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Journal of Planning Education and Research 2009 29: 7 originally published online 12 August 2009
DOI: 10.1177/0739456X09334141

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Abstract

There is long-standing interest in predicting if and when less advantaged urban neighborhoods will experience upsurges in their housing prices, yet little research has investigated year-to-year neighborhood price dynamics. The authors advance knowledge in this realm by employing anually updated, readily available indicators created from the Home Mortgage Disclosure Act and assessor's data from Washington, D.C., census tracts for 1995 to 2005 to estimate a hazard model of the year when consistent, substantial, and sustained housing price appreciation starts in disadvantaged neighborhoods, based on predictors measured one and two years in advance. The results suggest that proximity to stronger neighborhoods, a robust metropolitan housing market, and inflows of higher-status home buyers are key predictors of appreciation onset in disadvantaged neighborhoods, but replications and refinements are needed before firm generalizations about this process can be made.

Keywords: *neighborhoods; housing prices; appreciation; hazard models*

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There is widespread interest among practitioners, citizens, and scholars in better understanding and perhaps even predicting if and when disadvantaged urban neighborhoods will experience significant upsurges in their housing prices. City officials and private developers typically welcome such an event inasmuch as it heralds an improvement in the real estate tax base and investment opportunities in depressed property markets. Community development corporations may view this as a signal that their efforts have finally borne fruit in historically disadvantaged places. Local home owners in such places may be pleased with their rising home equity but also may worry about concomitant increases in their property tax bills. Renters of limited means may express even deeper concerns over the potential of rising rent burdens or even involuntary displacement as the neighborhood becomes less affordable. Planning scholars have a long-standing fascination with dynamic processes associated with revitalizing disadvantaged neighborhoods that manifest themselves as rising property values, fraught as they are with spatial interdependencies, gaming behaviors, externalities, and self-fulfilling prophecies that likely render market outcomes inefficient and inequitable (Galster 1987; Grigsby et al. 1987).

Despite this broad interest, there has been little research exploring the nuances, patterns, and predictors of yearly changes in the property values of urban neighborhoods. Our research reported here intends to contribute to filling this gap. We employ annually updated, readily available indicators created from the Home Mortgage Disclosure Act (HMDA) and assessor's data from Washington, D.C., census tracts for 1995 to 2005 to estimate a hazard model of the year when consistent, substantial, and sustained housing price appreciation starts in a disadvantaged neighborhood, based on time-varying predictors measured one and two years in advance. We believe that our model both confirms several conventional nostrums and reveals some unexpected factors that temporally lead the upturn of disadvantaged neighborhoods' property markets.

Our article is organized as follows. We first review four distinct strands of literature related to neighborhood change and residential property values and show how our efforts build upon, extend, and cross-cut them. Second, we present a microeconomic theory of neighborhood price change that serves as foundation for the empirical effort. Third, we describe our data sources and provide a descriptive portrait of the

Journal of Planning Education and Research 29:7-22
DOI: 10.1177/0739456X09334141
Initial submission, November 2007; revised submissions, June and December 2008; final acceptance, January 2009

housing price dynamics of less advantaged neighborhoods in our study site, Washington, D.C. Fourth, we specify leading indicator variables and estimate parameters of our hazard model of the start of consistent, substantial, and sustained housing price appreciation. Fifth, we discuss findings in terms of implications for our understanding about dynamics of disadvantaged neighborhoods. We conclude by analyzing caveats of the model and probing its potential applications for planning practice and extensions to future research.

► Previous Empirical Models of Neighborhood Change and Residential Property Values

Our research builds upon and extends four strands of empirical scholarly literature. The first models decadal changes in neighborhood indicators as a function of conditions at the beginning of a decade. The second focuses on annual changes in neighborhood indicators. The third measures differences in long-term home price appreciation across neighborhoods. The fourth investigates the degree to which neighborhood trends in housing values are altered by some exogenous intervention, such as a major redevelopment project. We consider these strands briefly below and how our work advances beyond each.

Models of Decadal Neighborhood Change

Virtually all of the previous empirical works related to building predictive models of neighborhood change have employed census data to model decennial changes in particular census tract characteristics of interest. Beginning in the 1970s, investigators of neighborhood change began using linear multiple regression analysis as the basis for empirically testing theories and building explanatory models. These modeling efforts specified how exogenous variables measured at the beginning of a decade correlated with subsequent decadal changes in neighborhood outcome indicators. Several variants of these models have been estimated, each addressing a specific neighborhood indicator, such as housing prices (Li and Rosenblatt (1997),[1] population density (Guest 1972, 1973), income or social class (Guest 1974; Vandell 1981; Galster and Peacock 1985; Galster and Mincy 1993; Galster, Mincy, and Tobin 1997; Carter, Schill, and Wachter 1998; Wyly and Hammel 1999, 2000; Wyly et al. 2001; Dewar et al. 2005), home ownership rates (Baxter and Lauria 2000), female headship rates (Krivo et al. 1998), vacancy rates (Dewar et al. 2005), and racial composition (Guest and Weed 1976; Schwab and Marsh 1980; Galster 1990a, 1990b; Ottensmann, Good, and Gleeson 1990; Denton and Massey 1991; Lee and Wood 1991; Ottensmann and Gleeson 1992; Lauria and Baxter 1999; Baxter and Lauria 2000; Crowder 2000; Ellen 2000).

As valuable as these efforts have been in building our understanding long-term neighborhood changes, data points separated by ten years impose many limitations when thinking about dynamics over a finer grain of time. One cannot precisely ascertain the degree to which decadal changes have been constant throughout the period; this is especially crucial when the phenomenon in question may be characterized by threshold points or other nonlinear adjustments (Galster, Quercia, and Cortes 2000).

Models of Annual Neighborhood Change

By contrast, relatively few efforts have attempted to exploit annual observations of neighborhood data to build more dynamic empirical models. Galster, Cutsinger, and Lim (2007) estimate a series of models of annual changes in a variety of neighborhood indicators across five cities during the 1990s. Their goal is to ascertain whether such dynamics are self-stabilizing, not explanation or prediction, and thus they include only lagged values of the dependent variables as independent variables. Immergluck and Smith (2005) econometrically estimate which neighborhood conditions most strongly correlate contemporaneously with annual home foreclosure rates across a panel of Chicago census tracts. Unfortunately, these promising approaches have not been applied to predicting neighborhood housing price dynamics in a framework using (1) a fine grain of space and time and (2) predictor variables that precede the price change in question.

Several cities tout the existence of Web sites that permit citizens, community groups, and other analysts to download up-to-date, local information providing richly textured portraits of their neighborhoods over time (see, e.g., CityNews Chicago, Neighborhood Planning for Community Revitalization–Minneapolis, Philadelphia Neighborhood Information System, Neighborhood Knowledge Los Angeles, and Providence Urban Land Reform Initiative). Although some of these Web sites proclaim that they provide an "early warning system" for predicting imminent neighborhood changes, in fact they leave it to the user to draw inferences from the data about the future or offer arbitrary and unproven weighting schemes for aggregating indicators into some notion of "forthcoming changes." Unfortunately, such neighborhood early warning systems have typically not been tested in a statistically rigorous way for their predictive power (Myotte 2000; Dewar et al. 2005).[2]

Studies of Differential Home Price Appreciation across Neighborhoods

Many studies have examined intertemporal changes in home prices at metropolitan or national scales, but relatively few have examined them in a neighborhood context. These studies focus on the question of whether individual homes appreciate differentially over the long term depending on their neighborhood socioeconomic, ethnic, or demographic contexts (Flippen 2004; Boehm 2004; Boehm and Schlottmann 2004; Stegman, Quercia, and Davis 2007). They typically report that homes in lower-income and predominantly black- or Latino-occupied neighborhoods appreciate less rapidly. However, they do not examine whether year-to-year price dynamics differ by neighborhood or attempt to develop predictive empirical models of differential home price appreciation or when disadvantaged neighborhoods begin to inflate more rapidly.

