatment areas experienced increases in residential mortgage applications that were larger by about 20 percent or more following the opening of an NFL stadium. The increase around M&T Bank Stadium was 59 percent greater than in the rest of the metropolitan Baltimore area. Tu (2005) examined single family residential property values around FedEx Field in suburban Washington DC using a difference-in-difference approach and found that house prices within 2.5 miles of this stadium increased after it opened. From Table 4, census tracts within two miles of FedEx field experienced a 48 percent decline in residential mortgage applications after the opening relative to the rest of the metropolitan area. Feng and Humphreys (2008) examined the relationship between residential property values and proximity to Nation-Wide Arena in Columbus Ohio and found that property values were higher in proximity to the facility. From Table 3, residential mortgage applications increased slightly faster in the area near this facility. Rosentraub (2009) examined successful sport facility-led urban redevelopment projects in several cities, including San Diego (PetCo Park), Los Angeles (Staples Center), and Columbus (Nationwide Arena). From Table 3, annual residential mortgage applications in the two-mile treatment area growth faster than the control area

Lawrence, MA-NH-ME-CT, Jobing.com Arena in Phoenix-Mesa, AZ and the University of Phoenix Stadium in Phoenix-Mesa, AZ.

TABLE 5: Differences in Census Tract Characteristics, Treatment and Control Areas

		Two-mile Radius			Three-Mile Radius		
Variable	Statistic	Treatment	Control	Difference	Treatment	Control	Difference
Population density (1,000/km^2)	Mean	4.4	1.8	2.6	4.2	1.7	2.4
	Std. err.	0.5	0.2	0.5	0.4	0.2	0.4
Average age of housing units	Mean	46.4	31.7	14.6	47.6	31.2	16.3
	Std. err.	1.7	1.0	1.4	1.5	1.0	1.2
Median household income	Mean	30.8	51.6	−20.7	33.1	52	−18.9
	Std. err.	1.40	0.9	1.5	1.4	0.9	1.4
Median house value	Mean	131.9	152.8	−21	135.7	153.3	−17.6
	Std. err.	11.6	8.1	8.1	12.4	8.0	8.4
% Black	Mean	34.7	14.1	20.6	33.9	13.6	20.3
	Std. err.	3.4	1.1	2.7	3.2	1.1	2.5
% Hispanic	Mean	17.9	11.8	6.2	17.6	11.6	6.0
	Std. err.	2.7	1.6	1.8	2.6	1.6	1.6
% Below Poverty Line	Mean	27.1	10.3	16.7	24.5	10.0	14.5
	Std. err.	1.3	0.3	1.3	1.1	0.3	1.2
% Renter-occupied Housing	Mean	63.1	32.6	30.5	57.9	32	25.9
	Std. err.	2.4	0.6	2.4	2.0	0.6	2

Notes: The statistics above are from an un-weighted sample of 56 facilities. Each treatment or control area associated with an individual facility is regarded as a single observation.

by 84 percent (PetCo Park), 3 percent (Staples Center), and 1 percent (Nationwide Arena) on average in the three years following the opening of these facilities. In all cases, the observed changes in residential mortgage applications from this difference-in-difference approach are consistent with the conclusions of these case studies.

Treatment Areas

The difference-in-difference analysis above assumes that there are no systemic differences between the treatment and control areas other than the proximity to new stadiums. In particular, it assumes that the census tracts in the treatment area were not selected because of some factor unobservable to econometricians but observable to those who make the location decision. This is unlikely to be the case, as local decision makers exercise control over the location of new facilities and, as discussed above, may view them as catalysts for urban redevelopment.

Table 5 compares observable characteristics of the census tracts in the treatment areas to the control areas based on their Census-2000 profiles. The difference in the characteristics of the treatment areas compared to the control areas are substantial and statistically significant. The treatment areas are more densely populated, poorer, have lower median house values, more renter-occupied housing units, and higher percentage of black and Hispanic residents. The average population density in the treatment areas (defined with a two-mile radius) is 4,400 persons per square kilometer versus 1,800 in the control areas. The treatment-control comparison in terms of median household income is \$30,800 to \$51,600. In terms of fraction of the population living below the poverty line the comparison is 27 percent to 10 percent. In terms of the share of renter-occupied housing units it is 63 percent to 33 percent. In median house value it is \$132,000 to \$153,000. In the share of black population it is 35 to 14 percent. In the share of Hispanic population, it is 18 to 12 percent. In terms of the average age of housing units, it is 46 to 32 years. The right panel on Table 5 repeats the comparison for the three-mile radius treatment area. The results are similar. Of course it is not surprising that new sports facilities are located in poor urban areas, since local revitalization is often touted as a potential benefit of a new sports facility, and used to justify large subsidies for the construction of these facilities.

From the perspective of an econometric analysis of residential mortgage applications, however, the location of new sports facilities in poor urban areas raises the possibility that the treatment-control differential documented above is biased upward. The observed difference in residential mortgage applications may not reflect the effect of a new sports facility on the area. It may instead reflect the tendency of poor urban areas to grow faster than other parts of metropolitan areas. One likely contributing factor is the expansion of mortgage credit over much of the sample period (for better or worse given the macroeconomic consequences), which likely had a greater impact on areas with a larger low-income population, such as the poor urban areas that new sports facilities tend to occupy.

In order to assess the importance of this selection effect, we compare the increase in residential mortgage applications in poor urban areas near new sports facilities to similar urban areas not located near new sports facilities over the sample period. Our approach is to analyze the relationship between residential mortgage applications and area-specific characteristics at the level of census tracts, using a regression model to control for local characteristics. This approach allows us to determine whether census tracts near new sports facilities experienced a greater increase in residential mortgage applications relative to census tracts located further away, in the same metropolitan area, that have a similar characteristics.

