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by

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Committee in charge:

Professor John Quigley, Co-chair
Professor Thomas Davidoff, Co-chair
Professor David Card
Professor Dwight M. Jaffee

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Abstract

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This dissertation explores the effects of fluctuations in housing values on household saving and investment decisions. Chapter 1 examines the relationship between changes in housing values and household saving decisions. Fluctuations in housing values may affect household saving and consumption by increasing households' perceived wealth, or by relaxing borrowing constraints. Moreover, the increased liquidity of home equity during the recent housing boom may have led household behavior to respond more than in past years to changes in housing wealth. This chapter is the first analysis to provide evidence from household-level microdata suggesting that the housing wealth effect may have increased in line with increased access to housing-collateralized debt. Using data from the Survey of Income and Program Participation for the years 1984 - 2003, I estimate an average elasticity of household active saving with respect to MSA-level house prices of -0.222, which corresponds to a 1 cent decrease in annual active saving when housing wealth increases by 1 dollar. When I estimate housing wealth effects separately between 1984 and 1990, and between 1996 and 2003, I find smaller effects during the earlier period, but large and significant effects during the later period. During the later period, I estimate an average elasticity of household active saving with respect to MSA-level house prices of -1.044, which corresponds to a 3 cent decrease in annual active saving when housing wealth increases by 1 dollar. Further evidence comparing the magnitude of the wealth effect between different subpopulations – older homeowners versus younger homeowners, and recent homebuyers versus those with longer tenure – suggests that a relaxation of liquidity constraints, rather than changes in the composition of the homeowner population, is a central factor contributing to the increase in the housing wealth effect.

Chapter 2 explores the connection between growth in housing values, uncertainty over future housing values, and property owners' investments in housing. Residential housing is a significant share of most American households' asset holdings. As such, the decision to build, to buy, or to make significant improvements to a home is driven not only by consumption considerations, but is also an investment decision. By modeling property owners' housing investment decisions

using a framework of optimal capital investment where investments are irreversible and there is uncertainty in future asset values, this analysis theoretically predicts and empirically estimates the extent to which property owners respond to changes in the profitability of housing investment by making investments in their stock of housing. Using a unique dataset of residential sales, geographic information, and the universe of building permits issued in Los Angeles between 1999 and 2008, and focusing on nonresident landlords and "improver-movers" - owner-occupiers who make improvements to their properties and subsequently sell the property, I find that when housing values increase, property owners are more likely to make capital investments, and that the value and square footage of these investments is larger. When house price volatility is high, property owners are less likely to make investments. However, conditional on the decision to invest, the value and square footage of investments is larger. This result is shown to be a consequence of property owners' optimally delaying capital investment when uncertainty over future prices is high.

Chapter 3 documents the extent to which residential real estate development is cyclical - exhibiting periods of rapid expansion followed by periods of rapid contraction - using New York City as a case study. This chapter provides an overview of residential development activity in New York City during the years 2000 - 2008. In this analysis, I describe the effects of this real estate "boom" on the housing market in New York City during these years, and characterize the long-term effects of the "boom" and subsequent "bust" in residential development on the composition of the City's housing stock. Economic theories of cyclicality in real estate markets, outlined in this chapter, show that uncertainty over the exact timing of price declines coupled with a long development lag can lead to buildings being completed and new units entering the market even as prices decline. Although the elasticity of housing supply is lower in New York City than in other areas, building activity tends to follow a boom-and-bust pattern similar to other areas. Neighborhoods with higher levels of amenities experienced more growth in residential housing supply, and public involvement in development activity (both to facilitate and to restrict development) became less important for builders as the boom progressed. As building activity slows, City officials and developers are taking steps to ensure that stalled construction sites, rather than becoming eyesores and safety hazards, are preserved for future use.

For Mamie Holland
who taught me the virtue of verbosity

and for Elizabeth McCombs
who led the way

# Contents

## Acknowledgments

At the risk of false modesty, talking about my own accomplishments has never been an enjoyable task for me, to the point that I even resent the convention of writing in the first person in economics articles. (Quote from my undergraduate thesis adviser: “Is this the ’royal’ we”?) So, I am overjoyed to acknowledge and thank all of those, named and unnamed, who helped me to complete this project.

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# Chapter 1

# Has the housing wealth effect increased over time? Household saving and housing wealth

## 1.1 Introduction

The decline in saving among American households has been an issue of national concern for almost two decades. Personal saving has declined steadily from the early 1980s to the current day, even during periods of robust growth in household income and economic output.[1] This decline in saving has been driven by an increase in household debt, and as outlined in Dynan and Kohn (2007), household indebtedness has accelerated since the year 2000. Increases in housing wealth seem to have influenced households' borrowing behavior, and this 'wealth effect' (the effect of increases in asset values on household consumption and borrowing) seems to be a more important determinant of household saving in recent years than in the previous period of rapid house price appreciation in the 1980s.[2]

Why would changes in housing wealth affect household saving decisions? Under a standard life-cycle model of saving and consumption, only changes in lifetime wealth or in preferences for current versus future consumption affect household saving and consumption in a given period. However, if households are liquidity constrained, the standard life-cycle model no longer applies because households are unable to perfectly smooth consumption by borrowing. In this case, increases in housing wealth can affect household consumption by increasing the amount of collateral available to borrow against, relaxing the liquidity constraint.

Why would the effect of changes in housing wealth on household saving be larger in the 2000s than in earlier periods? During the 1990s, there were a number of innovations in mortgage lending -

[1] In this paper, 'saving' or 'active saving' is defined as the annual change in household total net worth, excluding changes in asset values. 'Active saving' excludes all changes in asset values, and 'modified active saving' excludes changes in housing asset values only.

[2] In a speech at the 2007 Federal Reserve Jackson Hole conference, Fed chairman Ben Bernanke stated that "...the increased liquidity of home equity may lead consumer spending to respond more than in past years to changes in the value of their homes; some evidence does suggest that the correlation of consumption and house prices is higher in some countries, like the United States, that have more sophisticated mortgage markets. Whether the development of home equity loans and easier mortgage refinancing has increased the magnitude of the real estate wealth effect - and if so, by how much - is a much-debated question that I will leave to another occasion."

deregulation of loan terms and interest rates, the rise of credit scoring and automated underwriting, and the increasing securitization of mortgage assets - that allowed a wider range of individuals to borrow against the equity in their home, and allowed existing borrowers to take on more debt. This credit liberalization further relaxed homeowners' liquidity constraints, allowing them to borrow more against their homes when house prices rose.[3]

This paper contributes to the literature on household saving and wealth effects by documenting that the housing wealth effect has increased in magnitude between the period of house price appreciation in the 1980s and the most recent period of house price appreciation. Using household-level microdata from the Survey of Income and Program Participation (SIPP) for the years 1984 - 2003, I estimate an average elasticity of household saving with respect to MSA-level house prices of -0.222, which corresponds to a 1 cent decrease in annual active saving when housing wealth increases by 1 dollar. When I estimate housing wealth effects separately between 1984 and 1990, and between 1996 and 2003, I find statistically insignificant effects during the earlier period, but large and significant effects during the later period. During the later period, I estimate an average elasticity of household saving with respect to MSA-level house prices of -1.044, which corresponds to a 3 cent decrease in annual active saving when housing wealth increases by 1 dollar. I am not able to use variation in the availability of credit to test the liquidity constraints hypothesis against the standard life-cycle model with data from the SIPP, but evidence comparing the magnitude of the wealth effect between different subpopulations (older homeowners versus younger homeowners, and recent homebuyers versus those with longer tenure) suggests that changes in liquidity constraints are an important factor contributing to the increase in the housing wealth effect.

There are two hypotheses that argue against a causal relationship between housing wealth and household saving. The leading alternative explanation for the correlation between housing prices and household saving is that there are common unobserved factors, specifically income expectations, which affect both outcomes. Under this hypothesis, when households in an area expect that their incomes will increase in the future, they increase current consumption and decrease current saving. At the same time, house prices increase in expectation of higher local housing demand driven by higher local incomes and larger population inflows. While these unobservables would bias my estimates of the housing wealth effect upwards, they would not cause the housing wealth effect to be larger in later years relative to earlier years unless the unobservable process relating housing prices or household saving to expectations changed over time.

In order to address this potential bias in my estimates of the housing wealth effect, I include in the above model of household saving current and future MSA-level income growth, population growth, and unemployment rates to proxy for households' expectations of future local economic conditions. While these variables are excellent predictors of local house price growth, they are not good predictors of household saving, and their inclusion does not affect estimates of the housing wealth effect. The relationship between these variables and the outcomes of interest is also stable over time. I use these variables as instruments for house price growth, and find slightly larger estimates of the housing wealth effect.

The second explanation, outlined in Sinai and Souleles (2003), is that homeownership acts as a hedge against future fluctuations in housing prices. This hypothesis predicts that households who plan to purchase a larger home in the near future should not adjust their saving when house prices

[3] See Chomsisengphet and Pennington-Cross (2006) and Sitgraves (2007) for summaries of the development of the subprime mortgage market, a source of mortgage debt for many new borrowers during the late 1990s and early 2000s, and Merry (2006) for details on how housing leverage has changed over time for various categories of borrowers.

fluctuate, because they will have to spend more on housing in the future. Thus, housing wealth effects should be negligible for these groups of homeowners. I estimate housing wealth effects for younger homeowners who may be planning to 'trade up' in the near future, and older homeowners who may be planning to 'downsize' housing consumption, and find larger wealth effects for older homeowners.

Determining the response of household saving and consumption to changes in housing wealth, and the extent to which this response depends on the availability of mortgage credit, is particularly important in light of recent developments in the U.S. housing and mortgage markets. While this paper does not determine the effect of specific mortgage market innovations and increased mortgage credit availability on the size of the housing wealth effect, it is the first analysis to provide evidence from household-level data suggesting that the housing wealth effect may have increased in line with increased access to housing-collateralized debt. As housing prices fall and the amount of credit available to mortgage lenders and borrowers shrinks, economic planners could benefit from knowledge of the individual-level relationship between housing wealth, saving, and consumption, in order to target economic assistance (geographically, or otherwise) to households during a potential downturn.

This paper is organized as follows. Section 2 summarizes the existing literature on wealth effects on saving and consumption. Using Deaton's (1991) analysis as a guide, Section 3 presents a simple model of life-cycle consumption and saving in the presence of liquidity constraints, explicitly including housing wealth as a source of borrowing collateral. Section 4 describes the SIPP and construction of the dataset, and Section 5 presents the results. Section 6 concludes.

## 1.2 Literature Review

Many studies attempt to estimate the effects of changes in various components of household wealth on household saving and consumption decisions. These papers use both household-level and aggregate data, and estimate wealth effects by measuring changes in household consumption levels when asset values fluctuate (marginal propensities to consume) and by measuring changes in quantities of other assets accumulated when an asset's value fluctuates (marginal propensities to save). Table 1.10 summarizes the results cited in this section, including details on data sources and methodology. Generally, studies using microeconomic data find smaller housing wealth effects than financial wealth effects, and studies using macroeconomic data find the reverse, though due to varying definitions of assets, saving, and consumption there is no consensus on precise values of these effects.

Focusing initially on the analyses of saving behavior, a number of papers from the early 1990s use data from the Panel Study of Income Dynamics (PSID) on household asset accumulation to estimate the effects of changes in household housing wealth on self-reported consumption and saving (Skinner, 1993; Hoynes and McFadden, 1994; Engelhardt, 1996). Skinner's 1993 study, using data on saving rates between 1984 and 1989 from the PSID's topical module on asset accumulation, finds that households decrease their non-housing saving by 2.8 cents when self-reported housing values increase by 1 dollar. In contrast, Hoynes and McFadden's later study using the same data finds that non-housing saving rates increase by 0.126 percentage points when house price growth increases by 1 percentage point.

Although these results seem to be in conflict with each other, Engelhardt's 1996 study identifies differences between the two analyses that reconcile the differences in their results. Hoynes and McFadden include renters in their sample, and include capital gains in their measure of saving, which could bias results upwards if capital gains are correlated with local house price appreciation. Skinner uses self-reported housing values that may induce a measurement error-related downward bias in the estimated wealth effects. Engelhardt's analysis of Skinner's data finds that households reduce their non-housing wealth by 14 cents when housing wealth increases by 1 dollar, and this estimate is reduced to 3 cents when outlying values of saving are trimmed from the sample. Later studies, using the next wave of asset data available from the PSID, confirm this result. Following Engelhardt's empirical approach and correcting for measurement error-induced bias, Juster et. al. (2005) find that a 1 dollar increase in housing wealth reduces active saving by 3 cents and the effect of an increase in stock market wealth is over six times as large.[4]

The majority of studies, using both household-level and aggregate consumption data, focus on estimating the marginal propensity to consume gains in housing wealth and stock market wealth. Using information on food and utilities expenditures from the PSID as a measure of household consumption, Skinner (1989) and Lehnert (2004) find small elasticities of consumption with respect to housing wealth. Other studies (Gan, 2007; Dynan and Maki, 2001; Levin, 1998), using household-level data from a variety of sources, estimate significant dollar effects of housing wealth on household consumption, and even larger effects of financial wealth on consumption. In general, studies using data from the United States find larger effects than those using data from other countries. For example, Levin's study using Retirement History Survey data finds a marginal propensity to consume housing wealth of 6 cents, while Gan's study of Hong Kong credit card data finds an effect of only 1.6 cents.

Since detailed panel data on household consumption and assets are difficult to find, studies employ repeated cross-sections and matched data to construct 'pseudo-panels' of household-level observations. In their 2005 study, Bostic, Gabriel, and Painter match households between the Survey of Consumer Finances and the Consumer Expenditure Survey on income rank within demographically-defined cells, and estimate elasticities of consumption with respect to housing wealth of 0.04 to 0.06. Using data on consumption from the UK Family Expenditure Survey and on regional housing values from a British bank, Campbell and Cocco (2007) construct a pseudo-panel from repeated cross-sections of cohorts defined by five-year ranges of respondent year of birth and homeownership status. They estimate large elasticities of consumption with respect to housing wealth for homeowners – 1 for young homeowners and 1.7 for retirement-age homeowners – but negligible effects for renters. They also find that regional house price growth has a larger effect on consumption than national house price growth. Campbell and Cocco claim that these results favor a wealth effects explanation for the correlation between housing prices and consumption over one based on macroeconomic expectations.

In a follow-up to this analysis, Attanasio et. al. (2005) use the same data sources and pseudo-

[4]Other studies using micro data focus on the link between housing-collateralized borrowing and asset accumulation. In their 2002 study, Hurst and Stafford find that households in the PSID who experience an unemployment spell between 1991 and 1994 are 25 percent more likely to extract equity from their homes via mortgage refinance, and that the dollar effect of refinancing on saving is -0.66 (that is, households who extract 1 dollar of housing equity reinvest only one-third of that amount in their other assets). A similar study by Manchester and Poterba (1989) using SIPP data finds in cross-section that an additional dollar of second mortgage borrowing was associated with a 0.75 reduction in household total net worth.

panel approach, but find the opposite result: for cohorts defined by age group and region, the elasticity of consumption with respect to regional house prices is largest for young households at 0.21, and smaller for older households at 0.13. These differences stem from slight differences in the authors' empirical specifications. Attanasio et. al. group homeowners and renters within age categories, which biases estimates of the wealth effect downwards. They also include additional data from 1978 to 1988, and include cohort-level average wealth in their explanatory variables to capture differences in permanent income, while Campbell and Cocco include contemporaneous changes in income. While the authors claim that their results definitively support an expectations hypothesis over a wealth effects hypothesis, the results of both papers taken together imply that more research on the topic is needed.

The earliest studies (Elliott, 1980; Peek, 1983; Hendershott and Peek, 1985; Bhatia, 1987) modeled the saving and consumption decisions of a representative household, and estimated wealth effects using aggregate data on changes in assets and consumption flows.[5] More recent studies using data from the U.S. Flow of Funds accounts (Skinner, 1994; Benjamin, Chinloy and Jud, 2002; Case, Quigley and Shiller, 2005; Carroll, Otsuka and Slacalek, 2006) find that changes in housing wealth have larger effects on consumption than changes in stock market and other non-housing wealth. Estimates of the elasticity of consumption with respect to housing wealth range from 0.06 using quarterly state-level data imputed from the national Flow of Funds (Case, Quigley and Shiller, 2005) to 0.153 using quarterly Flow of Funds and NIPA data (Carroll, Otsuka and Slacalek, 2006).

Two recent papers using macroeconomic data attempt to explicitly measure the effects of credit liberalization on the magnitude of the housing wealth effect. In their 2006 paper, Aron and Muellbauer compare estimates of the housing wealth effect in the UK, where credit market liberalization was accompanied by a boom in housing values, to estimates from South Africa, where a similar response in asset values failed to occur. The authors include forecasted income as a control for expectations in the model, and interact their explanatory variables with a credit conditions index. The authors find that households consume 2 cents out of each dollar of housing wealth gains in the UK, and 10 cents in South Africa, and that these wealth effects are increasing in their measure of credit liberalization. A follow-up paper by Muellbauer (2007) comparing housing and stock market wealth effects in the US and the UK also finds that the interaction of the credit conditions index with changes in housing wealth is positively related to changes in consumption.

## 1.3 A Model of Saving under Liquidity Constraints

In order to characterize the connection between a household's housing wealth and per-period saving in the presence of liquidity constraints, I develop a simple modification to the standard model of saving and liquidity constraints presented in Deaton (1991).[6] In this model, households maximize a lifetime utility function with respect to an intertemporal budget constraint and a borrowing constraint: total borrowing must not exceed a set percentage of underlying collateral value. In my

[5]Although my study uses micro data, I include these references to provide a complete overview. See Davis and Palumbo (2001) for a comparison of different econometric approaches to estimating wealth effects using macroeconomic data.

[6]A similar concept of buffer-stock saving, which relies on unemployment risk in each period and a finite time horizon, is developed and empirically calibrated in Carroll (1992; 1997). Iacoviello (2004) derives a model for aggregate consumption when borrowing constraints depend on housing collateral.

version of the model, the collateral is housing wealth and the set percentage is the exogenously-determined maximum mortgage loan to value ratio.

There have been a number of theoretical analyses (Artle and Varaiya, 1978; Ortalo-Magne and Rady, 1999 and 2005; Gerardi, Rosen, and Willen, 2006) that examine the effects of mortgage borrowing constraints on the household's optimal tenure choice and housing price dynamics. I assume that all households are homeowners, and do not attempt to model the effects of changes in mortgage borrowing constraints on house prices, since I do not have information on how these constraints – loan initiation costs and credit requirements, maximum allowable loan to value ratio, and other measures of mortgage credit liberalization – vary by geographic area over time. I characterize the household's optimal consumption path under liquidity constraints, and derive a model relating changes in the household's optimal saving path to changes in the value of the housing stock.

Consider an infinitely-lived household with lifetime utility function

$$\mathcal{U} = \sum_{t=0}^{\infty} (1+\delta)^{-t} u(c_t, H_t)$$

The household derives instantaneous utility $u(c_t, H_t)$ from per-period consumption of their stock of housing assets $H_t$ and all other consumption $c_t$. For simplicity, instantaneous utility is separable in $c$ and $H$, and is assumed to be increasing, strictly concave, and differentiable. Future instantaneous utility is discounted at a rate of $1/(1+\delta)$.

For households without a mortgage, the cost of consuming housing level $H_t$ is the cost of housing maintenance and adjustments to the stock of housing assets.[7] Since these expenditures are somewhat discretionary (for example, housing maintenance can be postponed when income is lower than expected), they will be included in other consumption $c_t$. The price of this consumption is normalized to 1. For households with a mortgage, their per-period mortgage payments are determined by the function $h_t = h(M_{t-1}, r_M, t_M)$, where $M_{t-1}$ is the previous amount of mortgage debt, $r_M$ is the mortgage interest rate, and $t_M$ is the time elapsed since the mortgage was originated. In each period, mortgage debt evolves according to the following process:

$$M_t = M_{t-1} + m_t - g(M_{t-1}, t_M).$$

Mortgage debt $M_t$ is a function of mortgage debt in the prior period, $M_{t-1}$, any additional mortgage borrowing in the current period, $m_t$, and mortgage amortization $g(M_{t-1}, t_M)$. In this model, for simplicity I will assume that mortgage amortization is a function only of the previous period's mortgage balance $M_{t-1}$ and the duration of the mortgage $t_M$. While this abstracts from variation in mortgage amortization based on the type of mortgage, it reflects the relevant fact that larger mortgages have larger mortgage payments and mortgage payments towards the end of the life of the mortgage consist of more amortization and less interest repayment.
A household's nonhousing asset accumulation is governed by the following process:

$$A_{t+1} = (1+r_t)(A_t + y_t - c_t - h_t)$$

[7] In one sense, home maintenance can be thought of as an adjustment to the stock of housing assets, because these investments (such as repairing a roof) increase the household's quantity of housing consumed. Since durable assets depreciate, in order to consume the same amount of housing in each period a household must spend a positive amount on home maintenance.

where $A_t$ is the current stock of nonhousing assets, $y_t$ is current income, and $r_t$ is the interest rate. Households in this model face a borrowing restriction in each period,

$$(A_t + D) + (kp_t H_t - M_t) + (y_t - c_t - h_t) \geq 0$$

Households are constrained to have uncollateralized debt of no more than a given amount $D$, and housing-collateralized debt of no more than the maximum loan amount $kp_t H_t$, where $k$ is the maximum allowable loan-to-value ratio and $p_t$ is the current price per unit of housing. Without loss of generality, I will assume that $D = 0$.

In this model, under the assumption that $\delta > r_t$, households discount future consumption at a greater rate than the expected returns to saving. Thus, households have an incentive to borrow and the borrowing constraint is binding. Given that the vast majority of homeowners take out mortgages when buying a house and hold mortgage debt for long periods of time, this assumption seems plausible. I also assume that the derivative of the instantaneous utility function $u(c_t, H_t)$ with respect to consumption $c_t$ is convex. When future income becomes more uncertain, the convexity of the marginal utility function implies that future consumption becomes more valuable relative to current consumption, which provides a motive for precautionary saving. Thus, in this model households can simultaneously hold mortgage debt and nonhousing assets.

Given that households in this model are liquidity constrained, their optimal consumption path is determined by the following modified Euler equation:

$$u'(c_t) = \max\{u'(x_t), \beta \, \mathrm{E}_t \, u'(c_{t+1})\} \; ; \; x_t = A_t + (kp_t H_t - M_t) + (y_t - h_t)$$

where $\beta = (1 + r)/(1 + \delta)$. $x_t$ is the household's total stock of liquid assets, equal to total liquid assets plus liquid housing equity plus current-period discretionary income. When households receive a sufficiently negative income shock, they consume their entire stock of liquid assets and their marginal utility of consumption is higher than in the unconstrained maximum.

In this version of the model, housing wealth serves to relax the liquidity constraint. To see how changes in housing wealth affect saving behavior in this model, it is helpful to define 'active saving' as household per-period income minus per-period expenditures:

$$s_t = y_t - c_t - h_t \;=\; \text{(under liquidity constraints)} \; - (A_t + (kp_t H_t - M_t)).$$

If households borrow or spend down their assets, this measure can be negative. When households become liquidity constrained in this model, they consume their entire stock of liquid assets; i.e. $c_t = A_t + (kp_t H_t - M_t) + (y_t - h_t)$. Suppose that a liquidity constrained household receives a positive shock to liquid housing wealth, via an increase in housing prices which increases the value of the housing asset, or an increase in the maximum loan-to-value ratio k. In this period, the household will increase their consumption to as close to the unconstrained optimal level as possible. *Ceteris paribus*, as consumption increases, household active saving $s_t$ declines.

For unconstrained households, positive shocks to housing wealth affect the optimal consumption and saving path only if they increase the optimal consumption level in all future periods. This is possible in a finite-horizon life cycle model for a wealth shock which is large relative to lifetime income. The wealth shock affects total assets in the final period, which increases optimal consumption in the final period, which increases optimal consumption in the next-to-last period, and so on.

In this infinite-horizon model, only changes in lifetime income or in the discount parameters affect unconstrained consumption.[8]

If it were possible to observe housing quantities $H_t$, we could log-linearize the equation for active saving under liquidity constraints to estimate the elasticity of saving with respect to house price shocks, controlling for differences in quantity of housing consumed across households. However, empirically we only observe the value of housing $p_t H_t$. Moreover, to compare saving behavior across households, we have to control for differences among households that affect the likelihood of being liquidity constrained and the optimal level of saving and/or borrowing in the absence of shocks to housing wealth. Assuming that the representative household was liquidity constrained in the current year $t$ and in the previous year $t-1$, I substitute $kp_{t-1}H_{t-1}$ (the maximum allowable mortgage borrowing in $t-1$) for $M_t$ in the liquidity constrained active saving equation.[9] Further assuming that the household does not move between $t-1$ and $t$, so that $H_t = H_t - 1$, the new constrained active saving equation is

$$\begin{aligned} s_t &= -(A_t - (kp_t H_t - kp_{t-1}H_{t-1})) \\ &= -A_t - k\frac{\Delta p_t}{p_{t-1}} p_{t-1} H_{t-1} \end{aligned}$$

I approximate this equation with the following log-linearization

$$\ln s_{ijt} = \gamma_1 \ln \Delta p_{ijt} + \gamma_2 \ln R_{ijt-1} + \gamma_3 \ln A_{ijt-1} + \Gamma_1 X_{ijt} + \Gamma_2 V_{ijt} + \varepsilon_{ijt}$$

where $s_{ijt}$ is the active saving of household $i$ in MSA $j$ at time $t$, $\ln \Delta p_{ijt}$ is the percentage increase in the value of the household's home, $R_{ijt-1}$ is the household's housing wealth in time $t-1$ (which equals $p_{ijt-1}H_{ijt-1}$), and $A_{ijt}$ is the household's total non-housing asset wealth. The set of variables $X_{ijt}$ are household level characteristics which attempt to control for differences between households in the discount parameter $\delta$ which might affect whether a household is liquidity constrained or not, and $V_{ijt}$ are household and MSA-level variables which attempt to control for differences between households in the expected level of future consumption $\mathrm{E}_t\, u'(c_{t+1})$ which might also affect whether a household is liquidity constrained. These variables are described in further detail in the following section.

## 1.4 Data Description

### 1.4.1 Data sources and summary statistics

I obtain data on household-level income and assets from the Survey of Income and Program Participation (SIPP). The survey, initiated in 1983, was originally designed to introduce a new cohort (or panel) every year and interview this group every four months for a total of eight interviews (or waves). Each wave of data contains standard questions on household composition and income,

[8] In the empirical results section, I will show that older households, who may be closer to the final period, have larger wealth effects than younger households, which is consistent with a finite-horizon life cycle model.

[9] Not every household in my dataset is liquidity constrained. To the extent that some households are not liquidity constrained, the estimate of the housing wealth effect will be smaller than if I restricted my analysis to households who are more likely to be liquidity constrained, e.g. with mortgage loan-to-value ratios of 80 percent and above.

referred to as the core content, and additional questions on specific subjects which vary from wave to wave, referred to as topical modules. The topical module Assets and Liabilities contains data on households' total net worth and total secured and unsecured debt, real estate assets and total mortgage debt, assets in interest-earning bank accounts and other accounts, business and vehicle assets, stock and mutual fund assets, and other assets, and is the main source of household-level financial data in this analysis. The topical module Real Estate, Property and Vehicles contains detailed information on household mortgage debt, including origination year and interest rate for the household's first two mortgages. From 1984 to 1986, these topical modules were administered twice for each panel. However, funding problems shortened subsequent panels, and the asset modules were administered only once (or not at all) for panels beginning in 1987-1995. In 1996, the longitudinal structure of the survey was redesigned, and the asset topical modules were administered on a regular basis with minimal change to survey content between 1996 and 2003.[10]

The SIPP offers detailed information not available in other datasets that follow household income and asset dynamics over time. The SIPP has data on households' assets and liabilities in detailed categories (not available from the Current Population Survey or American Housing Survey), details on housing wealth and mortgage debt (not available in most years in the Panel Study of Income Dynamics), and information on households' city of residence (not publicly available from the Survey of Consumer Finances or the Consumer Expenditure Survey). Although the SIPP oversamples low-income households in order to track participation in government transfer programs, summary statistics using the nationally-representative weights are similar to those using the Survey of Consumer Finances (SCF).

Figures 1.1 through 1.7 show summary statistics from the SIPP, the SCF and other nationally representative surveys. Figure 1.1 shows the evolution of the homeownership rate between 1983 and 2003 for the SIPP and the Housing Vacancy Survey: homeownership rates were essentially flat during the 1980s, and rose slightly during the late 1990s and early 2000s. Figure 1.2 shows the same statistic, but for the sample of SIPP respondents residing in MSAs. Since the SIPP does not have MSA-level representative weights, this sample is unweighted at the household level for the remainder of the analysis. Data between 1996 and 1999, and 2001 and 2003, follow single panels of two cohorts over time, while earlier years are each represented by a single panel. Due to differential attrition of homeowners and renters, the percentage of homeowners within these panels is increasing over time. As my sample is restricted to homeowners, this does not affect my analysis.

Figures 1.3 and 1.4 compare median income between the SIPP MSA sample and the SCF over time. The path of median income is similar between the two surveys: increasing during the late 1980s, decreasing during the recession of the early 1990s, and recovering in the late 1990s. Figure 1.5 shows the path of average house values and housing debt between 1983 and 2003. Home values rose during the 1980s, and housing debt increased accordingly. During the early 1990s, housing values fell, but recovered and increased sharply during the early 2000s. Comparing the SIPP to the SCF, it appears that households in the SIPP experienced declining housing values earlier in the 1980s, and that house prices took longer to recover in the late 1990s, than in the SCF.

Figure 1.6 shows the evolution of mean home leverage, as measured by the ratio of total housing debt to total housing value, for two groups of homeowners: the entire population and those with a mortgage. Between 1985 and 1987, the increase in housing leverage was steeper for the

[10]For further detail on the history and content of the SIPP, the SIPP User's Guide (US Department of Commerce, 2001) is an excellent reference. The panel-waves of the SIPP that include the assets topical module are 1984-4, 1984-7, 1985-3, 1985-7, 1986-3, 1986-7, 1987-4, 1990-4, 1991-7, 1992-4, 1993-7, 1996-3,-6,-9,-12; and 2001-3,-6,-9.

overall population in the SIPP than for the sample of homeowners with a mortgage, suggesting that increasing numbers of homeowners were taking on mortgage debt. As housing values fell between 1987 and 1990, leverage among mortgage holders increased more sharply than in the general population of homeowners. Mean home leverage remained relatively constant during the following years, which casts some doubt on the hypothesis that households reduced their saving as house values increased by increasing their mortgage debt. However, Figure 1.7, which tracks the average number of home loans (including mortgages, home equity loans, and home equity lines of credit) per household, shows that this figure was steadily increasing over time for households in the SCF. For SIPP households, this measure is more volatile, but the average number of home loans was higher in the early 2000s than it was in the early 1980s.

Table 1.1 compares the demographic composition of the SIPP sample to that of the SCF. The most notable facts are that the SIPP subsample has fewer nonwhite and nonblack respondents than the SCF, the proportion of female-headed households in the SIPP sample is high (above 50 percent for all respondents and for homeowners), and that the percentage of married households in the SIPP is low relative to the general population. This reflects the fact that the SIPP was designed to track national participation in government transfer programs, many of which are targeted to single parents. These characteristics are included as explanatory variables in the empirical model.

### 1.4.2 Empirical implementation

As explained above, a number of SIPP panels do not administer the assets topical module twice, so I do not have panel data on assets for households in the panels administered between 1990 and 1994. Moreover, there is a large amount of measurement error in households' asset reporting, particularly for mortgage debt. To avoid overwhelming the true changes in household assets with measurement error related noise, I follow the approach of Deaton (1985), Browning et. al. (1985), Campbell and Cocco (2007), and Attanasio et. al. (2005) and create a pseudo-panel dataset using the SIPP data. For the panels with repeated data on the same household, I exclude households who drop out of the survey between waves. I group the data by MSA and year of birth in a 5-year range, and generate cohort-level averages of my household-level outcomes of interest for each year.[11] As each wave of the survey represents a draw from the population of homeowners in a given birth year group residing in a given MSA, this approach is consistent as the size of each cohort becomes large. In the estimations, I weight the cohort-level average data by the square root of the size of the underlying cohort.

Recall the regression model:

$$\ln s_{ijt} = \gamma_1 \ln \Delta p_{ijt} + \gamma_2 \ln R_{ijt-1} + \gamma_3 \ln A_{ijt-1} + \Gamma_1 X_{ijt} + \Gamma_2 V_{ijt} + \varepsilon_{ijt}$$

SIPP respondents do not report how much money they saved, spent, or borrowed during the previous year. In order to construct a measure of household active saving ($s_{ijt}$), I follow the approach of Juster et. al. (2005) and approximate household saving (income minus expenditures) by the change in household total net worth, net of changes in asset values.[12] I derive this amount

[11]For simplicity, the terms "household" and "cohort-level average" will both refer to the cohort-level average of the outcome among households in the cohort for the remainder of the paper, unless otherwise specified.

[12]Total net worth in the SIPP is calculated as the sum of primary residence housing equity, other housing equity, vehicle equity, business equity, interest-earning assets in the bank, other interest-earning assets, stock and mutual fund assets, and IRA assets, minus total unsecured debts.

by calculating the change in household total net worth minus housing and business equity, between $t-1$ and $t$. I subtract from this change the household's projected capital gains between $t-1$ and $t$. Capital gains are estimated as the amount of stock and mutual fund assets in $t-1$ multiplied by the percentage increase in stock prices between $t-1$ and $t$, plus the amount of interest-earning assets in $t-1$ multiplied by the interest rate.[13]

$$\ln s_{ijt} = \ln(\text{total net worth}-\text{housing equity}-\text{capital gains})_t - \ln(\text{total net worth}-\text{housing equity})_{t-1}$$

While this measure does not account for passive changes in the value of other assets (such as vehicle depreciation), it is an estimate of how much households are contributing to their total net worth from current income.[14] In the following section, I explore different measures of active saving as a robustness check.[15] In all of my specifications, I trim the outlying 5 percent of observations on the distribution of active saving.[16]

The measurement of changes in housing values $\Delta p_{ijt}$ also poses a challenge. Although households report their estimates of the value of their home, mistakes in this estimate can introduce division bias into estimates of the wealth effect. If the estimate of housing wealth is incorrectly low in $t-1$, the estimate of active saving (change in total net worth net of housing equity) will be incorrectly low and the estimated price change will be incorrectly high, which leads to a spurious negative correlation between changes in housing wealth and saving. To avoid this problem, I estimate changes in cohort-level average housing wealth using the percent change in the MSA-level house price index, using the OFHEO repeat-sales house price index.[17] To determine whether the wealth effect increases in magnitude over time, additional specifications interact the house price change variable with dummy variables for the time periods 1985 to 1990 and 1996 to 2003, years when house prices were increasing. As a robustness check for the choice of time periods, an additional specification interacts the house price measure with a year group variable that increases by 1 each year (1984 = 1, 1985 = 2, and so forth).

I include cohort-level average self-reported housing wealth and other wealth ($R_{ijt-1}, A_{ijt-1}$) to account for differences in household permanent income that might affect the magnitude of the housing wealth effect. The remaining variables in the model are included to control for differences between households that might affect whether a household is liquidity constrained (or, the extent to which the cohort is liquidity constrained) which affects the expected magnitude of the housing wealth effect. The set of variables $X_{ijt}$, household level characteristics which attempt to control for differences in the discount parameter $\delta$, includes race, education, and marital status group dummies, a quadratic function in age, and birth year group fixed effects. The set of variables $V_{ijt}$,

[13] Data on annual stock prices are annual averages of daily closing prices from Standard and Poor's, available from Robert Shiller's website: http://www.econ.yale.edu/ shiller/data/chapt26.xls. The interest rate is the yield on US Treasury securities at 1-year constant maturity, available from the Treasury department website.

[14] I cannot identify expenditures on home maintenance and improvement in the SIPP data. If every household were cashing out home equity only to improve their house or make other unobservable investments, this omission would bias estimates of the wealth effect downward. However, a decomposition of the uses of extracted home equity by Greenspan and Kennedy (2007) finds that between 9 and 11 percent of this wealth is used for home improvement.

[15] Although it would be possible to construct an estimate of consumption using cohort-level average active saving and average income, and estimate the marginal propensity to consume gains in housing wealth (in line with previous studies), the additional error introduced from using the difference between two composite variables as a dependent variable may bias the results towards finding no effect.

[16] The results are larger and have a higher level of statistical significance if these outliers are included.

[17] Calhoun (1996) contains details on the construction of the OFHEO house price index.

household and MSA-level variables which attempt to control for differences between households in the expected level of future consumption $\mathrm{E}_t\, u'(c_{t+1})$, includes household income, changes in household income and household family size, MSA-level population growth and average income growth between $t-1$ and $t$ and between $t-1$ and $t+4$, the MSA-level unemployment rate in $t-1$ and in $t+4$, and MSA and year fixed effects.[18] The error term $\varepsilon_{ijt}$ is assumed to be distributed normally with mean zero and an MSA-specific variance. To correct for heteroskedasticity, standard errors are estimated robustly and clustered at the MSA level.

### 1.4.3 Challenges to identification

The leading alternative explanation for variation in saving that is correlated with changes in housing wealth is that there is an unobserved factor, income expectations, that determines both outcomes. Under this hypothesis, the price of housing is the 'entrance fee' to participation in a local labor market, and is determined solely by local wages. High-wage MSAs have high housing prices, and economically depressed MSAs have low housing prices. When individuals expect that an area will experience rapid population and income growth in the near future (consider as an example Silicon Valley in the early 1990s), house prices in this area increase as expectations of higher future housing demand and income growth are capitalized into asset values. At the same time, households may decrease their saving, or younger households with lower levels of saving may move into the area, in response to expectations of higher future income growth. In this situation, the correlation between increases in housing wealth and decreases in saving is driven by expectations of future local income growth.

To control for differences in income expectations across MSAs, I include the set of variables $V_{ijt}$ as described above. The subset of these variables measured at the MSA level include forward-looking measures of local economic outcomes (income growth and population growth over the next 5 years, and the unemployment rate in 3 years) which represent households' best guess of their expected future income and employment prospects. I also estimate the model using a two-stage least squares approach, predicting local house price growth with MSA-level variables that are uncorrelated with household saving decisions. In either case, this endogeneity does not affect my primary innovation that the wealth effect has increased in magnitude over time as long as the relationships between unobservable expectations and outcomes have not also changed over time. I will explore this concern in the following section.

Another alternative explanation for the correlation between house price growth and household saving is that households with different preferences for saving sort across MSAs depending on the growth in local housing values. That is, if an area experiences high house price growth between $t-1$ and $t$, households who like to save choose to move out of the area between $t-1$ and $t$, driving down average saving among cohorts in that MSA. This explanation fails if households are choosing to move because of housing affordability, i.e. households that like to save also don't like to spend a lot on housing, because there are many areas with high house price growth that still have relatively low housing prices, like cities in the Sunbelt. There would have to be some other explanation for why households with low discount rates dislike growth in housing prices, particularly if they are already homeowners and thus hedged against increases in housing prices. A final objection to the

[18] Data on income and population are from the Current Population Survey, and data on unemployment rates are from the Bureau of Labor Statistics. Prior to 1990, the MSA-level unemployment rate is available only for selected MSAs, so the state-level unemployment rate is used instead.

finding that the housing wealth effect has increased in magnitude over time, which is that household saving overall has declined over the period in question, is easily accounted for by including year and birth-group fixed effects.