Studies of Neighborhood Price Impacts from Community Development Interventions

The last strand of relevant literature focuses on disadvantaged neighborhoods and tries to ascertain the degree to which significant investments aimed at community development succeed in changing the trajectory of the area's housing prices (Galster et al. 2004; Galster, Tatian, and Accordino 2006; Rossi-Hansberg, Sarte, and Owens 2008). This literature employs variants of the adjusted interrupted time series econometric method to determine if home price trends or levels in target areas change significantly after the intervention in question. It does not investigate, however, situations where private market forces took the leading role in triggering price gains in disadvantaged neighborhoods. Nor does it attempt to estimate predictive models of annual changes in neighborhood home prices.

Our Contribution

Our research bridges all four of the foregoing strands of literature. It represents the first effort to examine housing price trends in disadvantaged neighborhoods at a small grain of space and time and estimate a predictive model of a major alteration in these trends. More specifically, we contribute to this literature by using a decade-long panel of annual observations of a variety of publicly available indicators from Washington, D.C., to develop, test, and evaluate a predictive model of the market-driven onset of a consistent, substantial, and sustained period of home price appreciation in neighborhoods that begin the analysis period with below citywide median values per square foot. It is distinguished by its focus on being a tool for forward-looking prediction, not backward-looking explanation, inasmuch as all predictor variables are measured one- or two-years prior to when price is predicted.

▶ The Theory of Differential Neighborhood Price Appreciation

In overview, we see neighborhood home price appreciation fundamentally being driven by the interaction of metropolitan area-wide demand and supply forces appertaining to the housing quality submarket predominantly represented in the given neighborhood (Rothenberg et al. 1991). Upon this macroeconomic foundation is superimposed a sorting mechanism that guides household choices among a set of competing neighborhoods whose attributes are predetermined at the point of choice. In consort, these area-wide and neighborhood-specific forces potentially produce a spatial pattern of demand shifts that interact with the supply decisions of private property owners in each neighborhood to yield a spatial pattern of home price appreciation. Over time, the attributes of neighborhoods can change from both endogenous (residents and property owners) and exogenous (public and private institutions, transportation systems) forces, thereby further altering the patterns of demand (Galster 2001). In this section, we specify these relationships to provide a theoretical basis for operationalizing our empirical model below. Throughout we use the term "home" as shorthand for single-family detached and condominium properties, the subject of this article.

Perspectives at the Metropolitan Level

At the deepest level, the degree of home price appreciation experienced by any neighborhoods in a particular metropolitan area will be influenced by a broad set of contextual forces related to the regional economy, demographic shifts, housing production, local government regulations, transportation infrastructure, and technology operating at a much broader geographic scale than the neighborhood (Grigsby et al. 1987). These dimensions of metropolitan context establish base conditions on both the demand side and the supply side of the housing market. The former is represented by an aggregate population profile whose distributions by wealth, income, age, life-cycle stage, and ethnicity will shape the patterns of demand for dwelling packages with particular sorts of attributes (structure, parcel, local public service/tax packages, neighborhood physical, socioeconomic and demographic characteristics, accessibility, environmental amenities, etc.; see Galster 2001). The latter is represented by the existing stock of dwellings with particular combinations of attributes. Actions by governments and public and private institutions across the metropolitan area establish the attributes associated with the locations to which dwellings are attached, such as local public service/tax packages, accessibility, and environmental conditions.

From the metropolitan perspective, constituent neighborhoods will experience home price appreciation to the extent that the forces influencing the strength of housing demand overpower those influencing the strength of housing supply response over time. The resulting geographic patterns of appreciation can be, in principle, either quite general across all types of housing package types (and, thus, all neighborhoods) or confined to only a few such housing package types (and, thus, only those neighborhoods where these types are located). Metropolitan areas experiencing strong population and job growth of all types in the context of binding regulatory or geographic constraints on the supply of new housing will evince strong demands and concomitant appreciation in virtually every neighborhood, for example. By contrast, metropolitan areas evincing substantial immigration of households in only one income class likely produce increases in demand (and price) for only certain types of neighborhoods that are most consonant with the demands of the in-migrating group.

Perspectives at the Neighborhood Level

Since we are interested in modeling interneighborhood differences in appreciation, where the neighborhood is the unit of observation, we must examine the aforementioned forces from the individual neighborhood's perspective. On the demand side of a neighborhood's market, this perspective focuses on how households sort themselves into different neighborhoods across the metropolis, once the aggregate household profile has been established at the metropolitan scale. In this regard, we specify that the demand for homes in a particular neighborhood is related to the aggregate number of households in the metropolitan area with both the *ability* and the *willingness* to buy homes located there. The ability to buy is directly related to three household characteristics: wealth W (size of potential down payment), income net of nonhousing debt payments I (capacity to pay the recurrent mortgage and other housing expenses), and access to mortgage credit on attractive terms M. It is inversely related to the sales price of housing P in the particular neighborhood. The willingness to buy is inversely related to the operating costs of the home C[3] and directly related to the perceived quality of life to be experienced in the home and environs Q; the price of potential substitute homes in competing, close-substitute neighborhoods PS; and the optimistic expectations held by prospective purchasers about future appreciation in the area E.

On the supply side of the neighborhood's market, we are interested in the factors determining reservation prices of existing property owners in the neighborhood, that is, the minimum offer required to have them agree to sell (Galster and Rothenberg 1991; Rothenberg et al. 1991). We specify the willingness to offer a home for sale is directly related to the current sales prices P of homes in the neighborhood and the property's holding costs H and is inversely related to owners' optimistic expectations of future home appreciation E.[4]

The interface of the aforementioned neighborhood-level demand D and supply S relationships will determine whether and to what extent homes will appreciate during a particular period in that place. Should demand for the neighborhood surge compared to the number of owners who offer homes for sale, prices will begin to rise appreciably. Symbolically, appreciation will occur when, for the period in question,

$$D = f(-P, +W, +I, +M, -C, +Q, +PS, +E) >> S = f(+P, +H, -E),$$

where signs indicate expected relationship with quantities of homes demanded and supplied.

Expectations and the Onset of Home Appreciation

In this article, our goal is to develop an a priori predictive model of appreciation, not an ex post explanatory model. Thus, we must confront the issue of leading indicators: variables that predictably foreshadow upsurges in excess demand relative to supply in a particular neighborhood. Our challenge also may be seen as one of modeling expectations. More optimism about future home appreciation in the neighborhood—whether sensed by buyers or sellers—should encourage a self-fulfilling prophecy: the former group will intensify their willingness to purchase and the latter group will intensify their willingness to hold their properties off the market until later. Unfortunately, there is little evidence and even less theory available to guide our specification of excess demand leading indicators or upsurges in optimism. As explained below, our approach will rely upon a wide range of variables describing the neighborhood's mortgage and housing markets and characteristics of new home buyers, admittedly on an exploratory basis.

▶ Data Sources and Spatial Units of Analyses

Our exploratory empirical model relied on two data sets providing annual observations of data at the census tract scale. The first consisted of sales price data for single-family homes and condominiums sold in the District of Columbia from 1995 through 2005, obtained through the city tax assessor's office. We aggregated these data for a year at the census tract level of geography. The second consisted of annual data on mortgage lending patterns in individual census tracts provided through the HMDA from 1995 through 2004.

For the definition of "neighborhood" in this article, we used census tracts, geographic delineations designed to be relatively homogeneous in population and housing characteristics when they are first defined. As of Census 2000, there were 188 census tracts defined for the District of Columbia, with an average population of about three thousand persons per tract.