We estimate the following regression model:

$$\%\Delta m_{i,j} = \alpha D_{i,j}^{\text{treatment}} + \beta Z_i^{\text{census}} + \gamma_j D_j^{\text{stadium}} + u_{i,j}. \tag{2}$$

The subscripts i and j indicate census tracts and sports facilities, respectively. The dependent variable is the percentage change in annual residential mortgage applications in each census tract over the three years before the opening compared to over the three years after the opening. The variable $D_{i,j}^{\text{treatment}}$ is a 0-or-1 indicator equal to one when census tract i is in the treatment group associated with the opening of sports facility j. The control variables include Z_i^{census} a vector of Census-2000 profile variables for census tract i, and D_j^{stadium} a vector of 0-or-1 indicator variables for sports facility j. Note that the inclusion of the stadium dummy renders metropolitan area dummies and year dummies unnecessary, because the sports facility dummy incorporates both the location and year effects. The inclusion of the stadium dummies means we are comparing census tracts in the same metropolitan area during the same period of time, as in the difference-in-difference analysis above.

The regression model uses data from 56 metropolitan areas, each associated with one specific new sports facility, a total of about 45,000 census tracts. The model includes new facility indicator variables. In addition, we cluster-correct the error term $u_{i,j}$ at the treatment and control group level to account for any within-group correlation in the error term due to unobservable factors affecting all census tracts in the treatment and control areas in metropolitan areas. With 56 facilities in the sample, each having one control and one treatment group, the total number of clusters in the regression is 112. This clustering tends to increase the size of the estimated standard errors, as it indeed does in our case. The clustering thus imposes a more stringent requirement on statistical inference.

The dependent variable (percentage change in annual residential mortgage applications) is volatile, ranging from −100 to 13,433 percent. Examination of a histogram of the dependent variable suggests the existence of a small number of outliers. Before performing the regression analysis, we excluded observations with extreme values of the dependent variable. Specifically, we added a constant of 101 to each observation to avoid negative values before taking logs and then log transformed the dependent variable, so that the distribution appears to be normal. We then dropped observations whose

TABLE 6: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	*N*
% Change in residential mortgage applications	18.34	56.03	−80	420.84	42,176
Treatment-two miles	0.03	0.17	0	1	43,023
Treatment-three miles	0.06	0.24	0	1	43,023
Population density; 1,000 per km^2	3.06	5.54	0	88.82	43,020
Median household income in 1,000s	50.89	24.28	5	250	42,874
Median house value in 1,000s	175.85	140.98	5	1,250	42,173
Average age of housing units in years	38.59	14.32	0.9	75	42,883
% Residents living in poverty	12.57	12.03	0	100	42,909
% Renter occupied units	37.9	24.87	0	100	42,877
% Unemployed	6.56	6.36	0	100	42,903
% Residents with college degree	27.6	19.42	0	100	42,963
% Rresidents black alone	17.78	27.35	0	100	42,967
% Residents Hispanic	13.37	19.38	0	100	42,967
% Residents over 65	12.26	7.32	0	100	42,967
% sShare of employment in manufacturing	12.2	7.25	0	100	42,896

Notes: All census statistics are from the 2000 Census.

value in logs were more than 2.5 standard deviations from the mean. This removes about 2 percent of the observations (888 census tracts out of more than 45,000 in the sample). After this elimination we converted the dependent variable back to its original form in percentages. The elimination of outliers has a large impact on the standard deviation of the dependent variable in its original form, reducing it from 137.6 to 56.2 percent. The minimum and maximum of the sample without those outliers are −80 percent and 421 percent, respectively.

We also note that, in a few cities, two facilities opened very close to each other in the same year (e.g., PNC Park and Heinz Field in Pittsburgh both opened in 2001). This leads to a small amount of repeated observations: the mortgage data from the same census tracts over the same period enter the sample twice. We dealt with this problem by linking census tracts that have such a problems to the facility that is closer in distance, and remove them from the sample of the other more distant facility. This reduces the sample size to about 42,000. This deletion has little impact on the results. We get almost identical results from the full sample that includes the repeated observations. Summary statistics for census-tract level variables in the final sample are shown on Table 6.

Table 7 presents the results from applying OLS to Equation (2). In these regression models, census tracts are weighted by resident population, so smaller and likely less volatile tracts are weighted less. The next table, Table 8, presents estimates from the alternative three-mile treatment area.

The first column in Table 7 does not include any census tract level variables. The only explanatory variables are the treatment indicator and the sports facility indicator variables, which are not reported. The estimated impact in the treatment area is 20.4 percent, slightly higher than the 16.8 percent reported in Table 3 and Figure 1. The two estimates are both based on difference-in-differences approach and should yield similar results. We do not, however, expect them to be identical. The 16.8 percent is the average of 56 estimated treatment effects, each specific to an individual facility. The regression approach on the other hand assumes a common effect. In addition, the 16.8 percent estimate is the simple average of the 56 estimated effects, meaning that each stadium is treated equally. The regression approach, on the other hand, uses census tracts as the unit of observations and weights them by resident population size, thus allowing

TABLE 7: Regression Results, Two-mile Radius Treatment Area

	C1 (1)	C2 (2)	C3 (3)	C4 (4)	C5 (5)
Treatment-two miles	20.72	18.29	8.88	10.14	9.94
	(4.01)**	(4.13)**	(4.72)	(5.05)*	(4.79)*
Population density (1,000/km^2)		0.59	0.11	0.3	0.31
		(0.15)**	(0.14)	(0.1)**	(0.1)**
Median household income (1,000s)			−0.04	0.02	0.04
			(0.08)	(0.07)	(0.07)
% Below poverty line			0.61	0.72	0.58
			(0.16)**	(0.16)**	(0.12)**
Median house value (1,000s)				−0.02	−0.02
				(0.02)	(0.02)
% Renter occupied units				−0.05	−0.05
				(0.05)	(0.05)
Average age of housing units (years)				−0.08	−0.11
				(0.09)	(0.09)
% Residents black alone					0.1
					(0.07)
% Residents Hispanic					−0.03
					(0.05)
% Unemployed					0.2
					(0.16)
% Residents with college degree					−0.03
					(0.06)
% Residents over 65					0.008
					(0.07)
% Share of employment in manufacturing					−0.27
					(0.13)*
Obs.	42176	42174	42088	41527	41522
R^2	0.41	0.41	0.43	0.44	0.45

*Significant at the 95 percent significance level; **99 percent significance level.