## 1.5 Results

### 1.5.1 Baseline results

I present the results of the estimation of the empirical model in Table 1.2. The initial model (in Column 1) estimating the average effect of annual increases in house prices over the entire period of 1985-2003 masks significant variation in this effect over time. When the effect of increases in house prices is allowed to differ between time periods, we see that during the "Pre" period of 1985-1990 and the interim period of 1990-1995, the effect of house price growth on active saving is weakly positive and not statistically different from zero. In contrast, the effect of increases in house prices on active saving during the "Post" period of 1996-2003 is negative and significant. A 1 percent annual increase in the house price index during the Post period leads households to reduce their annual active saving by 1.13 percent on average.

To avoid spurious estimates that are the result of a convenient choice of endpoints for the Pre and Post periods, the third specification measures changes in the effect of house price growth on saving over time by interacting the house price measure with a year group variable that increases by 1 each year. This interaction effect is negative and significant, indicating that the effect of house price growth on saving has been increasing in magnitude during the most recent period of house price appreciation. In 1999, the midpoint of the Post period, a 1 percent annual increase in the house price index leads households to reduce their annual active saving by (0.146*11) - 1.027 = 0.58 percent on average.

The model estimated in columns (1) through (3) controls for differences in income, income growth, and demographic composition between cohorts that might affect both their saving behavior and their preferences for living in an MSA with high price growth. This initial model also controls for differences in expected local economic outcomes that might affect both saving behavior and local house prices. However, this simplified model implicitly assumes that increases in average local house prices affect households with different levels of housing and nonhousing wealth identically. This assumption is clearly invalid; households with higher levels of housing wealth reap larger windfalls when house prices rise, and households with higher levels of nonhousing assets might be less sensitive to fluctuations in housing asset values since this asset represents a smaller fraction of their total net worth.

In columns (4) through (6), I control for differences in housing wealth between cohorts by including cohort-level average housing wealth as a regressor in the model, and in columns (7) through (9), I also include average non-housing wealth. The effect of increases in housing wealth on active saving is smaller and less precisely estimated in these models. However, the overall pattern of the wealth effect increasing in magnitude over time is also evident in these specifications. Estimates of the average wealth effect in all years and in the Pre period are small and noisily estimated, while estimates of the average wealth effect in the Post period range from an elasticity of -1.265 in column (5) to -0.183 in column (9).

As described in the preceding section, my measure of active saving excludes capital gains by subtracting housing and business equity from total net worth, and subtracting predicted cohort-level average capital gains from interest-earning assets and equities from the change in total net worth. While the aim in doing this was to exclude passive changes in wealth from household saving, such passive gains can alternatively be included in household income, which could be spent or saved. Moreover, as outlined in the literature review, changes in the value of nonhousing assets also affect households' saving and consumption patterns. By simply subtracting predicted capital gains from changes in total wealth, the analysis constrains these effects to be equal to unity.[19] In order to address these concerns, I estimate the following model

$$\ln s_{ijt} = \gamma_1 \ln \Delta p_{ijt} + \gamma_2 \ln R_{ijt-1} + \gamma_3 \ln I_{ijt-1} + \gamma_4 \ln F_{ijt-1} + \alpha_1 r_{t-1} + \alpha_2 f_t + \Gamma_1 X_{ijt} + \Gamma_2 V_{ijt} + \varepsilon_{ijt}$$

where $\ln s_{ijt}$ is now the percent change in cohort-level average household total net worth excluding housing equity and business equity ("modified" active saving). I also now include, in separate terms, total cohort-level average interest-earning assets and stock assets ($I_{ijt-1}$ and $F_{ijt-1}$, respectively), the annualized interest rate $r_{t-1}$, and the annual percentage change in the Standard and Poor's composite stock price index, $f_t$.[20]

The results of this model are presented in columns (10) through (12). The pattern of larger wealth effects over time persists in this specification, and these estimates are larger in magnitude than in the previous model. In the specification including Pre and Post interactions, the estimate of the housing wealth effect in the Post period is -0.928, and in the specification including the year group interaction, the estimate of this elasticity at the midpoint of the Post period is -0.525.

In order to evaluate whether these estimates are plausible, they must be represented in dollar terms. In the initial model in column (2), an elasticity of active saving with respect to house prices of -1.13 translates to a dollar effect of 0.04 - that is, when average housing wealth increases by one dollar, average active saving decreases by 4 cents. The subsequent models with Pre and Post marginal effects have similar estimates, ranging from 0.04 in model 2 to 0.02 in model 3 and 0.04 in model 4. Estimates of the housing wealth effect in dollar terms in the models specified with annual marginal effects are smaller, at 0.02, 0.03, 0.01, and 0.02, respectively. These estimates are consistent with the majority of the estimates of the housing wealth effect reported in previous studies, although they are smaller than wealth effects on consumption estimated using cohort-level average data.[21]

The construction of the active saving variable in the regression models presented in Table 1.2 attempts to include all additions to household total net worth from annual income, and exclude all additions to total net worth, such as gains in housing and business equity, that involve passive changes in the value of underlying assets. By excluding all changes in housing equity, however, this saving measure fails to capture changes in housing equity that are the result of active household decision making, such as a cash-out refinance of the existing mortgage or a mortgage prepayment.

[19] Thanks to John Friedman and Marit Rehavi for pointing this out.

[20] The annualized interest rate is the nominal rate on U.S. Treasury 1-year constant maturities, and the stock price index data is updated data from Shiller, Market Volatility, Chapter 26, available on the author's website as cited above.

[21] I calculate the average effect of an increase in housing wealth on active saving in dollars by calculating the dollar amount of a one percent increase in average housing wealth in the Post period, and the dollar amount of a $\beta$ percent decrease in average active saving for the appropriate measure of active saving in the Post period. I divide the latter by the former to obtain the amount by which active saving decreases when housing wealth increases by 1 dollar.

These financial decisions are especially important to include because a primary explanation for why the housing wealth effect may have increased over time is that homeowners are now more able to borrow against the equity in their home, relaxing the liquidity constraint. In Table 1.3, I present the results of estimating the same models as in Table 1.2, but with active saving 2 as the dependent variable. Active saving 2,

$$\begin{aligned}\ln s_{ijt,2} = &\ln(\text{total net worth} - \text{housing equity} - \text{capital gains} - (\text{mortgage debt}_t - \text{mortgage debt}_{t-1}))_t \\ &- \ln(\text{total net worth} - \text{housing equity})_{t-1}\end{aligned}$$

is the change in cohort-level average total net worth excluding housing and business equity, excluding predicted capital gains to interest-earning assets and stock assets (except in columns (10) through (12), where capital gains are included in modified active saving 2) and including changes in total housing-collateralized debt. For households with a mortgage who made regular amortizing mortgage payments during the preceding year, the change in mortgage debt will be negative and the addition to total net worth will be positive. For households who increased their mortgage balance by extracting equity from their home, this measure will be positive and the calculated increase in total net worth will be lower. For households without a mortgage, this measure is zero.

Table 1.3 presents estimates of the housing wealth effect using active saving 2 as the measure of cohort-level average household saving. The estimates of the effect of increased housing wealth on active saving are similar to those estimated using active saving 1. Estimated elasticities of household saving with respect to housing prices/housing wealth in the Post period are -1.036, -1.274, and -0.392 in the Pre and Post marginal effects models with no controls, housing wealth controls, and both housing and other wealth controls, and -0.670, -0.777, and -0.343 in the year group marginal effects models, respectively. When I explicitly control for other wealth effects by including interest-earning assets, stock assets, and average returns on these assets as regressors in columns (10) through (12), the estimated elasticities are -1.044 and -0.660 in the Pre and Post and year group models respectively. The dollar effects are also similar to those in preceding models, ranging from a 3 cent decrease in active saving 2 when housing wealth increases by one dollar in the model in column (5) to a 1 cent decrease estimated in the model in column (9).

### 1.5.2 Results for subgroups

As mentioned in the preceding section, the increase in home ownership rates between the Pre and Post periods implies that many new households entered the homeowner population between the late 1980s and the end of the 1990s. The relaxation of borrowing constraints caused by a change in mortgage lending standards may have allowed households with higher discount rates and a lower propensity to save to become homeowners. If the size of this influx of households with lower tastes for saving were correlated with local house price growth, we would see a negative effect of house prices on cohort-level average saving in the Post period only because of this change in the composition of the population. In order to exclude households who were only able to become homeowners under less stringent downpayment and credit quality requirements, I estimate the same models (using active saving 2) for the subsample of homeowners who have resided in their current residence for at least 5 years. Although a household may have recently moved but also owned their previous residence, I cannot distinguish between these households and former renters because the SIPP does not ask respondents about their prior tenure in each wave of the survey.

I present the results of this estimation in Table 1.4. The sample size is smaller in each specification because excluding households causes the number of households in some cohorts to fall below the minimum size of 25. In each model, the effects are comparable to those from the full-sample model in both the Pre and the Post periods, with estimated elasticities in the Post period between -0.415 and -0.769. In all of the specifications, the estimated wealth effect in the Post period is larger than in the Pre period. The estimated wealth effects are smaller when nonhousing wealth is included as a control, which implies that there exists some correlation within MSAs over time between house price growth and nonhousing wealth.

Households' decisions to consume their housing windfalls may also depend on their expected future demand for housing. For young homeowners who are planning to 'trade up' in a few years, an increase in housing prices means an increase in the price they will have to pay for their next house. As such, they have an incentive to save their housing wealth gains. In contrast, older homeowners may be planning to 'trade down' their home in the near future (although this is less common than trading up). Reverse mortgages and other home equity cash-out products have become more common in recent years, as elderly households seek to access the wealth in their home without having to move. Because housing wealth windfalls represent discretionary wealth for older households, but not for younger households and households looking to 'trade up', we might expect to see larger wealth effects among older homeowners, and smaller effects among younger homeowners.

This pattern is borne out in Tables 1.5 and 1.6, which present estimates of the housing wealth effect on active saving 1 for heads of household aged 45-64 and 25-44, respectively. Due to the reduced sample sizes in these regressions, the estimated wealth effects for both groups of homeowners are smaller and more noisily estimated. However, estimates of the wealth effect in Table 1.5 show that in the Pre and Post periods, older homeowners tend to reduce their active saving when their housing wealth increases, and this effect is larger in magnitude in the Post period than in the Pre period. In contrast, estimated effects for young homeowners in the Post period are positive in some specifications and negative in others, and there is no discernable pattern of differences between the Pre and Post periods. Thus, it seems that the original estimates of the wealth effect are being generated largely by older homeowners.[22]

### 1.5.3 Competing explanations

The leading alternative explanation for variation in saving that is correlated with changes in housing wealth is that income expectations determine both outcomes. Regardless of the validity of this hypothesis, the problem of unobservable expectations affecting both saving and house prices cannot reproduce the pattern of results in the Pre and Post periods unless the relationship between these unobservables and saving or house prices changed between the Pre and Post periods. Specifically, either house prices or saving would have to be uncorrelated with unobservable expectations in the Pre period, but correlated in the Post period.

Tables 1.7 and 1.8 test this hypothesis using proxies for unobservable expectations of local economic conditions. Table 1.7 shows the results of regressions relating annual house price growth in each MSA to the contemporaneous unemployment rate and the rate in the next three years, MSA-level annual income and population growth, and income and population growth over the next five

[22]It could also be the case that older homeowners have more equity in their homes on average, and that these homeowners face lower costs to borrowing against housing wealth.

years. These variables represent households' best guess of local economic conditions in the coming years. House price growth is negatively related to current and future unemployment in all time periods, and is somewhat positively related to future income and population growth. Comparing the Pre and Post periods, house price growth is more strongly negatively correlated with current unemployment rates and less correlated with future unemployment rates in the Pre period, implying that employment expectations may have determined house price growth differentials between cities to a greater extent in the Post period. However, future income growth has more impact on house prices in the Pre period as measured by the size of the coefficients (although they are less precisely measured), which implies that income expectations had more of an effect on house price growth in the Pre period. [23]

Table 1.8 shows the results of regressions relating cohort-level average saving (as measured by active saving 1 and 2) to the same proxies for unobservable expectations. The results generally indicate no relationship between cohort-level average saving and local macroeconomic expectations, with the exception of contemporaneous income. Households with higher income growth during a given year save less during that year. When the sample is divided into Pre and Post periods, the results show no relationship between the MSA-level variables and household saving in either period. Given the results in Tables 1.7 and 1.8, there appears to be little evidence for the hypothesis that local macroeconomic expectations are the source of the relationship between housing wealth and saving, or that changes in this relationship over time are responsible for the change in the housing wealth effect between the Pre and Post periods.

Since there appears to be a strong relationship between local economic conditions and house prices, but less of a relationship between these variables and household saving, these variables can potentially be used as instruments for house price growth. The conditions for these variables to be valid instruments are that they are correlated with house price growth, and that they are orthogonal to unobservable factors influencing household saving.[24] Clearly, the first condition is satisfied; the more difficult task is to argue that these measures are uncorrelated with unobservable expectations affecting household saving.

In light of the preceding results, consider the following argument. Either observable MSA-level current and future economic indicators are good proxies for households' unobservable expectations of local economic conditions, or they are not good proxies. If these indicators are good proxies for unobservable expectations, then they are not valid instruments, but the results of the preceding section then imply that unobservable expectations do not affect households' saving decisions, which implies that an IV analysis is unnecessary. If these indicators are not good proxies for households' unobservable expectations, then it might be the case that the estimates of wealth effects from the previous section are biased upwards due to unobservable expectations, but this also means that these variables are valid instruments for house price growth.

The IV analysis of the relationship between housing wealth and active saving 2 is presented in Table 1.9. As expected, the first stage results show a strong relationship between MSA-level current and future economic indicators and house price growth. The test of joint significance of the first stage coefficients shows that they are significantly different from zero. The IV estimates

[23] Also, unemployment rates between 1984 and 1990 were only available from the Bureau of Labor Statistics at the MSA level for fewer than 10 percent of MSAs, with the rest of MSAs assigned data at the state level. The difference in coefficients between periods may only reflect differences in data quality.

[24] See Glaeser, Gyourko and Nathanson (2008); Gyourko, Mayer and Sinai (2006); and Glaeser, Gyourko and Saks (2005) for empirical analyses of the relationship between local economic conditions and house price dynamics.

of the effect of changes in housing wealth on household saving are larger in magnitude than the OLS estimates (perhaps due to measurement error in the calculation of house price growth), and the pattern of larger wealth effects in the Post period is also present in these estimates. Although these effects appear to be much larger compared to those in the OLS estimations, the implied dollar effects are similar. The average effect of a dollar increase in housing wealth on household saving ranges from 3 cents in the specification including no controls for wealth differences, to 6 cents in the specifications including housing and other wealth controls.

### 1.5.4 Macroeconomic implications

Are these estimated housing wealth effects sensible or economically meaningful? Figures 1.8 through 1.10 present aggregated predicted wealth effects over time. I predict wealth effects by cohort for MSA-level cohorts by calculating what active saving would have been in the absence of housing wealth effects, using the estimated coefficients from the modified active saving 2 model in Table 1.3.[25] Figures 1.8 and 1.9 show the path of aggregate and average household total net worth over time, and the counterfactual path of total net worth in the absence of housing wealth effects. Between 1998 and 2003, counterfactual total net worth is slightly higher than actual total net worth (in aggregate and on average), but this difference is small.

In Figure 1.10, I compare my estimates of the aggregate housing wealth effect to the amount of cash generated by home equity extraction that was used for personal consumption expenditures. This measure, calculated in Greenspan and Kennedy (2007), is the total amount of free cash resulting from home equity extraction (from home sales, home equity loans, and mortgage refinancings) net of home purchase expenditures, repayments of other debt, home improvement expenditures, and acquisitions of other assets. This estimate represents total reductions in housing equity that were not reinvested into other forms of wealth, and the difference between the total housing wealth effect and the home equity extraction represents how much households reduced their other forms of saving. The amount of home equity consumed is increasing steadily over time, and the total housing wealth effect, though more volatile, seems to be increasing at the same pace during the 1990s, with a sharp increase between 2001 and 2003. While we cannot draw any conclusions about changes in the composition of the reduction in assets due to increases in housing wealth between the Pre and Post periods from these estimates, household reductions in non-housing assets seem to be more important in magnitude than net reductions in home equity in the Post period.

## 1.6 Conclusion

This paper is the first analysis to provide evidence from household-level microdata suggesting that the housing wealth effect may have increased in line with increased access to housing-collateralized debt. I estimate an average elasticity of household active saving with respect to MSA-level house prices of -0.222, which corresponds to a 1 cent decrease in annual active saving when housing wealth increases by 1 dollar. When I estimate housing wealth effects separately between 1984 and 1990, and between 1996 and 2003, I find smaller effects during the earlier period, but large and

[25] I use MSA-level cohorts rather than the cohorts used in the empirical analysis because I want to include as many households as possible from each wave of the survey, so that the nationally-representative household-level weights will produce an accurate aggregate estimate of total net worth and of the wealth effect.

significant effects during the later period. During the later period, I estimate an average elasticity of household active saving with respect to MSA-level house prices of -1.044, which corresponds to a 3 cent decrease in annual active saving when housing wealth increases by 1 dollar. I address the endogeneity of housing prices by using an instrumental variables approach, and find larger effects of house prices on household saving.

Further evidence comparing the magnitude of the wealth effect between different subpopulations – older homeowners versus younger homeowners, and recent homebuyers versus those with longer tenure – suggests that a relaxation of liquidity constraints, rather than changes in the composition of the homeowner population, is a central factor contributing to the increase in the housing wealth effect. While I am not able to use direct measures of credit availability (for example, cohort-level average credit score) to test the liquidity constraints hypothesis against competing hypotheses, future versions of this paper will include lagged average debt-to-income ratios and mortgage loan-to-value ratios as proxies for households' ability to borrow against their housing equity. Housing wealth effects that are increasing in credit availability provide further support for a liquidity constraints hypothesis.

Determining the response of household saving and consumption to changes in housing wealth, and the extent to which this response depends on the availability of mortgage credit, is particularly important in light of recent developments in the U.S. housing and mortgage markets. Although the aggregated results suggest that the effect of housing wealth on household saving was small relative to changes in aggregate household total net worth between 1984 and 2003, continuing house price growth and credit liberalization between 2003 and 2006 may have contributed to larger housing wealth effects at the peak of the house price boom. While I do not want to overstate the significance of my results, understanding the household-level relationship between housing wealth, saving, and consumption is of central importance to the overall economy.

Table 1.1: Demographic Composition of SIPP versus SCF

| | All respondents | | Homeowners | |
|---|---|---|---|---|
| | SCF | SIPP - MSA sample | SCF | SIPP - MSA sample |
| Race: | | | | |
| White | 73.94 | 81.64 | 81.22 | 85.76 |
| Black | 13.34 | 13.63 | 8.89 | 10.11 |
| Other | 12.72 | 4.73 | 9.89 | 4.14 |
| Education: | | | | |
| Less than HS | 15.21 | 12.62 | 12.08 | 9.54 |
| HS graduate | 29.32 | 28.60 | 28.62 | 28.70 |
| Some college | 24.00 | 29.07 | 23.98 | 29.42 |
| College + | 31.39 | 29.65 | 35.25 | 32.29 |
| Family structure: | | | | |
| Married | 63.20 | 37.36 | 74.09 | 45.84 |
| Household size | 2.70 | 2.47 | 2.88 | 2.65 |
| Female-headed household: | | 52.05 | | 52.14 |

Notes for Table 1 and preceding Figures 1-7: Data from the 1983-2004 Survey of Consumer Finances, and the 1984-2003 Survey of Income and Program Participation. Sample restricted to heads of household aged 25-64. The SCF statistics are calculated using nationally-representative population weights, and the SIPP sample is limited to households residing in MSAs.

Table 1.2: Change in House Prices and Active Saving 1

| | Active Saving 1 | | | | | | | | | Modified AS1 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Δ(ln HPI) | 0.201 | 0.498 | 1.027 | -0.119 | -0.137 | 0.626 | -0.044 | 0.398 | 0.103 | -0.0131 | -0.0949 | 0.527 |
| | (0.175) | (0.332) | 0.393)*** | (0.175) | (0.337) | (0.381) | (0.139) | (0.282) | (0.284) | (0.163) | (0.305) | (0.353) |
| Δ(ln HPI) × Pre | | -0.159 | | | 0.234 | | | -0.498 | | | 0.274 | |
| | | (0.448) | | | (0.438) | | | (0.339) | | | (0.391) | |
| Δ(ln HPI) × Post | | -1.630 | | | -1.128 | | | -0.965 | | | -0.833 | |
| | | (0.593)*** | | | (0.574)** | | | (0.458)** | | | (0.524) | |
| Δ(ln HPI) × Year Group | | | -0.146 | | | -0.132 | | | -0.026 | | | -0.0956 |
| | | | (0.062)** | | | (0.060)** | | | (0.045) | | | (0.0563)* |
| Housing wealth included? | | | | X | X | X | X | X | X | X | X | X |
| Other wealth included? | | | | | | | X | X | X | X | X | X |
| Observations | 6629 | 6629 | 6629 | 6615 | 6615 | 6615 | 6567 | 6567 | 6567 | 6610 | 6610 | 6610 |
| R-squared | 0.11 | 0.11 | 0.11 | 0.14 | 0.14 | 0.14 | 0.44 | 0.44 | 0.44 | 0.22 | 0.22 | 0.22 |

Notes: Sample restricted to homeowners. All observations are annual MSA x birth-year group cohort level averages, available for 109 MSAs and 12 birth-year groups for the years 1985-2003. "Active Saving 1" is the percentage change in household total net worth, excluding capital gains to interest-earning assets and stock assets. "Δ(ln HPI)" is the change in the natural logarithm of the house price index between t-1 and t. All regressions include household-level and MSA-level control variables as described in the text, and MSA and year fixed effects. Robust standard errors are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 1.3: Change in House Prices and Active Saving 2

| | Active Saving 2 | | | | | | | | | Modified AS2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Δ(ln HPI) | -0.198 | 0.385 | 0.329 | -0.313 | 0.153 | 0.176 | -0.222 | 0.528 | -0.263 | -0.143 | 0.698 | 0.399 |
| | (0.301) | (0.639) | (0.533) | (0.302) | (0.645) | (0.536) | (0.277) | (0.613) | (0.470) | (0.275) | (0.538) | (0.496) |
| Δ(ln HPI) × Pre | | -0.629 | | | -0.482 | | | -0.982 | | | -0.965 | |
| | | (0.785) | | | (0.788) | | | (0.735) | | | (0.671) | |
| Δ(ln HPI) × Post | | -1.421 | | | -1.427 | | | -0.920 | | | -1.742 | |
| | | (0.831)* | | | (0.838)* | | | (0.771) | | | (0.740)** | |
| Δ(ln HPI) × Year Group | | | -0.0935 | | | -0.0866 | | | 0.00728 | | | -0.0963 |
| | | | (0.0752) | | | (0.0755) | | | (0.0665) | | | (0.0691) |
| Housing wealth included? | | | | X | X | X | X | X | X | X | X | X |
| Other wealth included? | | | | | | | X | X | X | X | X | X |
| Observations | 6205 | 6205 | 6205 | 6191 | 6191 | 6191 | 6143 | 6143 | 6143 | 6136 | 6136 | 6136 |
| R-squared | 0.086 | 0.086 | 0.086 | 0.090 | 0.091 | 0.090 | 0.337 | 0.337 | 0.337 | 0.168 | 0.169 | 0.169 |

Notes: Sample restricted to homeowners. All observations are annual MSA x birth-year group cohort level averages, available for 109 MSAs and 12 birth-year groups for the years 1985-2003. "Active Saving 2" is the percentage change in household total net worth, excluding capital gains to interest-earning assets and stock assets and including mortgage amortization. "Δ(ln HPI)" is the change in the natural logarithm of the house price index between t-1 and t. All regressions include household-level and MSA-level control variables as described in the text, and MSA and year fixed effects. Robust standard errors are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 1.4: Change in House Prices and Active Saving 2, Existing Homeowners

| | Active Saving 2 | | | | | | | | | Modified AS2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Δ(ln HPI) | -0.012 | 1.063 | 0.510 | -0.136 | 0.875 | 0.337 | -0.0912 | 0.830 | 0.136 | 0.051 | 0.912 | 0.426 |
| | (0.294) | (0.445)** | (0.613) | (0.300) | (0.457)* | (0.618) | (0.240) | (0.390)** | (0.508) | (0.258) | (0.408)** | (0.518) |
| Δ(ln HPI) × Pre | | -1.386 | | | -1.301 | | | -1.226 | | | -1.117 | |
| | | (0.619)** | | | (0.626)** | | | (0.517)** | | | (0.550)** | |
| Δ(ln HPI) × Post | | -1.773 | | | -1.644 | | | -1.286 | | | -1.337 | |
| | | (0.780)** | | | (0.784)** | | | (0.652)** | | | (0.652)** | |
| Δ(ln HPI) × Year Group | | | -0.0929 | | | -0.0841 | | | -0.0404 | | | -0.0667 |
| | | | (0.0963) | | | (0.0964) | | | (0.0802) | | | (0.0793) |
| Housing wealth included? | | | | X | X | X | X | X | X | X | X | X |
| Other wealth included? | | | | | | | X | X | X | X | X | X |
| Observations | 4892 | 4892 | 4892 | 4881 | 4881 | 4881 | 4842 | 4842 | 4842 | 4841 | 4841 | 4841 |
| R-squared | 0.102 | 0.104 | 0.103 | 0.106 | 0.107 | 0.106 | 0.479 | 0.480 | 0.479 | 0.215 | 0.216 | 0.215 |

Notes: Sample restricted to existing homeowners: homeowners who have lived in their current house for at least 5 years. All observations are annual MSA x birth-year group cohort level averages, available for 109 MSAs and 12 birth-year groups for the years 1985-2003. "Active Saving 2" is the percentage change in household total net worth, excluding capital gains to interest-earning assets and stock assets and including mortgage amortization. "Δ(ln HPI)" is the change in the natural logarithm of the house price index between t-1 and t. All regressions include household-level and MSA-level control variables as described in the text, and MSA and year fixed effects. Robust standard errors are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 1.5: Change in House Prices and Active Saving 1, Older Homeowners

| | Active Saving 1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Δ(ln HPI) | 0.0473 | 0.531 | 0.661 | -0.234 | 0.00622 | 0.261 | 0.110 | 0.604 | 0.0442 |
| | (0.246) | (0.511) | (0.607) | (0.245) | (0.519) | (0.597) | (0.178) | (0.407) | (0.407) |
| Δ(ln HPI) × Pre | | -0.472 | | | -0.180 | | | -0.595 | |
| | | (0.643) | | | (0.644) | | | (0.499) | |
| Δ(ln HPI) × Post | | -1.437* | | | -1.001 | | | -0.860 | |
| | | (0.828) | | | (0.815) | | | (0.651) | |
| Δ(ln HPI) × Year Group | | | -0.108 | | | -0.0872 | | | 0.0116 |
| | | | (0.0910) | | | (0.0889) | | | (0.0631) |
| Housing wealth included? | | | | X | X | X | X | X | X |
| Other wealth included? | | | | | | | X | X | X |
| Observations | 3620 | 3620 | 3620 | 3612 | 3612 | 3612 | 3591 | 3591 | 3591 |
| R-squared | 0.12 | 0.12 | 0.12 | 0.153 | 0.154 | 0.153 | 0.499 | 0.499 | 0.499 |

Notes: Sample restricted to homeowners ages 45-64. All observations are annual MSA x birth-year group cohort level averages, available for 109 MSAs and 8 birth-year groups for the years 1985-2003. "Active Saving 1" is the percentage change in household total net worth, excluding capital gains to interest-earning assets and stock assets. "Δ(ln HPI)" is the change in the natural logarithm of the house price index between t-1 and t. All regressions include household-level and MSA-level control variables as described in the text, and MSA and year fixed effects. Robust standard errors are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 1.6: Change in House Prices and Active Saving 1, Younger Homeowners

| | Active Saving 1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Δ(ln HPI) | 0.215 | 0.241 | 0.103 | -0.076 | -0.266 | -0.120 | 0.013 | -0.222 | -0.710 |
| | (0.344) | (0.545) | (0.751) | (0.346) | (0.555) | (0.725) | (0.268) | (0.416) | (0.555) |
| Δ(ln HPI) × Pre | | -0.005 | | | 0.281 | | | 0.237 | |
| | | (0.795) | | | (0.771) | | | (0.513) | |
| Δ(ln HPI) × Post | | -0.369 | | | -0.126 | | | 1.151 | |
| | | (1.195) | | | (1.172) | | | (0.910) | |
| Δ(ln HPI) × Year Group | | | 0.021 | | | 0.008 | | | 0.137 |
| | | | (0.126) | | | (0.119) | | | (0.099) |
| Housing wealth included? | | | | X | X | X | X | X | X |
| Other wealth included? | | | | | | | X | X | X |
| Observations | 2658 | 2658 | 2658 | 2651 | 2651 | 2651 | 2617 | 2617 | 2617 |
| R-squared | 0.12 | 0.12 | 0.12 | 0.14 | 0.14 | 0.14 | 0.44 | 0.44 | 0.44 |

Notes: Sample restricted to homeowners ages 25-44. All observations are annual MSA x birth-year group cohort level averages, available for 109 MSAs and 8 birth-year groups for the years 1985-2003. "Active Saving 1" is the percentage change in household total net worth, excluding capital gains to interest-earning assets and stock assets. "Δ(ln HPI)" is the change in the natural logarithm of the house price index between t-1 and t. All regressions include household-level and MSA-level control variables as described in the text, and MSA and year fixed effects. Robust standard errors are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 1.7: Predicting House Price Growth using MSA-level variables

| | Δ(ln HPI) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **All periods** | | | **1984-1990** | | | **1996-2003** | | |
| Unemployment Rate$_{t-1}$ | -0.875 | -0.876 | -0.874 | -1.989 | -1.97 | -1.986 | -1.181 | -0.863 | -0.864 |
| | (0.070)*** | (0.073)*** | (0.073)*** | (0.338)*** | (0.340)*** | (0.337)*** | (0.128)*** | (0.117)*** | (0.116)*** |
| Unemployment Rate$_{t+2}$ | -0.631 | -0.445 | -0.445 | -0.269 | -0.259 | -0.251 | -0.519 | -0.369 | -0.363 |
| | (0.099)*** | (0.095)*** | (0.094)*** | (0.214) | (0.208) | (0.208) | (0.193)*** | (0.129)*** | (0.128)*** |
| Change in household income$_{t-1 \rightarrow t}$ | 0.005 | | 0.002 | -0.000211 | | -0.0131 | 0.00242 | | -0.000306 |
| | (0.003) | | (0.003) | (0.00963) | | (0.0118) | (0.00403) | | (0.00336) |
| Change in population$_{t-1 \rightarrow t}$ | -0.001 | | 0.006 | -0.00194 | | -0.00641 | -0.00224 | | 0.0119 |
| | (0.005) | | (0.006) | (0.0193) | | (0.0210) | (0.00545) | | (0.00514)** |
| Change in household income$_{t-1 \rightarrow t+4}$ | | 0.009 | 0.009 | | 0.0151 | 0.0225* | | 0.00804 | 0.00838 |
| | | (0.003)*** | (0.003)*** | | (0.0101) | (0.0125) | | (0.00266)*** | (0.00292)*** |
| Change in population$_{t-1 \rightarrow t+4}$ | | 0.006 | 0.005 | | 0.000599 | 0.00325 | | 0.00358 | 0.00152 |
| | | (0.003)** | (0.003)* | | (0.0148) | (0.0149) | | (0.00337) | (0.00340) |
| Observations | 3472 | 2980 | 2980 | 742 | 742 | 742 | 1851 | 1417 | 1417 |
| R-squared | 0.42 | 0.32 | 0.32 | 0.584 | 0.586 | 0.586 | 0.608 | 0.580 | 0.581 |

All variables are calculated using MSA-level average data, available for 272 MSAs for the years 1984-2003. "Δ(ln HPI)" is the change in the natural logarithm of the house price index between t-1 and t. All regressions include MSA and year fixed effects. Robust standard errors are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 1.8, Panel 1: Predicting Household Saving using MSA-level variables - Active Saving 1

| | Active Saving 1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **All periods** | | | **1984-1990** | | | **1996-2003** | | |
| Unemployment Rate$_{t-1}$ | -0.0122 | -0.0105 | -0.0142 | -0.0430 | -0.0693* | -0.0717* | -0.0312 | -0.0319 | -0.0424 |
| | (0.0168) | (0.0168) | (0.0170) | (0.0381) | (0.0400) | (0.0417) | (0.0434) | (0.0472) | (0.0466) |
| Unemployment Rate$_{t+2}$ | -0.00995 | -0.04888 | -0.00205 | 0.00138 | -0.00687 | -0.00501 | -0.0295 | -0.0203 | -0.0208 |
| | (0.0203) | (0.0215) | (0.0215) | (0.0260) | (0.0216) | (0.0242) | (0.0522) | (0.0595) | (0.0561) |
| Change in household income$_{t-1 \rightarrow t}$ | -0.255 | | -0.353* | 0.0669 | | -0.0905 | -0.384 | | -0.586** |
| | (0.168) | | (0.185) | (0.268) | | (0.326) | (0.245) | | (0.297) |
| Change in population$_{t-1 \rightarrow t}$ | 0.273 | | 0.289 | 0.161 | | 0.0637 | 0.507 | | 0.529 |
| | (0.252) | | (0.259) | (0.266) | | (0.278) | (0.441) | | (0.461) |
| Change in household income$_{t-1 \rightarrow t+4}$ | | 0.163 | 0.255 | | 0.272 | 0.317 | | 0.149 | 0.373 |
| | | (0.143) | (0.155) | | (0.371) | (0.431) | | (0.211) | (0.248) |
| Change in population$_{t-1 \rightarrow t+4}$ | | 0.0282 | -0.00787 | | 0.676** | 0.670** | | 0.0133 | -0.0410 |
| | | (0.117) | (0.118) | | (0.299) | (0.319) | | (0.179) | (0.183) |
| Observations | 1041 | 1003 | 1002 | 217 | 217 | 217 | 657 | 618 | 618 |
| R-squared | 0.055 | 0.050 | 0.061 | 0.249 | 0.284 | 0.285 | 0.075 | 0.063 | 0.083 |

All variables are calculated using MSA-level average data, available for 109 MSAs for the years 1985-2003. "Active Saving 1" is the percentage change in household total net worth, excluding capital gains to interest-earning assets and stock assets. "$\Delta$(ln HPI)" is the change in the natural logarithm of the house price index between t-1 and t. All regressions include MSA and year fixed effects. Robust standard errors are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 1.8, Panel 2: Predicting Household Saving using MSA-level variables - Active Saving 2

| | Active Saving 2 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **All periods** | | | **1984-1990** | | | **1996-2003** | | |
| Unemployment Rate$_{t-1}$ | -0.00798 | -0.00635 | -0.00983 | -0.0433 | -0.0686* | -0.0710* | -0.0250 | -0.0255 | -0.0355 |
| | (0.0156) | (0.0155) | (0.0157) | (0.0377) | (0.0395) | (0.0412) | (0.0405) | (0.0438) | (0.0433) |
| Unemployment Rate$_{t+2}$ | -0.0120 | -0.00710 | -0.00470 | 0.00306 | -0.00464 | -0.00278 | -0.0291 | -0.0208 | -0.0215 |
| | (0.0189) | (0.0197) | (0.0196) | (0.0227) | (0.0209) | (0.0234) | (0.0478) | (0.0544) | (0.0512) |
| Change in household income$_{t-1 \rightarrow t}$ | -0.246 | | -0.336* | 0.0682 | | -0.0893 | -0.378 | | -0.559* |
| | (0.160) | | (0.177) | (0.259) | | (0.317) | (0.230) | | (0.280) |
| Change in population$_{t-1 \rightarrow t}$ | 0.231 | | 0.248 | 0.155 | | 0.0641 | 0.423 | | 0.454 |
| | (0.242) | | (0.250) | (0.259) | | (0.271) | (0.420) | | (0.443) |
| Change in household income$_{t-1 \rightarrow t+4}$ | | 0.148 | 0.234 | | 0.280 | 0.324 | | 0.119 | 0.332 |
| | | (0.132) | (0.144) | | (0.354) | (0.413) | | (0.197) | (0.232) |
| Change in population$_{t-1 \rightarrow t+4}$ | | 0.0146 | -0.0166 | | 0.644* | 0.638** | | -0.0243 | -0.0696 |
| | | (0.110) | (0.122) | | (0.288) | (0.307) | | (0.161) | (0.169) |
| Observations | 1041 | 1003 | 1002 | 217 | 217 | 217 | 657 | 618 | 618 |
| R-squared | 0.052 | 0.047 | 0.057 | 0.249 | 0.284 | 0.285 | 0.070 | 0.058 | 0.077 |

All variables are calculated using MSA-level average data, available for 109 MSAs for the years 1985-2003. "Active Saving 2" is the percentage change in household total net worth, excluding capital gains to interest-earning assets and stock assets and including mortgage amortization. "Δ(ln HPI)" is the change in the natural logarithm of the house price index between t-1 and t. All regressions include MSA and year fixed effects. Robust standard errors are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 1.9: Change in House Prices and Active Saving 2, IV Results

| | Active Saving 2 | | | | | | | | | Modified AS2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Δ(ln HPI) | 0.358 | 2.355*** | 2.568** | -1.097* | 0.990 | 0.0858 | -0.863 | 1.148 | -0.416 | -1.121* | 0.252 | -0.102 |
| | (0.527) | (0.775) | (1.031) | (0.642) | (1.232) | (1.136) | (0.588) | (1.100) | (1.000) | (0.596) | (1.059) | (1.095) |
| Δ(ln HPI) × Pre | | -2.823*** | | | -2.899** | | | -2.333** | | | -1.934* | |
| | | (1.046) | | | (1.254) | | | (1.101) | | | (1.146) | |
| Δ(ln HPI) × Post | | -3.742*** | | | -3.513* | | | -3.789** | | | -2.261 | |
| | | (0.990) | | | (1.811) | | | (1.652) | | | (1.463) | |
| Δ(ln HPI) × Year Group | | | -0.358** | | | -0.192 | | | -0.1727 | | | -0.167 |
| | | | (0.148) | | | (0.167) | | | (0.146) | | | (0.161) |
| Housing wealth included? | | | | X | X | X | X | X | X | X | X | X |
| Other wealth included? | | | | | | | X | X | X | X | X | X |
| Observations | 4892 | 4892 | 4892 | 4881 | 4881 | 4881 | 4842 | 4842 | 4842 | 4841 | 4841 | 4841 |
| R-squared | 0.102 | 0.104 | 0.103 | 0.106 | 0.107 | 0.106 | 0.479 | 0.480 | 0.479 | 0.215 | 0.216 | 0.215 |

First Stage

| | Δ(ln HPI) |
|---|---|
| Unemployment Rate$_{t-1}$ | -0.0168*** |
| | (0.00105) |
| Unemployment Rate$_{t+2}$ | -0.00647*** |
| | (0.00145) |
| Change in MSA average income$_{t-1 \rightarrow t}$ | 0.0288*** |
| | (0.00633) |
| Change in MSA population$_{t-1 \rightarrow t}$ | 0.0628*** |
| | (0.0110) |
| Change in MSA average income$_{t-1 \rightarrow t+4}$ | 0.0146*** |
| | (0.00539) |
| Change in MSA population$_{t-1 \rightarrow t+4}$ | 0.00202 |
| | (0.00434) |
| F(6, 5846) = 71.81 | |
| Observations | 5992 |
| R-squared | 0.438 |

Notes: Sample restricted to homeowners. All observations are annual MSA x birth-year group cohort level averages, available for 109 MSAs and 12 birth-year groups for the years 1985-2003. "Active Saving 2" is the percentage change in household total net worth, excluding capital gains to interest-earning assets and stock assets and including mortgage amortization. "Δ(ln HPI)" is the change in the natural logarithm of the house price index between t-1 and t. All regressions include household-level control variables as described in the text, and MSA and year fixed effects. Robust standard errors are in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