Because not all census tracts had adequate volume of residential property sales to permit accurate estimation of price trends, we eliminated from our analysis tracts that did not have at least one hundred total sales from 1995 through 2005

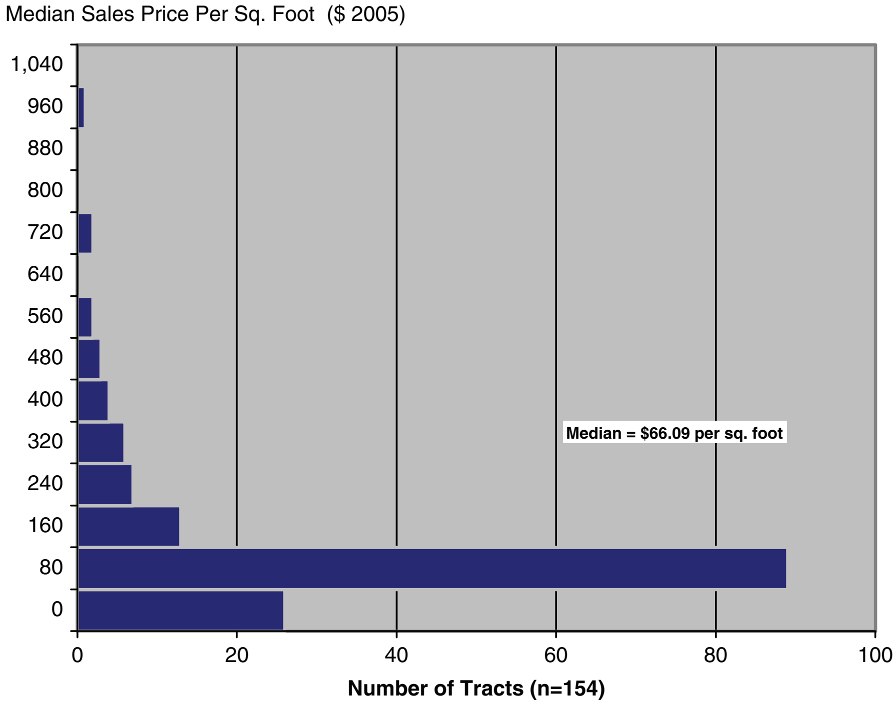

Figure 1. *Census tracts by 1995-1996 median sales price per square foot of single-family and condominium units, Washington, D.C.*

and that had fewer than five sales in two or more of the eleven years. This reduced the total number of tracts for our analysis to 154.

We further specified "disadvantaged neighborhoods" as census tracts with median home/condo prices per square foot that were below the citywide median at the start of the period of observation, 1995 and 1996. To minimize noise associated with year-to-year fluctuations in prices, we took a two-year average (1995 and 1996) of the median sales price per square foot of single-family homes and condominiums in each tract. The resulting distribution of prices across our 154 tracts, which is highly skewed, is shown in Figure 1.[5] The two-year average of median sales prices in 1995 and 1996 for all 154 tracts was $66.09 per square foot. We selected the 77 tracts below this figure for our analysis. We acknowledge that the term "disadvantaged" may be too strong a description for the quality of life in all these neighborhoods; we use the term hereafter as synonymous with the more precise but awkward term "below median value per square foot at the beginning of the study period."

▶ Housing Price Trends in Disadvantaged Neighborhoods: The Case of Washington, D.C.

For purposes of descriptive exposition only, we separated our seventy-seven Washington, D.C., disadvantaged census tracts into three groups of equal size, based on their overall rate of home price appreciation from 1995 through 2005. The price trends for each of the groups are shown in Figure 2. Each line in the graph represents the (unweighted) average of the median tract home prices (total price, not price per square foot) for the group. All groups began with median prices (expressed in constant 2005 dollars) between $100,000 and $135,000 in 1995. The tracts with the most rapid price appreciation (labeled "rapid") had real prices that increased an average of 305 percent between 1995 and 2005, or 11.8 percent average per year. Those in the moderate group grew at 225 percent, or 8.5 percent per year, over this same period. Even tracts with the slowest growth tracts (labeled "slow") still experienced 177 percent real price growth, or 5.9 percent per year, during these eleven years. In retrospect, we recognize that this was an exceptional period of market exuberance, fueled by unbridled mortgage market activities that we know in retrospect were unsustainable. But the salient point for this article is that this real estate exuberance was not equally felt across all disadvantaged neighborhoods nor at the same time. Clearly, some tracts that started in the same price position began to appreciate sooner and more rapidly than others. It is this variation that we attempt to model below.

We examine the spatial pattern of home price appreciation with Figure 3. The above-median-valued per square foot, advantaged tracts in 1995 and 1996 (displayed in white in Figure 3) are predominantly in northwest Washington, D.C., although others can be found around Capitol Hill. The 1995 and 1996 below-median-valued, disadvantaged tracts are shaded in Figure 3 based on their price appreciation evinced over the next ten years. The darkly shaded, most rapid growth disadvantaged tracts are concentrated in the center of the city, primarily east of Rock Creek Park, with additional rapid growth tracts found along two major roads, New York Avenue and Rhode Island

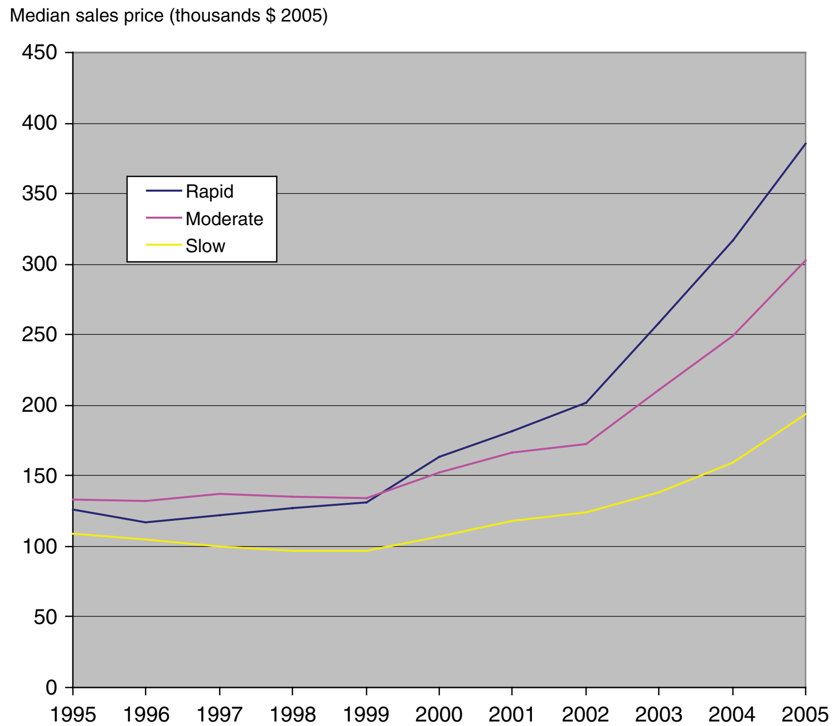

Figure 2. *Median sales prices of single-family and condominium units in tracts with below-median 1995-96 prices per square foot, by 1995-2005 appreciation terciles, Washington, D.C.*
Note: Outlier tract 58.00, with median price per square foot = $1,970, is not displayed but is included in median calculations.

Avenue, and east of Capitol Hill. Two additional rapid price growth disadvantaged tracts can be found east of the Anacostia River, one in the northeast and one in the southeast. The slow and moderate price growth disadvantaged tracts are located in the extreme northwest, northeast, and southeast quadrants, farthest from the commercial core of the city.[6] We explore statistically below the role of space in predicting the takeoff of consistent, substantial, and sustained appreciation.

▶ Building a Predictive Model of the Onset of Neighborhood Appreciation

We approached the challenge of creating a predictive model with a self-imposed constraint. We employed as predictive variables only those that feasibly could be obtained by public or private observers of the market prior to when a given disadvantaged neighborhood would be predicted to start substantially appreciating. That is, we employed only publicly available variables that *lead* by one or two years the event that they were predicting: whether consistent, substantial, and sustained price appreciation began.