Notes: (1) All regressions include facility-opening indicator variables, which precludes the inclusion of year and MSA dummies due to perfect collinearity. (2) The reported standard errors are cluster-adjusted at the level of facility-specific treatment and control groups. The sample has 56 facilities, each having one control group and one treatment group. There are thus 112 clusters. (3) The census information is from the 2000 Census, even if the facility involved was opened before 2000. The underlying assumption is that census characteristics are relatively stable over time. The 2000 Census is roughly the midpoint of our sample period of 1992–2010. (4) Census tracts are weighted by resident population.

stadiums from big urban centers to carry greater weight on the final estimate if they are close to more census tracts with more residents. Despite the difference, the estimates of the effect of a new sports facility are quite similar.

Next, we include variables from the 2000 Census in the regression model. The descriptive statistics for these variables are shown on Table 6. The second column on Table 7 contains the results when we add the population density to the regression model. This controls for the tendency of new sports facilities to be located in densely populated urban areas. The inclusion of population density reduces the estimated impact from 20.4 to 17.9 percent. The density variable has a positive coefficient that is statistically significant, suggesting that census tracts with higher population density experienced a larger increase in residential mortgage applications in the posttreatment period.

In the next column, we add the census tract's median household income and percentage of residents living below the poverty line to reflect local economic conditions. The

TABLE 8: Regression Results, Three-mile Radius Treatment Area

	C1 (1)	C2 (2)	C3 (3)	C4 (4)	C5 (5)
Treatment-three miles	16.68	14.62	6.50	8.00	7.42
	(3.54)**	(3.58)**	(3.91)	(4.25)	(4.14)
Population density (1,000/km^2)		0.56	0.11	0.3	0.32
		(0.13)**	(0.14)	(0.09)**	(0.1)**
Median household income (1,000s)			−0.04	0.02	0.04
			(0.08)	(0.07)	(0.07)
% Below poverty line			0.6	0.72	0.57
			(0.15)**	(0.15)**	(0.12)**
Median house value (1,000s)				−0.02	−0.02
				(0.02)	(0.02)
% Renter occupied units				−0.06	−0.05
				(0.05)	(0.05)
Average age of housing units (years)				−0.09	−0.12
				(0.09)	(0.09)
% Residents black alone					0.1
					(0.07)
% Residents Hispanic					−0.03
					(0.05)
% Unemployed					0.19
					(0.16)
% Residents with college degree					−0.03
					(0.06)
% Residents over 65					0.01
					(0.07)
% Share of employment in manufacturing					−0.26
					(0.13)*
Obs.	42176	42174	42088	41527	41522
R^2	0.41	0.41	0.43	0.44	0.45

*Significant at the 95 percent significance level; **99 percent significance level.

Notes: (1) All regressions include facility-opening indicator variables, which precludes the inclusion of year and MSA dummies due to perfect collinearity. (2) The reported standard errors are cluster-adjusted at the level of facility-specific treatment and control groups. The sample has 56 facilities, each having one control group and one treatment group. There are thus 112 clusters. (3) The census information is from the 2000 Census, even if the facility involved was opened before 2000. The underlying assumption is that census characteristics are relatively stable over time. The 2000 Census is roughly the midpoint of our sample period of 1992–2010. (4) Census tracts are weighted by resident population.

poverty variable has a significant parameter estimate; the income variable has a statistically insignificant parameter estimate. But both signs indicate that poorer/lower-income areas grew faster, holding the presence of a new sports facility constant. This is consistent with the hypothesis that poorer census tracts gained increased access to credit markets over the sample period. The inclusion of these two census tract characteristics diminishes the role of population density to statistical insignificance.

Most important for our research question, we find that including population density, income, and poverty variables reduces the effect of new sports facilities on residential mortgage applications to 8.7 percent from the initial 20.4 percent and makes the estimate statistically insignificant at the 5 percent level. This means that much of the estimated differential between the treatment and control areas is due to the income/poverty effect: new sports facilities tend to be located in poorer areas and poorer areas experienced larger increases in residential mortgage applications over the sample period with or without a new sports facility nearby. Much of the large effects shown in Figure 1, therefore, represent upward bias due to selection of the treatment based on unobservables; new sports facilities were located in areas that would have experienced larger increases in residential mortgage applications over the sample period even without the treatment.

In the remainder of the table, we add additional variables to the model in order to check the robustness of this finding. We first add three housing-related variables: median home values, the share of renter-occupied housing units and the average age of housing units. The estimated treatment-control differentials rises from 8.7 to 10.1 percent and regains a borderline significance at the 5 percent level. We then use a “kitchen-sink” approach, adding to the right-hand side a lengthy list of variables: percentage of population black, percentage of population Hispanic, percentage unemployed persons, percentage population with university degrees, percentage age over 65, as well as percentage employment in manufacturing industries. The estimated treatment-control differential remains at about 10 percent. This group of census tract variables are highly correlated. Their coefficients are likely sensitive to inclusion or exclusion of one another. But across the different specifications, the estimated coefficient on the poverty rate is consistently positive and statistically significant. In the “kitchen-sink” regression, we find that areas with more manufacturing jobs grew slower, which likely reflects the industry’s decline over time.