Table 1.10: Summary of Previous Literature and Results: Asset Data

| Authors | Pub Year | Data | Data Source | Data Years | Results |
|---|---|---|---|---|---|
| Juster, Lupton, Smith and Stafford | 2005 | Assets - active saving | PSID wealth modules, self-reported asset values | 1984, 1989, 1994 | Dollar effects of -0.19 for stocks, -0.03 for housing |
| Disney Henley Stears | 2002 | Assets - financial wealth | UK Retirement and Retirement Plans Survey, self-reported house prices | 1988, 1994 | Elasticities of -4.217 for housing for retirement-age movers, -0.567 for retirement-age stayers (insig.) |
| Engelhardt | 1996 | Assets - active saving | PSID wealth modules, self-reported house prices | 1984, 1989 | Dollar effects of -0.029 for housing overall; -0.008 for housing gains and 0.347 for losses |
| Hoynes and McFadden | 1994 | Assets - total net worth | PSID wealth modules, ACCRA/Census house prices | 1984, 1989 | Elasticities of 0.199 for housing - ACCRA data, 0.155 for housing - Census data |
| Hoynes and McFadden | 1994 | Assets - excl. housing | PSID wealth modules, ACCRA/Census house prices | 1984, 1989 | Elasticities of 0.043 for housing - ACCRA data, 0.126 for housing - Census data |
| Skinner | 1993 | Assets - active saving | PSID wealth modules, self-reported house prices | 1984, 1989 | Dollar effects of -0.028 for housing overall; -0.004 for housing gains and 0.10 for losses |

Table 1.10: Summary of Previous Literature and Results, Consumption Data

| Authors | Pub Year | Micro/Macro? | Data Source | Data Years | Results |
|---|---|---|---|---|---|
| Gan | 2007 wp | Micro | Quarterly credit card data, housing transactions data | 2000-2002 | Elasticities of 0.171 for housing; 0.166 for young and 1.499 for retirement-age households |
| Campbell and Cocco | 2007 | Micro | Quarterly UK Family Expenditure Survey | 1988-2000 | Elasticities of 0.651 for housing; 1 for young households, 1.7 for retirement-age households, zero for renter households |
| Carroll Otsuka Slacalek | 2006 wp | Macro | Quarterly Flow of Funds, National Income and Product Accounts | 1960-2004 | Dollar effects of 0.063 for stock wealth and 0.153 for nonstock wealth |
| Bostic Gabriel Painter | 2005 wp | Micro | SCF and CEX data matched on income within age-race-marital-educ cells | 1989-2001 triennally | Elasticities of 0.04 - 0.06 for housing and 0.02 - 0.03 for financial wealth |
| Case Quigley Shiller | 2005 | Macro | Quarterly U.S. state data imputed from Flow of Funds | 1982-1999 | Elasticities of 0.056 for housing, -0.003 for stocks (insig.) |
| | | | 14 countries, annual aggregate wealth/consumption | 1975-1996 | Elasticities of 0.167 for housing, -0.007 for stocks (insig.) |
| Lehnert | 2004 wp | Micro | PSID longitudinal data: food and utilities consumption | 1968-1999 | Elasticities of 0.0343 - 0.0344 for housing; hump-shaped age profile of elasticities |
| Dvornak and Kohler | 2003 | Macro | Australian state-level data, Housing Institute of Australia house prices | 1984-2001 | Elasticities of 0.03 for housing wealth and 0.06 - 0.09 for financial wealth |
| Benjamin Chinloy Jud | 2002 | Macro | Quarterly Flow of Funds, National Income and Product Accounts | 1952-2001 | Elasticities of 0.08 for housing wealth and 0.02 for financial wealth |
| Dynan and Maki | 2001 | Micro | Consumer Expenditure Survey, self-reported securities holdings | 1983-1999 | Dollar effects of between 0.05 and 0.15 for stocks |
| Levin | 1998 | Micro | Retirement History Survey - self-reported housing/wealth data | 1969-1979 | Dollar effects of 0.06 for housing equity and 0.12 for financial equity |
| Skinner | 1994 | Macro | Annual Flow of Funds - Nondurable consumption | 1950-1992 | Elasticities of 0.10 for stocks, 0.143 for housing |
| Skinner | 1989 | Micro | PSID longitudinal data: food, utilities, autos and imputed housing | 1973-1981 | Elasticity of -0.0107 for housing (insig.) |

Figure 1.1:

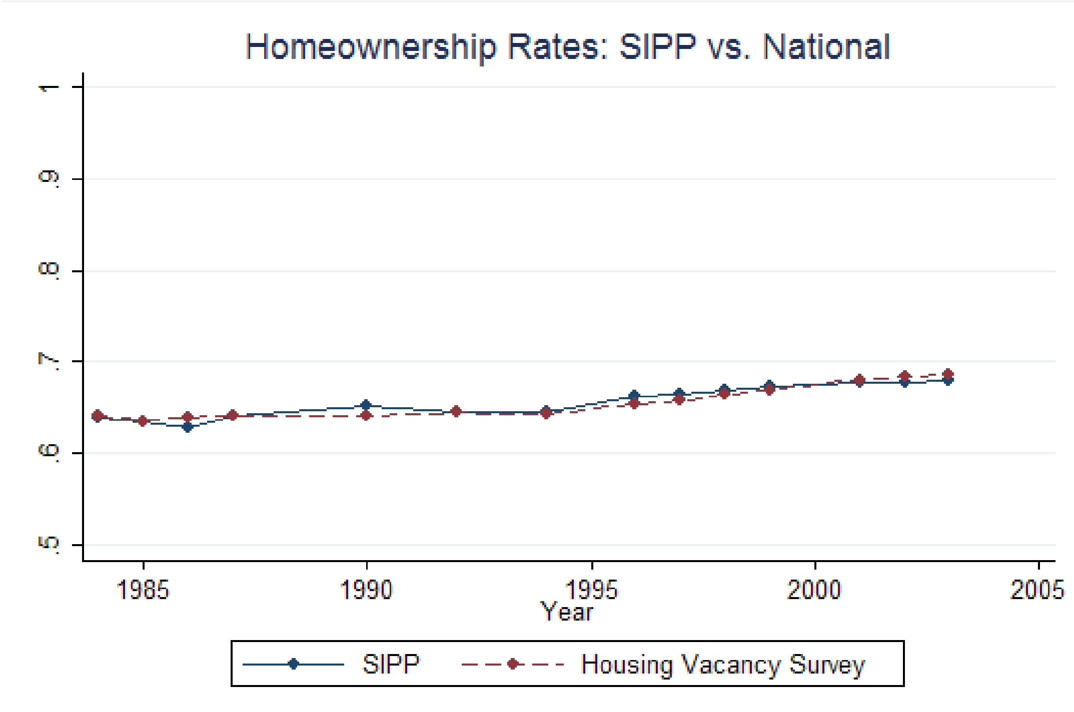



Figure 1.2:

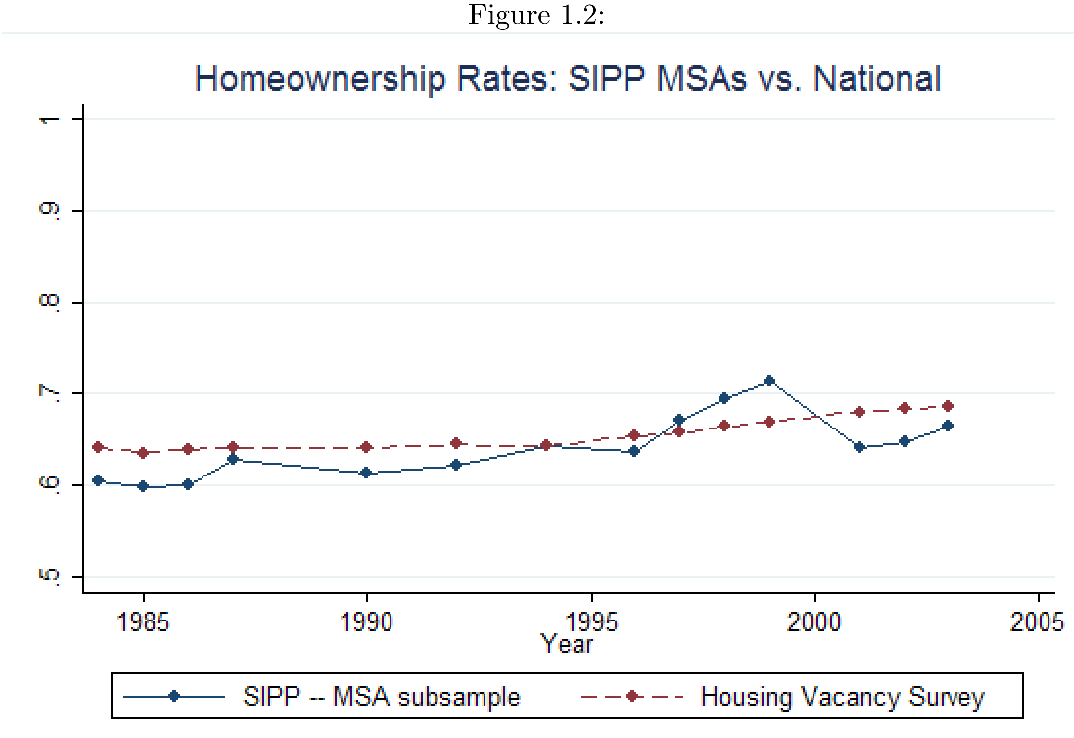


Figure 1.3:

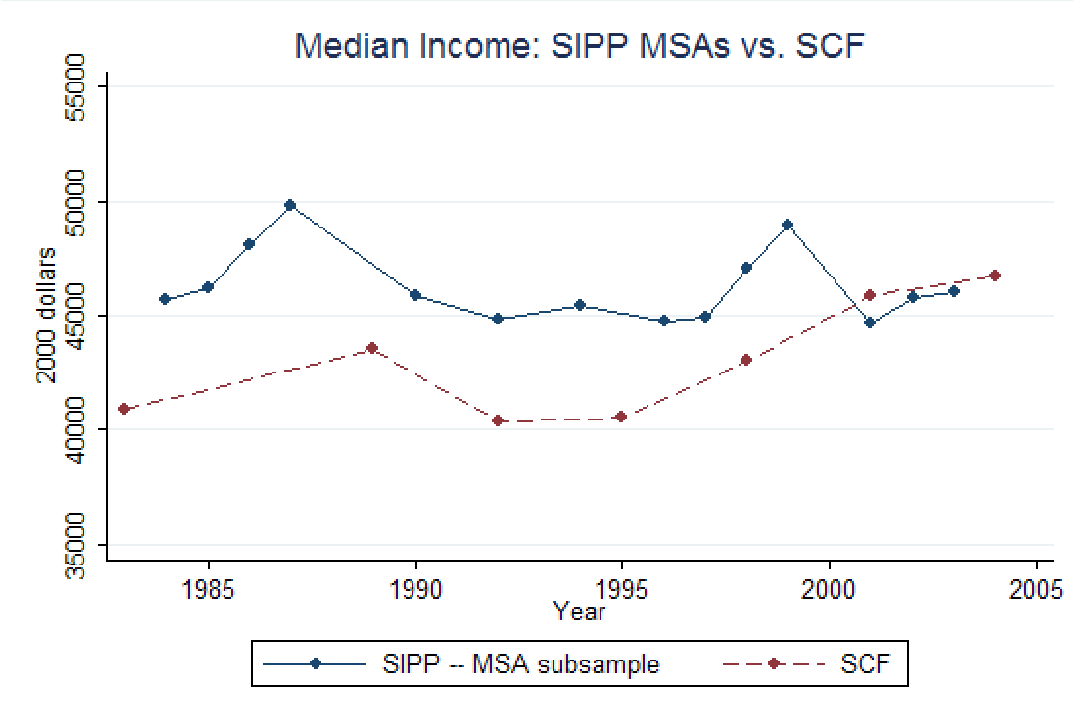
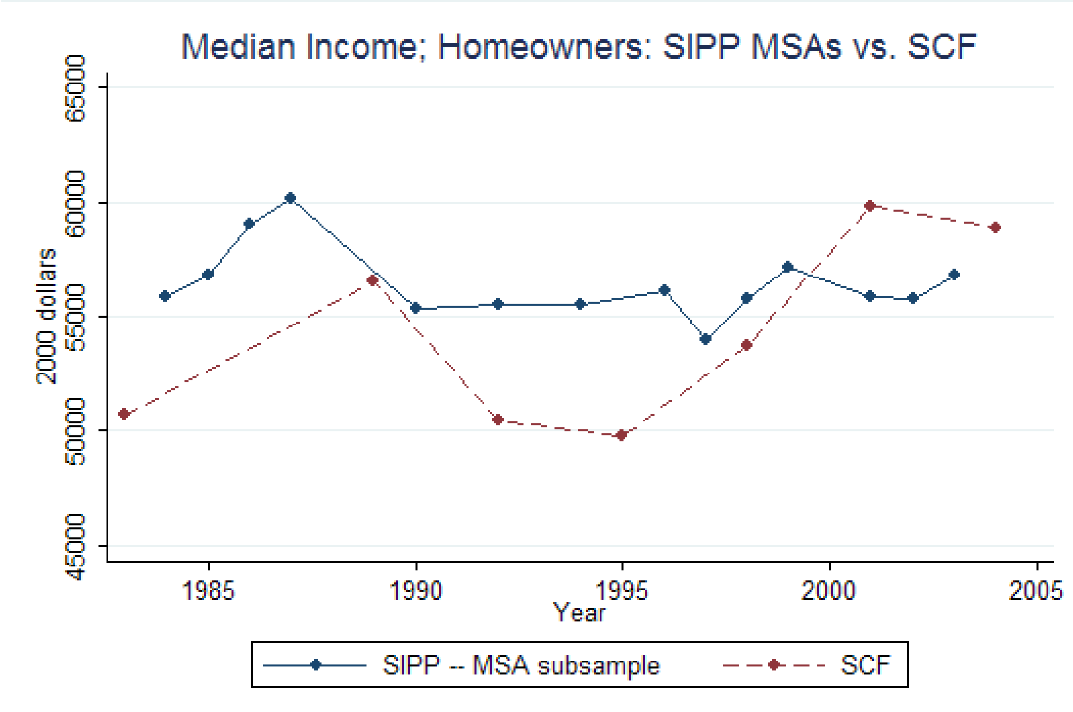



Figure 1.4:



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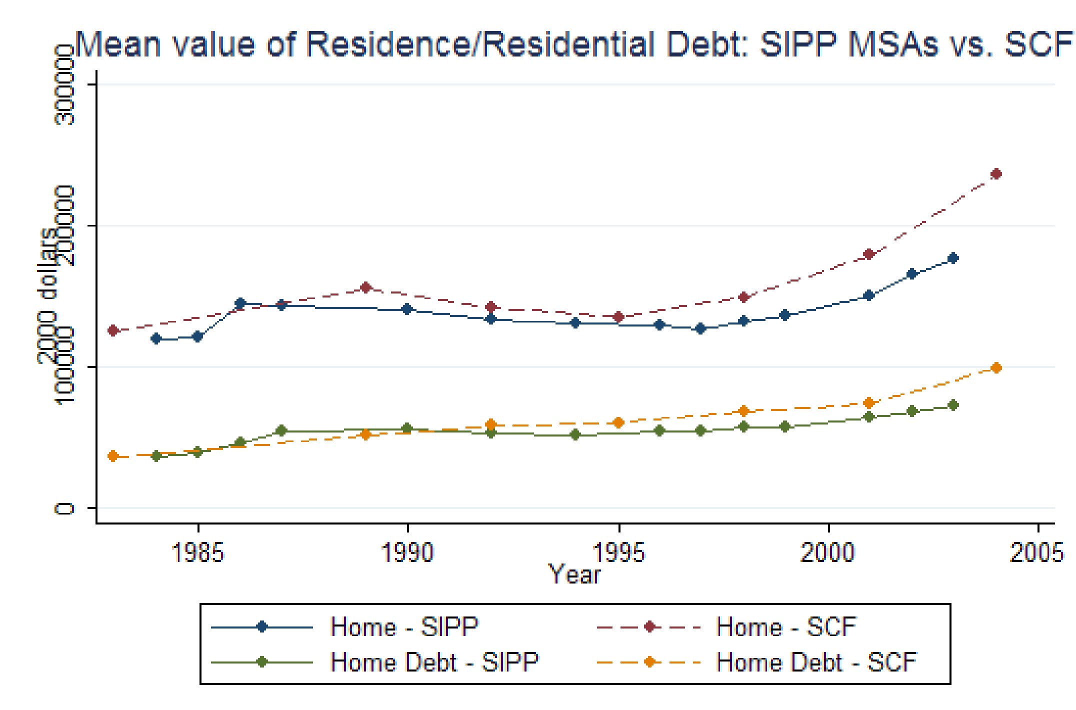


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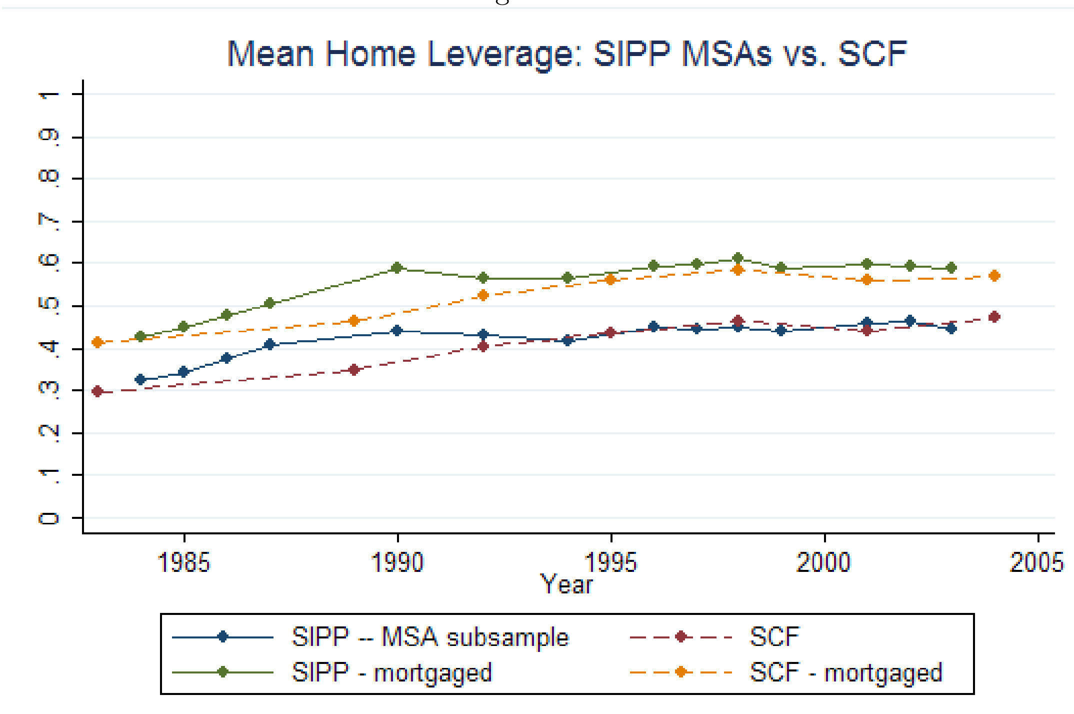

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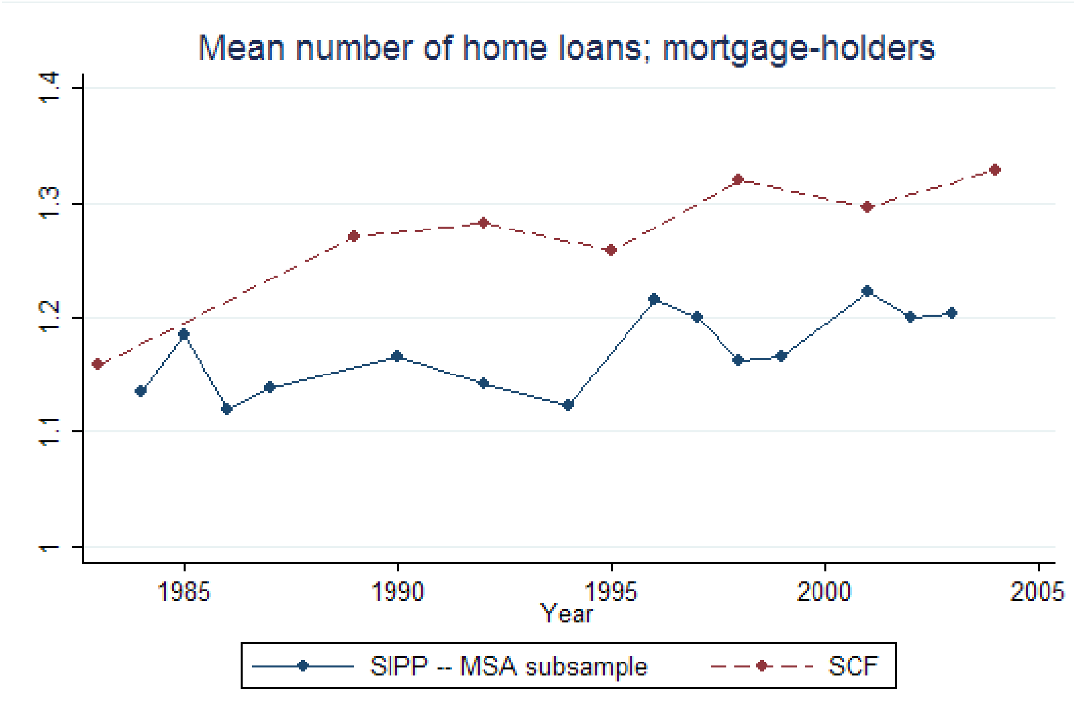



Figure 1.8:

Figure 1.9:

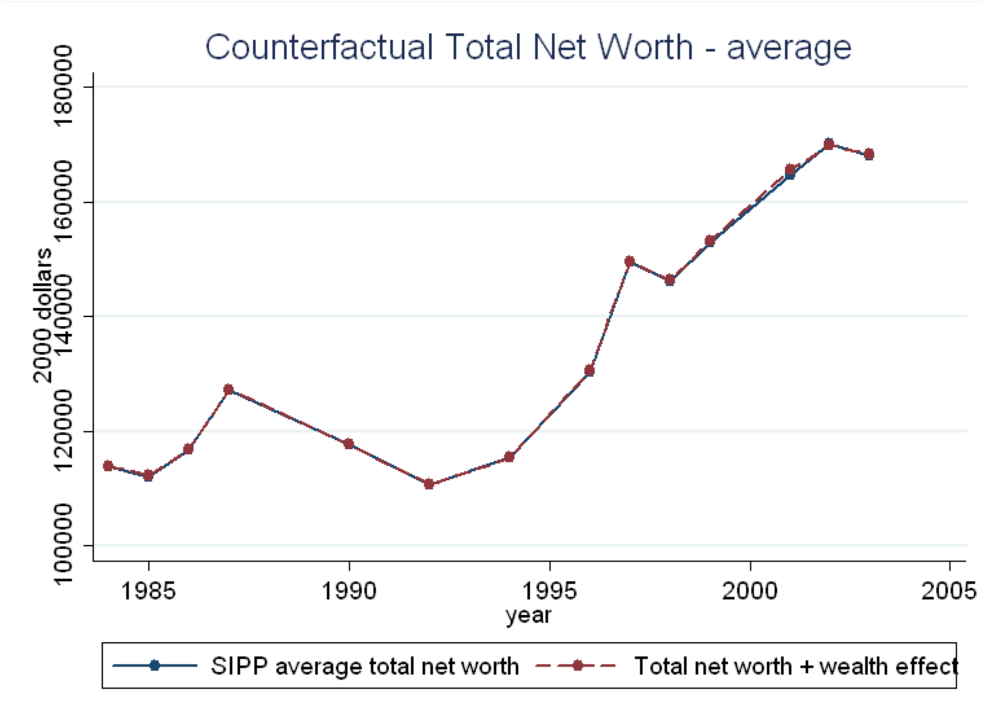
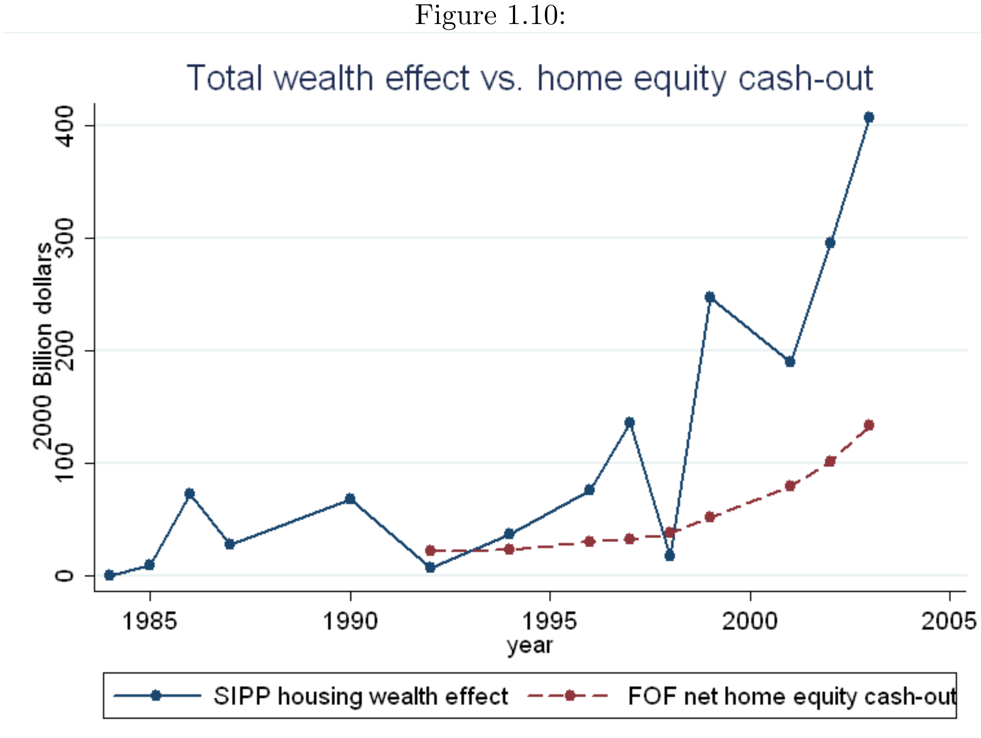



Figure 1.10:



# Chapter 2

# Flip That House?<br>House Price Dynamics and Housing Investment Decisions

## 2.1 Introduction

From turn-of-the-century tenements to postwar suburbanization, and from the exurban sprawl of the 1990s to the urban renewal of recent history, much of America's landscape - and indeed even her culture - has been shaped by the development of residential housing. While the majority of research analyzing the determinants of residential housing supply has focused on households' location and consumption decisions, recent events have highlighted the importance of residential housing as a large fraction of most American households' asset holdings. The decision to build or to buy a new home is not only driven by consumption considerations, but is also an investment decision that is responsive to fluctuations in housing values. To determine the extent to which property owners respond to changes in the profitability of housing assets by making investments in the housing stock, my research project focuses on the relationship between property owners' capital investment decisions and changes in the profitability of housing investment. In addressing this question, I hope not only to test economic theories of capital investment, but also to improve our understanding of the development process, particularly in urban areas.

In a standard model of housing investment based on neoclassical investment theory, property owners maximize the present discounted value of the future stream of rents from the house. This model predicts that property owners will invest in their properties up to the point where the market value of an additional unit of housing capital equals the marginal cost of this capital plus the fixed costs of adjusting the existing capital stock. Increases in the value of housing capital in place, which is represented by the value of the property, should lead to higher levels of investment.[1]

While this simple model provides a straightforward link between asset prices and investment flows (without needing to explicitly model the production technology, as noted by Hayashi, 1982), it assumes that investors are risk neutral. Investor risk aversion can change the optimal investment

[1]In this text, I use the terms "rents", "housing prices", and "output prices" to refer to the per-period price of housing services, and the terms "housing values", "house prices", and "asset prices" to refer to the present discounted value of the future stream of housing rents, i.e., the value of the housing asset.

strategy, particularly when there is uncertainty over future asset prices, and this effect could be especially pronounced in the case of housing investment, where properties are owned by individual households as well as by professional investors. Moreover, neoclassical theories also assume that capital investment can be increased or decreased flexibly in response to changes in the profitability of the capital in place. As in many industries, capital investments in housing depreciate at a very slow rate and it is particularly difficult to reduce the amount of housing capital in place once it is constructed.

Because of investor risk aversion and the virtual irreversibility of housing investment, the decision to invest is dependent on property owners' expectations of the future price of housing services, and the amount of uncertainty over future prices. Property owners can decide whether to invest in the current period or delay investment to see what the price of output will be in following periods. Similarly to put and call options on financial assets, the option to delay investment is an important component of the value of the housing asset, and investors choose the optimal timing and extent of investment to maximize the value of both the productive asset and the investment option.

To incorporate these issues, I begin by modeling the investor's decision under uncertainty when investment is irreversible. When the future profitability of irreversible capital investment is uncertain, there exists an 'option value' of waiting to invest to obtain more information on the future path of capital asset values. The additional cost to investment of losing the option to decrease the capital stock increases the required profitability level at which investment occurs, and there exists a range of asset values where investment which would otherwise occur is delayed. Increases in the uncertainty over future profitability further increase the threshold asset value at which investment occurs.

When price variance is high, the delay of investment causes the capital stock to remain at a lower level for longer, while the optimal amount of capital stock for the property increases, which increases the difference between the existing and optimal level of capital investment. The longer the delay in investing, the larger the gap between existing and optimal capital investment. Thus, the optimal quantity of improvement may depend indirectly on price uncertainty via the delay in investment induced by higher price uncertainty.

To formally derive a relationship between prices, price uncertainty, and the optimal quantity of capital investment, I also develop a modified version of the neoclassical model where investors are risk averse, by introducing an investor-specific utility function that is concave over profits. Both the real options model and the modified neoclassical model predict that investment is more likely when housing values are high. The modified neoclassical model further predicts that the optimal quantity of capital investment is higher when house prices are high. The real options model predicts that investment is less likely to occur when the uncertainty, or variance, in house prices is high. The modified neoclassical model further predicts that the optimal quantity of investment is larger relative to the standard case when uncertainty over house prices increases, and that this relationship is stronger for more risk averse investors. As outlined above, the real options model indirectly predicts a positive relationship between investment quantity and price uncertainty.

Real estate is an ideal asset to empirically examine theories of investment under uncertainty. To test the hypotheses outlined above, I employ a unique dataset incorporating information from multiple sources on housing values, property owners, and investment activity in the city of Los Angeles.

Using data from a California-based real estate company on the location, characteristics, and transaction history of all residential properties (including both land and developed properties) in the city of Los Angeles, I construct neighborhood- and property type-specific quality-adjusted hedonic price indices for 81 neighborhoods. The price indices measure changes in the value of housing in each neighborhood, and allow the relative value of property characteristics such as square footage, number of units, and various amenities to differ between neighborhoods and across years within a neighborhood. This dataset also includes information on whether the property is owner-occupied or renter-occupied, which I use to identify different types of property owners who may be more or less risk averse over investment decisions.

To measure property owners' capital investments, I use data on all building permits issued by the city of Los Angeles between 1999 and 2007. According to the California Building Code, "no building or structure shall be erected, constructed, enlarged, altered, repaired, moved, improved, removed, converted or demolished without a building permit," and in practice I observe a wide variety of investment activities in these records, from installing a water-saving toilet to constructing a new 30-story apartment building. The dataset identifies properties by the assessment parcel number, which I use to link investment activity for a given property to information on the property's location, building characteristics, and neighborhood-level housing values. The permits include the value and square footage of improvements, which allows me to employ multiple measures of investment quantity in my analysis, and also include detailed information on the type of improvement made to the property, which allows me to identify different types of investors who may be more or less risk averse.

Due to data limitations, the majority of studies in this area focus exclusively on new construction when estimating the relationship between house price dynamics and housing investment. What are the broader benefits of including these smaller investments in the analysis? First, the majority of property owners are not development corporations, but individual households who own their own homes or a single rental property. Focusing exclusively on new construction overlooks a significant number of decision-makers, and focuses specifically on those who are most likely to follow a risk-neutral, profit-maximizing approach to investment (while this behavior might not apply to the majority of property owners, who own the majority of the residential housing stock).

Excluding data on home improvements also excludes a significant share of investment in the housing stock. Figure 2.1 displays the aggregate value of new housing construction, and of improvements and repairs to the existing housing stock, between 1993 and 2007. Expenditures on home improvements represented almost half of total expenditures on housing production in 2000, and were still over a third of total expenditures in subsequent years, during which new construction accelerated dramatically.[2] Moreover, within urban areas where undeveloped land is scarce and the existing building stock may be historically valuable but dilapidated, an even larger share of housing investment is in improvements to existing properties. [3] By focusing exclusively on changes in the number of housing units, we may be understating the relationship between house price dynamics and housing supply in urban areas.

[2]Improvement expenditures, as measured by the Census Bureau, include "remodeling, additions, and major replacements subsequent to completion of original building. It includes construction of additional housing units in existing residential structures, finishing of basements and attics, modernization of kitchens, bathrooms, etc. Also included are improvements outside of residential structures, such as the addition of swimming pools and garages, and replacement of major equipment items such as water heaters, furnaces, and central air conditioners" (Census Bureau, Series C30 definitions).

[3]In his study of the determinants of neighborhood gentrification in Chicago, Helms (2003) reports that between 1995 and 2000, investment in new construction and in improvements to existing housing in that city, defined similarly to above and measured using building permit data, were virtually equal.

Assuming that variable and fixed costs of construction are roughly equivalent across neighborhoods in the city of Los Angeles (a single labor and regulatory market), I use variation in quality-adjusted, neighborhood- and property-type specific house prices and the volatility of these house prices across neighborhoods and years to estimate the relationship between prices, price growth, and volatility, and the probability of improvement activity, the value of improvements, and the square footage of improvements. By comparing neighborhoods within a metropolitan area, I can control for differences in development costs that might affect improvement decisions.

For many property owners, the house is a consumption good as well as an investment vehicle, and there may be factors - changes in the household's optimal housing consumption level, interpersonal utility comparisons or "keeping up with the Joneses", among others - that influence the housing investment decision and are also related to changes in house prices. I rule out these consumption-driven explanations by focusing on two types of property owners in my empirical analysis: nonresident landlords, and owner-occupiers who improve their properties and then move away. Nonresident landlords and "improver-movers" do not plan to consume the housing services associated with their improvements, and so their investment decisions are plausibly unaffected by other factors - such as shifts in neighborhood income or composition, or changes in household income or housing demand - that might affect both housing prices and optimal levels of housing consumption.

To account for differences in characteristics of the existing housing stock that may be correlated with house price dynamics and home improvement decisions, I include in the regressions measures of neighborhood-level median square footage, age, owner-occupied status, and other factors. After controlling for these observable characteristics, residual neighborhood-level price differences in the initial period form a baseline measure of pre-existing differences in demand generated by unobservable location-based amenities. If prices are always higher in a ritzy neighborhood, this does not imply that all housing investment will always take place in this neighborhood and not in the lower priced, up-and-coming areas; in fact, the reverse is probably true. To capture this aspect of neighborhood dynamics, I include in the regression specifications the minimum neighborhood price level since 1995 (the trough of average house prices in Los Angeles during the 1990s), and the one and five-year lagged prices, and estimate the relationship between house price growth and housing investment.

I find a positive relationship between housing values and the probability that a property is improved, the value of improvements, and the square footage of improvements. A 10 percent increase in housing values leads to a 6.1 percent increase in the percentage of properties improved in a neighborhood, a 5.3 percent increase in the value of improvements, and an 11.9 percent increase in the square footage of improvements. I also find a positive relationship between house price growth and housing investment. A doubling of annual house price growth rates is associated with a 36.7 percent increase in the percentage of properties improved, a 47 percent increase in the value of improvements, and a 90.6 percent increase in the square footage of improvements. Results for five-year and cumulative price growth are larger, but similar.

When house prices and house price growth are strong, the square footage of owner-occupiers' improvements increases, but the value of owner-occupiers' improvements decreases. There are two potential explanations for this latter result. First, additions may be more valuable relative to quality upgrades in the owner-occupied market when prices are increasing, and vice versa when prices are decreasing. Second, when house prices are decreasing, owner-occupiers are more likely to be "locked in" to their current residence (because of credit constraints or housing market conditions), so they may be more likely to adjust their housing consumption by making home improvements than by moving. When I limit the sample to "improver-movers", the relationship between house prices/price growth and value of improvements is positive, which suggests that credit constraints contribute to the relationship between price declines and improvement value for "stayers". The effect of credit constraints on the relationship between house price dynamics and housing investment is an interesting area for future research.

I find that property owners are less likely to make investments; that is, the *probability* that investment occurs is lower, when the variance of house prices is high. On average, a 10 percent increase in the variance of house prices leads to a 2 percent decrease in the percentage of properties improved in a neighborhood. These effects are larger for improvements to existing properties than for new construction, and are larger for renter-occupied properties than for owner-occupied properties, which suggests that investors who are more exposed to house price risk (due to lack of portfolio diversification, in the case of home improvers versus developers, and due to cash flow exposure, in the case of landlords versus owner-occupiers) are more sensitive to variation in house prices when deciding whether to invest or not.

As predicted by the models of investment under uncertainty, there is a positive relationship between house price variance and the *quantity* of investment. The effect of a doubling of price variance on the value and square footage of investment across groups ranges from 1.7 percent to 4.8 percent, and is largest in magnitude for additions to existing construction and the value of improvements to renter-occupied properties. The exception to this rule is for owner-occupied properties, where increases in volatility lead to steep declines in the value and square footage of investments, a result that is not explained by the analysis of this paper. Including investment quantities during the previous period in the regressions of current-period investment quantity on price variance eliminates the effect of price variance on investment quantity, which provides evidence in favor of the real options theory over the modified neoclassical theory.

The paper proceeds as follows. Section 2 reviews the literature on the determinants of housing supply, beginning with consumption-based models and empirical analyses of housing supply that incorporate price dynamics and continuing to investment-based theories and empirical studies. Section 3 outlines the option value, neoclassical, and modified neoclassical theories of housing investment and derives formal relationships between housing values, house price volatility, and investment. Section 4 reviews the datasets used and the construction of key variables, and section 5 describes the empirical strategy and addresses potential challenges to identification. Section 6 presents the results of the empirical analysis, and section 7 addresses potential concerns through a series of robustness checks. Section 8 concludes.

## 2.2 Literature review

### 2.2.1 Consumption-based models of housing supply

Traditional models of housing supply in the urban economics literature exploit differences in location-based amenities across properties, and changes in demand for these amenities, to predict patterns of housing investment. The foundational model in this literature is the monocentric city model of urban development, developed by Alonso (1964), Mills (1967), and Muth (1969), and outlined in a summary article by Brueckner (1987). In this model, the costs of commuting from the urban fringe to the city center must be offset by lower prices per square foot of housing and land, which results in a larger quantity of housing consumed at the urban fringe.