Defining the Onset of Appreciation in Neighborhood Home Prices

After extensive examination of price data for disadvantaged tracts in Washington, D.C., we devised the following criteria for identifying a tract's initial year of *consistent, substantial, and sustained appreciation*. We defined this onset of appreciation in tract X to have occurred in year t when *all* of the three conditions below were met for the two-year moving average of the median sales price in the tract:

1. *Consistent increases in next two years:* The changes in X from t to $t + 1$ and from $t + 1$ to $t + 2$ are both at least the average annual change in X for moderate appreciation tracts over the entire observation period.[7]
2. Substantial changes in next two years or significant shift in change from previous two years: This criterion is satisfied if any one of the following three conditions are true:
   a. change in X from $t + 1$ to $t + 2$ is greater than change from t to $t + 1$;
   b. changes in X from t to $t + 1$ and $t + 1$ to $t + 2$ are both at least twice the overall average annual change in X for moderate appreciation tracts; or
   c. changes in next two years are at least four times the overall average annual change in X for moderate appreciation tracts.
3. *Sustained changes over the remainder of the observation period:* The average annual change from t to the last observed year (2005) is at least as large as the overall average annual change in X for moderate appreciation tracts.

As before, we used the two-year moving average of the median sales price to smooth out noisy year-to-year fluctuations that might distort the results.

Based on our indicator of the onset of appreciation defined above, we constructed a binary time series for use as the dependent variable in our model, zeros representing years prior to

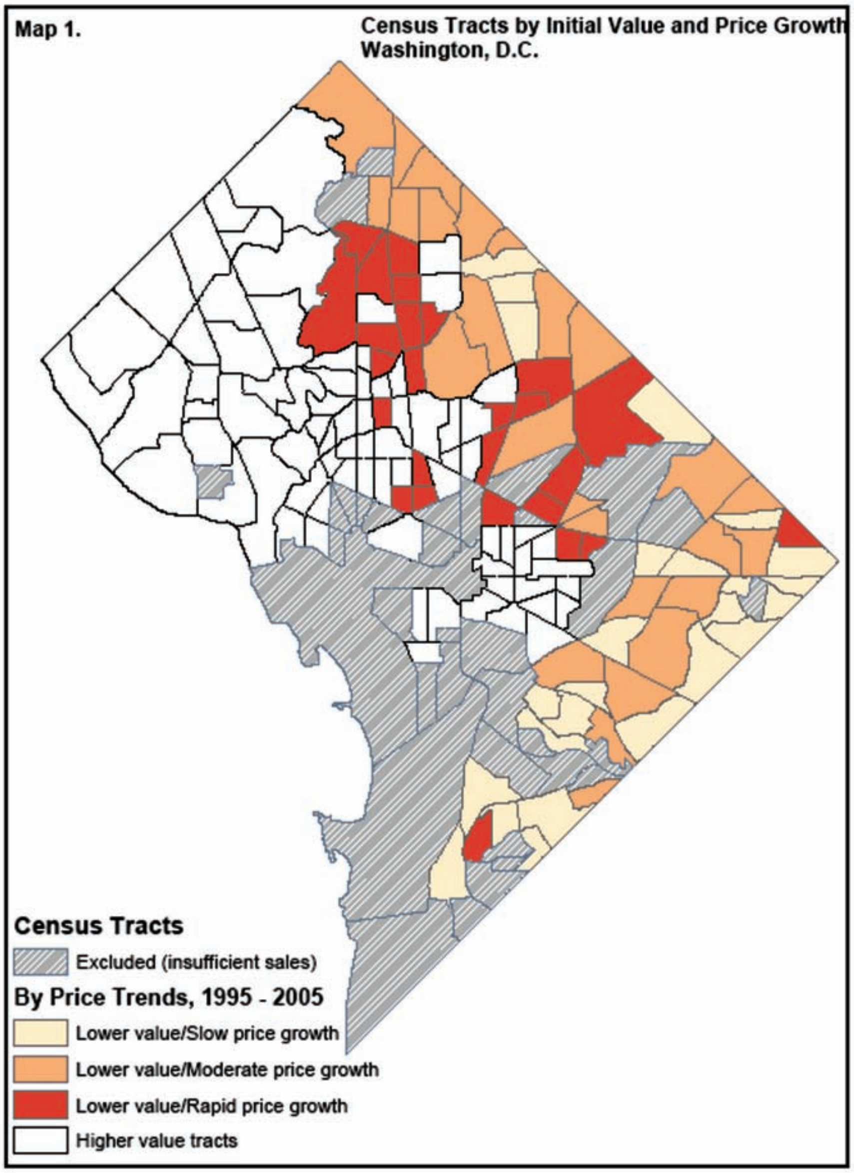

Figure 3. *Locations of census tracts with different rates of 1995-2005 appreciation of single-family and condominium units, Washington, D.C.*

the onset of appreciation and one marking the onset year. Because of the time lags involved in our independent variables, we were able to create such onset measures for all seventy-seven tracts from 1996 to 2003 (we reserved a year of recent data for subsequent model testing, as explained below).

The appreciation onset years for the seventy-seven disadvantaged Washington, D.C., census tracts based on the above criteria are presented in Table 1. As can be seen, fifty of the seventy-seven tracts exhibited the onset of appreciation between 1995 and 2005, with the largest number of tracts reaching their takeoff points in 2002 and 2003.

The other noteworthy aspect of the onset of appreciation in Washington, D.C.'s, disadvantaged neighborhoods is its spatial pattern. As shown in Figure 3, the disadvantaged tracts that took off first (and thus inflated the most during the period, shown in darkest shade) tended to be located adjacent to the already higher than median valued tracts. In turn, the subsequent wave of appreciation tended to occur adjacent to the prior wave. We will test below whether this apparent spatial pattern persists in a multivariate modeling framework.

Specifying the Predictor Variables

Following the theory of appreciation described above, in our model we try to develop leading indicators for situations where it is more likely that demand is outstripping supply and both sides of the market are becoming more optimistic. We

Table 1.
Number of "disadvantaged" census tracts in Washington, D.C., by starting year of consistent, substantial, sustained appreciation.[a]

	Number of Tracts	*Percentage*
All "disadvantaged" tracts	77	100.0
Appreciation starts—no appreciation onset during study period	27	35.1
1998	5	6.5
1999	6	7.8
2000	9	11.7
2001	9	11.7
2002	11	14.3
2003	10	13.0

Note: Includes only tracts with median per square feet prices below citywide median in 1995/1996.
a. See text for operational definition.

employ several HMDA-based variables measuring: the median income of home purchasers who use a mortgage, the rate at which households applying for mortgages to buy homes in the neighborhood are denied by the financial institution, and the racial-ethnic profile of home purchasers who use a mortgage. The first variable is self-explanatory. The denial rate has been shown to be a powerful proxy for multiple measures of the socioeconomic status of home buyers, such as education and occupation (Galster, Hayes, and Johnson 2005), variables that also correlate well with wealth and permanent income. The racial profile of home buyers serves as a proxy for wealth (Oliver and Shapiro 1997) and potential constraints on mortgage borrowing associated with discrimination (Turner and Skidmore 1999). We use the percentages of home purchase loans that are nonconventional (i.e., FHA/VA-financed) and that are made by subprime lenders as proxies for the availability of credit to nontraditional borrowers. We measure the price of potential substitute homes in competing neighborhoods as the cumulative percentage change in home prices in advantaged neighborhoods between 1995 and the present year. Our notion is that higher inflation in these neighborhoods will force more households to buy in disadvantaged neighborhoods as a more affordable substitute.[8] We use D.C. assessor's data on home sales to operationalize the affordability of homes in the particular neighborhood.