Table 8 uses the alternative radius of three miles to define the treatment area. The results are remarkably similar, except that all estimated impacts in the treatment areas are 2 or 3 percentage points lower. Without the inclusion of census tract characteristics, the three-mile treatment effect is 16.3 percent. After the inclusion of the census tract characteristics, the treatment-control differential falls to between 6.2 and 8 percent and are all statistically insignificant at the 5 percent level.

Taken together, the results suggest that a large part of what appears to be local revitalization from new sports facilities, as reflected by increased residential mortgage applications after the opening of new sports facilities, would have taken place even without the the opening of a new facility, because of the characteristics of the census tracts near the new facilities. Even the smaller estimates reported above may be biased upward, as local decision makers, armed with additional knowledge unobservable to econometricians, might have correctly identified areas where residential turnover would take place, and located the new facilities in those areas. In either case, the results suggest that the billions of dollars in public subsidies provided for the construction of these facilities may have had little to do with the local residential turnover that took place after the sports facilities opened.

Next, we split the sample period into two subperiods: one before the 2007 housing bust, the other after. The first subsample excludes five stadiums that were opened after 2005 (2006–2008 to be exact), thus dropping residential mortgage application data after 2007 when the housing crisis intensified. The second subsample includes only the five stadiums that were omitted from the first subsample. Table 9 shows the regression results for this robustness check. The first subsample, which includes 51 facilities, produces similar findings as the full sample containing all 56 facilities. Consider the results using the two-mile radius as an example. The estimated impact is about 12 percent with the inclusion of the population density, income, and poverty variables. The results again show that poorer areas grew faster in this pre-bust period: census tracts with a higher poverty rate, a lower median house price, a greater share of black residents, and a higher unemployment rate in the 2000 Census experienced greater increases in mortgage applications than better-off census tracts. In the second subsample, which includes only five facilities that were opened between 2006 and 2008, the estimated treatment effect is insignificant,

TABLE 9: Split-Sample Regressions by Years of Opening

	Two-mile Radius		Three-mile Radius	
	Opened between 1995 and 2005	2006 and 2008	1995 and 2005	2006 and 2008
Miles	11.63	0.5	9.45	0.89
	(5.16)*	(6.23)	(4.41)*	(4.80)
Population density (1,000/km^2)	0.19	0.37	0.16	0.37
	(0.43)	(0.12)**	(0.42)	(0.12)**
Median household income (1,000s)	0.06	0.02	0.06	0.02
	(0.08)	(0.08)	(0.08)	(0.08)
% Below poverty line	0.51	0.49	0.5	0.49
	(0.15)**	(0.06)**	(0.14)**	(0.06)**
Median house value (1,000s)	−0.04	0.01	−0.04	0.01
	(0.01)**	(0.008)	(0.01)**	(0.008)
% Renter occupied units	−0.01	−0.01	−0.01	−0.01
	(0.05)	(0.04)	(0.05)	(0.04)
Average age of housing units (years)	−0.16	0.01	−0.18	0.01
	(0.08)*	(0.03)	(0.08)*	(0.03)
% Residents black alone	0.18	−0.21	0.18	−0.21
	(0.07)**	(0.03)**	(0.06)**	(0.03)**
% Residents Hispanic	−0.005	−0.10	−0.006	−0.10
	(0.05)	(0.11)	(0.05)	(0.1)
% Unemployed	0.37	−0.26	0.37	−0.27
	(0.15)*	(0.1)**	(0.15)*	(0.1)**
% Residents with college degree	−0.02	0.14	−0.02	0.14
	(0.07)	(0.11)	(0.07)	(0.11)
% Residents over 65	0.006	0.17	0.01	0.17
	(0.09)	(0.1)	(0.09)	(0.1)
% Share of employment in manufacturing	−0.23	−0.35	−0.22	−0.35
	(0.15)	(0.11)**	(0.15)	(0.11)**
Obs.	34260	7262	34260	7262
R^2	0.24	0.25	0.24	0.25

*Significant at the 95 percent significance level; **99 percent significance level.

Notes: (1) All regressions include facility-opening indicator variables, which precludes the inclusion of year and MSA dummies due to perfect collinearity. (2) The reported standard errors are cluster-adjusted at the level of facility-specific treatment and control groups. (3) The census information is from the 2000 Census, even if the facility involved was opened before 2000. The underlying assumption is that census characteristics are relatively stable over time. The 2000 Census is roughly the midpoint of our sample period of 1992–2010.

with point estimates that are essentially zero. There appears to have been a reversal of fortune in poor urban areas: the decline in mortgage applications was greater in areas with more black residents and a higher unemployment rate in 2000, even though the fraction of the population under the poverty line variable still has a positive (and thus protective) coefficient. To summarize, excluding the housing bust period from the sample has little effect on our main finings. It instead provides further support to the hypothesis that poorer areas grew faster before the bust, consistent with the findings in Mian and Sufi (2009) that *subprime* areas experienced much greater growth in mortgage credit during the housing boom.

Alternative Model Specifications

We estimated several alternative empirical models as robustness checks. The first assumes a treatment effect that potentially diminishes with distance from facilities. The second uses the method of propensity score matching (PSM) to identify a narrower control area. The third allows the treated areas to have different pretreatment time trends compared to control areas.

First, we relax the assumption of a uniform treatment effect within treated areas. The cutoff point between the treatment and nontreatment areas must be specified by the researcher and this choice reflects a tradeoff: the shorter the distance, the fewer census tracts in the treatment area; the longer the distance, the weaker the estimated impact of a new facility in the treatment area. One solution is to choose a relatively large cutoff distance but allow for diminishing effects within the treatment area. We use a three-mile radius as the maximum distance in which an empirically detectable treatment effect exists. Ahlfeldt and Kavetsos (2013) used a five-kilometer radius of influence in their study of the effect of new sports facilities on property values in London. Also supporting this choice are estimates that indicate a quantitatively negligible treatment effect at the edge of the three-mile cutoff.