A study in this category focused primarily on estimating the relationship between house price growth and housing supply is Mayer and Somerville's (2000) empirical analysis of new housing investment, which is based explicitly on the monocentric city model. In their model, an increase in demand to live in a given city leads to an influx of new residents and an increase in the city size. As a result, the value of all properties in the city (except for those at the urban fringe) increases, because commuting costs for properties at the urban fringe have increased and spatial equilibrium requires that price differences across properties reflect differences in commuting costs. Mayer and Somerville use this model to propose that housing investment should depend on changes in prices, and not on differences in price levels *per se*, because differences in price levels within a city can exist in a spatial equilibrium where the amount of new construction is zero.[4]

Using aggregate data on housing starts, house prices, and construction costs, the authors estimate a positive relationship between quarterly house price growth and new construction, and also find that lagged values of house price growth (up to 2 previous quarters) are positively related to housing investment. While their incorporation of the spatial features of housing markets into a model of housing supply is innovative, it seems not to be incorporated into the empirical analysis as their estimation is based on national-level data. Moreover, the analysis does not account for other macroeconomic factors that might affect both house price growth and and housing starts, such as national income growth. As their analysis relies on variation over time in aggregate outcomes, it seems crucially important to control for macroeconomic trends.

The majority of variation in house prices and price changes occurs at the local level. As documented by Glaeser and Gyourko (2008), only one quarter of the variation in price changes across cities and years can be accounted for by annual, national-level trends. Motivated by this fact, the authors develop a model of housing supply and house price determination based on the spatial models of Rosen (1979) and Roback (1982), where housing prices adjust to account for differences in wages and location-based amenities across cities. Although the authors are primarily interested in explaining the predictability and high volatility of house price changes and housing investment, their analysis develops a model of housing investment by extending the Rosen-Roback framework to incorporate endogenous housing supply. In their model, increases in the growth rate of labor productivity or demand for local amenities in a given city generate immediate increases in housing prices, but lagged construction responses to price shocks create persistence over time in housing investment.

Glaeser and Gyourko's study is relevant to the current discussion because it explores a possible relationship between house price volatility and housing investment. In their model, cities where the housing stock adjusts rapidly to demand shocks (their example is cities in the Sunbelt) are predicted to have more volatile housing prices than cities where the housing stock is inelastically supplied. However, the calibrated model is unable to match the high price volatility in coastal cities. This suggests that there may exist unobservable differences across neighborhoods within cities that affect house price and housing supply dynamics, which motivates an analysis of housing supply that includes even finer geographic detail.

The most geographically-detailed analysis of the relationship between house price dynamics and housing investment that is based on a consumption-based model of housing supply is a dynamic

[4] The authors allude to a more investment-based concept of housing supply by relating increases in housing values to increases in the average $q$ of housing assets, but this approach is not pursued further in the model.

model presented by Murphy (2008). In the model, owners of undeveloped land choose the optimal timing of development, conditional on the profit-maximizing amount of square footage to be built. The determination of optimal square footage is based on neighborhood (Census tract) specific prices of land and square footage derived from a hedonic price model, and neighborhood and year specific variable costs of development, represented by neighborhood and year fixed effects. The decision to build or to delay is based on estimates of expected profit from the first stage estimation (that is, how much would profits be if the developer built in this period given predicted prices and predicted optimal square footage), and fixed costs of development, represented by city (Census PUMA) characteristics and a set of city and year fixed effects.

Murphy finds that properties are less likely to be developed in neighborhoods with higher levels of home ownership, and that the year fixed effects in the model of development timing vary pro-cyclically with aggregate construction levels. While he attributes these effects to variation in construction set-up costs and the regulatory environment, he does not include any measures of these costs (such as the cost and duration of the permit approval process, or changes in the physical attributes of developed parcels) that would distinguish these effects from other macroeconomic factors. However, his paper makes progress in bridging the gap between models of housing supply based on consumption of location-based amenities, and models of housing development by profit-maximizing investors, which I will cover in detail in the next section.

### 2.2.2 Investment-based models of housing supply

#### The present value theory of housing investment

As data on housing investment and house prices became more widely available and geographically detailed, researchers became increasingly interested in testing neoclassical theories of production and investment in the housing sector. The neoclassical model of investment applied in these studies has two representations of essentially the same concept. The earlier version, developed by Jorgenson (1963), derives the optimal capital stock by equating the marginal product of capital with its rental cost. The modified theory, developed by Tobin (1969), posits that the optimal capital stock is that at which the value of the marginal unit of capital in place is equal to its replacement cost; or, the ratio of the two (known as Tobin's $q$) is equal to 1.

Topel and Rosen's 1988 study of aggregate housing investment augments this basic model by introducing pro-cyclical construction costs. The authors estimate the time-series relationship between aggregate housing investment, house prices, and investment costs, and find that housing starts are positively related to house prices and negatively related to the interest and inflation rates and the median time on the market for house sales. To test their hypothesis (implied by cyclicality in costs) that long run and short run supply responses differ, the authors include leading and lagged measures of housing investment as proxies for market adjustment costs, and find that these factors significantly affect the amount of investment in the current period.

Large fluctuations in nominal interest rates in the 1970s, and changes in the tax deductibility of mortgage interest in the 1980s, spurred multiple studies estimating the effects of changes in the user cost of capital on the supply of housing. In his study of the impact of interest rates on the housing market, Poterba (1984) finds that the increase in housing values during the 1970s is primarily driven by decreases in new construction induced by credit costs, which include the carrying costs between the time the building is built and the time that it is sold. Focusing on the effects of changes in tax rates and depreciation provisions, DiPasquale and Wheaton (1992) estimate a significant relationship between the construction of new multifamily units and the user cost of capital. The authors predicted that rents would increase 8 percent in response to the Tax Reform Act of 1986, which reduced the tax benefits of real estate investment by increasing capital gains taxes, modifying depreciation schedules for investment properties, and decreasing marginal income tax rates (and thus the tax deduction for mortgage interest). Using data on rent indices and multifamily construction in Atlanta, Chicago, Dallas, and Oakland, Follain, Leavens, and Velz (1993) confirm DiPasquale and Wheaton's predictions for the supply of rental housing, but find that rents did not increase as predicted.

More recent papers have implemented direct tests of $q$ theory in the housing sector by estimating the relationship between asset values, capital replacement costs, and housing investment. One such paper by Gyourko and Saiz (2003) constructs a measure of average $q$ by dividing property owners' self-reported housing values by an estimate of replacement cost calculated using data on MSA-level average construction costs per square foot. Using data on renovation expenditures from the American Housing Survey, the authors find that owners of properties with average $q$ less than one spend up to 50 percent less on home improvements than do owners of similar homes with market values above construction costs. A subsequent paper by Jud and Winkler (2003) attempts to reproduce this result using quarterly aggregate data on single-family building starts and spending on structures from the National Income and Product Accounts. However, it is not clear how their measure of $q$ - the ratio of the price index of existing homes to the price index of new homes - adequately distinguishes changes in construction costs from changes in relative demand for existing versus new homes.

### Option theory and housing investment

Because of the virtual irreversibility of housing investment, the decision to invest is even more dependent on property owners' expectations of the future price of housing services. An early example of a theory of housing investment under uncertainty is Williams' (1991) derivation of the optimal timing and scale of housing investment. Williams allows property investors to choose both the timing and the density of construction, and incorporates uncertainty in both housing prices and development costs. Using a two-stage solution process, he derives the optimal quantity of housing construction by maximizing the expected value of the developed property, and then determines the optimal threshold value for housing prices by maximizing the value of the undeveloped land, which includes the value of the existing use and the option value of waiting to invest. Williams predicts that increases in the variance of housing prices and of construction costs increase both the threshold value and the optimal density of investment.

In a subsequent study extending the model to allow repeated redevelopment (Williams, 1997) the author finds that the option to redevelop repeatedly is more valuable than the option to (re)develop the property only once, and that investment occurs more frequently and at a lower price threshold when multiple investments are possible. Embedding the investment decision in a competitive market framework, Williams (1993) and Grenadier (1996) incorporate property owners' expectations of general equilibrium effects of additional housing investment on the price of housing services. When developers fear that they will be the last mover in the market, the option value of waiting to invest is eroded relative to the case where individual decisions have no effect on the market price, and housing investment exhibits "cascades" of development when the price of housing services reaches an optimal threshold, during which the price of housing services may even be falling as buildings are completed.

Due to the lack of data on housing investments at a sufficient level of disaggregation, to date there have been few empirical tests of the real options theory of investment in the housing sector. One of the studies addressing this question is Downing and Wallace (2000). The authors model owner-occupiers' decision to make improvements to their property in the real options framework outlined above, with the modification that investments in their model are additions to the existing stock (quantity or quality) of housing, rather than teardown redevelopments as in Williams' model. Using data from the American Housing Survey, the authors test whether the decision to make improvements is positively related to returns to investment in the housing market, negatively related to growth in the cost of housing capital, and discouraged by higher volatility in returns.

Downing and Wallace measure returns to housing investment by the annual percent change in SMSA-level house prices. The cost of housing capital is proxied by the short-term interest rate, and the volatility of housing returns is calculated as the average absolute deviation over the past two years of the spread between house price growth and the interest rate. Controlling additionally for the age of the property, SMSA-level income per capita, and the expected tenure of the homeowner, Downing and Wallace find that homeowners are more likely to make improvements when the spread between the return to housing and the cost of capital is large, and are less likely to invest when the volatility of this spread is large. The authors' approach is innovative among investment-based empirical studies because they focus on homeowners' incremental investments, rather than developers' new construction. A potential extension would be to employ their information on expected homeowner tenure (whether the survey respondents just moved in, or if the house is currently for sale) to distinguish between improvements that are made for own-consumption motivations and improvements that are made with a focus on resale or rental value.

To avoid conflating consumption and investment decisions, the majority of papers that empirically explore the relationship between uncertainty, housing investment, and the value of the option to develop limit their focus to new construction by developers on undeveloped parcels. In one of the earliest studies using housing data to estimate option values, Quigg (1993) models the value of undeveloped commercially-zoned property as a function of the sales price of the optimally-sized building to be built on the property, the construction costs of the building, and the option value of holding the undeveloped property. Using data on commercial property and land transactions in Seattle, she estimates that 6 percent of the sales price of land is generated by option value, and calculates implied annual standard deviations of commercial real estate prices in the range of 18 to 28 percent based on the parameters of the option pricing model.

Incorporating additional data on the timing of development, Cunningham (2006) uses a dataset of residential transactions, land transactions, and information on the development of land parcels in King County, Washington (the Seattle metro area) to examine whether uncertainty in house prices delays development and increases land values. His analysis finds that a one standard deviation increase in house price volatility reduces the hazard of development by 11.3 percent, and increases vacant land prices by 1.6 percent. This effect is strongest in areas of the county furthest from the city center, which suggests that (as predicted by Caballero (1991), Grenadier (2002), and Back and Paulsen (2009)) competition may weaken the relationship between price uncertainty and investment through the threat of preemptive development. A subsequent paper (Cunningham, 2007) demonstrates that regulations which limit housing density - in this case, an urban growth boundary in King County - reduce option value and also weaken the relationship between uncertainty and investment.

Bulan, Mayer, and Somerville (2002) examine the extent to which uncertainty affects housing investment, and also test two additional hypotheses: that the negative relationship between house price uncertainty and investment is driven not by increases in option value, but by a greater exposure to non-diversifiable risk; and that competition erodes option values. Using data on the location and timing of condominium developments in Vancouver, the authors find that increases in both idiosyncratic volatility, as measured by the variance of local prices, and market volatility, as measured by the amount of volatility in the Canadian stock market that covaries with local prices, have a negative impact on the probability of development. Property-specific volatility has a smaller impact on housing investment for properties surrounded by a larger number of potential competitors, and for the properties facing the most competition, idiosyncratic volatility has no effect on the timing of development.

## 2.3 Two models of the effects of uncertainty on investment

The real options theory of investment under uncertainty is the primary framework used to analyze the relationship between price uncertainty and optimal housing investment behavior. However, the theory in its standard form does not account for heterogeneity in investor risk preferences - all investors are assumed to be risk neutral. Moreover, the standard real options theory makes predictions regarding price uncertainty and the optimal *timing* of investment relative to the deterministic case, but does not directly predict how price levels, price growth, or price variance will affect the optimal *quantity* of capital investment. In order to provide a theoretical framework that relates price levels, price growth, and price variance, respectively, to the many different measures of housing investment available in the Los Angeles data, I present both the option theory of investment under uncertainty, and a modified version of the neoclassical investment model that incorporates investor risk aversion and stochastic prices.

The real options theory predicts that investment is more likely to take place when price growth is high, and the standard neoclassical model of capital investment further predicts larger quantities of investment when output prices are higher. Option theory predicts that investment is less likely to occur when price variance is high. Because investment is delayed, there are longer stretches of time between investments in areas with high price volatility than in areas with low price volatility. Assuming similar price growth overall, an indirect prediction of option theory is that investment quantities are larger when price volatility is higher. Modifying the neoclassical model to include investor risk aversion produces different predictions, depending on whether prices are deterministic or stochastic. Under deterministic prices, there is a negative relationship between risk aversion and investment. However, the model predicts larger quantities of investment when uncertainty over future prices increases. The direction of the correlation (negative or positive) depends on the relationship between total investment expenditures and the marginal cost of investment, and the magnitude of the relationship depends on the extent to which investors intertemporally adjust consumption levels in response to firm profitability.

### 2.3.1 Irreversibility, uncertainty, and investment

In the example of capital investment in real estate, the majority of investments are virtually irreversible. When the future profitability of irreversible capital investment is uncertain, there is an 'option value' of waiting to invest to obtain more information on the future path of industry profitability. The additional cost of losing the option to delay investment increases the required profitability level at which investment occurs, and there exists a range of asset prices where investment which would occur in the standard case is delayed. Increases in the uncertainty over future profitability (for example, an increase in the variance of future profits) further increase the threshold profitability level relative to the standard case.[5]

In this model, the decision maker determines the optimal threshold of firm profits at which to make an irreversible capital investment, given the firm's existing capital stock $k$. Firm-level per-period profits are given by

$$\pi = Y \cdot D(G(K))g(k) = YH(k) \ ,$$

where $D(G(K))$ is the industry's inverse demand function as a function of industry-level output $G(K)$, itself a function of aggregate industry capital $K$; $g(k)$ is the individual firm's output as a function of firm-level capital $k$, and $Y$ is a stochastic industry demand shifter which follows a geometric Brownian motion: $dY = \alpha Y dt + \sigma Y dz$. The firm-level profit function $YH(k)$ exhibits decreasing returns to scale.

The decision maker chooses a new level of capital stock $k'$ to maximize the value of the firm:

$$W(k, Y) = YH(k)dt + e^{-\rho dt}(\mathrm{E}[W(k', Y + dy)] - p(k' - k))$$

where $\rho$ is the investor's discount rate and $p$ is the cost of capital per unit. The first term of the maximization problem represents the flow value from existing capital stock $k$, and the second term is the discounted value of the firm at time $t + dt$ with adjusted capital stock $k'$.

To solve this dynamic programming problem, it is helpful to think about the firm's value function at the optimal level of capital stock. When Y changes and the firm is at (or above) the optimal level of capital, $k' \leq k$ and the firm takes no action to change the amount of capital investment. Optimal capital investment is defined by the boundary of this "range of inaction", where $k' = k$. Following this reasoning, we can rewrite the firm's value function at the optimal level of capital investment as

$$W(k, Y) = YH(k)dt + e^{-\rho dt}(\mathrm{E}[W(k, Y + dy)] \ .$$

Using Ito's Lemma, this value function can be expanded and rewritten as

$$W(k, Y) = YH(k)dt + (1 - \rho dt)[W(k, Y) + \alpha Y W_Y(k, Y)dt + \frac{1}{2}\sigma^2 Y^2 W_{YY}(k, Y)]dt \ .$$

The general solution for this partial differential equation (which is actually a differential equation in $Y$) is:

$$W(k, Y) = B_1(k)Y^{\beta_1} + B_2(k)Y^{\beta_2} + \frac{YH(k)}{\rho - \alpha}$$

where $\beta_1$ and $\beta_2$ are the positive and negative roots of the characteristic equation: $\frac{1}{2}\sigma^2\beta(\beta - 1) + \alpha\beta - \rho = 0$, and $B_1$ and $B_2$ are constants of integration that can be derived by considering the following boundary conditions, which follow from standard first-order conditions for capital investment:

[5] The following exposition is based on the model of optimal incremental investment under uncertainty outlined in Dixit and Pindyck (1994, ch.11). Readers interested in the derivations of these results can refer to the text as a guide.

| | | |
|---|---|---|
| (Y $\to$ 0) | $B_2(k) = 0$ | |
| (Y $\to$ investment threshold) | $W_k(k, Y) = p \to$ | $B_1'(k)Y^{\beta_1} + \frac{YH'(k)}{\rho-\alpha} = p$ |
| (Smooth pasting condition) | $W_{kY}(k, Y) = \frac{\partial}{\partial Y}(p) \to$ | $\beta_1 B_1'(k)Y^{\beta_1 - 1} + \frac{H'(k)}{\rho-\alpha} = 0$ |

The first boundary condition ensures that firm value is zero when industry demand $Y$ is zero. The second condition, also known as the value-matching condition, is analogous to the first-order condition with respect to investment in the standard case: invest up to the point where the marginal value of an additional unit of capital equals the marginal cost of capital. However, in this case the marginal value to the firm of an additional unit of capital investment includes the expected contribution to the capitalized profit flow, $\frac{YH'(k)}{\rho-\alpha}$, and the opportunity cost of the lost option to wait, $B_1'(k)Y^{\beta_1}$. The smooth pasting condition ensures that the choice of profitability level $Y$ at which investment occurs is optimal given the dynamics of the profit function $YH(k)$ and costs $p$ around the maximum.

Combining the latter two conditions yields the following investment rule. Invest when the demand shock

$$Y_t \geq \frac{\beta_1}{\beta_1 - 1} \cdot \frac{(\rho - \alpha)p}{H'(k)} \text{ or; } \frac{Y_t H'(k)}{\rho - \alpha} \geq \frac{\beta_1}{\beta_1 - 1} p \ .$$

This rule predicts that firms will invest in additional capital when the discounted expected present value of the marginal unit of capital $k$ (the first term in the second inequality) is greater than or equal to the per-unit cost of a unit of capital, $p$, multiplied by an "option premium" $\frac{\beta_1}{\beta_1 - 1}$ (the second term in the second inequality).

When demand for industry output $Y$ is higher, investment is more likely to occur. In addition, the mean and variance of the demand shifter $Y$ enter the function for the investment threshold in two ways. When the growth rate of industry-level demand $\alpha$ increases, $\rho - \alpha$ decreases and the optimal profitability threshold at which investment occurs decreases. Thus, for a given level of output prices, investment is more likely to occur when the expected growth in profitability is higher. When uncertainty over future profits (as measured by the variance of industry demand $\sigma$) increases, $\beta_1$ decreases and the optimal profitability threshold at which investment occurs increases.

This general formula can be interpreted more clearly using an example.[6] In this model, a building of size $q$ yields a flow profit of $qx_2$, and can be built at a cost of $q^\gamma x_1$, $\gamma > 1$. The profit per unit of housing, $x_2$, follows a geometric Brownian motion: $dx_2 = \mu_2 x_2 dt + \sigma_2 x_2 dz$, and the cost per unit of housing, $x_1$, grows at a constant rate equal to the rate of interest $r$. The existing capital stock $\beta$ yields a profit of $\beta x_2$, $\beta < 1$.

The decision maker chooses a new level of investment $q$ (to replace the existing capital stock $\beta$) and a profit threshold $x_2$ to maximize the value of the undeveloped property:

$$W(x_1, x_2) = \beta x_2 + e^{-rdt}(E[W(rx_1, x_2 + dx_2)]) - q^\gamma x_1$$

The value of the developed property at any given time, $P(x_2)$, can be derived from a similar Bellman equation and equals $\frac{1}{r - \mu_2 + \lambda_2 \sigma_2} qx_2$, where $\lambda_2$ is the excess mean return per unit of standard deviation of the stochastic process $x_2$. Using this, the optimal profit threshold $x_2^*$ given the cost of

[6] This example is similar to the model of Williams (1991), with simplified costs of housing investment that grow at a constant rate equal to the rate of interest. Readers interested in the derivations of the following results can refer to the article as a guide.

investment $x_1$ can be derived. To simplify the notation, define $y = \frac{x_2}{x_1}$, and $\pi = r - \mu_2 - \lambda_2\sigma_2$. The solution for this Bellman equation is

$$W(y) = \pi\beta y + \pi(q - \beta)y^* - q$$

subject to the following boundary conditions:

| | |
|---|---|
| (y $\rightarrow$ 0) | $W(0) = 0$ |
| (y $\rightarrow$ investment threshold) | $W(y) = \pi q y^* - q^{*\gamma}$ |
| (Smooth pasting condition) | $W'(y) = \pi q$ |

With the additional profit-maximizing constraint for the quantity of capital invested,

$$q^* = \arg\max_q \{\pi q x_2 - q^\gamma x_1^*\}$$

there exist analytical solutions for $q^*$ and $y^*$:

$$q^* = \frac{\beta\gamma}{\gamma - 1}$$
$$y^* = \frac{\gamma}{\pi}\frac{\beta\gamma}{\gamma - 1}^{\gamma-1} = \frac{\gamma}{r - \mu_2 + \lambda_2\sigma_2}\frac{\beta\gamma}{\gamma - 1}^{\gamma-1}$$

In this example, the optimal amount of capital investment depends only on the cost of investment and the value of the existing use. In contrast, the threshold profit level at which investment occurs depends clearly on the mean and variance of the stochastic process $x_2$. When the expected growth rate of per-period profits $\mu_2$ increases, the threshold profit level decreases, and investment is more likely. When the variability of the future profit stream $\sigma_2$ increases, the profitability threshold at which investment occurs increases.

This derivation assumes that the marginal product of capital is linear in $x_2$. If instead per-period profits were a concave function of $x_2$; for example, $\pi(x_2, q) = (qx_2)^\theta, \theta < 1$, greater uncertainty in $x_2$ would imply a smaller expected present value of the marginal unit of capital and an even higher value for the investment threshold for $x_2$. This effect could also be captured by using the original per-period profit function $qx_2$, but incorporating a risk-averse decision maker whose marginal utility of profits is concave. The effects of incorporating risk aversion into the investment decision will be explored in more detail, using a simpler model of decision-making, in the following section.

### 2.3.2 A neoclassical model of capital investment

In a standard model of capital investment where capital levels can be flexibly increased or decreased, the decision-maker maximizes the present value of firm profits

$$\Pi = \int_{t=0}^{\infty} e^{-rt}[\pi(K(t))k(t) - I(t) - C(I(t))]dt$$

where $r$ is the discount rate, which is set to the risk-free interest rate; $\pi(K(t))k(t)$ is the per-period profit function, where $\pi(K(t))$ is the industry-wide profit shifter and depends on total capital in the industry, $K(t)$, and $k(t)$ is the firm's capital stock at time $t$; $I(t)$ is the amount of investment at time $t$; and $C(I(t))$ is the cost to the firm of adjusting the capital stock.[7] Firm-level capital evolves according to the process $k(t+dt) = k(t) + I(t)dt$. The per-unit cost of capital is 1.[8]

The corresponding value function for this maximization problem is

$$W(k(t), I(t)) = (\pi(K(t))k(t) - I(t) - C(I(t))) + q(t)I(t)$$

where the first term in parentheses is the current flow value of firm profits, and the second term is the level of investment multiplied by the marginal effect of an additional unit of investment on the lifetime discounted value of the firm's profits, represented by $q(t)$. The first-order condition for this maximization with respect to the level of investment $I(t)$ is

$$1 + C'(I^*(t)) = q(t)$$

or, the marginal contribution of an additional unit of investment to firm value equals the marginal cost of an additional unit of investment at the optimum level of investment. Additionally, the optimal level of investment must satisfy a first-order profit-maximization condition with respect to the total level of firm capital $k(t)$:

$$\pi(K(t)) = rq(t) - dq(t), \text{ where } dq(t) = \frac{dq(t)}{dt}$$

or, the marginal revenue product of capital at the optimal level of capital equals the opportunity cost of a unit of capital - the risk-free return on a unit of capital in asset markets minus the appreciation in firm value from an additional unit of capital. In this model, $q(t)$ equals (integrating the above equation over $t = 0 \to \infty$

$$\int_{t=\tau}^{\infty} e^{-r(\tau-t)}\pi(K(\tau))d\tau$$

which is the common measure known as marginal $q$. Thus, in this simple model the firm's investment rule is to increase its capital stock if the market value of a marginal unit of capital exceeds the marginal costs plus the adjustment costs of acquiring an additional unit of capital.

### 2.3.3 Investor risk aversion, uncertainty, and investment

When the investor's utility from profits is linear, uncertainty has no effect on the optimal investment rule in this model. The decision maker increases the firm's capital stock until the *expected* market value of a marginal unit of capital (which equals the present discounted value of the stream of expected future marginal revenue products) equals the marginal costs of expanding the capital stock. If the investor exhibits risk aversion - that is, his utility function is a concave function of profits - the problem must be adjusted to account for this. Introducing risk aversion in the absence of uncertainty can cause the optimal amount of capital investment to be lower, relative to the standard case, when industry profitability is high, because introducing diminishing marginal utility causes the investor to intertemporally substitute consumption towards the current period when future

[7] Since the firm's production exhibits constant returns to scale in capital, it is necessary to introduce adjustment costs that are convex in the amount of investment so that the firm's optimal investment rate when industry profitability increases is not infinite.

[8] In the real estate market, the per-period profit is the price of housing services or housing rents, and the present value of per-period profits is equal to the house price, or the value of the housing asset.

profitability increases. In contrast, when future profitability is uncertain, and this uncertainty over future profitability increases, or the covariance between the investor's total income and industry profitability increases, the model predicts that the optimal quantity of capital investment is higher than in the standard case.

Given a concave utility function $u(x)$, the decision-maker maximizes the present value of utility

$$U(\Pi) = \int_{t=0}^{\infty} e^{-\rho t} u(\pi(K(t))k(t) - I(t) - F(I(t)))dt$$

where $\rho$ is the discount rate and $F(I(t))$ is the cost to the firm of adjusting the capital stock. All other variables and functions are defined as in the standard case, and firm-level capital evolves according to the process $k(t + dt) = k(t) + I(t)dt$. The per-unit cost of capital is again 1.

The corresponding value function for this maximization problem is

$$W(k(t), I(t)) = u(\pi(K(t))k(t) - I(t) - F(I(t))) + \lambda(t)I(t)$$

where the first term in parentheses is the current flow utility of firm profits, and the second term is the level of investment multiplied by the marginal contribution of an additional unit of investment to the lifetime discounted utility of the firm's profits, represented by $\lambda(t)$. Define 'cash flow' $c(t) = \pi(K(t))k(t) - I(t) - F(I(t)) + x(t)$, where $x(t)$ is the investor's other income from sources that are not determined by firm profits but may be correlated with firm profits.

The first-order condition for this maximization with respect to the level of investment $I(t)$ is

$$u'(c(t))(1 + F'(I^*(t))) = \lambda(t)$$

or, the marginal utility of an additional unit of investment equals the marginal utility cost of an additional unit of investment at the optimal level of investment. Additionally, the optimal level of investment must satisfy a first-order utility maximization condition with respect to the total level of firm capital $k(t)$:

$$u'(c(t))\pi(K(t)) = \rho\lambda(t) - d\lambda(t), \text{ where } d\lambda(t) \text{ defined as above.}$$

Integrating over $t = 0 \to \infty$ and combining with the first-order condition for investment yields the following investment rule: Invest up to the point where

$$1 + F'(I^*(t)) = \frac{1}{u'(c(t))} \int_{t=\tau}^{\infty} e^{-\rho(\tau - t)} u'(c(\tau))\pi(K(\tau))d\tau \ .$$

In this case, the decision maker increases the firm's capital stock until the marginal cost of an additional unit of investment equals the value of a marginal unit of capital, which equals the present discounted utility value of the sum of future marginal revenue products, relative to the utility value of today's consumption.

For risk neutral investors, $u'(c(\tau)) = 1$ regardless of industry profitability. For risk averse investors, $u'(c(\tau))$ varies with the investor's cash flow, which itself depends on industry profitability. If firm profits are a significant element of cash flow, or if other sources of cash flow $x(\tau)$ are highly correlated with industry profitability, when industry profits increase $u'(c(\tau))$ decreases relative to

$u'(c(t))$. Assuming that capital investment costs $I^*(t) + F(I^*(t))$ are small relative to total cash flow, so the decrease in cash flow resulting from investment does not offset the increase in cash flow resulting from increased firm profitability, the effect of a decrease in $u'(c(\tau))$ relative to $u'(c(t))$ implies that the decision maker's investment response is attenuated under risk aversion relative to the standard case, even in the absence of uncertainty over the project's future profitability.

When there is uncertainty over the path of $\pi(K(\tau))$ in the future, the investment rule can be written as

$$\begin{aligned} 1 + F'(I^*(t)) &= \frac{1}{u'(c(t))} \int_{t=\tau}^{\infty} e^{-\rho(\tau - t)} \, \mathrm{E}_t[u'(c(\tau))\pi(K(\tau))] d\tau \\ &= \frac{1}{u'(c(t))} \int_{t=\tau}^{\infty} e^{-\rho(\tau - t)} \left( \mathrm{E}_t[u'(c(\tau))] \, \mathrm{E}_t[\pi(K(\tau))] + \mathrm{Cov}(u'(c(\tau)), \pi(k(\tau))) \right) d\tau \ . \end{aligned}$$

There are three ways that risk aversion affects investment choice under uncertainty. First, the fact that $\mathrm{E}_t[u'(c(\tau))]$ differs from $u'(\mathrm{E}_t[c(\tau)])$ affects the optimal level of investment relative to the standard model. For any uncertain cash flow, a concave utility function implies that $\mathrm{E}_t[u'(c(\tau))] > u'(\mathrm{E}_t[c(\tau)])$, and this difference increases as the utility function becomes more concave. Thus, as an investor's risk aversion increases, the optimal value of the marginal cost of capital increases relative to the standard case, and the optimal investment amount for a given expected path of industry profits $\pi(K(\tau))$ increases.

Similarly, for two distributions of stochastic cash flow, $c_h(\tau)$ and $c_l(\tau)$, with the same expected value but the variance of $c_h(\tau)$ exceeding that of $c_l(\tau)$, concavity also implies that $\mathrm{E}_t[u'(c_h(\tau))] > \mathrm{E}_t[u'(c_l(\tau))]$. Therefore, if the distribution of industry profitability $\pi(K(\tau))$, or other elements of investor cash flow, increase in variance, the optimal investment amount at time $t$ also increases.

Finally, uncertainty in industry profitability and in investor cash flow both affect the optimal amount of investment via their covariance. If the covariance of industry profitability and investor cash flow is positive, which could happen if the flow profits from the investment represent a significant proportion of the investor's cash flow, or if the investor's portfolio contains assets whose values covary positively with the investment opportunity, then the optimal level of investment will be higher than in the standard case.

### 2.3.4 Empirical implications

Recalling the results of the model of irreversible investment under uncertainty,

$$\begin{aligned} q^* &= \frac{\beta\gamma}{\gamma - 1} \\ y^* &= \frac{\gamma}{\pi} \frac{\beta\gamma}{\gamma - 1}^{\gamma - 1} = \frac{\gamma}{r - \mu_2 - \lambda_2\sigma_2} \frac{\beta\gamma}{\gamma - 1}^{\gamma - 1} \end{aligned}$$

for any given level of output prices $x_2$, the probability of investment is higher when the expected growth rate of future output prices $\mu_2$ is higher, and the probability of investment is lower when the variability of output prices $\sigma_2$ is higher. In this model, the optimal quantity of capital investment does not depend on $\mu_2$ or $\sigma_2$. However, I am also interested in measuring the effects of price fluctuations on the quantity of investment. Recalling the results of the model of reversible capital investment under uncertainty,

$$1 + F'(I^*(t)) = \frac{1}{u'(c(t))} \int_{t=\tau}^{\infty} e^{-\rho(\tau - t)} \left( \mathrm{E}_t[u'(c(\tau))] \, \mathrm{E}_t[\pi(K(\tau))] + \mathrm{Cov}(u'(c(\tau)), \pi(k(\tau))) \right) d\tau \ ,$$

the optimal quantity of capital investment is increasing in output prices, in the variance of output prices, in investor risk aversion, and in the amount of covariance between property cash flow and income from other sources.

In the housing sector, the present discounted value of the future stream of per-period output prices (rents) is equivalent to the property value. Thus, increases in the expected growth rate of rents, $\mu_2$, can be measured by increases in house prices. Fluctuations in housing values capture changes in expectations of the future price of housing services, and when rents are more volatile, house prices are also more volatile. Thus, increases in the variability of rents, $\sigma_2$, can be proxied by increases in the variance of housing values.[9]

Although my datasets do not include information on property owners' income, employment, or any other information that would be useful in measuring risk aversion and the amount of covariance between real estate income and other sources of income, I can distinguish between owner-occupiers and nonresident landlords, and I have information on the type of investment made to the property - new construction or improvements to an existing building. Owners of renter-occupied property are likely to be more risk averse than owner-occupiers because owner-occupiers' housing consumption expenditures are hedged by implicit rent payments (see Sinai and Souleles, 20xx; and Banks et al, 2004) while landlords rely on monthly rental payments from tenants to cover property-related expenses. Similarly, developers building new houses are likely to be more able to hedge house price variation than less-sophisticated property owners making investments on a smaller scale (see Case, Shiller and Weiss, 1991). Thus, I estimate the relationship between house price variation and the value and square footage of investment for all properties, and separately for four groups: owner-occupied and renter-occupied properties, and new construction and improvements to existing buildings. According to the modified neoclassical model, the positive relationship between house price variance and the value/square footage of investment should be more pronounced for renter-occupied properties and for improvements to existing construction.

## 2.4 Description of data and summary statistics

### 2.4.1 House Price Data

My data on house prices and housing characteristics in Los Angeles are from a California-based real estate company that collects data from county records offices and annual property tax assessments. Tax assessment data are used to ensure that the property characteristics are updated annually and reflect any improvements made to the property. The data include all property parcels (both developed and undeveloped) in the county of Los Angeles, and are identified by the Assessment Parcel Number (APN), which is a unique identifier for each property. The data include the property's address and Census tract, property use (e.g. residential, commercial, government-owned, among other categories), and whether the owner claims the homeowner's tax exemption for the property, which I use to distinguish owner-occupiers from nonresident landlords. Property characteristics include the building square footage, the number of units, bedrooms, and bathrooms in the building, the year built, the type of heating, air conditioning, and pool (if any), the assessor's evaluation of

[9] The volatility of housing prices is likely to be higher than the volatility of rents because of the long-term nature of rental contracts, and because year-to-year changes in rents are capitalized into housing prices as an expected change in the lifetime stream of rents. However, geographically detailed data on rents is difficult to obtain. Therefore, I use the volatility of housing prices as a proxy for the volatility of the price of housing services.

building quality based on building materials and construction type, and the assessed value. Most importantly, the data include the date and sales price of the last three transactions for the property, which I use to construct a quality-adjusted price index for each neighborhood in the city.

Table 2.1 provides some basic facts about the properties in the dataset. The table displays the median sales price, square footage, and age of properties in the dataset, as well as the 25th and 75th percentiles of the distribution of these variables across the entire city, and the minimum and maximum values of these variables for properties in the dataset. There are 539,573 unique residential properties in the city of Los Angeles that have transacted between 1995 and 2007 in the data, and 630,909 transactions for these properties.[10] Around 51 percent of the properties are owner-occupied, and the median sales price in 2006 was approximately $376,000. The median building size is 1580 square feet, and the median building age is 49.

I obtain neighborhood geographic definitions from the Los Angeles Almanac, an index of information on the city and county of Los Angeles published by Given Place Media. The Almanac uses zip code, city planning, and neighborhood council maps to define 81 neighborhoods within the city of Los Angeles, and provides a listing of Census tracts included in each neighborhood.[11] Figure 2.2 maps the city and neighborhood boundaries. The blank areas enclosed in the city boundaries represent cities, such as Beverly Hills and Santa Monica, that are not part of the city of Los Angeles. Neighborhoods in Los Angeles vary greatly in geographic size and population, predominant housing type, socioeconomic composition of the population, and physical attributes of the land, features which will be explored in more detail in this section.

Figures 2.3 through 2.8 display the geographic distribution of selected neighborhood-level median property characteristics and socioeconomic outcomes across Los Angeles, and Table 2.2 displays the neighborhood-level median values of these characteristics for selected neighborhoods. For each neighborhood, I calculate the median sales price in 2006, median building square footage, and median age of buildings in the neighborhood. Figure 2.3 displays the geographic distribution of median sales price (unadjusted for differences in property characteristics), Figure 2.4 displays the distribution of median square footage, and Figure 2.5 displays the distribution of median building age, across neighborhoods. As expected, Figure 2.3 shows that the more-desirable coastal areas to the west have the highest median sales prices, while the inland areas to the east and south have lower prices. Figures 2.4 and 2.5 show that the more expensive areas also have more recently built and larger buildings. These figures also display more interesting aspects of specific neighborhoods in the city. For example, although the neighborhoods of Silver Lake, Echo Park and adjacent areas are not among the most expensive areas in Los Angeles, the median building size among properties in these neighborhoods is higher than in other neighborhoods, suggesting that multi-unit housing is a larger share of the housing stock in these neighborhoods than in others. Also, these figures indicate that more expensive suburban development is occurring to a greater extent in outlying neighborhoods to the northwest, such as Porter Ranch and Chatsworth, than in neighborhoods to the northeast of the city.

[10] I use the Census place definition of the boundaries of the city of Los Angeles to determine which Census tracts belong to the city.

[11] See http://www.laalmanac.com/LA/la99.htm for a listing of 2000 Census tracts by neighborhood. These neighborhoods are defined at a finer level of geography than the 5 Area Planning Commissions defined by the Los Angeles Department of City Planning. While the Department of City Planning also defines smaller Certified Neighborhood Council areas, these regions do not cover the entire city. Although a number of Census tracts can be said to straddle more than one community, and some even straddle city boundaries, the Almanac's community boundaries strictly follow census tract boundaries.

The first panel of Table 2.2 displays the median values of the above characteristics - sales price, square footage, and building age - for 5 selected neighborhoods: Wilshire, Central City, Arleta, Brentwood, and South LA. These neighborhoods were chosen because they represent different points in the distribution of neighborhoods by size - size meaning number of properties in the neighborhood - across the 81 neighborhoods in the sample. Wilshire has 2,774 properties within its geographic boundaries, the smallest neighborhood in Los Angeles.[12] In contrast, the largest neighborhood of South LA has 41,346 properties. Arleta, a neighborhood in the middle of the size distribution, has 5,352 properties. Central City and Brentwood are at the 25th and 75th percentile of this size distribution, with 5,031 and 9,585 properties, respectively. Although these neighborhoods were not selected for their diversity in other characteristics, fortunately these neighborhoods are also very different with respect to other housing and socioeconomic characteristics, and together they display the overall diversity of neighborhoods across the city of Los Angeles.

Figure 2.6 displays the percentage of residential properties that are owner-occupied in each neighborhood, Figure 2.7 shows the population density (number of residents per square kilometer) in each neighborhood, and Figure 2.8 displays the median household income in each neighborhood. Although Los Angeles famously lacks a single urban center, the population density is highest in the area surrounding the Central City neighborhood and in the beach neighborhoods south of Santa Monica. Larger, newer homes are located in the less-dense neighborhoods to the north and west, and smaller, older homes are clustered in the more heavily urbanized neighborhoods to the east and south. The geographic distribution of household income and of owner-occupied status are almost equivalent, with the exceptions of the Canoga Park - Van Nuys - North Hollywood “South Valley” area, and the neighborhoods west of South LA, which have a higher share of owner-occupiers compared to neighborhoods of similar income level. This may be explained by the lower housing prices in these areas compared to neighboring areas. The second panel of Table 2.2 shows the values of these economic and demographic outcomes for the 5 selected neighborhoods identified above. As mentioned before, there are large differences in these characteristics across neighborhoods. The percent of properties that are owner-occupied varies from 56.7 percent in Brentwood, where the median household income is over $100,000, to 22.4 percent owner-occupied in Central City, where median household income is a much lower $14,000. It is interesting to note, however, that two neighborhoods with almost identical median household incomes - Wilshire and South LA - have very different shares of the housing stock that is owner-occupied - 28.6 percent and 40.6 percent, respectively. The diversity of housing market characteristics across neighborhoods with similar socioeconomic composition implies that it is less likely that these socioeconomic outcomes are confounding the effects of housing characteristics on house prices, which makes it easier to obtain unbiased quality-adjusted estimates of housing values, a process which I describe in the following section.