As for expectations about future appreciation in the area, we employ four proxy variables. We suggest that if a disadvantaged neighborhood is located adjacent to an advantaged one, and/or is closer to a Metro subway station, prospective buyers and sellers will have stronger baseline confidence in future appreciation. As for time-varying predictors, we posit that the larger the average annual change in median sales prices in *adjacent* tracts, the greater should be the optimism in the particular tract. We also employ the (HMDA-based) percentage of home purchase loans in the neighborhood made to investors as another leading indicator for more optimistic expectations. Finally, a greater volume of home sales in the neighborhood (holding price constant) should be associated with rising optimism about increases in the relative desirability of homes in the area.[9]

In summary, the time-varying independent variables in our final model predicting the takeoff of consistent, substantial, and sustained home appreciation in year t were

- Number of residential sales per thousand housing units, year $t-1$
- Median sales price of homes and condominiums (in thousands of 2005 dollars), $t-1$
- Percentage home purchase loans to investors, $t-2$
- Percentage home purchase loans to non-Hispanic white borrowers, $t-2$
- Percentage home purchase loans to Hispanic borrowers, $t-2$
- Percentage home purchase loans to Asian/other race borrowers, $t-2$ (non-Hispanic black is the omitted reference category)
- Median borrower income (in thousands of 2005 dollars), $t-2$
- Denial rate for home purchase mortgage loans, $t-2$
- Percentage nonconventional home purchase mortgage loans, $t-2$
- Percentage home purchase loans made by subprime lenders, $t-2$
- Average change in median sales price in adjacent census tracts, $t-2$ to $t-1$
- Cumulative percentage change between 1995 and year $t-2$ in annual mean sales price of homes and condominiums in nondisadvantaged tracts

and the two variables that measure time-invariant, cross-tract differences are

- Tract was adjacent to a nondisadvantaged tract in 1995 and 1996 (1 = yes, zero = no)
- Distance between tract centroid and nearest Metro station, in meters (0 = in tract)

Hazard Model of the Onset of Appreciation

We used a discrete hazard model with both time-independent and time-dependent covariates (Allison 1990). The discrete form of the hazard model is appropriate for data where the observed time to an event is not continuous.[10] The hazard $P(t)$ is the probability that a particular tract will experience the onset of appreciation during a particular year t.[11] To be able to have an additional test of the model's predictive power, we estimated the model coefficients using only the first seven years of data (1996 to 2002). We then could measure the fit of the model both with "in-sample" data for 1996 to 2002, as well as "out-of-sample" data for 2003, as explained below.

The model is estimated as a logistic regression so that the probabilities predicted by the vector of time-invariant explanatory variables $[Y][\Phi]$ and time-varying explanatory variables $[X][\beta]$ are constrained to fall in the range of zero to one:

$$\text{Log}\ [\mathrm{P}(t)/1 - P(t)] = \alpha + [X][\beta] + [Y][\Phi].$$

The estimated coefficients of the independent variables $[\beta]$ and $[\Phi]$ can be interpreted as the strength of the corresponding explanatory factor in predicting the probability that a tract has started appreciating. The model presented here uses the twelve time-varying $[X]$ and two time-invariant explanatory variables $[Y]$, as delineated above.

In our specification, we have used both one- and two-year lags in the time-varying independent variables. For the HMDA-derived indicators, we have used two-year lags because of the one-year delay in the public availability of HMDA data compared to locally obtainable home sales data. Our notion is that our model should employ as predictors in any given year the most up-to-date information from these two sources that feasibly could be available for market decision makers (or planners) to use for predictions of the next year's appreciation.

▶ Results: Estimated Model Parameters and Interpretation

We estimated the model above as a logistic regression (LOGIT) using SAS's LOGISTIC procedure. Unlike a linear regression, estimated LOGIT coefficients cannot be interpreted directly but are normally converted to odds ratios: the odds of a disadvantaged tract with the particular characteristic in question having started consistent, substantial, and sustained appreciation, divided by the odds that the base case disadvantaged tracts have done so. The odds are defined as $p/(1 - p)$, where p is the probability of the tract in question having experienced the onset of appreciation.

Parameters and diagnostic statistics for the estimated hazard model are presented in Appendix A. Seven independent variables in the model had statistically significant coefficients (at the 10 percent level or better), which we discuss below. Three of these variables were based on HMDA data, three on sales price data, and one on spatial data. One way to assess the overall performance of a model such as ours is to see how well it predicts, both inside and outside of the analysis period; for details, see Appendix B. The association of predicated probabilities and observed responses from our LOGIT model "within sample" (i.e., 1996 to 2002) indicates a high degree of agreement (92 percent) between the model estimates and the original appreciation onset indicator. We also evaluated the model against "out-of-sample" data for 2003, which consisted of thirty-seven tracts that had not yet appreciated, and predicted 65 percent of these cases correctly. This suggests to us that our model offers a respectable degree of predictive power.[12]

The most powerful and statistically significant predictors of the onset of appreciation proved to be two of the spatial variables, consistent with our views about how proximity to hot market segments may bolster optimism. A disadvantaged tract adjacent to an advantaged one had a 422 percent higher baseline odds of appreciating sometime during our analysis period compared to an otherwise identical tract not adjacent to such advantaged neighborhoods. This size of this spatial spillover effect is remarkable and dwarfs that of other variables in the model (at least in normal ranges of variation). A second spatial variable, the average change in the median home and condo prices in adjacent tracts between one and two years prior, was also a statistically significant predictor of appreciation, with an odds ratio of 1.091. This may be interpreted as follows: a \$1,000 average increase in the median sales prices in adjacent tracts will increase the odds of the tract in question starting to appreciate a year later by 9.1 percent. A standard deviation (\$11,126) difference in this variable will yield a difference of 101 percent in the odds of two otherwise identical tracts starting their appreciation. These two results provide strong empirical support to the growing empirical consensus that neighborhood home price appreciation is a process involving powerful proximity effects (cf. Galster et al. 2004; Galster, Tatian, and Accordino 2006; Kolko 2007; Koschinsky 2008). The broader implications of this and other findings will be discussed below.

As for indicators based on HMDA data, the median income of home purchase mortgage borrowers in the tract in year $t-2$ was positively correlated with the probability of appreciation onset in year t, with an odds ratio of 1.042. This means that an increase in the median borrower income in $t - 2$ of \$1,000 increases the odds of a tract starting to appreciate in year t by 4.2 percent. A standard deviation (\$14,954) difference in this variable will yield a difference of 63 percent in the odds of two otherwise identical tracts starting their appreciation. This result has strong commonsense appeal: increasing median incomes of buyers of homes in a modest neighborhood are predictive of the onset of consistent, substantial, and sustained home price increases two years hence.

The denial rate for home purchase mortgages in year $t-2$ was negatively correlated with the probability of appreciation onset in year t, with an odds ratio of 0.972. A 1 percentage point decrease in the denial rate in $t-2$ increases the odds of a tract starting to appreciate in year t by 2.8 percent. A standard deviation (18.3 percentage points) difference in this variable will yield a difference of 51 percent in the odds of two otherwise identical tracts starting their appreciation. Consistent with the previous results on median borrower incomes, we believe that decreases in this variable signals a changing neighborhood economic profile whereby relatively socially disadvantaged households are being replaced by ones who are wealthier, more credit-worthy, and more prestigious, that is, college-educated, high occupational status (Galster, Hayes, and Johnson 2005). Consistent with the theory above, influxes of such buyers with a stronger ability to pay indeed increase the odds of an appreciation takeoff soon thereafter.