Specifically, we estimate an empirical model

$$\%\Delta m_{i,j} = \alpha_1 D_{i,j}^{3\text{miles}} + \alpha_2 S_{i,j} + \alpha_3 D_{i,j}^{3\text{miles}} \cdot S_{i,j} + \beta Z_i^{\text{census}} + \gamma_j D_j^{\text{stadium}} + u_{i,j}. \tag{3}$$

This model is Equation (2) with the treatment indicator replaced by three explanatory variables: a three-mile indicator $D_{i,j}^{3\text{miles}}$ that equals 1 if census tract i is within three miles of facility j and is zero otherwise; is a continuous variable, $S_{i,j}$, indicating the distance between census tract i and facility j; and the interaction between $D_{i,j}^{3\text{miles}}$ and $S_{i,j}$. The interaction term allows the treatment effect to vary with distance. For census tracts x miles away from the facility, the treatment effect is $\alpha_1 + \alpha_3 x$. A negative α_3 indicates a diminishing treatment effect.[8]

Table 10 shows the parameter estimates and contains evidence of a diminishing effect of new sports facilities on residential mortgage applications. The last column on Table 10 contains estimates from the model with all census control variables. The estimated effect is 17.6 percent at the facility, 13 percent one mile away, 8.4 percent two miles away, and 3.8 percent three miles away. Note that comparing parameter estimates across columns in Table 10 reveals a familiar pattern: controlling for local characteristics weakens the estimated effect by about one half at the facility. This is consistent with the idea that much of the apparent new facility effect would have occurred even without the facilities.

Next, we present results from a PSM (Rosenbaum and Rubin, 1983; O'Keefe, 2004) model. We use a two-step approach. In the first step, we use PSM to match individual census tracts in the treatment area to nontreated census tracts based on a predicted propensity score of receiving the treatment (i.e., having a new sports facility located nearby). The propensity is modeled as a function of census profile information, such as population density, median census tract income, poverty rates, and other observable factors. Each treated census tract is matched to one or more nontreated tracts ("matched neighbors") that have the closest predicted propensity score in the same city over the same time period. In the second step, we compare the growth in residential mortgage applications (the outcome variable of interest) in the treatment group to their matched matched closest neighbors, essentially repeating the difference-in-differences estimation, but using a narrower set of matched tracts as the control area. This approach addresses

[8]This model includes the continuous distance variable $S_{I,j}$ on its own to pick up potential confounding effects that are unrelated to facilities but are correlated with facility locations. For example, if facilities tend to locate downtown, the distance variable will capture the distance from downtown. But robustness tests removing this distance variable does not change our results in quantitatively important ways. This is expected because the estimate baseline distance effect is statistically insignificant.

TABLE 10: Regression Results—Allowing Treatment Effects to Diminish Over Distance to Stadium

	C1 (1)	C2 (2)	C3 (3)	C4 (4)	C5 (5)
Indicator—within three miles	29.59	27.96	15.68	16.59	17.61
	(5.91)**	(5.92)**	(6.74)*	(6.84)*	(6.27)**
Interaction: within three miles*	−6.64	−6.39	−4.20	−4.07	−4.64
distance to stadium	(2.16)**	(2.18)**	(2.20)	(2.18)	(2.08)*
Distance to stadium	−0.009	0.05	0.07	0.03	0.08
	(0.09)	(0.09)	(0.08)	(0.07)	(0.06)
Population density (1,000/km^2)		0.64	0.1	0.33	0.37
		(0.21)**	(0.15)	(0.11)**	(0.11)**
Median household income			−0.04	0.02	0.05
(1,000s)			(0.07)	(0.07)	(0.07)
% Below poverty line			0.63	0.71	0.55
			(0.15)**	(0.15)**	(0.12)**
Median house value (1,000s)				−0.02	−0.02
				(0.02)	(0.02)
% Renter occupied units				−0.05	−0.04
				(0.05)	(0.05)
Average age of housing units (years)				−0.08	−0.10
				(0.07)	(0.08)
% Residents black alone					0.11
					(0.07)
% Residents Hispanic					−0.02
					(0.06)
% Unemployed					0.19
					(0.16)
% Residents with college degree					−0.02
					(0.07)
% Residents over 65					0.01
					(0.07)
% Share of employment in manufacturing					−0.28
					(0.13)*
Stadium fixed effects covering both treated and nontreated tracts	Yes	Yes	Yes	Yes	Yes
Obs.	41522	41522	41522	41522	41522
R^2	0.42	0.43	0.44	0.44	0.45

*Significant at the 95 percent significance level; **99 percent significance level.

Notes: (1) All regressions include facility-opening indicator variables, which precludes the inclusion of year and MSA dummies due to perfect collinearity. (2) The reported standard errors are cluster-adjusted at the level of facility-specific treatment and control groups. The sample has 56 facilities, each having one control group and one treatment group. There are thus 112 clusters. (3) The census information is from the 2000 Census, even if the facility involved was opened before 2000. The underlying assumption is that census characteristics are relatively stable over time. The 2000 Census is roughly the midpoint of our sample period of 1992–2010. (4) Census tracts are weighted by resident population.

the concern that factors that influenced the assignment of the treatment (the choice of sports facility locations in this context) also affected the outcome variable of interest. Under PSM, if sports facilities tend to locate in or near low-income urban census tracts, the selected controls are more likely to include similar low-income urban tracts. This reduces the chance that the D-in-D comparison is contaminated by biases arising from nonrandom selection of sports facility location decisions. PSM cannot avoid such biases if the selection is based on unobserved factors that are correlated with later increases in residential mortgage applications. It does solve the problem entirely, but it confirms the robustness of earlier findings.