[12] Although the neighborhoods of Chinatown and Central City East have fewer residential properties, I merge these neighborhoods with Central City in my analysis because the sample size of sales observations by year is too small to generate meaningful estimates of quality-adjusted prices by housing type. As a result of this merge, Wilshire is the smallest neighborhood in my sample of neighborhoods.

### 2.4.2 Constructing a neighborhood-level house price index

There are many approaches to calculating a price index for housing.[13] The most simple house price indices track the average or median price of housing in a given geographic area over time. While easy to calculate, these indices do not account for changes in the quantity and quality of housing over time. Repeat sales indices attempt to control for changes in observable housing quantity or quality by comparing the initial and subsequent sales prices of a single house over time. These indices are more data-intensive than the median house price index, often include houses whose characteristics have changed over time (the widely-used index calculated by the Office for Federal Housing Enterprise and Oversight does not make adjustments for improvements made to the houses in its sample), and are subject to revision as new sales observations enter the dataset. Moreover, it is not possible to calculate changes in the relative value of different housing characteristics using a repeat-sales index. Therefore, my analysis uses a hedonic price index to calculate changes in house prices, accounting for changes in the relative value of different attributes of the house.

I use the following log-linear hedonic specification to estimate the relative values of housing characteristics:

$$\ln P_{ijt} = \alpha_{jt} + X_{ijt}\beta_{jt} + \varepsilon_{ijt}$$

where $P_{ijt}$ is the price of house $i$ in neighborhood $j$ in year $t$, and $X_{ijt}$ is a matrix of housing characteristics. Included in $X_{ijt}$ are the log of the house's square footage, building age and age squared, and dummy variables for the number of units in the building, whether it is owner-occupied, and whether it has air conditioning or a pool. $\beta_{jt}$ is a vector of neighborhood-year specific coefficients representing the relative value of each characteristic in each neighborhood for each year, and $\varepsilon_{ijt}$ is a normally distributed error.

I divide my sample of 630,909 sales observations into 2,464 cells, one cell for each of 77 neighborhoods and 32 years (1976-2007), and estimate the hedonic regression described above for the observations in each cell. Each of the over two thousand hedonic regressions produces a set of coefficients $\beta_{jt}$ for each year within each neighborhood.[14] Table 2.3 describes the size distribution of these cells for the 1,001 regressions, one for each of 77 neighborhoods and 13 years (1995-2007), that I use in my analysis of housing investment. The minimum sample size for these hedonic regressions is 30, and the median sample size for these neighborhood-year cells is 388. The most precisely estimated of these regressions produces an R-squared of 0.745, while the median R-squared among these regressions is 0.20.

Tables 4 and 5 report the results of the hedonic regression analysis for two neighborhoods: Brentwood and South LA. Each row of the table represents a separate regression, one for each year. In both neighborhoods, owner-occupied properties are worth less relative to owner-nonresident properties; square footage, air conditioning, and a pool increase the value of the property; and older buildings are worth less than newer buildings. Observing changes in the magnitude of the coefficients within each neighborhood over time reveals interesting patterns and differences across neighborhoods. For example, the relative value of square footage (as represented by the coefficient

[13] For a good overview of the many different methods of calculating house price indices, see Bourassa et. al., 2005 and Quigley et. al., 2006.

[14] I exclude land parcels and trim the upper and lower 5 percent of sales prices and square footage by neighborhood. This is to censor transactions that are plausibly not "arms-length" transactions, and to censor observations of large properties (such as high-rise apartment buildings) that are not generally representative of the neighborhood housing stock.

on log square footage) is decreasing over time in Brentwood, but remains relatively constant over time in South LA. In general, square footage is a more important component of value in Brentwood than in South LA. These differences generate variation in prices and price variance across neighborhoods, and within neighborhoods over time, that identifies the effect of prices and price variance on investment activity.

To calculate quality-adjusted measures of house prices by neighborhood and year, I create a "neighborhood-level median house" by calculating the median values of square footage, age, number of units, owner-occupied status, and presence of air conditioning or pool across all properties, in each neighborhood. For each neighborhood, I predict the value of its "median house" in each year using the neighborhood-year specific coefficients calculated above. Using this approach, differences in predicted house prices across time reflect changes in demand for a given bundle of housing characteristics and location-based amenities, and not changes in the quantity or quality of the housing stock. Moreover, by creating a different "median house" separately for each property type, I can calculate a type-specific price index for any category of residential property within a neighborhood. For example, I can divide the sample of houses in each neighborhood into single-family and multi-unit properties, calculate the median values of the above property characteristics separately for each sample, and compare the price dynamics of single-family and multifamily properties within a neighborhood over time. This is of particular interest in the current project because property owners might respond more to the price dynamics of houses similar to their own than to house price dynamics in the neighborhood in general. In theory, it is possible to calculate a different price index for each house in the sample, and use each house's property-specific price dynamics to analyze investment behavior. Increasing the granularity and specificity of house price indices is a promising area for future research (see MacDuff (2008) for an overview of research in this area).

Figure 2.9 displays the geographic distribution of quality-adjusted prices across neighborhoods in 2006, and Figures 2.10 and 2.11 graph the average (over all neighborhoods) price index over time for three groups: all properties, and owner-occupied versus renter-occupied properties. As Figure 2.9 indicates, adjusting house prices for differences in housing characteristics has little effect on the geographic distribution of prices, but compresses the distribution of prices overall by adjusting prices on the high end for differences in size and quality. Average prices in Los Angeles rose in the mid-to-late 1970s and again in the mid-to-late 1980s, but the growth in housing prices during these previous housing booms was dwarfed by the behavior of house prices during the recent episode. During the previous housing cycles, the price of rental properties grew at a slower pace than owner-occupied prices, but during the 2000s the price of rental property grew by more than owner-occupied prices, perhaps reflecting the intense speculative nature of the recent boom.

Figures 2.12 and 2.13 plot the one and five-year price change between 2005 and 2006, and between 2001 and 2006, for each neighborhood. While most neighborhoods experienced price declines between 2005 and 2006, particularly neighborhoods that experienced strong price growth during the previous five years, prices were up overall between 2001 and 2006. Strikingly, many of Los Angeles' inner-city neighborhoods (such as South LA, Southeast LA, and Watts) experienced almost zero growth in prices during the housing boom.

Figure 2.14 graphs the quality-adjusted price index over time for the 5 neighborhoods described in Table 2.2, and Figure 2.15 graphs the price index for 5 additional neighborhoods: Cypress Park, Harbor City, Hyde Park, Lake Balboa, and Hollywood. These neighborhoods were also chosen to represent small, medium, and large neighborhoods. Cypress Park is the second-smallest neighborhood in the sample of neighborhoods, with 3,299 properties, Hollywood is the second-largest neighborhood with 26,904 properties, and the others fall in between. Prices in these neighborhoods follow similar trends over time, although there is substantial variation across neighborhoods in a given year. The neighborhoods with fewer properties seem to have somewhat higher price volatility than the larger neighborhoods. I will explore the potential correlation between neighborhood size and price volatility in calculating the neighborhood-level price variance.

### 2.4.3 Constructing measures of house price variance

There are also many ways to measure property owners' uncertainty about future prices. Investors in other markets typically examine the observed volatility of the traded asset over the recent past. Other papers using house price variance as an independent variable calculate the variance of prices over a horizon ranging from 2 periods (Downing and Wallace (2000)) to 8 periods (Bulan, Mayer, and Somerville (2007)). My initial measure of house price variance in each year $t$ is the simple variance of housing prices in neighborhood $j$ during the previous 5 years:

$$\sigma^2_{p,jt} = \frac{1}{N}\sum_{k=1}^{N}\left(P_{j,t-k} - \overline{P}_{j,t}\right)^2 \;\; ; \;\; N = 5 \; .$$

While this measure of price variance is straightforward and easy to calculate, the analysis is complicated by the fact that real estate markets lack many features of more complete asset markets such as numerous buyers and sellers, modest holding costs and a homogeneous good. As a result, one can often forecast housing prices in the near term (Case and Shiller, 1989). If price growth in neighborhood A is higher than in neighborhood B, the measured variance in prices in neighborhood A will appear to be larger than in neighborhood B because prices increased by more, but these changes may have been anticipated by property owners. To address this issue, I construct an adjusted measure of price variance by calculating the variance of residuals from an autoregressive pricing model:

$$P_{jt} = \alpha_{0j} + \alpha_{1j}P_{j,t-1} + \varepsilon_{jt} \; ;$$
$$\sigma^2_{p,jt} = \frac{1}{N}\sum_{k=1}^{N}\left(\widehat{\varepsilon}_{j,t-k} - \overline{\widehat{\varepsilon}}_{j,t}\right)^2 \;\; ; \;\; N = 5 \; .$$

This adjusted measure of price variance controls for property owners' expectations of price growth based on previous prices by measuring the variance of *unexpected* price fluctuations.

My analysis is further complicated by the fact that my preferred measure of housing values is not an average or median selling price, but is derived from neighborhood-specific estimates of the value of different housing characteristics in each year. Since there is variation in the number of transactions in each neighborhood and year because each neighborhood is a different size, my quality-adjusted estimates of house prices have a neighborhood-year specific estimation variance $\eta_{jt}$:

$$P_{ijt} = \alpha_{jt} + X_{ijt}\beta_{jt} + \eta_{ijt} \;\rightarrow\; \widehat{P}_{jt} = P_{jt} - \eta_{jt}$$

which enters the autoregressive model of housing prices used to adjust house price variance estimates for anticipated price growth:

$$\widehat{P}_{jt} = \alpha_{0j} + \alpha_{1j}\widehat{P}_{j,t-1} + \varepsilon_{jt} + (\eta_{jt} - \alpha_{1j}\eta_{j,t-1}) \; .$$

In other words, because the prices used to estimate the adjusted price variance are themselves estimated prices, some of the measured variance in quality-adjusted house prices, Var $(\widehat{\varepsilon}_{jt})$, comes from the variance of the estimator, $\varepsilon^{\eta}_{jt}$, and not from true variation in house prices $\varepsilon^{P}_{jt}$:

$$\widehat{\varepsilon}_{jt} = \left(\widehat{P}_{jt} - (\alpha_{0j} + \alpha_{1j}\widehat{P}_{j,t-1})\right) - (\eta_{jt} - \alpha_{1j}\eta_{j,t-1}) \equiv \widehat{\varepsilon}^{P}_{jt} - \widehat{\varepsilon}^{\eta}_{jt} \ .$$

$$\begin{aligned}
\text{Var } \widehat{\varepsilon}_{jt} &= \frac{1}{N}\sum_{k=1}^{N}\left(\widehat{\varepsilon}_{j,t-k} - \overline{\widehat{\varepsilon}_{j,t}}\right)^2 \\
&= \sum_{k=1}^{N}\left((\widehat{\varepsilon}^{P}_{j,t-k} - \widehat{\varepsilon}^{\eta}_{j,t}) - (\overline{\widehat{\varepsilon}^{P}_{j,t-k} - \widehat{\varepsilon}^{\eta}_{j,t}})\right)^2 \\
&= \frac{1}{N}\sum_{k=1}^{N}\left(\widehat{\varepsilon}^{P}_{j,t-k} - \overline{\widehat{\varepsilon}^{P}_{j,t}}\right)^2 - \frac{1}{N}\sum_{k=1}^{N}\left(\widehat{\varepsilon}^{\eta}_{j,t-k} - \overline{\widehat{\varepsilon}^{\eta}_{j,t}}\right)^2 + \text{second-order errors.}
\end{aligned}$$

The second term of the last equation is equal to the variance of residuals from a first-order autoregressive model of the hedonic price regression errors $\eta_{jt}$. Because of this dependence, the variance of quality-adjusted prices might be correlated with neighborhood-level characteristics, such as number of properties and homogeneity of the housing stock within the neighborhood, that may be correlated with the amount of improvement activity. To correct my estimates of the quality-adjusted price variance, I include the variance of the hedonic regression errors in my regressions estimating the relationship between unadjusted price variance and investment activity, and I include the variance of residuals from a first-order autoregressive model of the price regression errors when I use the adjusted house price variance.

The distribution of the (unadjusted) variance of quality-adjusted prices across neighborhoods in 2006 is plotted in Figure 2.16. While the higher-priced neighborhoods to the west have less variable prices, more peripheral but still expensive neighborhoods (such as Hollywood, Westlake, and the North Valley) have price variances that are higher than those in eastern LA. Surprisingly, the amount of variation in estimated median quality-adjusted prices seems to be unrelated to the number of properties in the neighborhood, which suggests that the hedonic pricing model performs equally well in neighborhoods with smaller and larger sample sizes.

### 2.4.4 Housing investment data

To measure property owners' housing capital investments, I use data on building permits issued by the Los Angeles Department of Building and Safety (DBS). The LADBS issues permits for all new construction, additions, alterations and repairs, demolitions, grading, retrofitting, and other improvements in the city of Los Angeles, and keeps records of building permits issued since 1905. I use information on all building permits issued to residential properties since 1999 in my analysis. The permit records include the property APN, which I use to merge permitting information by property with information on building characteristics and transactions from the assessment dataset, and the date the permit was issued. Each permit is categorized by improvement type (new construction, addition, alteration/repair, demolition, grading, pool, and so forth) and by property use, and includes information on the estimated value and net new square footage (positive or negative) of the planned improvements. Each record also includes a short description of the work to be performed, which I use to observe what types of improvements are permitted. Permits in Los Angeles are valid for two years from the date of issuance, but the work must begin within six months of issuing the permit. I can observe when permits are renewed in my dataset, and use the latest date to record when the improvements took place.

According to the California Building Code, "no building or structure shall be erected, constructed, enlarged, altered, repaired, moved, improved, removed, converted or demolished without a building permit".[15] The law states that even a simple improvement such as installing a low-flow toilet requires a building permit (however, cosmetic improvements such as painting and replacing carpet do not require a permit). According to the building code, the fines imposed on property owners who are caught engaging in home improvement without a permit can range from hundreds to thousands of dollars.[16] However, there are many reasons why property owners might choose to forgo the permitting process. Obtaining a building permit is time-consuming and costly. The cost of the permit depends on the value of the improvements, which might lead property owners to understate their true value. Once construction is completed, the improvements must be inspected by a representative of the LADBS, which is also time-consuming and introduces an additional element of uncertainty over whether further time and money will need to be spent to meet the inspector's requirements. Finally, the probability of being caught doing unpermitted improvements is very low in many situations.

Thus, we must assume that many home improvements are unpermitted. In practice, I observe few permits for simple maintenance activities, like replacing fixtures, where the property owner is unlikely to get caught doing improvements without a permit. However, I do observe in my data many permits for work that is not visible from the street, such as constructing a shed in the backyard or upgrading cabinets and appliances in the kitchen, suggesting that people do not always forgo permitting when the probability of being caught in violation of the building code is low. Moreover, these imperfections in the measurement of housing investment are only problematic for my analysis insofar as the propensity for property owners to understate investment is negatively correlated with house prices and with house price growth, or is positively correlated with house price variance, which seems unlikely. Therefore, I do not attempt to estimate the extent of unpermitted improvement activity in this analysis.

I focus on three measures of improvement activity in my analysis: whether an improvement took place, the value of the improvement, and the square footage (if any) added by the improvement. Figure 2.17 displays the percent of properties improved in each neighborhood in 2006, and Figures 2.18 through 2.21 display the geographic distribution of median investment amounts across neighborhoods for three categories of investment: the value of improvements, the square footage of improvements, and the square footage of new construction and additions, respectively.[17] The third panel of Table 2.2 reports the median values of these improvement measures for the selected neighborhoods described above. Across the entire city of Los Angeles, on average 5.8 percent of properties were associated with a permit in a given neighborhood and year. The median value of housing investments between 1999 and 2007 was $6,750, and the median square footage of all construction activity was 473 square feet. The median size of new construction was 1382 square

[15]Statement from the California Department of Consumer Affairs, http://www.cslb.ca.gov/CONSUMERS.

[16]Employing workers without coverage for injury compensation seems to be a particularly serious violation of building permit regulations and carries steep fines, as outlined by the signature declaration of the permit application, found at http://netinfo.ladbs.org.

[17]The "new construction" designation assigned by the Department of Building and Safety includes any type of new freestanding structure, including garages and sheds. Thus, the figure for median square footage of new construction is lower than that for new buildings.

feet, and the median size of additions was 410 square feet. The incidence of improvement in 2006 (as measured by percent improved) seems to be evenly distributed across high-price and low-price areas, while the median value of improvements is higher in high-price neighborhoods. The median square footage of all construction and of new construction is highest in higher-income and more densely populated areas (reflecting differences in the types of residential housing built in high-density neighborhoods), while the median square footage of additions is more evenly distributed across neighborhoods.

To measure the amount of housing investment at the neighborhood level, I must translate my property-specific improvement measures to neighborhood aggregate measures that account for differences across neighborhoods in aggregate housing quantity and quality. I measure the incidence of improvement; or, the probability that a property is improved, in a given neighborhood and year by calculating the percentage of properties in each neighborhood with any permitting activity in a given year. I measure the amount of capital investment in housing by calculating the total dollar value of all improvements in each neighborhood as a share of the total value of the housing stock in the neighborhood. I normalize the total dollar value of all improvements by the total value of the housing stock, estimated using property- and year-specific hedonic prices, to account for the different numbers of properties in each neighborhood. Finally, I measure the amount of capital investment in housing in a second way, by measuring the amount of additional housing constructed. I measure the square footage of housing investment by calculating the total square footage of all additions and new construction as a share of the total amount of residential square footage in the neighborhood.

Figure 2.22 provides a spatial representation of the regression analysis presented later in the text. It plots the distribution of median quality-adjusted housing prices, the percent of properties improved, the growth in quality-adjusted prices during the previous five years, and the variance in prices over the past five years, across neighborhoods in 2006. While investment activity seems to be evenly distributed across high-price and low-price neighborhoods, neighborhoods that experienced large price increases between 2001 and 2006 (such as the neighborhoods east of Inglewood and the areas surrounding Elysian Park) have a high percentage of properties improved in 2006. Neighborhoods with high price variance (such as the areas in the far North Valley) have less investment activity, even if they experienced strong price growth. Neighborhoods where prices did not increase by much (such as the Pacific Palisades and the neighborhoods west of Inglewood) also have less investment activity, and areas with sluggish price growth and high variance in prices (such as South LA) experienced the least investment activity in 2006. I outline my methodology for estimating the relationship between prices, price variance, and investment activity, using this information, in the following section.

## 2.5 Empirical strategy

Recalling the results of the theoretical section, the real options theory predicts that investment is more likely to take place when price growth is high, and the standard neoclassical model of capital investment further predicts larger quantities of investment when output prices are higher. Option theory predicts that investment is less likely to occur when price variance is high. Because investment is delayed, there are longer stretches of time between investments in areas with high price volatility than in areas with low price volatility. Assuming similar price growth overall, an indirect prediction of option theory is that investment quantities are larger when price volatility is higher. The modified neoclassical model also predicts a positive relationship between price variance and the quantity of investment, and further predicts that the relationship between uncertainty and investment is more pronounced for more risk averse investors.

Log-linearizing the equation for the threshold value of output prices ($x_2$) around the optimal level of capital investment yields the following relationship:

$$\ln x_2 = \ln \gamma + \ln(r - \mu_2 - \lambda_2 \sigma_2) + \ln x_1 + (\gamma - 1) \ln q^* \ ,$$

which I can estimate using the following equation:

$$Y_{ijt} = \alpha_0 + \alpha_1 p_{ijt} + \alpha_2 \sigma^2_{p,ijt} + \alpha_3 \ln x_{1,ijt} + \Pi X_{ijt} + \varepsilon_{ijt} \ ,$$

where $Y_{ijt}$ are my measures of housing investment for property $i$ in neighborhood $j$ in year $t$: the probability that investment occurs, the value of improvements, and the square footage of improvements; $p_{ijt}$ is the value of the property; $\sigma^2_{p,ijt}$ is the price variance of the property; $x_{1,ijt}$ is the cost of housing capital; $X_{ijt}$ are other factors that affect the optimal quantity of capital investment in the property; and $\varepsilon_{ijt}$ is a normally distributed error term.

In theory, it is possible to estimate this equation by using data on individual home improvements and property values. However, because real estate markets lack many features of more complete asset markets such as numerous buyers and sellers, frequently traded properties, and a homogeneous good, in practice it is impossible to observe the market price of each house in each period. Thus, I use quality-adjusted, neighborhood-level median prices in my analysis, and estimate the relationship between neighborhood-level median prices and neighborhood-level housing investment, as measured by the percentage of properties improved, the value of improvements as a share of the total value of the housing stock, and the square footage of improvements as a share of the total neighborhood square footage, across neighborhoods and years within the city of Los Angeles. Provided that fluctuations in house prices and house price variance are exogenously determined across neighborhoods and years, this model can be empirically estimated using basic regression analysis.

### 2.5.1 Identification strategy

What is the exogenous source of variation in house price dynamics across neighborhoods and years in this empirical model? Recalling the monocentric city model of housing demand, if city population is stable house prices are constant, new housing investment is zero, and rents increase in the neighborhood's proximity to the city center. If there is a positive shock to city population, demand for new housing units increases and new housing investments are made at the urban fringe, which expands the size of the city. To ensure that households obtain equal utility from from living in houses at the now more-distant edge of town and from occupying more centrally-located existing units (a requirement of the monocentric model), the value of existing units must increase. Thus, at the city level increases in demand lead to new investment and growth in housing values.

If (as in Los Angeles) the city size is fixed, increases in demand result in increases in the optimal amount of capital investment in existing neighborhoods. In the standard monocentric model, units of housing are homogeneous and this capital investment takes the form of more units of housing in each neighborhood. In this study, I am able to use a more general measure of housing investment - the amount of money invested - and am not restricted to looking at only one way of increasing the density of capital investment in housing. My measure of housing "density" is the amount of actual capital investment, which can include upgrades to the existing stock as well as increases in square footage and numbers of housing units.

The central result of this model is that housing investment occurs only when the city experiences a shock to residential housing demand which increases the equilibrium quantity of housing capital, a shock that spurs house price growth. The key identifying assumption for relating increases in house prices and house price volatility to housing investment is that variation in housing values across neighborhoods within a given year, and across years within a given neighborhood, is uncorrelated with other factors affecting housing investment decisions. The next section outlines in detail potential challenges to these assumptions, and how to address them using additional neighborhood-level information.

### 2.5.2 Challenges to the identification strategy

In order to estimate the effects of house price dynamics on housing investment, it is helpful to identify a number of alternate reasons for why property owners might choose to make improvements, as some may be motivated by other factors which also affect neighborhood-level price growth and may be confounding factors to a purely investment-motivated story. The primary concern for residential housing is that much of it is owner-occupied, making the house is a consumption good as well as an asset. Households might want to adjust their housing consumption for any number of reasons - changes in income or wealth could increase the household's desired level of housing consumption, while changes in family size or composition could also make it necessary to add space or upgrade housing amenities. Household utility from housing consumption might depend not only on the level of housing services consumed, but also on how the quantity and quality of housing compares to their neighbor's housing - the effect of "keeping up with the Joneses". Changes in the household's access to credit could also allow households to finance home improvement, moving from a liquidity-constrained to an optimal level of housing consumption.

There could also be connections between changes in preferred housing consumption and neighborhood-level price changes. For example, if incomes increase among neighborhood residents, these residents might improve their homes to satisfy their higher desired housing consumption levels, and the change in neighborhood socioeconomic composition might also attract more higher-income residents to the neighborhood, which could lead to an increase in prices. In the data, it might appear that housing investment is responding to increases in neighborhood property values, but both are increasing in response to neighborhood-level income trends. To identify the response of home improvement to neighborhood house price appreciation, it is important to identify property owners who are motivated primarily by the profits they can gain by improving their properties, and not by the consumption benefits of improvements. To account for the potential psychological effects of others' home improvements on the utility of housing consumption, it is important to identify property owners who are plausibly unaffected by interpersonal comparisons.

I address these problems by focusing primarily on nonresident owners of residential properties in my analysis. Owners of rental property are mainly interested in investing in their properties in order to maximize the value of their revenue-generating asset. Moreover, few landlords in my sample live in the same neighborhood as their rental properties. These nonresident landlords do not consume the housing improvements or the neighborhood amenities associated with the improved property, and so their improvement decisions cannot be attributed to consumption or "keeping up with the Joneses" motivations.

In Los Angeles, the stock of residential housing is equally divided between owner-occupied and rental housing, so it is less likely that rental housing is an unrepresentative subsample of residential housing. However, I also analyze the decision-making behavior of owner-occupiers for the purposes of comparison. As a robustness check for the results for owner-occupiers, I also focus on a subsample of owner-occupiers who make improvements and then move away. These "improver-movers" also do not plan to consume the housing improvements or the neighborhood amenities associated with the improved property, but make improvement decisions based on the future selling price of the property. By focusing on these two groups, I can identify improvement decisions made for investment reasons and can rule out any explanations for observed improvements that might be confounded with house price growth via the personal characteristics of property owners.

All of the housing supply models outlined above assume that housing services are homogeneous across neighborhoods, and the cost of an additional unit of capital is independent of the value of the existing capital in place. While this is a useful simplification, there may be characteristics of a neighborhood's housing stock, such as the age and size of the houses, that are correlated both with the incidence and amount of home improvement and with neighborhood-level house price dynamics. For example, new houses are less likely to require improvement because of depreciation, and neighborhoods where large amounts of new construction is taking place may have more variability in housing prices because of the difference in price between new and existing construction. Similarly, the cost of housing capital investment may be correlated with housing values across neighborhoods because of differences in property characteristics. For example, properties with desirable geographic features such as a location in the hills may be more expensive to develop, but are also more valuable. Recalling the results from the theoretical section, higher costs per unit of housing capital discourage investment.

One benefit of restricting the empirical analysis to a single city is that many of the costs of home improvement are equal across neighborhoods in the city. According to the analysis of Gyourko and Saiz (2006), the primary contributors to building cost differentials include local wages and unionization within the construction sector, the regulatory environment, and geographic features of the area such as high hills and mountains. As the city of Los Angeles represents a single labor and regulatory market, with the exception of topography these factors are the same across neighborhoods. To control for city-level trends in building costs or other factors that might affect housing investment in all neighborhoods, I include year fixed effects in all regression specifications. To account for differences in characteristics of the existing housing stock that may be correlated with house price dynamics and home improvement decisions, I include in the regressions measures of square footage, age, owner-occupied status, and presence of a pool or air conditioning for the neighborhood-level median house.

While many of these characteristics are observable and can be accounted for, others, such as differences in the quality of the housing stock, are not. After controlling for observable characteristics of a neighborhood's housing stock, the residual price differences contain information on differences in unobservable location-based amenities. The monocentric model predicts that differences in initial price levels alone do not indicate where investment is likely to take place (if the current housing stock in each neighborhood is an equilibrium supply given demand for the location), because these differences form a baseline measure of pre-existing differences in demand generated by these unobservables. That is, if prices are always higher in a ritzy neighborhood, this does not imply that all housing investment will always take place in this neighborhood and not in the lower priced, up-and-coming areas; in fact, the reverse is probably true. When there is a positive shock to demand for a given neighborhood, the price of housing in that neighborhood rises and investment in the neighborhood becomes more profitable.

To capture this aspect of neighborhood-level price dynamics, I include the minimum neighborhood price level since 1995 (the trough of the house price slump in Los Angeles during the 1990s), and the one and five-year lagged prices, as controls for the baseline unobservable inherent desirability of the neighborhood. As a robustness check, I also include specifications with both neighborhood and year fixed effects. Neighborhood fixed effects capture the entire effect of differences in any and all neighborhood-level characteristics on housing investment.

In neighborhoods with large amounts of housing investment, the average house sold is more recently built (or improved) than in a similar neighborhood that did not experience the same level of improvement activity. Therefore, there may be some reverse causality between housing investment and neighborhood-level median house prices. While building permits are issued before the work begins, the majority of improvement is completed within a year of the permit approval date. Thus, buildings permitted in the beginning of the year could appear in the transactions data for that year. To address this problem, I use the one-year lagged median house price in the empirical analysis. As a robustness check, I use the same-year predicted price from an autoregressive model of house prices, to represent investors' expectations of property values in that year given the behavior of past prices.

These sample restrictions and control variables do not completely resolve the issue of credit constraints, as the homeowner's cost of capital may be correlated with house price dynamics via the availability and cost of housing-collateralized borrowing. As housing values increase, home equity increases and existing loan-to-value ratios decrease, making it easier to refinance an existing mortgage and to borrow against home equity. By linking geographic data on mortgage lending activity (such as data collected by the Home Mortgage Disclosure Act) to neighborhood-level outcomes, it may be possible to account for these effects. This is a promising area for future research.

To summarize, I estimate the following equation:

$$\overline{y}_{jt} = \alpha_0 + \alpha_1 \overline{p}_{j,t-1} + \alpha_2 \sigma^2_{\overline{p},jt-1} + \alpha_3 \sigma^2_{\eta,jt-1} + \Pi \overline{X}_{jt} + \pi_t + \varepsilon_{jt} \ ,$$

across neighborhoods and years within the city of Los Angeles, where $\overline{y}_{jt}$ is the percentage of properties improved, the value of improvements as a share of the total value of the housing stock, and the square footage of improvements as a share of the total neighborhood square footage; $\overline{p}_{j,t-1}$ is the quality-adjusted, one-year lagged neighborhood-level median price; $\sigma^2_{\overline{p},jt}$ is the variance of the corresponding house price measure, adjusted for persistence in house prices; $\sigma^2_{\eta,jt}$ is the variance of residuals from a first-order autoregressive model of the hedonic price regression errors, to control for variance in house prices induced by variation in neighborhood size and building diversity; $\overline{X}_{jt}$ include neighborhood-level median log square footage, age, age squared, and the percent of properties that are owner-occupied; $\pi_t$ are year fixed effects, and $\varepsilon_{ijt}$ is a normally distributed error term.

I estimate the relationship between house price dynamics and investment activity for all properties, and separately for owner-occupied and renter-occupied properties, and for new construction and improvements to existing buildings. In each specification, the dependent variable - percent of properties improved, value of improvements, and square footage of improvements - is calculated as a share of the total for properties in the respective group. For example, the percent of owner-occupied properties improved is calculated as the number of owner-occupied properties with permitting activity in a given neighborhood and year divided by the total number of owner-occupied properties in the neighborhood. The independent variables - price, price variance, and median characteristics of the housing stock - are also calculated for properties in the respective group. For example, the price variance in the specification with the sample limited to owner-occupiers is calculated using the prices of owner-occupied properties only. The total value of the housing stock for each sample in each neighborhood and year is calculated using the predicted price of each property in the sample from the neighborhood-year hedonic pricing models. For new construction, the percent of properties newly built is calculated as a share of vacant, residentially-zoned land parcels, and the value and square footage of new construction as a share of total value/square footage is calculated as a share of all properties (including both new and existing construction) within the neighborhood. For new construction, the median characteristics of the housing stock are also calculated over the entire housing stock. As robustness checks, I also include specifications with the sample limited to properties owned by "improver-movers"; including one-year lagged investment measures; including neighborhood fixed effects $\pi_j$; limiting the sample to buildings not subject to rent control; using current-year predicted neighborhood-level median prices in place of lagged prices; and using unadjusted measures of house price variance.

## 2.6 Empirical results

The following tables present the results of the above estimation for all properties, for new construction, for improvements to existing buildings, for owner-occupied properties, and for renter-occupied properties. In each table, there are 5 regression results for each of 3 investment measures: percent of properties improved, value of improvements, and square footage of improvements. The regression results in the upper half of each table include the standard set of control variables, and the results reported in the lower half of the table also include as regressors lagged measures of housing values, to estimate the relationship between house price growth and housing investment.

### 2.6.1 Housing investment and house prices

For all measures of housing investment - the percent of properties improved, the value of investments, and the square footage of investments - the neighborhood and group-specific median log house price is positively related to investment. When house prices are higher, investment is more likely to take place, and the value and square footage of investments is larger. This relationship holds for new construction, improvements and additions to existing properties, and for owner- and renter-occupied properties. For all properties grouped together, a 10 percent increase in median house prices leads to a 0.003 percentage point increase in the share of properties improved (representing a 6 percent increase in the share of properties improved at the mean), a 5.3 percent increase in the value of improvements, and an 11.9 percent increase in the square footage of improvements.

The estimated effect of house prices is larger for new construction than for improvements to existing properties: a 10 percent increase in house prices leads to an 11.9 percent increase in the value of new construction compared to a 2 percent increase in the value of improvements, and a 15.2 percent increase in the square footage of new construction versus a 6.9 percent increase in the square footage of additions. Investments in rental properties are also more price sensitive than investments in owner-occupied properties: a 10 percent increase in house prices leads to a 0.005 percentage point increase in the percent of renter-occupied properties improved (representing an 8 percent increase at the mean) compared to a 0.001 percentage point increase in the percent of owner-occupied properties improved (a 5 percent increase at the mean). Results for the value and square footage of improvements for renter and owner-occupied properties compare similarly.

The exceptions to this general finding are the results for the percent of land parcels developed and the value of improvements to owner-occupied properties. The estimates for the effect of house prices on the probability of development are positive, but marginally significant, and this may be due to measurement error in the number of available land parcels.[18] When control variables are included in the model of the value of improvements for owner-occupied properties, the effect of price on investment is not statistically significantly different from zero. This result may have something to do with the relative valuation of square footage versus quality in the owner-occupied housing market when prices are high, and vice versa when prices are low. When demand for owner-occupied housing is high in a neighborhood, square footage may be more valuable relative to other investments because new owner-occupiers may value the option to customize quality upgrades to their individual tastes. For example, my husband and I might value an additional bedroom or garage space equally, but he might place a higher value on a new home theatre system and I might place a higher value on a new kitchen. Owners of rental property do not face this issue because tenants are not able to alter the property to suit their tastes.

In the majority of specifications, including neighborhood-level median characteristics of the housing stock strengthens the relationship between house prices and investment. As expected, neighborhoods with older houses have a higher share of properties (of all types) improved, although these neighborhoods are less likely to experience new development. Neighborhoods with older housing stock also have larger and more costly improvements. Properties in neighborhoods with a larger share of owner-occupiers are no more likely to be improved, and the value and square footage of improvements is smaller. This effect is driven by new construction, however, which suggests that some “not in my backyard” activity might be taking place in neighborhoods that are predominantly owner-occupied.

Interestingly, although neighborhoods with larger homes on average have a larger share of properties improved, the value and square footage of improvements is smaller. Even homes newly constructed in neighborhoods with larger buildings are smaller and less valuable. The relationship between neighborhood-level median building square footage and the value and square footage of additions may reflect an upper bound on the allowable building density. For new construction, the negative relationship between median building size and the value of new development may be due to the fact that controlling for median prices, median square footage may be an indicator that a neighborhood has more multi-unit buildings, and developers may build lower quality structures for multifamily housing than for single-family housing. This intuition is supported by the empirical result that owner-occupied properties in neighborhoods with larger buildings on average have more valuable improvements, while renter-occupied properties in neighborhoods with larger buildings have less valuable improvements.

### 2.6.2 Housing investment and house price variance

Following the predictions of the theoretical section, the relationship between housing investment and house price variance differs depending on the measure of investment used and on the char-

[18] If a land parcel was not previously zoned for residential use, it will not be included in my count of land parcels at risk of development until the year that it was developed as a residential property. If the parcel was never zoned or developed as a residential property, it will not be counted. I plan to obtain data from another source on the share of land in each neighborhood and year that is developable to improve this measure.

acteristics of the property owner. As predicted by the option value model, there is a negative relationship between house price variance and the probability that a property is improved. This negative relationship holds for all groups, and it is larger in magnitude for improvements to existing properties and for renter-occupied properties than for new construction and improvements to owner-occupied properties.

In general, a doubling of price variance leads to a 0.001 percentage point decrease in the probability that any property will be improved (a 2 percent decrease). By group, at mean values of the group-specific neighborhood-level price variance, a doubling of price variance leads to a 0.002 point decrease in the probability that a land parcel will be developed (a 0.15 percent decrease), a 0.001 point decrease in the probability of improvements to existing properties (a 2 percent decrease), a 0.001 point decrease for owner-occupied properties (a 2 percent decline), and a 0.003 point decrease for renter-occupied properties (a 5 percent decline). These results confirm the predictions of the risk aversion model: that individual investors who are less able to hedge fluctuations in the price of housing will be more sensitive to expected price variance than professional developers, who are responsible for the majority of new construction; and that investors whose cash flow is more dependent on the price of housing services, such as owners of renter-occupied buildings, will be more sensitive to volatility than owner-occupiers, who pay themselves implicit rents and whose housing expenses are thus fully hedged against changes in the price of housing services until they sell their home.

The relationship between investment and volatility is very different for the value and square footage of investments. For renter-occupied properties, a doubling of price variance causes the value of investments to increase by 4.8 percent, and the square footage of investments to also increase by 4.1 percent. There also exist positive relationships between price volatility and the value and square footage of investment for new construction and for existing construction, and for all properties grouped together. The effect of a doubling of price variance on these measures of investment across groups ranges from 1.7 percent to 3.3 percent, and is largest in magnitude for additions to existing construction and the value of improvements to renter-occupied properties. In contrast, for owner-occupied properties, increases in volatility lead to steep declines in the value and square footage of investments. At the mean price variance of 0.02, a doubling of price variance causes the value of investments to fall by 6.4 percent and the square footage of investments to fall by 8.1 percent.

These positive relationships further confirm the predictions of the modified neoclassical model, and imply that risk aversion may be a more important factor for smaller, less sophisticated investors, such as those making improvements to existing properties, and for property owners whose income and consumption are more exposed to house price risk, such as nonresident landlords. However, the unexpected negative relationship between volatility and investment quantity for owner-occupiers is not predicted by either model. In the following section, I will analyze the behavior of improver-movers, who are exposed to consumption house price risk due to their decision to move, to see if the relationship between price variance and amount of investment differs for this group.

The positive relationship between volatility and the quantity of investment (excluding owner-occupied properties), while predicted by the modified neoclassical model, might also have something to due with differences in the frequency of improvement between low-volatility and high-volatility areas. When price volatility is high, investment is delayed until price levels reach a threshold higher than that implied by the "marginal $q$" condition. This means that the capital stock remains at a lower level for longer, while the optimal amount of capital stock for the property (as determined by the marginal $q$) increases, which increases the difference between the existing and optimal level of capital investment. The longer the delay in investing, the larger the gap between existing and optimal capital investment. Thus, the optimal quantity of improvement may depend positively on the price volatility via the delay in investment induced by higher price volatility. I directly test this hypothesis in the following section by including lagged investment as a measure of the amount of adjustment in the capital stock that occurred in the last period, a proxy for the extent to which capital investment was delayed in the last period.