In concert, these results indicate that the improving economic profile of in-moving home buyers is viewed as an unmistakable harbinger of appreciation. We note that this could be both for symbolic and real reasons. Symbolically, such in-movers may signal the increasing attractiveness of the neighborhood to a new market segment with greater ability to pay. It could equally signal improved prospects for enhanced quality of neighborhood life. Home owner income is strongly correlated with investments in home maintenance and improvements (Galster 1987), and higher socioeconomic status of neighbors is typically viewed as an attractive neighborhood attribute in its own right. Previous work has demonstrated that home owners who anticipate improvements in the neighborhood's quality of life will invest more to improve their own home (Galster 1987), thus encouraging a "virtuous cycle" of enhanced neighborhood physical quality, status of in-movers, and so on.

Finally, the HMDA-based percentage of home purchase mortgages to Hispanic borrowers in year $t - 2$ is positively correlated with the probability of appreciation in year t, with an odds ratio of 1.047. This suggests that each percentage point increase in Hispanic mortgage borrowers (and a corresponding decrease in black borrowers, the reference category) will raise the odds of appreciation two years hence by 4.7 percent. Put differently, a standard deviation (7.94 percentage point) difference in this variable will yield a difference of 37 percent in the odds of two otherwise-identical tracts starting their appreciation. This is a more surprising result, given the conventional wisdom that the archetypical "pioneers" moving into revitalizing neighborhoods are non-Hispanic whites. We offer a tentative explanation for this result. During the period in question, Washington witnessed a large increase in first-time Hispanic home buyers; their home ownership rate rose 38 percent (8 percentage points, to 28.3 percent) from 1990 to 2000. Moreover, these new home buyers often moved into stable, predominantly home owner areas where Hispanics were a small minority share. Arguably, they may have been perceived there as a new, but benign, phenomenon, with no prior history of negative associations with their in-migration triggering a process of neighborhood transition, tipping, and displacement. Regardless of whether these areas were predominantly white- or black-occupied, this upsurge in Hispanic home buying apparently was greeted as a harbinger of appreciation. Two neighborhoods serve as exemplars. Tract 19.01 in the Brightwood neighborhood, with more than 90 percent black and 80 percent home owning households in 2000 increased from 0 percent new Hispanic home buyers in 1995 to 22 percent in 2004. Over the same period, the median home price in the tract grew 106 percent in real terms, or an average of 8.4 percent per year, to $284,000 in 2004. Tract 8.01 in northwest D.C., with 80 percent white and 60 percent home owning households in 2000, increased from 1.3 percent new Hispanic home buyers in 1995 to 11.2 percent in 2004, while the median home price grew 112 percent, or an average of 8.7 percent per year, reaching $543,000 in 2004. We can only speculate why such communities perceived new Hispanic buyers so favorably. Perhaps such in-movers, typically with their large number of children, signaled that the area was gaining attractiveness to family purchasers. Whatever the explanation, caution must be exercised in interpreting this result because it may be D.C.-specific.

Two variables derived from sales transactions data also proved predictive in the expected manner. The number of home and condominium sales per one thousand such units in year $t - 1$ was positively associated with the start of appreciation in year t, with an odds ratio of 1.019. This means that in a tract with one thousand homes or condominiums (a typical number in D.C.), each additional sale in a year will raise the odds of an appreciation takeoff the following year by 1.9 percent. A standard deviation (17.85) difference in this variable will yield a difference of 34 percent in the odds of two otherwise identical tracts starting their appreciation. This finding is consistent with our theoretical position above that growing sales rates (holding price constant) signal stronger market optimism on the part of buyers and sellers. Apparently, an active market raises owners' reservation prices, leading them to bide their time in offering their properties to the market until it improves still further.

The cumulative percentage increase in home and condo prices between 1995 and year $t - 2$ in the *nondisadvantaged* parts of Washington also was positively associated with the start of appreciation of a disadvantaged tract in year t, with an odds ratio of 1.099. A disadvantaged tract thus will have its odds of starting appreciation during year t raised by 9.9 percent for each 1 percentage point increase in cumulative price appreciation in the nondisadvantaged tracts. A standard deviation (10.24 percentage points) difference in this variable will yield a difference of 101 percent in the odds of two otherwise identical tracts starting their appreciation. This strong result is indicative of the power of overall housing market strength to eventually pull up prices in even less advantaged neighborhoods. It is consistent with our notion that higher prices in more desirable neighborhoods will, if they persist, eventually push demand into other, less attractive neighborhoods. Of course, it is also a plausible proxy for more generalized market optimism about future appreciation prospects in all neighborhoods.

We found that the *level* of a neighborhood's home prices one year earlier did not, however, aid one's ability to predict the takeoff point of appreciation. This finding suggests that one cannot simply examine current prices to see how "hot" a local housing market is and get a clear reading of whether further appreciation is imminent. This is not surprising, given the foregoing theory, inasmuch as current price levels have offsetting impacts on buyers and sellers.

More surprising is the comparative lack of explanatory power of several other variables in the model (see Appendix A). Despite conventional wisdom to the contrary, we find no evidence that increasing shares of home buyers who are investors signals imminent appreciation, once other leading economic characteristics of borrowers (i.e., income of borrowers and the overall denial rate for mortgage applications) and proxies for optimism (i.e., home sales rates and accumulated appreciation in nondisadvantaged tracts) and spatial spillovers have been controlled. Finally, proximity to a Metro stop did not help in predicting appreciation takeoff, probably because there was no intertemporal variation in this variable over the analysis period because the system was already built out in disadvantaged areas. This means that the value of a proximate Metro stop could well have been capitalized into home prices in a lump-sum fashion at the time the stop was opened (or announced) but that it had no effect on subsequent appreciation. This is consistent with several other (though not all) examples of community development initiatives that yielded a one-time-only fillip in housing prices nearby without altering appreciation rates (Galster et al. 2004).

Taken collectively, we believe that these findings offer substantial support for our foregoing theoretical discussion of the origins of when disadvantaged neighborhoods begin undergoing consistent, substantial, and sustained periods of home price appreciation. As higher-income, better-qualified home buyers begin moving in, the market clearly takes this as a leading indicator of rising demand and/or prospective enhancements to the real quality of neighborhood conditions. As home turnover rates rise, the market apparently reads this as a signal of the future market strength. A further fillip of optimism occurs if the rest of the city's home prices have inflated more rapidly, signaling that as the advantaged districts get too pricey, buyers will soon be deflected into the less-advantaged neighborhoods. The closer these advantaged and higher-inflating areas (whether advantaged or not) are, the better the odds that the given neighborhood will also start appreciating strongly. We cannot be certain whether these spatial spillovers are due to demanders perceiving quality of life decaying with distance from higher-inflating areas and/or whether both sides of the market take proximate appreciation as a more powerful leading indicator of their own prospects than more distant appreciation.

▶ Conclusions, Implications for Planners, and Suggestions for Future Research

The analysis presented here explored the empirical relationships between static and annually changing neighborhood characteristics and the subsequent onset of consistent, substantial, and sustained home price appreciation in disadvantaged neighborhoods in the District of Columbia. It represents the first effort to examine housing price trends in disadvantaged neighborhoods at a fine grain of space and time and estimate a predictive model of a major alterations in these trends. In particular, our discrete hazard model attempted to predict the probability that a below citywide median value census tract in Washington, D.C., will start to appreciate in the next year, based only on data that the analyst could readily have available at that moment. We found that the key predictors of the onset of appreciation were (1) the income levels, denial rates, and Hispanic shares of those taking out mortgages to buy homes and condominiums in the neighborhood *two* years earlier; (2) adjacency to high-priced neighborhoods in 1995 and to neighborhoods that were rapidly appreciating during the prior *two* years; (3) the rate of home and condo sales in the neighborhood *one* year before; and (4) the cumulative home appreciation since 1995 evinced up to *two* years prior in the parts of the city that began the period with above citywide median home prices per square foot. We view our prototype model as promising, inasmuch as the estimated parameters closely conformed to theoretical expectations about the etiology of home price appreciation and its intrasample and extrasample predictive abilities proved strong.