We estimate a probit model in the first step to predict the propensity score. The predictor variables include all the census profile variables in the last column of Table 7. Our default approach is one-to-one matching. Each treated census tract is matched to its closest neighbor in terms of the predicted propensity. Since we have multiple facilities in the sample, we need to avoid matching a treated census tract to a tract in a different city during a different time period, so we perform the prediction-and-matching procedure for each of the facilities individually. Following O'Keefe (2004), we allow for single nontreated tracts to be matched to multiple treated tracts. This avoids bringing imperfect matches into the control group. The choice turns out to not be important, as PSM without replacement yielded similar results. For robustness, we experimented with matching treated tracts to their closest two and three neighbors. The estimated effects were similar and not reported here.

In the second stage, we repeat the difference-in-differences estimation approach using the matched neighbors as the control group. All regression models include facility-specific indicators to ensure that we compare census tracts within the same city over the same time period. Table 11 contains the results. The table has the same format as Table 7 above that used the full sample of census tracts instead of the propensity matched sample. The first column is for a model with no census control variables; later columns add additional control variables. Even without any census-profile controls, the estimated sports facility effect (8.07 percent) is much smaller than that reported in Table 7 (20.72 percent). As we add control variables to the model, the estimated sports facility effect is little changed, ranging from 6.59 to 8.10 percent. The lack of substantial changes is expected, as the matched samples have the closest predicted propensity scores, making it likely that they have similar characteristics. Finally, we note these PSM-based estimates are similar to those on Table 7 after controlling for all the census profile variables (9.94 percent). This suggests that, in our regressions, PSM plays a similar role as does adding census controls.

The third alternative specification allows the treated and nontreated census tracts to have different time trends before a sports facility was opened. Systematic differences in local trends are possible for several reasons. If policy makers systemically locate sports facilities in urban areas in decline—hoping to reverse the deterioration—a simple pre- and post-opening comparison may underestimate the correlation between the opening of a new sports facility and residential mortgage applications. But the potential biases from these trends do not all go in the same direction. Treatment areas in this sample tend to contain poorer census tracts that were more influenced by the subprime mortgage expansion. Residential mortgage applications in these tracts might have grown faster before the sports facility opened. Galster, Tatian, and Smith (1999) discussed the problems of heterogenous trends in their study on the impact of nearby Section 8 vouchers on property values. Their solution was to use panel data allowing different pretreatment trends. This robustness check adopts a similar approach, using yearly panel data consisting of the three years before and the three years after the opening of new sports facilities. The choice of time frame is the same as in the previous analysis that compares the three-year average before the opening to the three-year average after the opening.

Specifically, we estimate the following model:

$$\widetilde{m}_{i,j,t} = \alpha_{j,t} + \beta D_{i,j} + \gamma D_{i,j} \cdot T_t + \delta D_{i,j} \cdot \mathrm{Post}_t + \zeta D_{i,j} \cdot \mathrm{Post}_t \cdot (T_t - 3) + \eta Z_i^{\mathrm{census}} + u_{i,j,t}. \tag{4}$$

TABLE 11: Regression Results—Comparing Treated Tracts to Control Tracts Selected by Propensity Score Matching

	C1 (1)	C2 (2)	C3 (3)	C4 (4)	C5 (5)
Treatment-two miles	8.07	8.10	7.65	7.27	6.59
	(2.59)**	(2.57)**	(2.53)**	(2.47)**	(2.58)*
Population density (1,000/km^2)		−0.22	−0.52	−0.86	−0.68
		(0.44)	(0.44)	(0.46)	(0.43)
Median household income (1,000s)			−0.36	0.03	0.37
			(0.16)*	(0.2)	(0.24)
% Below poverty line			0.22	0.16	−0.17
			(0.24)	(0.26)	(0.32)
Median house value (1,000s)				−0.03	−0.01
				(0.01)*	(0.02)
% Renter occupied units				0.45	0.65
				(0.15)**	(0.15)**
Average age of housing units (years)				0.36	0.48
				(0.25)	(0.28)
% Residents black alone					0.42
					(0.12)**
% Residents Hispanic					0.11
					(0.18)
% Unemployed					−0.07
					(0.35)
% Residents with college degree					−0.19
					(0.23)
% Residents over 65					0.47
					(0.39)
% Share of employment in manufacturing					−0.65
					(0.43)
Stadium fixed effects covering both treated and nontreated tracts	Yes	Yes	Yes	Yes	Yes
Obs.	2222	2222	2222	2222	2222
R^2	0.39	0.39	0.4	0.41	0.43

*Significant at the 95 percent significance level; **99 percent significance level.

Notes: (1) The estimates are from a two-step approach. The first step uses a probit model to match each individual census tract in the treatment group to one nontreated census tract, from the same city over the same period, that has the closest propensity score of having a new stadium nearby. All census-profile control variables in the last column of Table 7 are used to predict the propensity scores. The second step is difference-in-differences estimations using the group of the closet neighbors as the control group. All regressions include facility-opening indicator to ensure that we are comparing census tracts in the same city over the same period. (2) The reported standard errors are cluster-adjusted at the level of facility-specific treatment and control groups. The sample has 56 facilities, each having one control group and one treatment group. There are thus 112 clusters. (3) The census information is from the 2000 Census, even if the facility involved was opened before 2000. The underlying assumption is that census characteristics are relatively stable over time. The 2000 Census is roughly the midpoint of our sample period of 1992–2010. (4) Census tracts are weighted by resident population.

The dependent variable $\widetilde{m}_{i,j,t}$ is the number of residential mortgage applications per 1,000 residents in census tract i located in the city where sports facility j was opened.[9] The

[9]Note that with annual data at the census tract level, defining the dependent variable as year-to-year growth creates missing observations if a census tract has zero mortgage applications in a particular year, because any positive number of applications in the following year leads to an infinite growth rate.

subscript t indicates the order of the time observation in the six-year sample around the facility opening, with 1 being the first year, 2 the second, and so on. The following lists and describes variables on the right hand side of Equation (4).