### 2.6.3 Housing investment and house price growth

Because neighborhood-level median house prices are also a measure of unobservable neighborhood characteristics that may affect the probability of housing investment, I also estimate the relationship between investment and house price growth during the previous year and during the previous 5 years. I also measure the growth in house prices from a "baseline" level, the minimum price level since 1995, to estimate the effect of long-term price growth on current investment. In general, there is a positive relationship between house price growth and housing investment. Houses are more likely to be improved when house price growth is strong, and this result holds across groups (with the exception of new construction, where the relationship is positive but imprecisely estimated). The magnitude of these effects is similar to the effect of house prices on the probability of improvement: a 10 percent increase in annual house price growth increases the probability of improvement for all properties grouped together by 0.002 percentage points (a 4 percent increase), and a 10 percent increase in price growth during the past 5 years increases the probability of improvement by a similar amount. The results are similar for new and existing construction, and for owner and renter-occupied properties.

When house price growth is strong, the square footage of improvements is larger across all property types. These effects are comparatively large: a 10 percent increase in annual price growth leads to a 9.1 percent increase in the square footage of all improvements, and increases of 11.2 percent, 4 percent, 3.9 percent, and 8.9 percent for new construction, additions, improvements to owner-occupied properties and renter-occupied properties, respectively. A 10 percent increase in 5-year price growth leads to a 13.8 percent increase in the size of all improvements, and these figures for the other property types are 16 percent, 6.3 percent, 3.4 percent, and 13.2 percent, respectively. Similarly to the results for price levels, investments in new properties and rental properties seem to be more responsive to price growth than investments in existing and owner-occupied properties.

The effect of price growth on the value of investment is similar, with the exception of investments in owner-occupied properties. A 10 percent increase in annual price growth leads to a 4.7 percent increase in the value of improvements for all properties, and increases of 9.3 percent, 2.5 percent, and 3.9 percent for new construction, additions, and investments in renter-occupied properties, respectively. A 10 percent increase in 5-year price growth leads to a 7.7 percent increase in the value of all improvements, and these figures for the other property types are 14.2 percent, 1.9 percent, and 6.4 percent, respectively. For owner-occupied properties, a 10 percent increase in annual price growth leads to a 3.1 percent increase in the value of improvements, but this amount is imprecisely estimated, and a 10 percent increase in 5-year price growth leads to a 4.6 percent *decrease* in the value of improvements.

Similarly to the lack of relationship between house price levels and home improvement expenditures for owner-occupied properties, a possible explanation may be that additions are more valuable relative to quality upgrades in the owner-occupied market when prices are increasing. In contrast, when house prices are decreasing, the number of unsold homes on the market increases and competition among sellers becomes more intense, so property owners have a financial incentive to upgrade the quality of the existing capital stock to distinguish their houses from others on the market (in other words, quality upgrades are more valuable relative to additions when prices are decreasing). Measuring the difference in the rate of return from different types of improvements under different market conditions is an interesting, but underexplored, area of research in real estate economics.[19]

It might also be the case that other features of owner-occupied housing that affect the decision to make additions and quality upgrades vary with house price growth. For example, when house prices are increasing, owner-occupiers are less likely to be "locked in" to their current residence (because of mortgage debt or market conditions) so they may be more able to adjust their housing consumption and investment by selling their house and buying another one. In contrast, when house prices are flat or declining, owner-occupiers might be less able to sell their homes, and may prefer to adjust their housing consumption by making alterations to their current property. In the next section, I address this question by focusing on the investment behavior of improver-movers, who are able to adjust their housing investment by moving. A negative relationship between house price growth and investment quantity for improver-movers would provide evidence in favor of the "lock-in" hypothesis, while a positive relationship would favor the investment models presented in this analysis.

## 2.7 Robustness analysis

The following section presents the results of estimating specifications with the sample limited to properties owned by "improver-movers", including one-year lagged investment measures, including neighborhood fixed effects, limiting the sample to buildings not subject to rent control, using current-year predicted neighborhood-level median prices in place of lagged prices, and using unadjusted measures of house price variance. The results of the previous section - that the probability of investment, value of investment, and square footage of investment is positively related to house prices and house price growth; that the probability of investment is negatively related to price variance; and that the value and square footage of investment are positively related to price variance - are generally unaffected by the choice of specification. The notable exception is that including lagged investment quantities in the regressions of investment quantity on price variance eliminates the effect of price variance on investment quantity, which provides evidence in favor of the real options theory of investment over the modified neoclassical theory of investment.

### 2.7.1 Results for "Improver-Movers"

In order to exclude from the sample owner-occupiers who make improvements to their properties for reasons unrelated to optimal investment decisions - e.g. for consumption purposes or due to interpersonal comparisons - I redo my analysis restricting the sample of owner-occupied properties (and improvements to owner-occupied properties) to owner-occupiers who move within 4 years of making improvements to the property. These "improver-movers" do not plan to consume the housing improvements associated with the investment decision, but make improvement decisions based on the expected return from selling the property. I redo my analysis excluding owner-occupier "stayers" for owner-occupied properties, for all properties together, and for improvements

[19] See Remodeling Pulse (2008) for a survey of property owners addressing this question.

to existing construction. I do not redo the analysis for renter-occupied properties or for new construction, because these two samples do not include any owner-occupiers in the original analysis.

When the sample of owner-occupied properties is restricted to homeowners who make improvements and subsequently move, the relationship between house prices and improvement is even more pronounced. The magnitude of the estimated coefficients is larger for owner-occupied properties and for all properties grouped together, and is larger for improvements to existing construction. The coefficients are larger in magnitude for the relationship between house prices and the probability of improvement, the value of improvements, and the square footage of improvements, for all groups excluding owner-occupier "stayers". Moreover, the relationship between house prices and the value of improvements for improver-mover occupied properties is positive, in contrast to the relationship between house prices and the value of improvements for all owner-occupiers, which was negative. The relationship between house price variance and the probability of improvement, value of improvements, and square footage of improvements, for all properties and for improvements to existing properties, is similar in this analysis excluding "stayers" to the results of the analysis including all owner-occupiers. However, the relationship between house price variance and improvement quantities (value and square footage of improvements) is larger and more negative for improver-movers than for all owner-occupiers grouped together.

Similarly to the results for house prices, the relationship between house price growth and housing investment is positive and larger in magnitude for all groups excluding owner-occupier "stayers", and for all measures of housing investment: the probability that a property is improved, the value of improvements, and the square footage of improvements. Focusing on owner-occupied properties, the relationship between house prices/house price growth and the square footage of improvements is positive for both improver-movers and stayers, while the relationship between house prices/house price growth and the value of improvements is positive for improver-movers but is zero or negative for the entire sample of owner-occupied properties (including movers and stayers). These contrasting results for movers and stayers suggest that improver-movers' home improvement decisions are more in line with the predictions of economic theory, and that credit constraints may play an important role in the ability of owner-occupiers to make housing investments. Movers, who are less likely to be constrained by mortgage debt, respond to increases in housing values by investing more in their properties, while stayers, who are more likely than movers to be credit constrained, do not respond to changes in house prices by making investments. The negative relationship between investment quantities and house price variance for owner-occupiers, which is not predicted by either theory of investment under uncertainty, is not explained by differences between movers and stayers. This relationship merits further theoretical and empirical exploration in future work.

### 2.7.2 Results including lagged measures of investment

Both the option theory of investment under uncertainty, and the modified neoclassical model of investment incorporating investor risk aversion, predict a positive relationship between price uncertainty and quantity of investment. However, this positive relationship is driven by different factors in the two models. In the real options model, high price volatility causes investment to be delayed in periods when the marginal revenue product of capital equals the marginal cost of capital - periods when investment would be predicted to occur under the standard neoclassical model - because the marginal value of additional capital to the firm must exceed the cost of capital plus the value of the option to invest in future periods. Delaying investment causes there to be a larger gap between the existing capital stock and the optimal amount of capital investment, and when investment occurs, the amount of investment needed to close the gap is larger. In contrast, in the modified neoclassical model the optimal quantity of investment depends on price uncertainty via investor risk aversion. In this model, even if investment occurs in each period, risk averse investors will invest larger quantities of capital when price uncertainty is higher.

To determine which mechanism is responsible for the positive relationship between investment quantities and price variance observed in the data, I include in the regressions the amount of investment in the previous period. Under the option theory of investment, including lagged investment as a measure of the gap between the existing and optimal amounts of investment should cause there to be no relationship between price variance and quantity of investment. In contrast, under the modified neoclassical model including lagged investment should not affect the relationship between price variance and current-period investment.

Including lagged improvement value and lagged improvement square footage in the regressions has no effect on the positive relationships between house prices/house price growth and the value and square footage of improvements, respectively. However, the relationship between price variance and quantity of investment is completely wiped out by including the lagged quantity of investment. This result holds for all property types (all properties, owner-occupied, and renter-occupied properties) and all investment types (all improvements, new construction, and improvements to existing buildings). This analysis implies that the somewhat counter-intuitive prediction that risk averse investors invest more when prices are more uncertain is not supported empirically, while the option theory of investment under uncertainty is supported by the data.

### 2.7.3 Other robustness checks

To control for any unobserved differences between neighborhoods that might be correlated with both house prices/price growth and with property owners' investment decisions, I include specifications with neighborhood-level fixed effects. Including neighborhood fixed effects (and excluding other neighborhood-level control variables) leaves the estimated coefficients on house prices, price variance, and price growth largely unchanged from the original specifications.

As in many cities, certain renter-occupied properties in Los Angeles are subject to rent control. Los Angeles rent control ordinances limit the amount by which rents can be increased in each year to 4 percent. Prior to July 2006, this amount was 3 percent. There are a number of additional fees which landlords can charge tenants, and situations where landlords are exempt from rent control rules. The broadest categories of exempt properties are single family dwellings and units built after 1978.[20]

Rent control rules limit the amount to which rents are affected by market conditions such as house prices. Because of this, I include specifications with the sample limited to properties not subject to rent control legislation. I do not redo the analysis for new construction or for owner-occupied properties because these property types are not subject to rent control. Excluding multi-unit renter-occupied properties built before 1978, and improvements made to these properties, from the remaining specifications strengthens the relationship between housing market conditions (house prices, price variance, and house price growth) and the probability of improvement, value of improvements, and square footage of improvements. The coefficients are larger in magnitude

[20] A summary of the Los Angeles rent control regulations and link to the full text of the ordinance can be found at: http://www.caltenantlaw/LARSO.htm .

for all properties, for improvements to existing properties, and particularly for improvements made to renter-occupied properties. Excluding rent-controlled properties, where property owners are less able to profit from investments made to the property by increasing rents, from the analysis strengthens the results in favor of the theoretical models of investment, which implies that profit-maximizing motivations likely play a central role in nonresident landlords' decisions to make housing improvements.

To rule out the possibility that functional form may be driving the relationship between lagged housing market conditions (lagged house prices, lagged price variance, and lagged house price growth) and investment, I estimate the original models using current-year predicted housing market conditions (predicted house prices, the variance of predicted house prices, and predicted house price growth) predicted from a single-order autoregressive model of house prices. The estimated coefficients in these regression specifications are larger in magnitude than the original estimates, across all property groups and investment types. These results suggest that property owners may be making investment decisions based on their predictions of future prices, rather than current housing market conditions at the time when they are making their plans.

Finally, to rule out the possibility that the functional form of my adjustment to house price variance (which adjusts for the predictable aspect of price variance) may be driving the relationship between lagged housing market conditions and investment, I also separately estimate the original models using the unadjusted variance of prices during the previous 5 years, and the unadjusted variance of the root mean squared error of the hedonic price regressions. These robustness checks also produce estimated coefficients that are larger in magnitude than the original estimates, across all specifications. These results suggest that the original adjustment to price variance was likely necessary to control for the relationship between price growth and unadjusted price variance.

## 2.8 Conclusions and Extensions

### 2.8.1 Conclusions

The goals of this analysis were twofold: to determine whether property owners respond positively to growth in housing values by making investments in their properties, and to observe whether increased uncertainty over future house prices has a negative effect on housing investment. By using information from building permits on the value and square footage of construction, the empirical analysis is one of the first to explore the connection between uncertainty and the *amount* of capital investment, rather than focusing on just the incidence of investment. Similarly, by linking information on investment activity to sales records for the property, the study excludes property owners who make improvements for consumption purposes, and explores differences in the relationship between prices, price growth, and price uncertainty, and investment decisions, for property owners with varying degrees of risk aversion.

Focusing on nonresident landlords and improver-movers - owner-occupiers who make improvements to their properties and subsequently sell the property, I find that when housing values increase, property owners are more likely to make capital investments, and that the value and square footage of these investments is larger. When house price volatility is high, property owners are less likely to make investments. This relationship is stronger for improvements to existing properties than for new construction, and is stronger for renter-occupied properties than for owner-occupied properties, which suggests that investors who are more exposed to house price risk are more sensitive to uncertainty over future housing values. Conditional on the decision to invest, however, the value and square footage of investments is larger. This result is shown to be a consequence of property owners' optimally delaying capital investment when uncertainty over future prices is high.

### 2.8.2 Extensions

This study introduces a number of areas to be explored in future work. The most important is the relationship between house price growth and credit constraints. The relationship between housing values and improvement value is negative for "stayers", which might be an indicator that when house prices decline, credit constrained households remain in their current residence and make improvements, rather than moving to another house. Information on neighborhood-level borrowing activity could easily be incorporated using data gathered under the Home Mortgage Disclosure Act on cash-out mortgage refinance loans. Another interesting extension to the analysis would be to distinguish between short-run and long-run responses to price growth, by incorporating a more complicated lag structure in house prices or looking at price growth over a longer time period. Finally, it would be interesting to see if some sort of feedback loop exists between house price growth, housing investment, and subsequent house price growth at the local level. Neighborhood revitalization programs such as Business Improvement Districts rely on the premise that targeted capital investments in local real estate and infrastructure can encourage further investment by improving the overall atmosphere in the neighborhood. It would be valuable to determine if this reasoning is well founded.

The subtitle of this paper, "Flip That House", refers to a very specific subset of investors who buy depreciated properties in growing real estate markets, make significant improvements, and quickly sell the property at a higher price. The scope of this analysis is much broader than house flipping, and I did not expect to find much evidence of this behavior in the data. However, improver-movers tend to behave much more like investors than owner-occupying stayers. These results suggest that the house flipping phenomenon, while not widespread, may have had some impact on everyday homeowners' improvement decisions during the past decade.

Table 2.1 - Summary statistics: All properties

| | | *Min* | *25th pctile* | *Median* | *75th pctile* | *Max* |
|---|---|---|---|---|---|---|
| Total number of properties: | 539,573 | | | | | |
| Percent owner-occupied: | 50.8 | | | | | |
| Sales price, 2006 $: | | 24,809 | 173,584 | 376,116 | 600,000 | 68,400,000 |
| Square footage: | | 50 | 1203 | 1580 | 2244 | 996,978 |
| Property Age: | | 0 | 33 | 49 | 67 | 106 |

Note: untrimmed values. In analysis, upper and lower 5% of values trimmed as described in text.

Table 2.2 - Summary statistics: Selected neighborhoods

| | Wilshire | Central City | Arleta | Brentwood | South LA |
|---|---|---|---|---|---|
| Number of neighborhoods: 77 | | | | | |
| Number of properties | 2774 | 5031 | 5352 | 9585 | 41346 |
| Median sales price, 2006 $ | 533,095 | 481,000 | 320,001 | 761,586 | 253,053 |
| Median square footage, 2006 | 2373 | 1110 | 1304 | 2172 | 1470 |
| Median property age, 2006 | 66 | 40 | 50 | 37 | 80 |
| Percent owner-occupied, 2006 | 28.6 | 22.4 | 50.6 | 56.7 | 40.6 |
| Population density/sq km, 1999 | 2449 | 1092 | 1408 | 312 | 270 |
| Median income, 1999 $ | 23,035 | 14,017 | 47,956 | 103,268 | 23,055 |
| Percent of properties improved, 2006 | 6.0 | 3.6 | 4.9 | 11.5 | 7.9 |
| Median value of improvements, 2006 $ | 6,450 | 7,500 | 15,000 | 10,000 | 7,000 |
| Median sq ft of construction, 2006 | 440 | 1434 | 414 | 1005 | 460 |
| Median sq ft of new construction, 2006 | 43264 | 30529 | 434 | 4508 | 610 |
| Median sq ft of additions, 2006 | 288 | 987 | 411 | 623 | 440 |

Table 2.3 - Summary statistics: Neighborhood-Year Cells

| | | *Min* | *25th pctile* | *Median* | *75th pctile* | *Max* |
|---|---|---|---|---|---|---|
| Total number of sales observations: | 630,909 | | | | | |
| Number of neighborhood-year cells: | 1001 | | | | | |
| *Distribution across neighborhood-year cells:* | | | | | | |
| Number of properties in each cell | | 30 | 189 | 388 | 821 | 8985 |
| Neighborhood median quality-adjusted log price | | 11.05 | 12.12 | 12.41 | 12.72 | 13.97 |
| $R^2$ of hedonic price regression for each neighborhood-year cell | | .047 | .125 | .200 | .334 | .745 |
| Neighborhood log price variance | | .001 | .009 | .020 | .035 | 1.32 |
| Neighborhood 1-year price growth, percent | | -46.8 | -0.1 | 9.8 | 18.5 | 57.0 |
| Neighborhood 5-year price growth, percent | | -21.7 | 16.3 | 30.5 | 45.3 | 139.0 |

Each observation in the regression models is a neighborhood-year “cell”: an average, median, or percentage value of price and improvement measures calculated for a group of properties, where the groups are defined by neighborhood and year. Thus, this table displays summary statistics for the 1,001 neighborhood-year cells: 77 neighborhoods over 13 years. The table summarizes the distributions of the number of properties in each cell, the $R^2$ of the hedonic price regression executed within each cell to construct the neighborhood- and year-specific hedonic price index, the quality-adjusted log price for the neighborhood-specific median house within each neighborhood-year cell, the variance of these prices over 5 years, and the growth in quality-adjusted median prices over 1 year and 5 years. The table summarizes the distributions of these variables by reporting the minimum value, the values at the 25th, 50th, and 75th percentiles, and the maximum value, across neighborhood-year cells.

Table 2.1 source: Census Bureau - Manufacturing, Mining, and Construction Statistics, Series C30. Data on the total value of new residential construction reported in Series C30 is from the Survey of Construction, and estimates of the total value of improvements and repairs to residential units reported in Series C30 are based on data from the Consumer Expenditure Survey.

## Table 2.4 - Hedonic Price Regressions, 1976 - 2007: Brentwood

| *Regressions, by Year:* | Owner Occupied Indicator | Log Square Feet | Age | $Age^2$ | A/C Indicator | Pool Indicator | Constant | $N$ | $F$ | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | -0.17088 | 1.07209 | -0.0343 | 0.00043 | 0.07163 | 0.1187 | 4.61276 | 15 | 7.04093 | 0.87564 |
| 1977 | 0.03789 | 0.61138 | -0.02956 | 0.00074 | -0.34562 | 0.33416 | 7.94951 | 20 | 7.90252 | 0.78482 |
| 1978 | -0.31222 | 0.61497 | 0.00704 | 0.00027 | (dropped) | 0.63075 | 7.50353 | 14 | 6.23971 | 0.84248 |
| 1979 | -0.24814 | 1.07972 | -0.00915 | 0.00001 | -0.12837 | 0.08025 | 4.65522 | 18 | 3.27236 | 0.69611 |
| 1980 | -0.35698 | 1.05508 | -0.05074 | 0.00119 | -0.4381 | -0.438 | 5.46958 | 29 | 5.54754 | 0.72435 |
| 1981 | 0.17389 | 0.18989 | -0.02458 | 0.00033 | -0.14628 | 0.2055 | 11.14075 | 32 | 1.37059 | 0.28559 |
| 1982 | -0.44016 | 0.80126 | -0.03086 | 0.00048 | 0.22852 | 0.36194 | 6.90362 | 38 | 6.36734 | 0.5977 |
| 1983 | -0.32273 | 1.00215 | -0.02686 | 0.00045 | -0.21188 | -0.04188 | 5.64091 | 35 | 3.44551 | 0.55365 |
| 1984 | -0.00806 | 0.6004 | -0.01431 | 0.00012 | 0.1544 | 0.22355 | 8.19006 | 42 | 4.64101 | 0.52943 |
| 1985 | -0.16052 | 0.64084 | -0.02059 | 0.00032 | -0.01764 | 0.15519 | 8.00475 | 52 | 3.56072 | 0.39848 |
| 1986 | -0.30051 | 0.84089 | 0.00096 | -0.00006 | -0.28123 | 0.16188 | 6.60533 | 110 | 9.99584 | 0.40688 |
| 1987 | -0.41863 | 0.8996 | 0.00423 | 0.00003 | 0.09465 | 0.06945 | 5.9119 | 86 | 11.71089 | 0.51243 |
| 1988 | -0.35906 | 0.82759 | -0.01811 | 0.0003 | 0.14889 | 0.17541 | 6.7239 | 102 | 8.30203 | 0.41662 |
| 1989 | -0.23371 | 0.65345 | -0.04392 | 0.00069 | 0.08736 | 0.31134 | 8.33456 | 136 | 12.17438 | 0.4934 |
| 1990 | -0.374 | 0.72619 | -0.04735 | 0.00063 | 0.02313 | -0.01241 | 8.10635 | 138 | 11.12942 | 0.40835 |
| 1991 | -0.33411 | 0.73544 | -0.01951 | 0.00033 | 0.15152 | 0.05656 | 7.54897 | 154 | 12.36827 | 0.37225 |
| 1992 | -0.1645 | 0.82823 | -0.0117 | 0.00025 | 0.19333 | 0.12612 | 6.53906 | 215 | 18.07881 | 0.44249 |
| 1993 | -0.11079 | 0.94089 | -0.00771 | 0.00018 | 0.14548 | 0.0694 | 5.63159 | 259 | 19.06732 | 0.43466 |
| 1994 | -0.20762 | 0.9936 | 0.00334 | 0.00003 | 0.20147 | 0.06433 | 5.19963 | 209 | 21.12219 | 0.48856 |
| 1995 | -0.32215 | 1.04923 | -0.002 | 0.00007 | 0.12892 | 0.13125 | 4.94311 | 180 | 16.70559 | 0.43869 |
| 1996 | -0.19564 | 0.91866 | 0.0008 | 0.00005 | 0.11364 | 0.11478 | 5.78732 | 225 | 17.41792 | 0.42167 |
| 1997 | -0.01619 | 0.86924 | -0.00799 | 0.00012 | 0.0302 | 0.27066 | 6.25309 | 354 | 20.35503 | 0.39566 |
| 1998 | -0.16475 | 1.08761 | -0.01702 | 0.00022 | -0.11337 | -0.06636 | 5.17232 | 383 | 29.44489 | 0.46611 |
| 1999 | -0.15834 | 0.98993 | -0.01209 | 0.00022 | 0.08659 | 0.19355 | 5.59635 | 413 | 49.07485 | 0.54971 |
| 2000 | -0.25317 | 0.90302 | -0.01512 | 0.0002 | -0.08807 | 0.03212 | 6.62867 | 394 | 30.75763 | 0.44539 |
| 2001 | -0.13713 | 0.90302 | -0.01311 | 0.0002 | 0.00743 | 0.1522 | 6.49593 | 520 | 53.24438 | 0.53552 |
| 2002 | -0.13709 | 0.85362 | -0.00981 | 0.00016 | 0.04509 | 0.0939 | 6.90114 | 1061 | 84.90334 | 0.47099 |
| 2003 | -0.10956 | 0.87934 | -0.00992 | 0.00018 | 0.05559 | 0.0025 | 6.77479 | 1539 | 116.87835 | 0.4571 |
| 2004 | -0.10395 | 0.71558 | -0.00872 | 0.00013 | -0.00431 | 0.06875 | 8.20935 | 1315 | 69.1771 | 0.36869 |
| 2005 | -0.0818 | 0.74401 | -0.00873 | 0.00013 | -0.01057 | 0.04751 | 8.07863 | 1280 | 51.9318 | 0.31059 |
| 2006 | -0.32109 | 0.60305 | -0.01617 | 0.00023 | 0.0336 | 0.06121 | 9.3445 | 1058 | 39.8769 | 0.27582 |
| 2007 | -0.21647 | 0.73598 | -0.01471 | 0.00018 | 0.0173 | 0.0248 | 8.33696 | 721 | 33.13527 | 0.33954 |

Table displays results of 32 hedonic price regressions (each row is a separate regression), each using sales observations in the Brentwood neighborhood in each year 1976 through 2007. Indicator variables for 2 units, 3 units, 4 units, 5 or more units, and missing number of units are suppressed.

Table 2.5 - Hedonic Price Regressions, 1976 - 2007: South LA

| *Regressions, by Year:* | Owner Occupied Indicator | Log Square Feet | Age | $Age^2$ | A/C Indicator | Pool Indicator | Constant | $N$ | $F$ | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | -0.0406 | 0.49515 | -0.00276 | -0.00004 | 0.27061 | (dropped) | 7.37533 | 129 | 10.23412 | 0.4363 |
| 1977 | -0.01003 | 0.36785 | -0.01874 | 0.00014 | 0.06698 | 0.31371 | 8.56017 | 188 | 6.47956 | 0.26798 |
| 1978 | -0.04887 | 0.53987 | 0.00164 | -0.0001 | 0.04048 | 1.07799 | 7.15371 | 207 | 8.71678 | 0.30783 |
| 1979 | -0.06025 | 0.57243 | -0.00447 | -0.00003 | 0.33507 | -0.44466 | 7.22804 | 293 | 13.52824 | 0.34622 |
| 1980 | -0.11194 | 0.54136 | -0.00847 | 0.00008 | 0.09733 | 0.27 | 7.41803 | 200 | 4.20466 | 0.19744 |
| 1981 | -0.05402 | 0.31474 | -0.00527 | 0.00001 | 0.61926 | 0.25834 | 9.05722 | 166 | 3.1096 | 0.1671 |
| 1982 | -0.01521 | 0.3181 | -0.01206 | 0.00005 | 0.34195 | 0.69862 | 9.25991 | 160 | 4.59599 | 0.23574 |
| 1983 | -0.11373 | 0.44794 | -0.00083 | 0.00003 | 0.1436 | (dropped) | 7.85269 | 260 | 7.58915 | 0.21458 |
| 1984 | -0.15235 | 0.39562 | -0.01341 | 0.00009 | 0.32268 | 0.78893 | 8.81539 | 307 | 13.43778 | 0.31223 |
| 1985 | -0.02896 | 0.19924 | -0.01381 | 0.00011 | -0.043 | 0.55566 | 10.14103 | 285 | 3.10134 | 0.11108 |
| 1986 | -0.02996 | 0.33662 | -0.00509 | 0.00002 | -0.10695 | 0.76025 | 8.99762 | 402 | 9.93123 | 0.21882 |
| 1987 | -0.05869 | 0.4787 | -0.00416 | 0.00002 | 0.46335 | (dropped) | 8.03625 | 456 | 9.47454 | 0.17554 |
| 1988 | 0.02401 | 0.34717 | -0.01037 | 0.0001 | 0.15136 | 0.09207 | 9.03889 | 502 | 5.99792 | 0.11867 |
| 1989 | -0.04587 | 0.29644 | -0.01871 | 0.00016 | -0.07003 | 0.13437 | 9.81536 | 522 | 7.09205 | 0.13267 |
| 1990 | 0.02834 | 0.32582 | -0.00628 | 0.00005 | -0.01351 | 0.52353 | 9.33366 | 718 | 8.66766 | 0.11898 |
| 1991 | -0.03251 | 0.19033 | -0.01497 | 0.00012 | 0.36634 | 0.34204 | 10.65455 | 753 | 4.67664 | 0.06492 |
| 1992 | -0.01155 | 0.21204 | -0.01958 | 0.00016 | 0.12315 | 0.16444 | 10.6645 | 813 | 6.56057 | 0.08265 |
| 1993 | -0.08502 | 0.15149 | -0.02509 | 0.0002 | 0.14698 | 0.32542 | 11.18661 | 867 | 8.58729 | 0.09949 |
| 1994 | -0.09569 | 0.16918 | -0.01902 | 0.00015 | 0.14935 | 0.01776 | 10.9164 | 856 | 6.15146 | 0.07422 |
| 1995 | -0.12183 | 0.09702 | -0.02446 | 0.00022 | -0.02125 | 0.44648 | 11.37742 | 745 | 7.6921 | 0.10349 |
| 1996 | -0.18157 | 0.26724 | -0.01561 | 0.00012 | -0.00711 | 0.15192 | 10.10294 | 866 | 5.76425 | 0.06912 |
| 1997 | -0.19826 | 0.24117 | -0.02288 | 0.00017 | 0.09715 | 0.25663 | 10.57359 | 966 | 11.67423 | 0.11864 |
| 1998 | -0.11498 | 0.26717 | -0.01213 | 0.00008 | -0.03123 | 0.20764 | 10.11919 | 1105 | 8.56472 | 0.0726 |
| 1999 | -0.14558 | 0.4288 | -0.02472 | 0.0002 | 0.02337 | 0.42697 | 9.25077 | 1396 | 21.12364 | 0.14376 |
| 2000 | -0.13387 | 0.1988 | -0.01625 | 0.00012 | 0.01559 | 0.2555 | 10.69165 | 1381 | 15.49241 | 0.1107 |
| 2001 | -0.07272 | 0.29747 | -0.01219 | 0.00009 | 0.02093 | 0.1317 | 10.00802 | 1927 | 20.66212 | 0.10609 |
| 2002 | -0.06571 | 0.3492 | -0.00738 | 0.00005 | 0.08911 | 0.34668 | 9.59727 | 3718 | 53.19319 | 0.13636 |
| 2003 | -0.06979 | 0.29603 | -0.00876 | 0.00007 | -0.00291 | 0.34021 | 10.11306 | 5518 | 69.98587 | 0.12267 |
| 2004 | -0.17319 | 0.17887 | -0.00456 | 0.00003 | 0.00679 | 0.26019 | 11.05593 | 6253 | 81.48218 | 0.12558 |
| 2005 | -0.25347 | 0.07344 | -0.00844 | 0.00007 | -0.01995 | -0.06238 | 12.09609 | 7043 | 53.18019 | 0.07681 |
| 2006 | -0.46793 | -0.05902 | -0.01129 | 0.00009 | 0.19683 | 0.22421 | 13.18535 | 7224 | 79.21384 | 0.1078 |
| 2007 | -0.44575 | -0.02438 | -0.01118 | 0.00008 | -0.01885 | 0.3926 | 12.83302 | 3497 | 34.03061 | 0.097 |

Table displays results of 32 hedonic price regressions (each row is a separate regression), each using sales observations in the South LA neighborhood in each year 1976 through 2007. Indicator variables for 2 units, 3 units, 4 units, 5 or more units, and missing number of units are suppressed.

## Table 2.6 - All properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0263** | 0.0269** | | 0.449** | 0.533** | | 1.018** | 1.194** |
| | | (0.00118) | (0.00201) | | (0.0568) | (0.101) | | (0.0733) | (0.122) |
| Adjusted price variance | | -0.0196** | -0.0418** | | 1.172** | 0.988* | | 0.935** | 1.084* |
| | | (0.00563) | (0.00819) | | (0.272) | (0.413) | | (0.350) | (0.497) |
| Log square footage | | | 0.00755* | | | -0.467* | | | -1.572** |
| | | | (0.00369) | | | (0.186) | | | (0.224) |
| Pct owner-occupied | | | 0.000000228 | | | -0.506** | | | -0.359** |
| | | | (0.00130) | | | (0.0656) | | | (0.0789) |
| Age | | | 0.000813** | | | 0.0566** | | | 0.0548** |
| | | | (0.000254) | | | (0.0128) | | | (0.0154) |
| Age$^2$ | | | -0.00000345 | | | -0.000498** | | | -0.000567** |
| | | | (0.00000235) | | | (0.000118) | | | (0.000142) |
| Adj hedonic reg error | | | 0.310** | | | -9.101$^+$ | | | -13.71* |
| | | | (0.105) | | | (5.317) | | | (6.395) |
| R-squared | | 0.42 | 0.57 | | 0.12 | 0.28 | | 0.24 | 0.46 |
| Log house price | 0.00864** | 0.0180** | 0.0158** | 0.807** | 0.467** | 0.745** | 1.291** | 0.899** | 1.335** |
| | (0.00284) | (0.00290) | (0.00276) | (0.150) | (0.148) | (0.142) | (0.182) | (0.177) | (0.171) |
| Adjusted price variance | -0.0110 | -0.0387** | -0.0308** | 0.527 | 1.011* | 0.778$^+$ | 0.922$^+$ | 1.187* | 0.946$^+$ |
| | (0.00855) | (0.00812) | (0.00823) | (0.452) | (0.415) | (0.423) | (0.546) | (0.497) | (0.510) |
| Log square footage | 0.000114 | 0.00274 | 0.000613 | -0.356$^+$ | -0.502* | -0.335$^+$ | -1.533** | -1.731** | -1.485** |
| | (0.00360) | (0.00381) | (0.00380) | (0.191) | (0.195) | (0.195) | (0.230) | (0.233) | (0.236) |
| Pct owner-occupied | -0.00329* | -0.000464 | -0.00111 | -0.457** | -0.509** | -0.485** | -0.342** | -0.375** | -0.345** |
| | (0.00129) | (0.00129) | (0.00129) | (0.0683) | (0.0658) | (0.0661) | (0.0825) | (0.0789) | (0.0797) |
| Age | 0.000982** | 0.000754** | 0.000834** | 0.0541** | 0.0562** | 0.0562** | 0.0539** | 0.0528** | 0.0545** |
| | (0.000242) | (0.000251) | (0.000248) | (0.0128) | (0.0128) | (0.0128) | (0.0154) | (0.0154) | (0.0154) |
| Age$^2$ | -0.00000427$^+$ | -0.00000268 | -0.00000321 | -0.000486** | -0.000492** | -0.000502** | -0.000563** | -0.000542** | -0.000570** |
| | (0.00000223) | (0.00000233) | (0.00000230) | (0.000118) | (0.000119) | (0.000118) | (0.000143) | (0.000142) | (0.000142) |
| Adj hedonic reg error | 0.201* | 0.263* | 0.267** | -7.464 | -9.445$^+$ | -8.281 | -13.14* | -15.27* | -13.17* |
| | (0.101) | (0.105) | (0.103) | (5.339) | (5.349) | (5.317) | (6.448) | (6.412) | (6.410) |
| Baseline price | 0.0267** | | | -0.400* | | | -0.141 | | |
| | (0.00308) | | | (0.163) | | | (0.197) | | |
| Log house price(t-1) | | 0.0123** | | | 0.0899 | | | 0.405* | |
| | | (0.00290) | | | (0.148) | | | (0.177) | |
| Log house price(t-5) | | | 0.0170** | | | -0.324* | | | -0.214 |
| | | | (0.00295) | | | (0.152) | | | (0.183) |
| R-squared | 0.61 | 0.58 | 0.59 | 0.29 | 0.28 | 0.29 | 0.46 | 0.47 | 0.46 |

*N = 693.* $^+$significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.7 - All properties: new construction

| | Percent of properties newly built | | | Value of new construction | | | Square footage of new construction | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0913** | 0.00142 | | 0.929** | 1.187** | | 1.188** | 1.525** |
| | | (0.00899) | (0.0129) | | (0.102) | (0.187) | | (0.0961) | (0.172) |
| Adjusted price variance | | -0.147** | -0.0774 | | 1.219* | 0.568 | | 1.004* | 0.772 |
| | | (0.0430) | (0.0526) | | (0.488) | (0.764) | | (0.453) | (0.689) |
| Log square footage | | | 0.0147 | | | -1.131** | | | -1.808** |
| | | | (0.0237) | | | (0.344) | | | (0.317) |
| Pct owner-occupied | | | -0.00292 | | | -0.804** | | | -0.548** |
| | | | (0.00836) | | | (0.121) | | | (0.110) |
| Age | | | -0.000533 | | | 0.0666** | | | 0.0562* |
| | | | (0.00163) | | | (0.0237) | | | (0.0221) |
| $Age^2$ | | | -0.00000214 | | | -0.000620** | | | -0.000567** |
| | | | (0.0000151) | | | (0.000219) | | | (0.000204) |
| Adj hedonic reg error | | | -0.799 | | | -8.604 | | | -12.08 |
| | | | (0.678) | | | (9.837) | | | (8.888) |
| R-squared | | 0.13 | 0.54 | | 0.13 | 0.24 | | 0.20 | 0.35 |
| Log house price | -0.0546** | 0.0239 | 0.00716 | 1.506** | 0.921** | 1.376** | 1.597** | 1.106** | 1.555** |
| | (0.0190) | (0.0188) | (0.0181) | (0.279) | (0.273) | (0.263) | (0.253) | (0.248) | (0.241) |
| Adjusted price variance | 0.0168 | -0.0852 | -0.0831 | 0.0310 | 0.661 | 0.382 | 0.650 | 0.911 | 0.744 |
| | (0.0572) | (0.0528) | (0.0542) | (0.839) | (0.766) | (0.785) | (0.758) | (0.689) | (0.708) |
| Log square footage | -0.00802 | 0.0268 | 0.0183 | -1.001** | -1.274** | -1.014** | -1.777** | -2.039** | -1.790** |
| | (0.0241) | (0.0248) | (0.0250) | (0.354) | (0.360) | (0.363) | (0.327) | (0.331) | (0.333) |
| Pct owner-occupied | -0.0130 | -0.00176 | -0.00235 | -0.746** | -0.817** | -0.785** | -0.535** | -0.570** | -0.544** |
| | (0.00865) | (0.00838) | (0.00846) | (0.127) | (0.122) | (0.123) | (0.115) | (0.110) | (0.111) |
| Age | -0.0000140 | -0.000386 | -0.000544 | 0.0637** | 0.0649** | 0.0663** | 0.0556* | 0.0527* | 0.0562* |
| | (0.00162) | (0.00163) | (0.00163) | (0.0237) | (0.0237) | (0.0237) | (0.0222) | (0.0221) | (0.0221) |
| $Age^2$ | -0.00000465 | -0.00000405 | -0.00000226 | -0.000606** | -0.000598** | -0.000624** | -0.000564** | -0.000523* | -0.000568** |
| | (0.0000150) | (0.0000151) | (0.0000151) | (0.000219) | (0.000220) | (0.000219) | (0.000204) | (0.000204) | (0.000204) |
| Adj hedonic reg error | $-1.133^{+}$ | -0.681 | -0.777 | -6.697 | -10.00 | -7.878 | -11.64 | -14.20 | -11.98 |
| | (0.676) | (0.681) | (0.680) | (9.904) | (9.887) | (9.862) | (8.965) | (8.905) | (8.913) |
| Baseline price | 0.0817** | | | -0.466 | | | -0.106 | | |
| | (0.0206) | | | (0.302) | | | (0.273) | | |
| Log house price(t-1) | | -0.0308 | | | 0.365 | | | 0.578* | |
| | | (0.0188) | | | (0.273) | | | (0.247) | |
| Log house price(t-5) | | | -0.00873 | | | -0.287 | | | -0.0447 |
| | | | (0.0194) | | | (0.282) | | | (0.257) |
| R-squared | 0.55 | 0.54 | 0.54 | 0.25 | 0.24 | 0.24 | 0.35 | 0.36 | 0.35 |