Implications for Understanding Neighborhood Dynamics and Planning Practice

What have we learned about the home price dynamics of disadvantaged neighborhoods? First, we have discovered a more nuanced version of the old adage "a rising tide lifts all boats." Indeed as would be expected, we have found that metropolitan-wide or citywide forces that spawn generalized appreciation (like strong immigration or job growth) increase the odds that even disadvantaged neighborhoods will take off on a path of consistent, substantial, and sustained price appreciation. However, we have also discovered that such a "rising tide," though helpful, is by no means a sufficient condition, even during a historically robust market as our study period. A substantial number of our study neighborhoods in Washington never evinced such a market takeoff before the bottom fell out of the local market (see Table 1). Moreover, unlike a body of water, such a "rising tide" lifts *closer* "boats" (neighborhoods) much more than distant ones. This leads into our second major finding: the pivotal role played by spatial spillovers cannot be exaggerated. We observed appreciation spreading wave-like across the Washington landscape, beginning first in disadvantaged areas adjacent to nondisadvantaged ones, then spreading from disadvantaged ones that had already appreciated more. Our third finding of import relates to the role of home sales volumes. Even if prices have not yet risen, merely increasing the volume of sales substantially provided a strong signal of the incipient appreciation of the neighborhood. Looking at the opposite side of the coin, this finding provides further indication that appreciation is extremely unlikely in highly distressed neighborhoods where, for a variety of potential reasons, the local market has withered and there is a negligible volume of home sales.

Our findings provide suggestive guidance to planners and policy makers interested in trying to spark some housing market appreciation in disadvantaged neighborhoods. First, following on the prior discussion, it is clear that planners in weak-market cities may need to *create a market* in neighborhoods that historically have seen few homes transacting. This might be done by targeting, for example, rehabilitation of rental dwellings or infill construction designed for affordable home ownership opportunities, public infrastructure improvements, selective property tax abatements for new buyers, or aggressive marketing campaigns aimed at first-time buyers (Galster 1987; Galster, Tatian, and Accordino 2006). Second, our findings strongly support the dictum "build from strength." The market is clearly more prone to respond optimistically if planners' scarce investments are strategically targeted to disadvantaged neighborhoods located near advantaged ones. Third, whatever plans are undertaken, a good deal of circumspection is appropriate. The observed empirical importance of (1) the cumulative appreciation of advantaged neighborhoods and (2) the inflows of higher-income, higher-status, and more credit-worthy home buyers in spurring appreciation in disadvantaged neighborhoods reconfirms the importance of metropolitan-wide and citywide forces in shaping their destiny. Unfortunately, local planners and policy makers typically are not able to shape substantially these broader forces.

Of course, our findings also hold potential relevance to those who may look askance at the appreciation of disadvantaged neighborhoods because it may foreshadow the involuntary displacement of low-income residents. From this perspective, if planners and policy makers could more quickly identify in which neighborhoods consistent, substantial, and sustained appreciation would soon be occurring, they potentially could respond more efficaciously. A recent Urban Institute survey of strategies to minimize displacement found that several approaches, if taken in advance, could be effective (Levy, Comey, and Padilla 2006). In this regard, our model might be viewed as a prototype "early warning indicator" of incipient displacement.[13] Planners interested in this application could adapt our approach and estimate the parameters for their own community, using the same readily available, historical data sources as we employed. These models could then be employed to generate out-of-sample predictions for all disadvantaged neighborhoods, thus identifying places with the highest future probabilities of appreciation that might be targeted for interventions to minimize displacement.

Caveats and Directions for Future Research

Several caveats and suggestions for more research are in order before closing. First, the model needs to be replicated in a variety of metropolitan areas and during different periods before we can have confidence that the significant predictors of the onset of appreciation and the parameters indicating their predictive power can be generalized. In particular, the model should be reestimated for neighborhoods located in a metropolitan area with less robust regime of home price appreciation than Washington, D.C., experienced from 2000 to 2005.[14] During our analysis period, we saw only stable and rising home prices, never declines. Thus, it would be inappropriate to generalize our results beyond periods that might be described as a localized housing bubble. Second, researchers should identify additional neighborhood-level variables from annually updated data sources that likely will add to the predictive power of the model. In particular, we think that the inclusion of building permit data and demolition data would prove efficacious, were such readily available from a local jurisdiction on a timely basis (which, unfortunately, they were not in Washington). Other variables may also prove predictive but are likely to necessitate considerable effort to obtain; these include location-specific investments by local governments, retail property owners, and rental property owners. Third, further tests of the model are appropriate to assess its robustness to alterations in the operationalization of appreciation takeoff point. Though the criteria we employed were sensible in the context of Washington, D.C., in the 1995 to 2005 period, others might be in a different situation. Fourth, although our model focused upon the onset of appreciation, it would also be intriguing to explore the onset of *depreciation* in other metropolitan contexts and epochs. We would presume that the predictors of these processes are not completely symmetric. Fifth, we modeled the spatial propagation of appreciation crudely with adjacency measures only. Experiments with more sophisticated spatial lags should be undertaken. Finally, appreciation may occur in spatial pockets that are considerably smaller than census tracts. This means that the model should be tested for smaller-scale geographies using point data for home sales, although then HMDA-based data would not be available for modeling at such small scales. In any event, we believe that this article has demonstrated that the predictive modeling of home price appreciation in disadvantaged areas is feasible, provides useful insights into neighborhood dynamic processes, and offers practical guidance to planners concerned about neighborhood revitalization and displacement.

▶ Appendix A

Predictive Model Estimation Results
List of model variable acronyms.

Variable	Label
Dependent variable	
medprice2yr	Tract started appreciating based on changes in median sales price (2 yr) (1 = yes, 0 = no) (see text for criteria of onset of consistent, sustained, substantial appreciation)
Independent variables	
adj_high_val_tract	Tract is adjacent to above-median-value tract, $t = 0$ (1 = yes, 0 = no)
adj_mean_dif_medprice_1_lag	Mean difference in median sales price in adjacent tracts, $t - 2$ to $t - 1$
distance_metro	Distance to nearest Metro station (meters, 0 = station in tract)
hval_cum_pct_medprice_2	Cum. pct. change in avg. median sales price (single-family + condo, 1,000s $2005) in above-median-valued tracts, 0 to $t - 2$
medianmrtginc_adj_lag2	Median borrower income (1,000s $2005), $t - 2$
medprice_lag	Median sales price (single-family + condo, 1,000s $2005), $t - 1$
mrtgdenialrate_lag2	Denial rate for conventional home purchase mortgage loan applications (%), $t - 2$
numsal_hu_lag	Number of residential sales per 1,000 housing units, $t - 1$
pctmrtgorighisp_lag2	Pct. home purchase loans to Hispanic borrowers, $t - 2$
pctmrtgoriginvest_lag2	Pct. home purchase loans to investors, $t - 2$
pctmrtgorigothr_lag2	Pct. home purchase loans to Asian/other borrowers, $t - 2$
pctmrtgorigwhite_lag2	Pct. home purchase loans to white borrowers, $t - 2$
pctnonconvmrtg_lag2	Pct. nonconventional home purchase mortgage loans, $t - 2$
pctsubprmmrtg_lag2	Pct. subprime conventional home purchase mortgage loans, $t - 2$

▶ Estimated Logit Parameters and Related Statistics

Analysis of maximum likelihood estimates.