The first term $\alpha_{j,t}$ is a facility (j) and time (t) fixed effect. It applies to all census tracts in the facility-time group whether they are in the treatment or the control group. It captures common levels and time trends specific to all census tracts associated with facility j. The second term, $D_{i,j}$, is a 0-or-1 indicator for whether census tract i is near facility j (defined by a two-mile radius). It does not have a time subscript and depends solely on location. It captures the possibility that the census tracts near a facility have systematically different levels of residential mortgage applications relative to those farther away. Note that the estimated difference β is not the treatment effect of interest; it is just a control for the nonrandomness of facility location decisions.

The potential differences in time trends between treated and nontreated groups is captured by the third term $\gamma D_{i,j} \cdot T_t$. The first factor $D_{i,j}$, is the location indicator for census tract i near facility j. The second factor T_t is the time trend. It is 1 if $t = 1$, 2 if $t = 2$, and so on. The estimate γ is the estimated coefficient on the relative time trend. If $\gamma > 0$, the area where facilities locate tends to grow faster than other census tracts; if $\gamma < 0$, the opposite is true. The time trend is relative because it is in addition to the common time trend captured by $\alpha_{j,t}$, the facility-year fixed effects.

There are two posttreatment effects under this approach. The first is the impact on levels, captured by $\delta D_{i,j} \cdot \text{Post}_t$. The indicator Post_t is one after the opening of a new sports facility (i.e., after the third year of the sample), and zero otherwise. The posttreatment effect applies only to census tracts near sports facilities, thus Post_t is interacted with the location indicator $D_{i,j}$. The coefficient δ captures how the opening of a new sports facility changes the level of mortgage applications in nearby census tracts.

The second posttreatment impact is in the time trends, captured by $\zeta D_{i,j} \cdot \text{Post}_t \cdot (T_t - 3)$. ζ reflects the change in the slope of the relative time trend after the opening of a new facility in nearby census tracts. The change is estimated using only data from census tract within the treatment area (with $D_{i,j} = 1$) and after a new facility opens (where $\text{Post}_t = 1$).

The vector Z_i^{census} includes the census control variables. Finally we note that new facility dummy indicators, which are present in all our previous regressions, are no longer included here due to perfect collinearity with $\alpha_{j,t}$, the stadium-time fixed effects.

Tables 12 presents the results of this panel data approach. The treatment-control division is based on a two-mile radius around new facilities. Results from a three-mile radius are similar and not reported. We begin with the simplest model without controls for local census tract characteristics. The estimates indicate a positive though statistically insignificant relative time trend in treated areas. The positive sign of the estimate γ implies that the treated areas were growing faster than the control areas even before the new facility openings. This might be attributable to poor urban areas, where new facilities tend to locate, gaining increased access to mortgage credit during the subprime expansion. As for the two posttreatment effect parameters, both are not statistically different from zero, implying that the opening of new facilities did not have any detectable impacts on the level or the trends in residential mortgage applications. Adding census control variables does not lead to substantial changes in estimates of the two posttreatment effects. Compared to findings based on cross-sectional variation, the evidence of treatment effects is much weaker in the panel data approach. This supports our earlier contention that the new facility effect found in simple pre- and post-opening comparisons, shown in

In addition, transforming the mortgage applications to per-resident levels allows the model to account for systemic differences in the levels of outcome variables between the treated and nontreated areas, like in Galster et al. (1999).

TABLE 12: Regression Results—Allowing Heterogeneous Pre-treatment Time Trends between Treated and Control Areas

	C1 (1)	C2 (2)	C3 (3)	C4 (4)	C5 (5)
Near stadium (two-mile radius) – $\widehat{\beta}$	−7.19	−4.66	2.69	5.52	5.01
	(0.63)**	(1.44)**	(1.28)*	(1.26)**	(1.17)**
Posttreatment effect in levels – $\widehat{\delta}$	−0.03	−0.03	−0.03	−0.03	−0.03
	(0.61)	(0.61)	(0.61)	(0.61)	(0.61)
Relative time trend in treatment group – $\widehat{\gamma}$	0.19	0.19	0.18	0.19	0.19
	(0.39)	(0.39)	(0.39)	(0.39)	(0.39)
Posttreatment effect in trends – $\widehat{\zeta}$	−0.002	−0.004	0.006	−.0003	−0.002
	(0.53)	(0.53)	(0.53)	(0.53)	(0.53)
Population density (1,000/km^2)		−0.64	−0.14	0.13	0.14
		(0.28)*	(0.1)	(0.05)**	(0.05)**
Median household income (1,000s)			0.1	−0.04	−0.16
			(0.03)**	(0.03)	(0.03)**
% Below poverty line			−0.42	−0.20	−0.14
			(0.03)**	(0.02)**	(0.04)**
Median house value (1,000s)				0.009	0.007
				(0.005)	(0.005)
% Renter occupied units				−0.18	−0.24
				(0.03)**	(0.03)**
Average age of housing units (years)				−0.29	−0.27
				(0.03)**	(0.03)**
% Residents black alone					−0.02
					(0.02)
% Residents Hispanic					−0.08
					(0.03)**
% Unemployed					−0.07
					(0.04)
% Residents with college degree					0.12
					(0.02)**
% Residents over 65					−0.27
					(0.04)**
% Share of employment in manufacturing					−.03
					(0.05)
Stadium-time fixed effects covering both treated and nontreated tracts	Yes	Yes	Yes	Yes	Yes
Obs.	248500	248500	248500	248500	248500
R^2	0.18	0.2	0.27	0.3	0.31

*Significant at the 95 percent significance level; **99 percent significance level.