$N = 693$. $^{+}$significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.8 - All properties: existing construction

| | Percent of properties improved | | | Value of additions | | | Square footage of additions | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0218** | 0.0242** | | 0.101** | 0.199** | | 0.681** | 0.685** |
| | | (0.00109) | (0.00172) | | (0.0364) | (0.0646) | | (0.0657) | (0.109) |
| Adjusted price variance | | -0.0130* | -0.0308** | | 0.548** | 0.595* | | 0.507 | 1.124* |
| | | (0.00523) | (0.00697) | | (0.175) | (0.262) | | (0.316) | (0.441) |
| Log square footage | | | 0.00712* | | | -0.287* | | | -1.125** |
| | | | (0.00316) | | | (0.119) | | | (0.200) |
| Pct owner-occupied | | | 0.000932 | | | -0.126** | | | 0.0399 |
| | | | (0.00111) | | | (0.0419) | | | (0.0705) |
| Age | | | 0.000944** | | | 0.0582** | | | 0.0497** |
| | | | (0.000217) | | | (0.00817) | | | (0.0138) |
| $Age^2$ | | | -0.00000396* | | | -0.000471** | | | -0.000513** |
| | | | (0.00000201) | | | (0.0000757) | | | (0.000127) |
| Adj hedonic reg error | | | 0.237** | | | -5.938$^{+}$ | | | -12.67* |
| | | | (0.0893) | | | (3.360) | | | (5.656) |
| R-squared | | 0.37 | 0.59 | | 0.03 | 0.21 | | 0.15 | 0.40 |
| Log house price | 0.00993** | 0.0157** | 0.0132** | 0.0869 | 0.245** | 0.188* | 0.362* | 0.399* | 0.615** |
| | (0.00246) | (0.00247) | (0.00234) | (0.0963) | (0.0945) | (0.0909) | (0.162) | (0.158) | (0.153) |
| Adjusted price variance | -0.00675 | -0.0278** | -0.0201** | 0.784** | 0.578* | 0.606* | 1.669** | 1.225** | 1.192** |
| | (0.00735) | (0.00689) | (0.00694) | (0.288) | (0.263) | (0.270) | (0.484) | (0.442) | (0.454) |
| Log square footage | 0.00136 | 0.00259 | 0.000317 | -0.332** | -0.262* | -0.294* | -1.255** | -1.278** | -1.168** |
| | (0.00312) | (0.00326) | (0.00323) | (0.122) | (0.125) | (0.126) | (0.205) | (0.209) | (0.211) |
| Pct owner-occupied | -0.00164 | 0.000500 | -0.000149 | -0.146** | -0.124** | -0.127** | -0.0185 | 0.0252 | 0.0329 |
| | (0.00112) | (0.00110) | (0.00109) | (0.0438) | (0.0421) | (0.0424) | (0.0735) | (0.0705) | (0.0714) |
| Age | 0.00108** | 0.000888** | 0.000964** | 0.0592** | 0.0585** | 0.0582** | 0.0527** | 0.0478** | 0.0498** |
| | (0.000209) | (0.000214) | (0.000211) | (0.00819) | (0.00819) | (0.00818) | (0.0137) | (0.0137) | (0.0138) |
| $Age^2$ | -0.00000460* | -0.00000324 | -0.00000372$^{+}$ | -0.000476** | -0.000475** | -0.000471** | -0.000528** | -0.000488** | -0.000511** |
| | (0.00000193) | (0.00000199) | (0.00000195) | (0.0000757) | (0.0000760) | (0.0000758) | (0.000127) | (0.000127) | (0.000128) |
| Adj hedonic reg error | 0.155$^{+}$ | 0.193* | 0.198* | -6.588$^{+}$ | -5.697$^{+}$ | -5.978$^{+}$ | -14.54* | -14.17* | -12.92* |
| | (0.0862) | (0.0884) | (0.0868) | (3.382) | (3.381) | (3.370) | (5.673) | (5.667) | (5.671) |
| Baseline price | 0.0208** | | | 0.164 | | | 0.472** | | |
| | (0.00266) | | | (0.104) | | | (0.175) | | |
| Log house price(t-1) | | 0.0116** | | | -0.0632 | | | 0.393* | |
| | | (0.00247) | | | (0.0945) | | | (0.158) | |
| Log house price(t-5) | | | 0.0166** | | | 0.0174 | | | 0.107 |
| | | | (0.00251) | | | (0.0973) | | | (0.164) |
| R-squared | 0.63 | 0.61 | 0.62 | 0.21 | 0.21 | 0.21 | 0.40 | 0.40 | 0.40 |

*N = 693.* $^{+}$significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.9 - Owner-occupied properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0176** | 0.0185** | | 0.0690$^{+}$ | -0.00832 | | 0.562** | 0.408** |
| | | (0.00113) | (0.00190) | | (0.0398) | (0.0751) | | (0.0555) | (0.103) |
| Adjusted price variance | | -0.00428 | -0.0448** | | -2.080** | -3.178** | | -2.779** | -4.034** |
| | | (0.0150) | (0.0170) | | (0.525) | (0.673) | | (0.733) | (0.921) |
| Log square footage | | | 0.0199** | | | 0.380* | | | -0.127 |
| | | | (0.00382) | | | (0.151) | | | (0.207) |
| Age | | | 0.00154** | | | 0.0820** | | | 0.0908** |
| | | | (0.000221) | | | (0.00875) | | | (0.0120) |
| $Age^2$ | | | -0.00000924** | | | -0.000665** | | | -0.000825** |
| | | | (0.00000204) | | | (0.0000808) | | | (0.000111) |
| Adj hedonic reg error | | | 0.0474 | | | 4.850 | | | 6.875 |
| | | | (0.0791) | | | (3.132) | | | (4.291) |
| R-squared | | 0.26 | 0.54 | | 0.03 | 0.23 | | 0.14 | 0.35 |
| Log house price | 0.00264 | 0.00924** | 0.00634* | -0.0604 | 0.0303 | -0.0447 | 0.398* | 0.392* | 0.348* |
| | (0.00312) | (0.00332) | (0.00294) | (0.127) | (0.133) | (0.119) | (0.174) | (0.182) | (0.163) |
| Adjusted price variance | -0.00609 | -0.0402* | -0.0350* | -3.050** | -3.197** | -3.148** | -4.009** | -4.026** | -3.985** |
| | (0.0176) | (0.0169) | (0.0168) | (0.718) | (0.675) | (0.677) | (0.984) | (0.925) | (0.928) |
| Log square footage | 0.0115** | 0.0162** | 0.0131** | 0.353* | 0.396* | 0.360* | -0.132 | -0.134 | -0.160 |
| | (0.00394) | (0.00394) | (0.00395) | (0.161) | (0.157) | (0.160) | (0.220) | (0.216) | (0.219) |
| Age | 0.00154** | 0.00148** | 0.00149** | 0.0820** | 0.0823** | 0.0818** | 0.0908** | 0.0907** | 0.0905** |
| | (0.000215) | (0.000220) | (0.000217) | (0.00876) | (0.00879) | (0.00877) | (0.0120) | (0.0120) | (0.0120) |
| $Age^2$ | -0.00000879** | -0.00000860** | -0.00000847** | -0.000663** | -0.000667** | -0.000662** | -0.000825** | -0.000824** | -0.000821** |
| | (0.00000199) | (0.00000204) | (0.00000201) | (0.0000809) | (0.0000812) | (0.0000811) | (0.000111) | (0.000111) | (0.000111) |
| Adj hedonic reg error | 0.0299 | 0.0279 | 0.0727 | 4.792 | 4.931 | 4.926 | 6.863 | 6.841 | 6.998 |
| | (0.0770) | (0.0788) | (0.0777) | (3.136) | (3.142) | (3.140) | (4.297) | (4.306) | (4.301) |
| Baseline price | 0.0212** | | | 0.0696 | | | 0.0133 | | |
| | (0.00335) | | | (0.137) | | | (0.187) | | |
| Log house price(t-1) | | 0.0113** | | | -0.0473 | | | 0.0194 | |
| | | (0.00335) | | | (0.133) | | | (0.183) | |
| Log house price(t-5) | | | 0.0162** | | | 0.0486 | | | 0.0795 |
| | | | (0.00304) | | | (0.123) | | | (0.168) |
| R-squared | 0.56 | 0.55 | 0.56 | 0.23 | 0.23 | 0.23 | 0.35 | 0.35 | 0.35 |

*N = 693.* $^{+}$significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.10 - Renter-occupied properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0429** | 0.0512** | | 0.567** | 0.422** | | 1.122** | 1.153** |
| | | (0.00197) | (0.00369) | | (0.0634) | (0.122) | | (0.0835) | (0.145) |
| Adjusted price variance | | -0.0303** | -0.0698** | | 0.764* | 1.203* | | 0.405 | 1.036+ |
| | | (0.01000) | (0.0152) | | (0.322) | (0.502) | | (0.423) | (0.592) |
| Log square footage | | | -0.0102+ | | | -0.235 | | | -1.523** |
| | | | (0.00589) | | | (0.194) | | | (0.233) |
| Age | | | -0.000843+ | | | 0.0291+ | | | 0.0246 |
| | | | (0.000480) | | | (0.0158) | | | (0.0186) |
| $Age^2$ | | | 0.0000120** | | | -0.000272+ | | | -0.000317+ |
| | | | (0.00000439) | | | (0.000145) | | | (0.000170) |
| Adj hedonic reg error | | | 0.601** | | | -7.124 | | | -9.593 |
| | | | (0.203) | | | (6.695) | | | (7.916) |
| R-squared | 0.19 | 0.41 | 0.48 | 0.00 | 0.12 | 0.18 | 0.01 | 0.22 | 0.42 |
| Log house price | 0.0191** | 0.0353** | 0.0283** | 0.937** | 0.386* | 0.623** | 1.414** | 0.878** | 1.281** |
| | (0.00587) | (0.00550) | (0.00540) | (0.198) | (0.183) | (0.182) | (0.236) | (0.216) | (0.216) |
| Adjusted price variance | -0.0134 | -0.0622** | -0.0475** | 0.300 | 1.220* | 1.008+ | 0.575 | 1.170+ | 0.913 |
| | (0.0169) | (0.0152) | (0.0154) | (0.570) | (0.507) | (0.519) | (0.678) | (0.597) | (0.613) |
| Log square footage | -0.0125* | -0.0166** | -0.0189** | -0.199 | -0.250 | -0.159 | -1.502** | -1.637** | -1.476** |
| | (0.00571) | (0.00606) | (0.00595) | (0.193) | (0.202) | (0.200) | (0.233) | (0.242) | (0.240) |
| Age | -0.000798+ | -0.000927+ | -0.000851+ | 0.0284+ | 0.0289+ | 0.0292+ | 0.0242 | 0.0231 | 0.0246 |
| | (0.000464) | (0.000476) | (0.000469) | (0.0157) | (0.0158) | (0.0158) | (0.0186) | (0.0186) | (0.0187) |
| $Age^2$ | 0.0000127** | 0.0000133** | 0.0000130** | -0.000284* | -0.000269+ | -0.000281+ | -0.000323+ | -0.000295+ | -0.000322+ |
| | (0.00000424) | (0.00000436) | (0.00000429) | (0.000144) | (0.000145) | (0.000144) | (0.000170) | (0.000171) | (0.000171) |
| Adj hedonic reg error | 0.372+ | 0.510* | 0.531** | -3.456 | -7.328 | -6.504 | -7.683 | -11.19 | -9.209 |
| | (0.199) | (0.203) | (0.199) | (6.742) | (6.745) | (6.702) | (8.027) | (7.959) | (7.933) |
| Baseline price | 0.0401** | | | -0.643** | | | -0.326 | | |
| | (0.00581) | | | (0.196) | | | (0.233) | | |
| Log house price(t-1) | | 0.0209** | | | 0.0468 | | | 0.363+ | |
| | | (0.00539) | | | (0.180) | | | (0.211) | |
| Log house price(t-5) | | | 0.0310** | | | -0.272 | | | -0.171 |
| | | | (0.00542) | | | (0.183) | | | (0.216) |
| R-squared | 0.51 | 0.49 | 0.50 | 0.20 | 0.18 | 0.19 | 0.42 | 0.42 | 0.42 |

*N = 693.* +significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.11 - Sample excludes owner-occupier "stayers" - Owner-occupied properties

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0240** | 0.0267** | | 0.108+ | 0.113 | | 0.644** | 0.599** |
| | | (0.00161) | (0.00287) | | (0.0577) | (0.116) | | (0.0790) | (0.154) |
| Adjusted price variance | | -0.000178 | -0.0218 | | -2.852** | -4.047** | | -3.474** | -4.784** |
| | | (0.0214) | (0.0242) | | (0.811) | (0.973) | | (1.158) | (1.339) |
| Log square footage | | | 0.0178** | | | 0.267 | | | -0.394 |
| | | | (0.00582) | | | (0.234) | | | (0.315) |
| Age | | | 0.00191** | | | 0.0930** | | | 0.115** |
| | | | (0.000332) | | | (0.0135) | | | (0.0180) |
| $Age^2$ | | | -0.0000114** | | | -0.000760** | | | -0.00105** |
| | | | (0.00000305) | | | (0.000124) | | | (0.000165) |
| Adj hedonic reg error | | | -0.159 | | | 6.428 | | | 9.817 |
| | | | (0.123) | | | (5.567) | | | (7.401) |
| R-squared | | 0.27 | 0.50 | | 0.03 | 0.16 | | 0.11 | 0.29 |
| Log house price | 0.0226** | 0.0239** | 0.0224** | 0.225 | 0.360+ | 0.217 | 0.917** | 0.685* | 0.759** |
| | (0.00492) | (0.00491) | (0.00456) | (0.201) | (0.211) | (0.184) | (0.272) | (0.290) | (0.248) |
| Adjusted price variance | -0.0128 | -0.0200 | -0.0191 | -4.285** | -4.176** | -4.109** | -5.423** | -4.826** | -4.861** |
| | (0.0258) | (0.0244) | (0.0243) | (1.035) | (0.976) | (0.977) | (1.411) | (1.345) | (1.342) |
| Log square footage | 0.0159** | 0.0166** | 0.0157** | 0.317 | 0.360 | 0.316 | -0.244 | -0.362 | -0.314 |
| | (0.00612) | (0.00606) | (0.00607) | (0.246) | (0.243) | (0.244) | (0.333) | (0.329) | (0.330) |
| Age | 0.00191** | 0.00189** | 0.00189** | 0.0928** | 0.0945** | 0.0934** | 0.115** | 0.115** | 0.116** |
| | (0.000332) | (0.000333) | (0.000332) | (0.0135) | (0.0135) | (0.0135) | (0.0180) | (0.0181) | (0.0180) |
| $Age^2$ | -0.0000113** | -0.0000112** | -0.0000112** | -0.000761** | -0.000775** | -0.000766** | -0.00105** | -0.00105** | -0.00106** |
| | (0.00000305) | (0.00000307) | (0.00000306) | (0.000124) | (0.000125) | (0.000125) | (0.000165) | (0.000166) | (0.000166) |
| Adj hedonic reg error | -0.156 | -0.167 | -0.142 | 6.057 | 5.661 | 5.894 | 8.705 | 9.487 | 8.970 |
| | (0.123) | (0.123) | (0.124) | (5.596) | (5.589) | (5.617) | (7.437) | (7.467) | (7.474) |
| Baseline price | 0.00536 | | | -0.145 | | | -0.414 | | |
| | (0.00525) | | | (0.214) | | | (0.292) | | |
| Log house price(t-1) | | 0.00348 | | | -0.298 | | | -0.103 | |
| | | (0.00493) | | | (0.213) | | | (0.293) | |
| Log house price(t-5) | | | 0.00566 | | | -0.136 | | | -0.210 |
| | | | (0.00464) | | | (0.187) | | | (0.254) |
| R-squared | 0.50 | 0.50 | 0.50 | 0.16 | 0.17 | 0.16 | 0.29 | 0.29 | 0.29 |

*N = 693.* +significant at 10%; *significant at 5%; **significant at 1%.

Table 2.12 - Sample excludes owner-occupier ”stayers” - all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0360** | 0.0302** | | 0.638** | 0.621** | | 1.263** | 1.276** |
| | | (0.00149) | (0.00268) | | (0.0632) | (0.113) | | (0.0829) | (0.135) |
| Adjusted price variance | | -0.0298** | -0.0517** | | 0.887** | 0.793$^+$ | | 0.482 | 0.778 |
| | | (0.00709) | (0.0108) | | (0.302) | (0.456) | | (0.395) | (0.544) |
| Log square footage | | | 0.0126* | | | -0.518* | | | -1.623** |
| | | | (0.00492) | | | (0.207) | | | (0.248) |
| Pct owner-occupied | | | 0.000430 | | | -0.445** | | | -0.241** |
| | | | (0.00174) | | | (0.0735) | | | (0.0877) |
| Age | | | 0.000185 | | | 0.0480** | | | 0.0481** |
| | | | (0.000346) | | | (0.0146) | | | (0.0174) |
| Age$^2$ | | | 0.00000143 | | | -0.000439** | | | -0.000529** |
| | | | (0.00000319) | | | (0.000134) | | | (0.000160) |
| Adj hedonic reg error | | | 0.363** | | | -8.903 | | | -13.23$^+$ |
| | | | (0.139) | | | (5.876) | | | (7.012) |
| R-squared | | 0.46 | 0.55 | | 0.15 | 0.30 | | 0.26 | 0.50 |
| Log house price | 0.00695$^+$ | 0.0199** | 0.0155** | 0.877** | 0.517** | 0.781** | 1.320** | 0.945** | 1.361** |
| | (0.00381) | (0.00388) | (0.00369) | (0.168) | (0.165) | (0.159) | (0.201) | (0.196) | (0.190) |
| Adjusted price variance | -0.0124 | -0.0480** | -0.0373** | 0.362 | 0.830$^+$ | 0.636 | 0.704 | 0.895 | 0.695 |
| | (0.0114) | (0.0108) | (0.0109) | (0.501) | (0.458) | (0.468) | (0.600) | (0.544) | (0.559) |
| Log square footage | 0.00304 | 0.00702 | 0.00341 | -0.413$^+$ | -0.574** | -0.418$^+$ | -1.606** | -1.801** | -1.571** |
| | (0.00484) | (0.00511) | (0.00507) | (0.213) | (0.217) | (0.219) | (0.255) | (0.258) | (0.261) |
| Pct owner-occupied | -0.00371* | -0.0000884 | -0.00101 | -0.400** | -0.451** | -0.430** | -0.233* | -0.258** | -0.233** |
| | (0.00174) | (0.00173) | (0.00172) | (0.0766) | (0.0737) | (0.0742) | (0.0917) | (0.0877) | (0.0887) |
| Age | 0.000391 | 0.000112 | 0.000203 | 0.0457** | 0.0473** | 0.0478** | 0.0477** | 0.0458** | 0.0480** |
| | (0.000331) | (0.000343) | (0.000338) | (0.0146) | (0.0146) | (0.0146) | (0.0175) | (0.0174) | (0.0174) |
| Age$^2$ | 0.000000483 | 0.00000236 | 0.00000183 | -0.000429** | -0.000430** | -0.000443** | -0.000528** | -0.000500** | -0.000532** |
| | (0.00000304) | (0.00000317) | (0.00000312) | (0.000134) | (0.000135) | (0.000134) | (0.000160) | (0.000160) | (0.000160) |
| Adj hedonic reg error | 0.227$^+$ | 0.309* | 0.309* | -7.406 | -9.454 | -8.313 | -12.97$^+$ | -14.98* | -12.92$^+$ |
| | (0.134) | (0.139) | (0.137) | (5.908) | (5.912) | (5.886) | (7.071) | (7.031) | (7.033) |
| Baseline price | 0.0340** | | | -0.373* | | | -0.0639 | | |
| | (0.00413) | | | (0.182) | | | (0.218) | | |
| Log house price(t-1) | | 0.0142** | | | 0.143 | | | 0.455* | |
| | | (0.00388) | | | (0.165) | | | (0.196) | |
| Log house price(t-5) | | | 0.0224** | | | -0.244 | | | -0.128 |
| | | | (0.00395) | | | (0.170) | | | (0.203) |
| R-squared | 0.59 | 0.56 | 0.57 | 0.31 | 0.30 | 0.30 | 0.50 | 0.50 | 0.50 |

*N = 693.* $^+$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.13 - Sample excludes owner-occupier ”stayers” - improvements to existing construction

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0312** | 0.0287** | | 0.192** | 0.247** | | 0.850** | 0.733** |
| | | (0.00140) | (0.00238) | | (0.0388) | (0.0708) | | (0.0761) | (0.129) |
| Adjusted price variance | | -0.0204** | -0.0400** | | 0.547** | 0.683* | | 0.133 | 1.081* |
| | | (0.00669) | (0.00960) | | (0.186) | (0.285) | | (0.365) | (0.521) |
| Log square footage | | | 0.0127** | | | $-0.227^{+}$ | | | -1.017** |
| | | | (0.00438) | | | (0.130) | | | (0.237) |
| Pct owner-occupied | | | 0.00193 | | | -0.126** | | | 0.0985 |
| | | | (0.00155) | | | (0.0460) | | | (0.0840) |
| Age | | | 0.000841** | | | 0.0545** | | | 0.0437** |
| | | | (0.000307) | | | (0.00913) | | | (0.0167) |
| $Age^2$ | | | -0.00000300 | | | -0.000447** | | | -0.000478** |
| | | | (0.00000283) | | | (0.0000841) | | | (0.000153) |
| Adj hedonic reg error | | | 0.314* | | | $-7.003^{+}$ | | | -16.31* |
| | | | (0.123) | | | (3.667) | | | (6.692) |
| R-squared | | 0.42 | 0.57 | | 0.05 | 0.19 | | 0.16 | 0.38 |
| Log house price | 0.0109** | 0.0179** | 0.0129** | 0.132 | 0.274** | 0.213* | 0.383* | $0.359^{+}$ | 0.659** |
| | (0.00343) | (0.00343) | (0.00324) | (0.105) | (0.103) | (0.0996) | (0.192) | (0.188) | (0.182) |
| Adjusted price variance | -0.00997 | -0.0361** | -0.0246* | 0.879** | 0.674* | 0.717* | 1.674** | 1.214* | 1.153* |
| | (0.0102) | (0.00952) | (0.00954) | (0.314) | (0.287) | (0.294) | (0.572) | (0.521) | (0.536) |
| Log square footage | 0.00549 | 0.00691 | 0.00288 | -0.274* | -0.213 | $-0.249^{+}$ | -1.160** | -1.219** | -1.063** |
| | (0.00435) | (0.00452) | (0.00446) | (0.134) | (0.136) | (0.137) | (0.244) | (0.248) | (0.250) |
| Pct owner-occupied | -0.00122 | 0.00139 | 0.000380 | -0.146** | -0.125** | -0.129** | 0.0361 | 0.0797 | 0.0912 |
| | (0.00156) | (0.00153) | (0.00151) | (0.0480) | (0.0462) | (0.0465) | (0.0874) | (0.0838) | (0.0849) |
| Age | 0.000998** | 0.000764* | 0.000860** | 0.0556** | 0.0547** | 0.0546** | 0.0468** | 0.0410* | 0.0437** |
| | (0.000298) | (0.000304) | (0.000297) | (0.00915) | (0.00915) | (0.00914) | (0.0167) | (0.0166) | (0.0167) |
| $Age^2$ | -0.00000373 | -0.00000203 | -0.00000256 | -0.000452** | -0.000449** | -0.000446** | -0.000492** | -0.000444** | -0.000476** |
| | (0.00000274) | (0.00000280) | (0.00000274) | (0.0000841) | (0.0000844) | (0.0000842) | (0.000153) | (0.000153) | (0.000154) |
| Adj hedonic reg error | $0.212^{+}$ | 0.258* | 0.258* | -7.670* | $-6.863^{+}$ | $-7.126^{+}$ | -18.33** | -18.28** | -16.57* |
| | (0.120) | (0.122) | (0.120) | (3.691) | (3.690) | (3.677) | (6.717) | (6.699) | (6.710) |
| Baseline price | 0.0259** | | | 0.169 | | | 0.511* | | |
| | (0.00371) | | | (0.114) | | | (0.208) | | |
| Log house price(t-1) | | 0.0148** | | | -0.0366 | | | 0.514** | |
| | | (0.00343) | | | (0.103) | | | (0.188) | |
| Log house price(t-5) | | | 0.0241** | | | 0.0523 | | | 0.113 |
| | | | (0.00346) | | | (0.107) | | | (0.195) |
| R-squared | 0.60 | 0.58 | 0.60 | 0.19 | 0.19 | 0.19 | 0.38 | 0.38 | 0.38 |

*N = 693.* $^{+}$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.14 - Including lagged investment measures - All properties: all improvements

| | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|
| Log house price | | 0.449** | 0.477** | | 1.018** | 0.718** |
| | | (0.0568) | (0.0982) | | (0.0733) | (0.125) |
| Adjusted price variance | | 1.172** | 0.335 | | 0.935** | 0.491 |
| | | (0.272) | (0.389) | | (0.350) | (0.475) |
| Lagged improvement value | | | 0.391** | | | |
| | | | (0.0361) | | | |
| Lagged improvement sq ft | | | | | | 0.345** |
| | | | | | | (0.0364) |
| Log square footage | | | -0.624** | | | -0.964** |
| | | | (0.180) | | | (0.226) |
| Pct owner-occupied | | | -0.334** | | | -0.312** |
| | | | (0.0654) | | | (0.0786) |
| Adj hedonic reg error | | | -4.817 | | | -6.691 |
| | | | (5.003) | | | (6.145) |
| R-squared | | 0.12 | 0.40 | | 0.24 | 0.50 |
| Log house price | 0.772** | 0.589** | 0.746** | 0.915** | 0.636** | 0.859** |
| | (0.142) | (0.143) | (0.138) | (0.177) | (0.174) | (0.172) |
| Adjusted price variance | -0.189 | 0.281 | 0.0576 | 0.139 | 0.528 | 0.349 |
| | (0.427) | (0.392) | (0.399) | (0.525) | (0.478) | (0.490) |
| Lagged improvement value | 0.398** | 0.400** | 0.401** | | | |
| | (0.0360) | (0.0371) | (0.0361) | | | |
| Lagged improvement sq ft | | | | 0.350** | 0.339** | 0.349** |
| | | | | (0.0365) | (0.0374) | (0.0365) |
| Log square footage | -0.501** | -0.564** | -0.465* | -0.874** | -1.017** | -0.874** |
| | (0.184) | (0.188) | (0.188) | (0.233) | (0.240) | (0.238) |
| Pct owner-occupied | -0.274** | -0.323** | -0.297** | -0.272** | -0.319** | -0.294** |
| | (0.0684) | (0.0662) | (0.0664) | (0.0825) | (0.0792) | (0.0800) |
| Adj hedonic reg error | -2.650 | -4.091 | -3.653 | -5.233 | -7.231 | -6.100 |
| | (5.031) | (5.047) | (4.994) | (6.207) | (6.199) | (6.163) |
| Baseline price | -0.439** | | | -0.298 | | |
| | (0.153) | | | (0.189) | | |
| Log house price(t-1) | | -0.156 | | | 0.120 | |
| | | (0.143) | | | (0.177) | |
| Log house price(t-5) | | | -0.400** | | | -0.213 |
| | | | (0.145) | | | (0.179) |
| R-squared | 0.40 | 0.40 | 0.40 | 0.50 | 0.50 | 0.50 |

*N = 693.* $^{+}$significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.15 Including lagged investment measures - All properties: new construction

| | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|
| Log house price | | 0.929** | 0.909** | | 1.188** | 1.081** |
| | | (0.102) | (0.176) | | (0.0961) | (0.169) |
| Adjusted price variance | | 1.219* | 0.177 | | 1.004* | 0.281 |
| | | (0.488) | (0.684) | | (0.453) | (0.630) |
| Lagged improvement value | | | 0.402** | | | |
| | | | (0.0342) | | | |
| Lagged improvement sq ft | | | | | | 0.392** |
| | | | | | | (0.0355) |
| Log square footage | | | -1.175** | | | -1.457** |
| | | | (0.321) | | | (0.305) |
| Pct owner-occupied | | | -0.478** | | | -0.354** |
| | | | (0.115) | | | (0.105) |
| Adj hedonic reg error | | | -6.868 | | | -8.154 |
| | | | (8.866) | | | (8.141) |
| R-squared | | 0.13 | 0.38 | | 0.20 | 0.45 |
| Log house price | 1.181** | 0.864** | 1.157** | 1.201** | 0.883** | 1.146** |
| | (0.254) | (0.252) | (0.247) | (0.237) | (0.232) | (0.233) |
| Adjusted price variance | -0.298 | 0.195 | -0.0677 | 0.0721 | 0.352 | 0.220 |
| | (0.754) | (0.688) | (0.704) | (0.694) | (0.633) | (0.649) |
| Lagged improvement value | 0.404** | 0.400** | 0.405** | | | |
| | (0.0342) | (0.0348) | (0.0343) | | | |
| Lagged improvement sq ft | | | | 0.394** | 0.383** | 0.393** |
| | | | | (0.0356) | (0.0363) | (0.0356) |
| Log square footage | -1.059** | -1.200** | -1.025** | -1.401** | -1.590** | -1.418** |
| | (0.330) | (0.337) | (0.337) | (0.315) | (0.323) | (0.321) |
| Pct owner-occupied | -0.424** | -0.482** | -0.446** | -0.329** | -0.371** | -0.345** |
| | (0.121) | (0.116) | (0.117) | (0.111) | (0.106) | (0.107) |
| Adj hedonic reg error | -4.932 | -7.129 | -5.879 | -7.337 | -9.273 | -7.929 |
| | (8.952) | (8.934) | (8.885) | (8.222) | (8.187) | (8.166) |
| Baseline price | -0.406 | | | -0.182 | | |
| | (0.273) | | | (0.252) | | |
| Log house price(t-1) | | 0.0631 | | | 0.292 | |
| | | (0.253) | | | (0.234) | |
| Log house price(t-5) | | | -0.372 | | | -0.0964 |
| | | | (0.258) | | | (0.240) |
| R-squared | 0.39 | 0.38 | 0.39 | 0.45 | 0.45 | 0.45 |

*N = 693.* $^{+}$significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.16 - Including lagged investment measures - All properties: existing construction

| | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|
| Log house price | | 0.101** | 0.211** | | 0.681** | 0.364** |
| | | (0.0364) | (0.0614) | | (0.0657) | (0.113) |
| Adjusted price variance | | 0.548** | 0.124 | | 0.507 | 0.472 |
| | | (0.175) | (0.242) | | (0.316) | (0.433) |
| Lagged improvement value | | | 0.449** | | | |
| | | | (0.0358) | | | |
| Lagged improvement sq ft | | | | | | 0.312** |
| | | | | | | (0.0384) |
| Log square footage | | | -0.407** | | | -0.732** |
| | | | (0.113) | | | (0.206) |
| Pct owner-occupied | | | -0.0446 | | | -0.0195 |
| | | | (0.0400) | | | (0.0711) |
| Adj hedonic reg error | | | 0.126 | | | -4.290 |
| | | | (3.116) | | | (5.564) |
| R-squared | | 0.03 | 0.37 | | 0.15 | 0.43 |
| Log house price | 0.272** | 0.480** | 0.328** | 0.249 | 0.237 | 0.319* |
| | (0.0911) | (0.0899) | (0.0881) | (0.160) | (0.159) | (0.156) |
| Adjusted price variance | 0.0123 | -0.0117 | -0.00223 | 0.684 | 0.529 | 0.518 |
| | (0.271) | (0.241) | (0.251) | (0.482) | (0.436) | (0.447) |
| Lagged improvement value | 0.457** | 0.490** | 0.464** | | | |
| | (0.0368) | (0.0368) | (0.0367) | | | |
| Lagged improvement sq ft | | | | 0.306** | 0.304** | 0.310** |
| | | | | (0.0388) | (0.0389) | (0.0386) |
| Log square footage | -0.383** | -0.273* | -0.341** | -0.786** | -0.808** | -0.761** |
| | (0.116) | (0.116) | (0.118) | (0.213) | (0.217) | (0.217) |
| Pct owner-occupied | -0.0319 | -0.0229 | -0.0287 | -0.0417 | -0.0266 | -0.0247 |
| | (0.0424) | (0.0398) | (0.0408) | (0.0745) | (0.0713) | (0.0722) |
| Adj hedonic reg error | 0.631 | 2.108 | 0.737 | -5.181 | -5.113 | -4.479 |
| | (3.166) | (3.115) | (3.127) | (5.635) | (5.611) | (5.586) |
| Baseline price | -0.0887 | | | 0.174 | | |
| | (0.0983) | | | (0.174) | | |
| Log house price(t-1) | | -0.364** | | | 0.179 | |
| | | (0.0896) | | | (0.159) | |
| Log house price(t-5) | | | -0.171$^{+}$ | | | 0.0677 |
| | | | (0.0926) | | | (0.163) |
| R-squared | 0.37 | 0.38 | 0.37 | 0.43 | 0.43 | 0.43 |

*N = 693.* $^{+}$significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.17 - Including lagged investment measures - Owner-occupied properties: all improvements

| | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|
| Log house price | | $0.0690^{+}$ | 0.0921 | | 0.562** | 0.257** |
| | | (0.0398) | (0.0671) | | (0.0555) | (0.0955) |
| Adjusted price variance | | -2.080** | -2.322** | | -2.779** | -2.255** |
| | | (0.525) | (0.594) | | (0.733) | (0.858) |
| Lagged improvement value | | | 0.517** | | | |
| | | | (0.0344) | | | |
| Lagged improvement sq ft | | | | | | 0.474** |
| | | | | | | (0.0350) |
| Log square footage | | | -0.0510 | | | -0.268 |
| | | | (0.136) | | | (0.190) |
| Adj hedonic reg error | | | 5.732* | | | 4.460 |
| | | | (2.686) | | | (3.847) |
| R-squared | | 0.03 | 0.46 | | 0.14 | 0.51 |
| Log house price | 0.173 | 0.393** | 0.132 | $0.273^{+}$ | 0.485** | 0.220 |
| | (0.111) | (0.120) | (0.108) | (0.156) | (0.168) | (0.152) |
| Adjusted price variance | -2.495** | -2.414** | -2.349** | -2.291* | -2.327** | -2.227* |
| | (0.623) | (0.591) | (0.597) | (0.902) | (0.858) | (0.863) |
| Lagged improvement value | 0.522** | 0.533** | 0.519** | | | |
| | (0.0347) | (0.0346) | (0.0346) | | | |
| Lagged improvement sq ft | | | | 0.474** | 0.480** | 0.473** |
| | | | | (0.0351) | (0.0352) | (0.0351) |
| Log square footage | -0.00863 | 0.0544 | -0.0301 | -0.260 | -0.179 | -0.289 |
| | (0.144) | (0.139) | (0.143) | (0.203) | (0.198) | (0.202) |
| Adj hedonic reg error | 5.790* | 6.381* | 5.659* | 4.470 | 4.908 | 4.532 |
| | (2.687) | (2.677) | (2.692) | (3.851) | (3.851) | (3.857) |
| Baseline price | -0.109 | | | -0.0214 | | |
| | (0.118) | | | (0.168) | | |
| Log house price(t-1) | | -0.363** | | | -0.279 | |
| | | (0.120) | | | (0.170) | |
| Log house price(t-5) | | | -0.0514 | | | 0.0490 |
| | | | (0.109) | | | (0.155) |
| R-squared | 0.46 | 0.47 | 0.46 | 0.51 | 0.51 | 0.51 |

$N = 693$. $^{+}$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.18 - Including lagged investment measures - Renter-occupied properties: all improvements

| | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|
| Log house price | | 0.567** | 0.312** | | 1.122** | 0.678** |
| | | (0.0634) | (0.117) | | (0.0835) | (0.145) |
| Adjusted price variance | | 0.764* | 0.481 | | 0.405 | 0.269 |
| | | (0.322) | (0.466) | | (0.423) | (0.549) |
| Lagged improvement value | | | 0.409** | | | |
| | | | (0.0359) | | | |
| Lagged improvement sq ft | | | | | | 0.369** |
| | | | | | | (0.0357) |
| Log square footage | | | -0.287 | | | -0.998** |
| | | | (0.186) | | | (0.230) |
| Adj hedonic reg error | | | -3.094 | | | -1.917 |
| | | | (6.228) | | | (7.356) |
| R-squared | | 0.12 | 0.31 | | 0.22 | 0.48 |
| Log house price | 0.854** | 0.421* | 0.529** | 1.049** | 0.554** | 0.760** |
| | (0.186) | (0.174) | (0.177) | (0.224) | (0.206) | (0.213) |
| Adjusted price variance | -0.529 | 0.415 | 0.260 | -0.430 | 0.343 | 0.185 |
| | (0.535) | (0.473) | (0.485) | (0.636) | (0.556) | (0.572) |
| Lagged improvement value | 0.414** | 0.414** | 0.412** | | | |
| | (0.0356) | (0.0365) | (0.0360) | | | |
| Lagged improvement sq ft | | | | 0.373** | 0.363** | 0.370** |
| | | | | (0.0356) | (0.0363) | (0.0357) |
| Log square footage | -0.253 | -0.244 | -0.220 | -0.972** | -1.060** | -0.973** |
| | (0.185) | (0.193) | (0.191) | (0.230) | (0.241) | (0.235) |
| Adj hedonic reg error | 1.637 | -2.324 | -2.271 | 1.387 | -2.806 | -1.594 |
| | (6.292) | (6.296) | (6.240) | (7.492) | (7.432) | (7.387) |
| Baseline price | -0.681** | | | -0.469* | | |
| | (0.183) | | | (0.217) | | |
| Log house price(t-1) | | -0.145 | | | 0.172 | |
| | | (0.171) | | | (0.203) | |
| Log house price(t-5) | | | -0.281 | | | -0.107 |
| | | | (0.172) | | | (0.203) |
| R-squared | 0.33 | 0.31 | 0.31 | 0.48 | 0.48 | 0.48 |

*N = 693.* $^{+}$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.19 - Neighborhood fixed effects - All properties: all improvements

| | Percent of properties improved | | | | Value of improvements | | | | Square footage of improvements | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Log house price | 0.0258** | 0.00501* | 0.00517* | 0.00485* | 1.002** | 0.570** | 0.553** | 0.558** | 2.011** | 0.995** | 0.956** | 0.979** |
| | (0.00125) | (0.00227) | (0.00228) | (0.00226) | (0.0793) | (0.158) | (0.158) | (0.157) | (0.100) | (0.194) | (0.193) | (0.193) |
| Adjusted price variance | -0.0203** | -0.00886 | -0.00802 | -0.00895 | -0.956** | 0.225 | 0.139 | 0.218 | -0.958* | 0.753 | 0.551 | 0.744 |
| | (0.00504) | (0.00677) | (0.00682) | (0.00674) | (0.319) | (0.470) | (0.474) | (0.468) | (0.404) | (0.577) | (0.579) | (0.573) |
| Adj hedonic reg error | | 0.0540 | 0.0593 | 0.0641 | | -14.77** | -15.32** | -14.02* | | -17.07* | -18.36** | -16.04* |
| | | (0.0820) | (0.0822) | (0.0818) | | (5.698) | (5.707) | (5.681) | | (6.991) | (6.971) | (6.961) |
| Log house price(t-1) | | | -0.00220 | | | | 0.224 | | | | 0.529** | |
| | | | (0.00229) | | | | (0.159) | | | | (0.195) | |
| Log house price(t-5) | | | | -0.00633* | | | | -0.468* | | | | -0.642** |
| | | | | (0.00267) | | | | (0.186) | | | | (0.227) |
| R-squared | 0.82 | 0.86 | 0.86 | 0.86 | 0.52 | 0.55 | 0.55 | 0.55 | 0.60 | 0.64 | 0.65 | 0.65 |
| Log house price | 0.0255** | 0.00484* | 0.00509* | 0.00473* | 1.033** | 0.628** | 0.606** | 0.620** | 2.006** | 1.028** | 0.977** | 1.016** |
| | (0.00127) | (0.00226) | (0.00227) | (0.00225) | (0.0799) | (0.156) | (0.157) | (0.156) | (0.102) | (0.193) | (0.193) | (0.192) |
| Price variance | -0.0150** | -0.0109+ | -0.0102 | -0.0112+ | -1.299** | -0.126 | -0.189 | -0.143 | -0.842* | 0.340 | 0.197 | 0.316 |
| | (0.00537) | (0.00661) | (0.00664) | (0.00658) | (0.337) | (0.457) | (0.459) | (0.455) | (0.428) | (0.565) | (0.564) | (0.561) |
| Adj hedonic reg error | | 0.134 | 0.143 | 0.146 | | -20.25** | -20.99** | -19.40** | | -16.87+ | -18.54* | -15.72+ |
| | | (0.102) | (0.102) | (0.101) | | (7.035) | (7.047) | (7.010) | | (8.684) | (8.663) | (8.642) |
| Log house price(t-1) | | | -0.00249 | | | | 0.227 | | | | 0.511** | |
| | | | (0.00226) | | | | (0.156) | | | | (0.192) | |
| Log house price(t-5) | | | | -0.00648* | | | | -0.474* | | | | -0.652** |
| | | | | (0.00267) | | | | (0.184) | | | | (0.227) |
| R-squared | 0.81 | 0.86 | 0.86 | 0.86 | 0.53 | 0.55 | 0.55 | 0.55 | 0.60 | 0.64 | 0.65 | 0.65 |

*N = 693.* +significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.20 - Neighborhood fixed effects - All properties: new construction

| | Percent of properties improved | | | | Value of improvements | | | | Square footage of improvements | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Log house price | 0.249** | 0.00988 | 0.0132 | 0.00897 | 1.630** | 0.822** | 0.793** | 0.809** | 2.174** | 1.103** | 1.059** | 1.099** |
| | (0.0127) | (0.0191) | (0.0191) | (0.0191) | (0.145) | (0.288) | (0.288) | (0.288) | (0.135) | (0.265) | (0.264) | (0.265) |
| Adjusted price variance | -0.257** | -0.0791 | -0.0619 | -0.0797 | -1.464* | 0.664 | 0.514 | 0.656 | -1.134* | 1.264 | 1.023 | 1.259 |
| | (0.0509) | (0.0569) | (0.0572) | (0.0569) | (0.582) | (0.857) | (0.864) | (0.856) | (0.536) | (0.778) | (0.781) | (0.778) |
| Adj hedonic reg error | | 0.196 | 0.306 | 0.254 | | -26.22* | -27.18** | -25.40* | | -27.95** | -29.76** | -27.54** |
| | | (0.690) | (0.689) | (0.690) | | (10.39) | (10.40) | (10.39) | | (9.457) | (9.443) | (9.473) |
| Log house price(t-1) | | | -0.0453* | | | | 0.393 | | | | 0.661* | |
| | | | (0.0192) | | | | (0.290) | | | | (0.264) | |
| Log house price(t-5) | | | | -0.0365 | | | | -0.515 | | | | -0.260 |
| | | | | (0.0225) | | | | (0.339) | | | | (0.312) |
| R-squared | 0.52 | 0.74 | 0.74 | 0.74 | 0.51 | 0.53 | 0.54 | 0.54 | 0.56 | 0.60 | 0.60 | 0.60 |
| Log house price | 0.254** | 0.00396 | 0.00868 | 0.00331 | 1.661** | 0.887** | 0.849** | 0.877** | 2.175** | 1.125** | 1.066** | 1.123** |
| | (0.0127) | (0.0190) | (0.0190) | (0.0190) | (0.146) | (0.286) | (0.287) | (0.285) | (0.137) | (0.263) | (0.263) | (0.263) |
| Price variance | -0.308** | -0.0305 | -0.0172 | -0.0318 | -1.781** | 0.193 | 0.0864 | 0.174 | -1.085+ | 1.003 | 0.830 | 0.991 |
| | (0.0536) | (0.0557) | (0.0557) | (0.0557) | (0.616) | (0.836) | (0.840) | (0.835) | (0.568) | (0.760) | (0.760) | (0.760) |
| Adj hedonic reg error | | -0.298 | -0.143 | -0.232 | | -33.41** | -34.66** | -32.48* | | -34.63** | -36.83** | -34.13** |
| | | (0.857) | (0.856) | (0.857) | | (12.86) | (12.89) | (12.86) | | (11.70) | (11.69) | (11.72) |
| Log house price(t-1) | | | -0.0477* | | | | 0.383 | | | | 0.636* | |
| | | | (0.0190) | | | | (0.286) | | | | (0.260) | |
| Log house price(t-5) | | | | -0.0370 | | | | -0.527 | | | | -0.268 |
| | | | | (0.0225) | | | | (0.338) | | | | (0.312) |
| R-squared | 0.53 | 0.74 | 0.74 | 0.74 | 0.51 | 0.54 | 0.54 | 0.54 | 0.56 | 0.60 | 0.60 | 0.60 |

$N$ = *693*. +significant at 10%; *significant at 5%; **significant at 1%.