Parameter	Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square
Intercept	–8.6263	2.1554	16.0177	<.0001
numsal_hu_lag	0.0189	0.0110	2.9823	.0842
medprice_lag	0.00461	0.00892	0.2667	.6056
pctmrtgoriginvest_la	–0.0487	0.0374	1.7012	.1921
pctmrtgorigwhite_lag	0.0183	0.0245	0.5527	.4572
pctmrtgorighisp_lag2	0.0455	0.0249	3.3455	.0674
pctmrtgorigothr_lag2	0.0358	0.0325	1.2113	.2711
medianmrtginc_adj_la	0.0491	0.0264	3.4491	.0633
mrtgdenialrate_lag2	–0.0282	0.0170	2.7493	.0973
pctnonconvmrtg_lag2	0.00903	0.0180	0.2525	.6153
pctsubprmmrtg_lag2	0.0163	0.0115	2.0250	.1547
adj_high_val_tract	1.6521	0.5237	9.9518	.0016
distance_metro	–0.00012	0.000440	0.0807	.7764
adj_mean_dif_medpric	0.0867	0.0233	13.8978	.0002
hval_cum_pct_medpric	0.0944	0.0254	13.8165	.0002

(continued)

Appendix A (continued)

Model fit statistics.

Criterion	*Intercept Only*	*Intercept and Covariates*
Akaike Information Criterion (AIC)	261.432	185.017
Schwarz Criterion (SC)	265.416	244.776
–2 log likelihood	259.432	155.017

	Chi-Square	*df*	*Pr > Chi-Square*
Likelihood ratio	104.4149	14	<.0001

Odds ratio estimates.

Effect	*Point Estimate*	*95% Wald Confidence Limits*
numsal_hu_lag	1.019	0.997-1.041
medprice_lag	1.005	0.987-1.022
pctmrtgoriginvest_la	0.952	0.885-1.025
pctmrtgorigwhite_lag	1.018	0.971-1.069
pctmrtgorighisp_lag2	1.047	0.997-1.099
pctmrtgorigothr_lag2	1.036	0.972-1.105
medianmrtginc_adj_la	1.050	0.997-1.106
mrtgdenialrate_lag2	0.972	0.940-1.005
pctnonconvmrtg_lag2	1.009	0.974-1.045
pctsubprmmrtg_lag2	1.016	0.994-1.040
adj_high_val_tract	5.218	1.869-14.564
distance_metro	1.000	0.999-1.001
adj_mean_dif_medpric	1.091	1.042-1.141
hval_cum_pct_medpric	1.099	1.046-1.155

▶ Appendix B

How Well Does the Model Predict the Onset Of Appreciation?

A common way to assess the overall performance of a model such as ours is to see how well it predicts, both inside and outside of the analysis period. The association of predicated probabilities and observed responses from our LOGIT model "within sample" (i.e., 1996 to 2002) indicates a high degree of agreement between the model estimates and the original appreciation onset indicator. The share of observations that agree on predicted and actual values is 92.2 percent. Another 7.7 percent of observations disagree and 0.1 percent were tied. Put differently, whenever the model predicted that a particular tract would not begin appreciation in a particular year (i.e., estimated $P[t] < .50$), it proved correct in 344 of 370 (93 percent) of the tract-year cases but produced a "false negative" prediction in the remaining 7 percent. Whenever the model predicted that a particular tract would begin appreciation in a particular year, it proved correct in 14 of 22 (64 percent) of the tract-year cases but produced a "false positive" prediction in the remaining 36 percent.

We also evaluated the model against "out-of-sample" data for 2003, which consisted of thirty-seven tracts that had not yet appreciated. Our criteria indicated that ten of these tracts had appreciation onset in 2003. To test further our model's predictive

(continued)

Appendix B (continued)

power, we applied the previously estimated model coefficients to the (appropriately lagged) values of the independent variables for these thirty-seven tracts and compared the predicted probabilities of appreciation against the actual onset indicator. As before, when the model's predicted hazard exceeded .50, we flagged that observation as "expected to begin appreciating."

Out of the thirty-seven tracts eligible for appreciation in 2003, the model correctly predicted that eighteen of the tracts did not begin and that six tracts did begin appreciating in that year, for an overall correct prediction rate of 65 percent. When the model predicted that a particular tract would not begin appreciation in 2003 (i.e., estimated $P[t] < .50$), it proved correct in eighteen of twenty-two (82 percent) of the cases but produced a "false negative" prediction in the remaining four (18 percent). When the model predicted that a particular tract would begin appreciation in 2003, it proved correct in six of fifteen (60 percent) of the cases and produced a "false positive" prediction in the remaining nine (60 percent). Thus, the model evinced a considerably weaker performance on the out-of-sample than on the within-sample test, which is typical for such tests. However, further analysis of the 2003 false negatives indicated that all of them had a predicted probability of appreciation for 2004 of .72 or higher. This implies that, though our model missed the appreciation onset of particular tract in 2003, it caught it the following year. This suggests to us that our model offers a respectable degree of predictive power.

▶ Notes

1. Li and Rosenblatt (1997) model home price appreciation over two 5-year periods.
2. For a review of four cities' experiences with neighborhood early warning systems, see Snow et al. (2004).
3. Operating costs include property taxes, utilities, insurance, maintenance and repairs, and federal and state tax reductions associated with home ownership.
4. Our focus is on the short-term period, so short that prices are influenced primarily on the supply side by the aforementioned reservation prices, not by modifications to the existing housing stock or new construction in the neighborhood, though over sufficient time, such can certainly occur (Galster and Rothenberg 1991; Rothenberg et al. 1991).
5. Price per square foot was used to provide a more reasonable comparison between prices of single-family homes and condominiums. All dollar amounts in our analysis have been converted to constant 2005 dollars using the Consumer Price Index.
6. Demographic and housing stock characteristics of these three different classes of "disadvantaged" tracts are available upon request from the first author.
7. For the two-year average median sales price, the overall annual change for moderate appreciation tracts from 1995/1996 to 2004/2005 was about $14,450 per year.
8. This variable changes value yearly but assumes this same value across all observations of disadvantaged tracts that period. We recognize that this variable may also measure the cumulative strength of demand pressures impinging on the overall municipal housing market, under the assumption that the baseline hazard of appreciation in disadvantaged neighborhoods will be directly related to such pressures.
9. We also tested several 1990 census indicators of population composition and housing characteristics, both individually and as interaction terms with the time-series variables. These

census-derived independent variables did not contribute to the explanatory power of the model, however, and so are not included in the final specification presented here.

10. We recognize that our appreciation measures begin in 1995, which may appear as an arbitrary starting point upon which to base a hazard analysis. However, our examination of real estate market trends in Washington, D.C., over the prior decade suggests that there were few, if any, pressures for appreciation for any of these tracts. It is thus not unrealistic to posit that the only nontrivial hazard of beginning appreciation began in the period under investigation.

11. According to the Housing in the Nation's Capital report, real house prices in the District of Columbia grew 15.9 percent per year on average from 1999 through 2004, an extraordinary rate of growth (Turner et al., 2005: 20-21).

12. Details of these tests are available upon request to the first author.

13. This would be similar in spirit to a few previous efforts to develop neighborhood early warning indicators. Scafidi et al. (1998) and Hillier et al. (2003) use data on residential parcels from the Philadelphia Neighborhood Information System to develop logistic models of whether an individual property will be abandoned and become "imminently dangerous" during 2000, based on characteristics of the property and surrounding neighborhood.

14. According to *Housing in the Nation's Capital*, house prices in the District of Columbia grew 15.9 percent per year on average from 1999 to 2004, an extraordinary rate of growth (Turner et al. 2005, 20-21).

Authors' Note: *The authors thank Kartik Athreya, Alan Berube, Shawn Closkey, Ira Goldstein, Julia Koschinsky, Kathy O'Regan, Roby Simons, Dan Tatar, Mark Spranca, Chris Walker, and participants in seminars at the Urban Institute, the Reinvestment Fund, and the Federal Reserve Banks of Richmond and Houston for their helpful suggestions on earlier versions of this project. Anonymous referees also provided seminal suggestions for recasting the article. This research was supported by the Federal Reserve Bank of Richmond, although the views expressed are the authors' and do not necessarily reflect those of the bank or its officers or either of the authors' home institutions.*

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