Notes: The dependent variable is the number of mortgage application per 1,000 residents. (1) All regressions contains a set of stadium-year dummy indicators absorbing stadium-specific flexible time trends applied to all census tract associated with the opening of a stadium whether they are nearby or not. (2) The reported standard errors are cluster-adjusted at the level of facility-specific treatment and control groups. The sample has 56 facilities, each having one control group and one treatment group. There are thus 112 clusters. (3) The census information is from the 2000 Census, even if the facility involved was opened before 2000. The underlying assumption is that census characteristics are relatively stable over time. The 2000 Census is roughly the midpoint of our sample period of 1992–2010. (4) Census tracts are weighted by resident population.

Figures 1 and 2, weakens substantially when taking into account additional confounding factors. In the case of the panel analysis, the effects are negligible. We also run the regression with census-tract fixed effects, under which only the pre-opening trend and the two treatment effects remain in the regression model. The estimated treatment effects again are statistically insignificant and close to zero. The estimated pre-stadium trend is positive and significant, suggesting that some of the post-opening positive impact can be attributed to the pre-opening trend, which are correlated with local socioeconomic characteristics.

4. CONCLUSIONS

We examine the relationship between the opening of new sports facilities and residential mortgage applications. The results from a difference-in-difference analysis suggest that census tracts near new sports facilities saw substantial increases in annual residential mortgage applications in the three years following the opening of 56 new sports facilities in U.S. cities over the period 1995–2008. These results are consistent with several case studies focusing on the relationship between sports facilities and housing prices in the literature. Local redevelopment represents one explanation for this increase in residential mortgage applications, but the results here do not support the notion that new sports facilities generate local redevelopment; other factors can also explain the increase in applications.

An alternative analysis that controls for the characteristics of the areas where the new facilities were located suggests that much of the observed increase in residential mortgage applications can be attributed to the characteristics of the locations. Poor and low-income urban census tracts experienced increases in residential mortgage applications over the sample period, probably because of increased access to consumer credit markets. After controlling for observable characteristics of the facility locations, the size of the relationship between a new sports facility and subsequent residential mortgage applications declines and becomes statistically insignificant, suggesting that much of the observed redevelopment would have occurred independent of the opening of a new sports facility. Alternatively, local decision makers placed new facilities in these areas by design, so the redevelopment project would succeed. In this case, the subsidies used to build these new facilities were not needed, and those public funds could have been used for other projects.

Our analysis provides new evidence in the debate over public subsidies for the construction of professional sports facilities. Recently, this debate shifted from the issue of tangible economic benefits generated by new sports facilities in the broader urban economy to the ability of professional sports facilities to drive urban revitalization in specific urban areas. Little evidence currently exists about localized impacts of new professional sports facilities outside the growing, case study based literature on sports facilities and property values. Our results cast some doubt on the ability of a new professional sports facility to spur urban redevelopment, at least as reflected in residential mortgage applications. However, an analysis of other indicators of urban redevelopment, notably in the form of new businesses openings or commercial real estate prices, might paint a different picture.

Our results highlight the importance of location decisions when assessing the potential impact of new professional sports facilities on the urban economy. Controlling for observable characteristics of facility locations significantly reduces the estimated effect of a new sports facility on residential mortgage applications in this setting. In the context of the literature on the econometric evaluation of programs, recently reviewed by Imbens and Wooldridge (2009), the unconfoundedness assumption plays a critical role here. Imbens and Wooldridge (2009) discuss a number of alternative approaches for econometric program evaluation when the unconfoundedness assumption does not hold, including exploiting bounds, IV approaches, and regression discontinuity designs, that may be useful under some conditions. Further research could also examine the effects of facility heterogeneity, including size and quality of architecture, on the impact of new facilities.

APPENDIX: THE BETWEEN-CENSUS REVISION IN THE AREA DEFINITION OF CENSUS TRACTS

The Bureau updates area definitions between censuses to reflect population changes; the revisions "often involve[s] the subdivision of an existing census tract (or census tracts) into two or more new units." These revisions potentially can affect both the location of the population centroid for a census tract and residential mortgage application counts.

First, consider the consequences for population centroids in census tracts. The Census Bureau provides the longitude and latitude of a census tract's centroid based on resident population in the 2000 Census under the Census-2000 definition of census tracts. No equivalent information is available for the 1990 Census (and in any case, the population count will be outdated even if such centroid information is provided). Most of our mortgage application data, however, uses the Census-1990 area definition. The difference in definitions can be reconciled by re-weighting the centroid using the between-Census relationship file from the Census Bureaus. This relationship file comes with information on the distribution of resident population. We define the population-weighted centroid of a census tract under the 1990-definition as the population-weighted average of the longitudes and latitudes of all relevant parts in the relationship file that consists of the census tract; the weights are based on the resident population in the 2000 Census. For example, if a census tract under the 1990-definition was split into multiple descendant tracts, the population weighted centroid of the parent tract is the weighted average of the longitudes and latitudes of all the descendant tracts in the 2000 Census. We use the Census-2000 residents as weights to reflect demographic-allocation patterns in 2000, which is roughly the midpoint of our sample period (1992–2010). If multiple census tracts in 1990 were merged into a single census tract in 2000, all those parental tracts share the same population centroid as the descendant tract. Other types of revisions are handled in a consistent way, using the Census-2000 population as weights. Finally, we assign census tract to MSAs defined in the 2000 Census. This does not play an important role, because few census tract switch metropolitan areas between censuses. The only difference is that in our tables of descriptive statistics, we will see MSA names as they were in the 2000 Census, instead of as they were in the 1990 Census.

Second, consider the consequences for mortgage counts. The HMDA reports incorporated the census updates with a lag, starting with the 1990-Census definition in 1992 before updating to the 2000-Census definition in 2003. A majority of our data (those from 1992 to 2002) are thus under the 1990-definition. The rest (those from 2003 to 2008) are under the 2000-definition. The Census Bureau provides geographic and demographic relationship files between these definitions. Using the relationship file and the information on resident population contained in them that that we use as weights, we allocate the mortgage applications in the 2003–2008 period to the 1990-Census definition of census tracts.

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