Table 2.21 - Neighborhood fixed effects - All properties: existing construction

| | Percent of properties improved | | | | Value of improvements | | | | Square footage of improvements | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Log house price | 0.0202** | 0.00208 | 0.00233 | 0.00198 | 0.430** | 0.128 | 0.143 | 0.118 | 1.415** | 0.197 | 0.181 | 0.177 |
| | (0.00114) | (0.00204) | (0.00204) | (0.00204) | (0.0467) | (0.0932) | (0.0932) | (0.0924) | (0.0954) | (0.177) | (0.177) | (0.175) |
| Adjusted price variance | -0.0155** | -0.00400 | -0.00277 | -0.00405 | -0.445* | -0.0489 | 0.0273 | -0.0532 | 0.683$^+$ | 1.542** | 1.464** | 1.534** |
| | (0.00460) | (0.00604) | (0.00607) | (0.00603) | (0.189) | (0.276) | (0.277) | (0.273) | (0.386) | (0.523) | (0.527) | (0.517) |
| Adj hedonic reg error | | 0.0215 | 0.0303 | 0.0275 | | -2.968 | -2.426 | -2.347 | | -0.366 | -0.920 | 0.881 |
| | | (0.0727) | (0.0728) | (0.0728) | | (3.328) | (3.326) | (3.299) | | (6.307) | (6.322) | (6.245) |
| Log house price(t-1) | | | -0.00336 | | | | -0.207* | | | | 0.212 | |
| | | | (0.00205) | | | | (0.0938) | | | | (0.178) | |
| Log house price(t-5) | | | | -0.00384 | | | | -0.394** | | | | -0.792** |
| | | | | (0.00240) | | | | (0.109) | | | | (0.206) |
| R-squared | 0.81 | 0.85 | 0.85 | 0.85 | 0.55 | 0.57 | 0.58 | 0.58 | 0.50 | 0.59 | 0.59 | 0.60 |
| Log house price | 0.0199** | 0.00222 | 0.00256 | 0.00215 | 0.451** | 0.178$^+$ | 0.197* | 0.171$^+$ | 1.393** | 0.259 | 0.234 | 0.246 |
| | (0.00116) | (0.00203) | (0.00203) | (0.00202) | (0.0470) | (0.0925) | (0.0927) | (0.0915) | (0.0963) | (0.176) | (0.177) | (0.174) |
| Price variance | -0.0111* | -0.00778 | -0.00683 | -0.00793 | -0.687** | -0.551* | -0.498$^+$ | -0.567* | 0.920* | 0.787 | 0.719 | 0.756 |
| | (0.00487) | (0.00591) | (0.00593) | (0.00590) | (0.198) | (0.270) | (0.270) | (0.267) | (0.406) | (0.514) | (0.516) | (0.508) |
| Adj hedonic reg error | | 0.100 | 0.112 | 0.107 | | 1.249 | 1.890 | 1.976 | | 13.48$^+$ | 12.66 | 14.90$^+$ |
| | | (0.0909) | (0.0910) | (0.0909) | | (4.151) | (4.150) | (4.113) | | (7.905) | (7.920) | (7.828) |
| Log house price(t-1) | | | -0.00342$^+$ | | | | -0.194* | | | | 0.249 | |
| | | | (0.00202) | | | | (0.0923) | | | | (0.176) | |
| Log house price(t-5) | | | | -0.00395$^+$ | | | | -0.401** | | | | -0.783** |
| | | | | (0.00240) | | | | (0.108) | | | | (0.206) |
| R-squared | 0.81 | 0.85 | 0.85 | 0.85 | 0.56 | 0.58 | 0.58 | 0.58 | 0.50 | 0.59 | 0.59 | 0.59 |

*N = 693*. $^+$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.22 - Neighborhood fixed effects - Owner-occupied properties: all improvements

| | Percent of properties improved | | | | Value of improvements | | | | Square footage of improvements | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Log house price | 0.0132** | -0.00367 | -0.00327 | -0.00364 | 0.321** | 0.213 | 0.214 | 0.214 | 1.190** | 0.573** | 0.568** | 0.574** |
| | (0.00129) | (0.00300) | (0.00299) | (0.00299) | (0.0534) | (0.134) | (0.135) | (0.134) | (0.0813) | (0.191) | (0.191) | (0.190) |
| Adjusted price variance | 0.00135 | -0.00409 | -0.00410 | -0.00292 | -1.204* | -1.919** | -1.919** | -1.886* | 0.920 | -0.321 | -0.321 | -0.259 |
| | (0.0136) | (0.0163) | (0.0163) | (0.0163) | (0.565) | (0.730) | (0.731) | (0.731) | (0.860) | (1.036) | (1.037) | (1.037) |
| Adj hedonic reg error | | 0.0740 | 0.101 | 0.0751 | | 5.925+ | 6.006+ | 5.955+ | | 7.113 | 6.797 | 7.169 |
| | | (0.0693) | (0.0702) | (0.0693) | | (3.105) | (3.157) | (3.105) | | (4.407) | (4.481) | (4.405) |
| Log house price(t-1) | | | -0.00643* | | | | -0.0194 | | | | 0.0757 | |
| | | | (0.00298) | | | | (0.134) | | | | (0.190) | |
| Log house price(t-5) | | | | -0.00452 | | | | -0.130 | | | | -0.237 |
| | | | | (0.00285) | | | | (0.128) | | | | (0.181) |
| R-squared | 0.77 | 0.81 | 0.81 | 0.81 | 0.58 | 0.60 | 0.60 | 0.60 | 0.57 | 0.64 | 0.64 | 0.64 |
| Log house price | 0.0124** | -0.00452 | -0.00392 | -0.00448 | 0.365** | 0.337* | 0.339* | 0.338* | 1.164** | 0.633** | 0.628** | 0.635** |
| | (0.00132) | (0.00306) | (0.00305) | (0.00305) | (0.0543) | (0.136) | (0.137) | (0.136) | (0.0834) | (0.195) | (0.196) | (0.195) |
| Price variance | 0.0293* | -0.00348 | -0.00477 | -0.00259 | -2.104** | -2.729** | -2.734** | -2.705** | 1.311+ | -1.268 | -1.257 | -1.224 |
| | (0.0124) | (0.0146) | (0.0146) | (0.0146) | (0.510) | (0.653) | (0.654) | (0.654) | (0.782) | (0.933) | (0.935) | (0.934) |
| Adj hedonic reg error | | 0.215* | 0.256** | 0.214* | | 7.901* | 8.048* | 7.883* | | 13.37* | 13.01* | 13.33* |
| | | (0.0853) | (0.0865) | (0.0852) | | (3.806) | (3.882) | (3.806) | | (5.436) | (5.544) | (5.434) |
| Log house price(t-1) | | | -0.00734* | | | | -0.0260 | | | | 0.0632 | |
| | | | (0.00295) | | | | (0.132) | | | | (0.189) | |
| Log house price(t-5) | | | | -0.00449 | | | | -0.122 | | | | -0.221 |
| | | | | (0.00283) | | | | (0.126) | | | | (0.180) |
| R-squared | 0.78 | 0.81 | 0.82 | 0.82 | 0.59 | 0.61 | 0.61 | 0.61 | 0.57 | 0.64 | 0.64 | 0.64 |

*N = 693.* +significant at 10%; *significant at 5%; **significant at 1%.

Table 2.23 - Neighborhood fixed effects - Renter-occupied properties: all improvements

| | Percent of properties improved | | | | Value of improvements | | | | Square footage of improvements | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Log house price | 0.0411** | 0.00721 | 0.00712 | 0.00718 | 1.018** | 0.460* | 0.465* | 0.458* | 1.961** | 0.779** | 0.794** | 0.775** |
| | (0.00204) | (0.00456) | (0.00456) | (0.00457) | (0.0859) | (0.206) | (0.206) | (0.206) | (0.110) | (0.253) | (0.253) | (0.253) |
| Adjusted price variance | -0.0348** | -0.0160 | -0.0145 | -0.0160 | -1.076** | 0.0454 | -0.0295 | 0.0455 | -0.962+ | 0.553 | 0.424 | 0.555 |
| | (0.00924) | (0.0125) | (0.0126) | (0.0125) | (0.389) | (0.565) | (0.568) | (0.565) | (0.495) | (0.690) | (0.692) | (0.690) |
| Adj hedonic reg error | | -0.00306 | 0.0162 | -0.000338 | | -13.81* | -14.74* | -13.62+ | | -14.70+ | -16.56+ | -14.15+ |
| | | (0.155) | (0.156) | (0.155) | | (6.978) | (7.013) | (6.991) | | (8.543) | (8.580) | (8.546) |
| Log house price(t-1) | | | -0.00513 | | | | 0.247 | | | | 0.455+ | |
| | | | (0.00433) | | | | (0.195) | | | | (0.239) | |
| Log house price(t-5) | | | | -0.00169 | | | | -0.118 | | | | -0.360 |
| | | | | (0.00481) | | | | (0.217) | | | | (0.264) |
| R-squared | 0.80 | 0.83 | 0.83 | 0.83 | 0.48 | 0.51 | 0.51 | 0.51 | 0.57 | 0.62 | 0.62 | 0.62 |
| Log house price | 0.0409** | 0.00709 | 0.00702 | 0.00707 | 1.049** | 0.516* | 0.519* | 0.515* | 1.954** | 0.796** | 0.808** | 0.795** |
| | (0.00211) | (0.00459) | (0.00459) | (0.00459) | (0.0883) | (0.206) | (0.206) | (0.206) | (0.113) | (0.255) | (0.254) | (0.254) |
| Price variance | -0.0241* | -0.0136 | -0.0118 | -0.0137 | -1.233** | -0.103 | -0.192 | -0.109 | -0.640 | 0.399 | 0.254 | 0.381 |
| | (0.00965) | (0.0126) | (0.0127) | (0.0126) | (0.403) | (0.565) | (0.568) | (0.565) | (0.514) | (0.692) | (0.695) | (0.692) |
| Adj hedonic reg error | | -0.0531 | -0.0347 | -0.0485 | | -22.57* | -23.47** | -22.29* | | -18.72+ | -20.40+ | -17.91 |
| | | (0.201) | (0.201) | (0.201) | | (9.006) | (9.025) | (9.027) | | (11.05) | (11.06) | (11.06) |
| Log house price(t-1) | | | -0.00528 | | | | 0.258 | | | | 0.440+ | |
| | | | (0.00430) | | | | (0.193) | | | | (0.237) | |
| Log house price(t-5) | | | | -0.00186 | | | | -0.115 | | | | -0.360 |
| | | | | (0.00481) | | | | (0.216) | | | | (0.264) |
| R-squared | 0.79 | 0.83 | 0.83 | 0.83 | 0.48 | 0.51 | 0.51 | 0.51 | 0.57 | 0.62 | 0.62 | 0.62 |

*N = 693.* +significant at 10%; *significant at 5%; **significant at 1%.

Table 2.24 - Excluding rent-controlled properties - All properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0279** | 0.0280** | | 0.432** | 0.458** | | 1.020** | 1.128** |
| | | (0.00152) | (0.00213) | | (0.0611) | (0.104) | | (0.0735) | (0.123) |
| Adjusted price variance | | -0.00328 | -0.0338** | | 1.558** | 1.088** | | 1.601** | 1.354** |
| | | (0.00723) | (0.00858) | | (0.291) | (0.421) | | (0.351) | (0.495) |
| Log square footage | | | 0.0193** | | | -0.123 | | | -1.130** |
| | | | (0.00391) | | | (0.192) | | | (0.225) |
| Pct owner-occupied | | | -0.00800** | | | -0.711** | | | -0.639** |
| | | | (0.00138) | | | (0.0678) | | | (0.0798) |
| Age | | | 0.00119** | | | 0.0627** | | | 0.0704** |
| | | | (0.000275) | | | (0.0135) | | | (0.0158) |
| Age$^2$ | | | -0.00000409 | | | -0.000507** | | | -0.000659** |
| | | | (0.00000253) | | | (0.000124) | | | (0.000146) |
| Adj hedonic reg error | | | 0.279* | | | -8.058 | | | -12.25$^+$ |
| | | | (0.111) | | | (5.426) | | | (6.379) |
| R-squared | | 0.33 | 0.66 | | 0.12 | 0.34 | | 0.26 | 0.47 |
| Log house price | 0.0148** | 0.0200** | 0.0204** | 0.876** | 0.434** | 0.750** | 1.349** | 0.859** | 1.342** |
| | (0.00310) | (0.00308) | (0.00297) | (0.154) | (0.153) | (0.146) | (0.183) | (0.179) | (0.172) |
| Adjusted price variance | -0.0116 | -0.0310** | -0.0264** | 0.384 | 1.097** | 0.803$^+$ | 0.981$^+$ | 1.449** | 1.145* |
| | (0.00924) | (0.00855) | (0.00875) | (0.460) | (0.423) | (0.430) | (0.544) | (0.496) | (0.508) |
| Log square footage | 0.0139** | 0.0150** | 0.0146** | 0.0472 | -0.136 | 0.0577 | -1.040** | -1.275** | -0.998** |
| | (0.00393) | (0.00406) | (0.00408) | (0.196) | (0.201) | (0.201) | (0.232) | (0.235) | (0.237) |
| Pct owner-occupied | -0.0103** | -0.00840** | -0.00874** | -0.637** | -0.712** | -0.682** | -0.600** | -0.653** | -0.618** |
| | (0.00141) | (0.00138) | (0.00139) | (0.0702) | (0.0681) | (0.0682) | (0.0832) | (0.0798) | (0.0805) |
| Age | 0.00131** | 0.00114** | 0.00120** | 0.0590** | 0.0625** | 0.0623** | 0.0685** | 0.0685** | 0.0702** |
| | (0.000269) | (0.000273) | (0.000272) | (0.0134) | (0.0135) | (0.0134) | (0.0159) | (0.0158) | (0.0158) |
| Age$^2$ | -0.00000462$^+$ | -0.00000337 | -0.00000388 | -0.000490** | -0.000505** | -0.000515** | -0.000650** | -0.000634** | -0.000664** |
| | (0.00000247) | (0.00000252) | (0.00000251) | (0.000123) | (0.000125) | (0.000123) | (0.000146) | (0.000146) | (0.000146) |
| Adj hedonic reg error | 0.202$^+$ | 0.237* | 0.251* | -5.613 | -8.186 | -6.985 | -10.95$^+$ | -13.67* | -11.46$^+$ |
| | (0.109) | (0.110) | (0.110) | (5.419) | (5.462) | (5.412) | (6.421) | (6.401) | (6.385) |
| Baseline price | 0.0192** | | | -0.609** | | | -0.322 | | |
| | (0.00336) | | | (0.167) | | | (0.198) | | |
| Log house price(t-1) | | 0.0110** | | | 0.0331 | | | 0.369* | |
| | | (0.00308) | | | (0.153) | | | (0.179) | |
| Log house price(t-5) | | | 0.0115** | | | -0.444** | | | -0.324$^+$ |
| | | | (0.00318) | | | (0.156) | | | (0.185) |
| R-squared | 0.68 | 0.67 | 0.67 | 0.35 | 0.34 | 0.35 | 0.47 | 0.47 | 0.47 |

*N = 693.* $^+$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.25 - Excluding rent-controlled properties - All properties: existing construction

| | Percent of properties improved | | | Value of additions | | | Square footage of additions | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0230** | 0.0262** | | 0.162** | 0.264** | | 0.728** | 0.722** |
| | | (0.00105) | (0.00171) | | (0.0374) | (0.0653) | | (0.0629) | (0.106) |
| Adjusted price variance | | -0.0231** | -0.0371** | | 0.598** | 0.709** | | 1.045** | 1.437** |
| | | (0.00505) | (0.00690) | | (0.179) | (0.263) | | (0.301) | (0.426) |
| Log square footage | | | 0.00455 | | | -0.277* | | | -0.930** |
| | | | (0.00315) | | | (0.120) | | | (0.194) |
| Pct owner-occupied | | | 0.00296** | | | -0.120** | | | -0.114+ |
| | | | (0.00111) | | | (0.0424) | | | (0.0686) |
| Age | | | 0.00100** | | | 0.0638** | | | 0.0650** |
| | | | (0.000221) | | | (0.00842) | | | (0.0136) |
| $Age^2$ | | | -0.00000472* | | | -0.000504** | | | -0.000625** |
| | | | (0.00000203) | | | (0.0000775) | | | (0.000125) |
| Adj hedonic reg error | | | 0.209* | | | -7.220* | | | -11.90* |
| | | | (0.0887) | | | (3.381) | | | (5.468) |
| R-squared | | 0.41 | 0.60 | | 0.05 | 0.25 | | 0.19 | 0.41 |
| Log house price | 0.00865** | 0.0168** | 0.0141** | 0.125 | 0.295** | 0.294** | 0.354* | 0.456** | 0.675** |
| | (0.00239) | (0.00245) | (0.00232) | (0.0971) | (0.0954) | (0.0918) | (0.156) | (0.154) | (0.149) |
| Adjusted price variance | -0.00746 | -0.0337** | -0.0253** | 0.943** | 0.698** | 0.679* | 2.059** | 1.532** | 1.483** |
| | (0.00712) | (0.00680) | (0.00683) | (0.290) | (0.265) | (0.271) | (0.466) | (0.426) | (0.438) |
| Log square footage | -0.00258 | -0.000502 | -0.00296 | -0.333** | -0.260* | -0.258* | -1.080** | -1.073** | -0.959** |
| | (0.00303) | (0.00323) | (0.00319) | (0.123) | (0.126) | (0.127) | (0.198) | (0.203) | (0.205) |
| Pct owner-occupied | -0.000153 | 0.00249* | 0.00178 | -0.145** | -0.119** | -0.117** | -0.180* | -0.128+ | -0.119+ |
| | (0.00109) | (0.00110) | (0.00108) | (0.0442) | (0.0426) | (0.0429) | (0.0712) | (0.0686) | (0.0694) |
| Age | 0.00116** | 0.000937** | 0.00102** | 0.0651** | 0.0641** | 0.0638** | 0.0682** | 0.0631** | 0.0650** |
| | (0.000207) | (0.000217) | (0.000213) | (0.00843) | (0.00844) | (0.00843) | (0.0136) | (0.0136) | (0.0136) |
| $Age^2$ | -0.00000544** | -0.00000388+ | -0.00000439* | -0.000510** | -0.000507** | -0.000505** | -0.000640** | -0.000601** | -0.000623** |
| | (0.00000190) | (0.00000200) | (0.00000196) | (0.0000775) | (0.0000778) | (0.0000776) | (0.000125) | (0.000125) | (0.000126) |
| Adj hedonic reg error | 0.108 | 0.160+ | 0.166+ | -8.017* | -7.058* | -7.111* | -14.02* | -13.30* | -12.07* |
| | (0.0836) | (0.0875) | (0.0856) | (3.400) | (3.403) | (3.391) | (5.473) | (5.481) | (5.484) |
| Baseline price | 0.0256** | | | 0.202+ | | | 0.537** | | |
| | (0.00258) | | | (0.105) | | | (0.169) | | |
| Log house price(t-1) | | 0.0129** | | | -0.0421 | | | 0.365* | |
| | | (0.00245) | | | (0.0954) | | | (0.154) | |
| Log house price(t-5) | | | 0.0184** | | | -0.0466 | | | 0.0718 |
| | | | (0.00248) | | | (0.0983) | | | (0.159) |
| R-squared | 0.65 | 0.61 | 0.63 | 0.26 | 0.25 | 0.25 | 0.42 | 0.42 | 0.41 |

*N = 693.* +significant at 10%; *significant at 5%; **significant at 1%.

Table 2.26 - Excluding rent-controlled properties - Renter-occupied properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0485** | 0.0596** | | 0.605** | 0.371** | | 1.157** | 1.044** |
| | | (0.00204) | (0.00380) | | (0.0702) | (0.135) | | (0.0842) | (0.154) |
| Adjusted price variance | | -0.0444** | -0.0826** | | 0.911* | 1.466** | | 0.770+ | 1.831** |
| | | (0.0104) | (0.0155) | | (0.356) | (0.553) | | (0.427) | (0.627) |
| Log square footage | | | -0.0149* | | | 0.216 | | | -0.740** |
| | | | (0.00606) | | | (0.215) | | | (0.248) |
| Age | | | -0.000601 | | | 0.0358* | | | 0.0450* |
| | | | (0.000494) | | | (0.0176) | | | (0.0199) |
| $Age^2$ | | | 0.0000104* | | | -0.000284+ | | | -0.000418* |
| | | | (0.00000451) | | | (0.000160) | | | (0.000182) |
| Adj hedonic reg error | | | 0.563** | | | -10.05 | | | -18.38* |
| | | | (0.207) | | | (7.370) | | | (8.374) |
| R-squared | | 0.45 | 0.52 | | 0.12 | 0.17 | | 0.23 | 0.36 |
| Log house price | 0.0259** | 0.0408** | 0.0363** | 1.155** | 0.413* | 0.815** | 1.606** | 0.846** | 1.404** |
| | (0.00602) | (0.00564) | (0.00555) | (0.219) | (0.203) | (0.201) | (0.250) | (0.231) | (0.230) |
| Adjusted price variance | -0.0237 | -0.0736** | -0.0603** | 0.0949 | 1.445** | 1.039+ | 0.839 | 1.928** | 1.489* |
| | (0.0172) | (0.0155) | (0.0157) | (0.624) | (0.558) | (0.568) | (0.715) | (0.632) | (0.646) |
| Log square footage | -0.0173** | -0.0225** | -0.0237** | 0.272 | 0.233 | 0.384+ | -0.695** | -0.823** | -0.610* |
| | (0.00586) | (0.00621) | (0.00612) | (0.213) | (0.224) | (0.221) | (0.247) | (0.258) | (0.255) |
| Age | -0.000554 | -0.000700 | -0.000609 | 0.0347* | 0.0360* | 0.0359* | 0.0441* | 0.0440* | 0.0450* |
| | (0.000477) | (0.000487) | (0.000483) | (0.0173) | (0.0176) | (0.0175) | (0.0198) | (0.0199) | (0.0199) |
| $Age^2$ | 0.0000112* | 0.0000119** | 0.0000114** | -0.000301+ | -0.000287+ | -0.000303+ | -0.000430* | -0.000401* | -0.000432* |
| | (0.00000436) | (0.00000446) | (0.00000442) | (0.000158) | (0.000161) | (0.000160) | (0.000181) | (0.000182) | (0.000182) |
| Adj hedonic reg error | 0.328 | 0.455* | 0.495* | -4.604 | -9.811 | -8.762 | -14.36+ | -19.53* | -17.36* |
| | (0.203) | (0.206) | (0.203) | (7.366) | (7.426) | (7.341) | (8.450) | (8.431) | (8.367) |
| Baseline price | 0.0421** | | | -0.977** | | | -0.703** | | |
| | (0.00596) | | | (0.216) | | | (0.247) | | |
| Log house price(t-1) | | 0.0247** | | | -0.0547 | | | 0.261 | |
| | | (0.00553) | | | (0.199) | | | (0.226) | |
| Log house price(t-5) | | | 0.0315** | | | -0.600** | | | -0.483* |
| | | | (0.00558) | | | (0.202) | | | (0.230) |
| R-squared | 0.55 | 0.53 | 0.54 | 0.20 | 0.17 | 0.18 | 0.37 | 0.36 | 0.36 |

*N = 693.* +significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.27 - Current-year predicted house prices - All properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Predicted house price | | 0.0177** | 0.0122** | | 0.304** | 0.311** | | 0.646** | 0.543** |
| | | (0.00113) | (0.00127) | | (0.0491) | (0.0607) | | (0.0661) | (0.0751) |
| Adjusted price variance | | 0.00829 | -0.0169$^+$ | | 1.649** | 1.546** | | 2.000** | 2.189** |
| | | (0.00627) | (0.00867) | | (0.273) | (0.414) | | (0.367) | (0.513) |
| Log square footage | | | 0.0283** | | | -0.157 | | | -0.656** |
| | | | (0.00307) | | | (0.147) | | | (0.182) |
| Pct owner-occupied | | | 0.000266 | | | -0.500** | | | -0.348** |
| | | | (0.00137) | | | (0.0656) | | | (0.0812) |
| Age | | | 0.000959** | | | 0.0579** | | | 0.0612** |
| | | | (0.000267) | | | (0.0128) | | | (0.0158) |
| Age$^2$ | | | -0.00000544* | | | -0.000516** | | | -0.000655** |
| | | | (0.00000247) | | | (0.000118) | | | (0.000146) |
| Adj hedonic reg error | | | 0.263* | | | -10.51* | | | -15.81* |
| | | | (0.112) | | | (5.337) | | | (6.604) |
| R-squared | | 0.26 | 0.52 | | 0.09 | 0.28 | | 0.15 | 0.43 |
| Predicted house price | 0.00916** | 0.00476 | 0.00449 | 0.313** | 0.411 | 0.490** | 0.599** | 0.613$^+$ | 0.670** |
| | (0.00246) | (0.00580) | (0.00277) | (0.118) | (0.278) | (0.133) | (0.145) | (0.344) | (0.165) |
| Adjusted price variance | -0.0170$^+$ | -0.0180* | -0.0226* | 1.546** | 1.560** | 1.679** | 2.190** | 2.198** | 2.283** |
| | (0.00866) | (0.00870) | (0.00880) | (0.415) | (0.416) | (0.423) | (0.513) | (0.515) | (0.524) |
| Log square footage | 0.0255** | 0.0274** | 0.0231** | -0.155 | -0.145 | -0.0383 | -0.606** | -0.647** | -0.571** |
| | (0.00360) | (0.00314) | (0.00346) | (0.172) | (0.150) | (0.166) | (0.213) | (0.186) | (0.206) |
| Pct owner-occupied | -0.0000558 | 0.0000579 | -0.000390 | -0.499** | -0.497** | -0.485** | -0.342** | -0.346** | -0.337** |
| | (0.00139) | (0.00138) | (0.00138) | (0.0665) | (0.0661) | (0.0664) | (0.0823) | (0.0818) | (0.0822) |
| Age | 0.000987** | 0.000976** | 0.00109** | 0.0578** | 0.0576** | 0.0549** | 0.0607** | 0.0611** | 0.0591** |
| | (0.000268) | (0.000267) | (0.000269) | (0.0128) | (0.0128) | (0.0129) | (0.0159) | (0.0158) | (0.0160) |
| Age$^2$ | -0.00000551* | -0.00000555* | -0.00000631* | -0.000515** | -0.000514** | -0.000495** | -0.000654** | -0.000654** | -0.000641** |
| | (0.00000247) | (0.00000247) | (0.00000247) | (0.000118) | (0.000118) | (0.000119) | (0.000146) | (0.000146) | (0.000147) |
| Adj hedonic reg error | 0.267* | 0.271* | 0.325** | -10.51* | -10.61* | -11.93* | -15.87* | -15.88* | -16.82* |
| | (0.112) | (0.112) | (0.113) | (5.342) | (5.348) | (5.414) | (6.609) | (6.618) | (6.708) |
| Baseline price | 0.00458 | | | -0.00421 | | | -0.0846 | | |
| | (0.00316) | | | (0.151) | | | (0.187) | | |
| Predicted house price(t-1) | | 0.00788 | | | -0.106 | | | -0.0745 | |
| | | (0.00599) | | | (0.287) | | | (0.355) | |
| Predicted house price(t-5) | | | 0.0103** | | | -0.240 | | | -0.171 |
| | | | (0.00330) | | | (0.159) | | | (0.197) |
| R-squared | 0.52 | 0.52 | 0.52 | 0.28 | 0.28 | 0.28 | 0.43 | 0.43 | 0.43 |

$N$ = *693.* $^+$significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.28 - Current-year predicted house prices - All properties: new construction

| | Percent of properties newly built | | | Value of new construction | | | Square footage of new construction | | |
|---|---|---|---|---|---|---|---|---|---|
| Predicted house price | | 0.0385** | -0.00352 | | 0.772** | 0.853** | | 0.834** | 0.797** |
| | | (0.00807) | (0.00773) | | (0.0870) | (0.111) | | (0.0861) | (0.106) |
| Adjusted price variance | | -0.0590 | -0.0801 | | 2.260** | 1.966** | | 2.282** | 2.259** |
| | | (0.0448) | (0.0528) | | (0.483) | (0.756) | | (0.465) | (0.703) |
| Log square footage | | | 0.0218 | | | -0.673* | | | -0.757** |
| | | | (0.0187) | | | (0.268) | | | (0.252) |
| Pct owner-occupied | | | -0.00297 | | | -0.787** | | | -0.537** |
| | | | (0.00836) | | | (0.120) | | | (0.112) |
| Age | | | -0.000428 | | | 0.0657** | | | 0.0598** |
| | | | (0.00163) | | | (0.0233) | | | (0.0224) |
| $Age^2$ | | | -0.00000355 | | | -0.000609** | | | -0.000627** |
| | | | (0.0000150) | | | (0.000215) | | | (0.000207) |
| Adj hedonic reg error | | | -0.773 | | | -12.83 | | | -15.08$^+$ |
| | | | (0.680) | | | (9.734) | | | (9.049) |
| R-squared | | 0.04 | 0.54 | | 0.12 | 0.26 | | 0.14 | 0.33 |
| Predicted house price | -0.0258$^+$ | 0.0292 | 0.00683 | 0.785** | 1.068* | 1.092** | 0.871** | 0.967* | 1.068** |
| | (0.0149) | (0.0353) | (0.0170) | (0.214) | (0.506) | (0.243) | (0.199) | (0.470) | (0.225) |
| Adjusted price variance | -0.0807 | -0.0755 | -0.0724 | 1.964** | 1.996** | 2.143** | 2.260** | 2.283** | 2.460** |
| | (0.0527) | (0.0530) | (0.0540) | (0.756) | (0.759) | (0.773) | (0.703) | (0.706) | (0.717) |
| Log square footage | 0.00194 | 0.0258 | 0.0287 | -0.734* | -0.647* | -0.514$^+$ | -0.687* | -0.736** | -0.566$^+$ |
| | (0.0219) | (0.0191) | (0.0212) | (0.314) | (0.274) | (0.304) | (0.298) | (0.258) | (0.288) |
| Pct owner-occupied | -0.00532 | -0.00205 | -0.00209 | -0.794** | -0.781** | -0.767** | -0.529** | -0.532** | -0.513** |
| | (0.00846) | (0.00842) | (0.00846) | (0.121) | (0.121) | (0.121) | (0.113) | (0.112) | (0.113) |
| Age | -0.000226 | -0.000502 | -0.000602 | 0.0663** | 0.0652** | 0.0617** | 0.0592** | 0.0595** | 0.0560* |
| | (0.00163) | (0.00163) | (0.00165) | (0.0234) | (0.0233) | (0.0236) | (0.0225) | (0.0225) | (0.0226) |
| $Age^2$ | -0.00000405 | -0.00000308 | -0.00000239 | -0.000611** | -0.000606** | -0.000582** | -0.000626** | -0.000625** | -0.000604** |
| | (0.0000150) | (0.0000150) | (0.0000151) | (0.000216) | (0.000216) | (0.000217) | (0.000207) | (0.000207) | (0.000208) |
| Adj hedonic reg error | -0.749 | -0.808 | -0.855 | -12.76 | -13.06 | -14.73 | -15.15$^+$ | -15.27$^+$ | -17.25$^+$ |
| | (0.679) | (0.681) | (0.690) | (9.742) | (9.754) | (9.883) | (9.056) | (9.069) | (9.182) |
| Baseline price | 0.0335$^+$ | | | 0.103 | | | -0.114 | | |
| | (0.0192) | | | (0.276) | | | (0.258) | | |
| Predicted house price(t-1) | | -0.0347 | | | -0.227 | | | -0.181 | |
| | | (0.0365) | | | (0.523) | | | (0.485) | |
| Predicted house price(t-5) | | | -0.0139 | | | -0.320 | | | -0.371 |
| | | | (0.0203) | | | (0.290) | | | (0.272) |
| R-squared | 0.54 | 0.54 | 0.54 | 0.26 | 0.26 | 0.26 | 0.33 | 0.33 | 0.33 |

*N = 693.* $^+$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.29 - Current-year predicted house prices - All properties: existing construction

| | Percent of properties improved | | | Value of additions | | | Square footage of additions | | |
|---|---|---|---|---|---|---|---|---|---|
| Predicted house price | | 0.0145** | 0.0107** | | 0.0338 | 0.0895* | | 0.399** | 0.294** |
| | | (0.00102) | (0.00110) | | (0.0311) | (0.0389) | | (0.0582) | (0.0662) |
| Adjusted price variance | | 0.0104$^+$ | -0.00852 | | 0.643** | 0.779** | | 1.216** | 1.744** |
| | | (0.00572) | (0.00743) | | (0.174) | (0.264) | | (0.325) | (0.449) |
| Log square footage | | | 0.0261** | | | -0.132 | | | -0.573** |
| | | | (0.00265) | | | (0.0941) | | | (0.160) |
| Pct owner-occupied | | | 0.00116 | | | -0.124** | | | 0.0463 |
| | | | (0.00118) | | | (0.0420) | | | (0.0715) |
| Age | | | 0.00108** | | | 0.0593** | | | 0.0539** |
| | | | (0.000231) | | | (0.00818) | | | (0.0139) |
| Age$^2$ | | | -0.00000584** | | | -0.000486** | | | -0.000570** |
| | | | (0.00000213) | | | (0.0000756) | | | (0.000129) |
| Adj hedonic reg error | | | 0.198* | | | -6.266$^+$ | | | -13.71* |
| | | | (0.0952) | | | (3.379) | | | (5.751) |
| R-squared | | 0.23 | 0.54 | | 0.02 | 0.21 | | 0.08 | 0.38 |
| Predicted house price | 0.00802** | 0.00239 | 0.00156 | 0.109 | 0.226 | 0.0666 | 0.529** | 0.392 | 0.319* |
| | (0.00212) | (0.00505) | (0.00238) | (0.0754) | (0.180) | (0.0856) | (0.128) | (0.306) | (0.146) |
| Adjusted price variance | -0.00862 | -0.00969 | -0.0154* | 0.780** | 0.798** | 0.762** | 1.753** | 1.758** | 1.763** |
| | (0.00743) | (0.00745) | (0.00751) | (0.264) | (0.265) | (0.270) | (0.448) | (0.451) | (0.460) |
| Log square footage | 0.0236** | 0.0250** | 0.0200** | -0.114 | -0.115 | -0.147 | -0.364$^+$ | -0.561** | -0.556** |
| | (0.00310) | (0.00271) | (0.00297) | (0.110) | (0.0965) | (0.107) | (0.187) | (0.164) | (0.182) |
| Pct owner-occupied | 0.000878 | 0.000932 | 0.000389 | -0.122** | -0.120** | -0.126** | 0.0710 | 0.0490 | 0.0484 |
| | (0.00120) | (0.00119) | (0.00118) | (0.0426) | (0.0423) | (0.0426) | (0.0723) | (0.0721) | (0.0724) |
| Age | 0.00111** | 0.00110** | 0.00124** | 0.0591** | 0.0590** | 0.0597** | 0.0518** | 0.0536** | 0.0535** |
| | (0.000231) | (0.000230) | (0.000230) | (0.00821) | (0.00819) | (0.00829) | (0.0139) | (0.0139) | (0.0141) |
| Age$^2$ | -0.00000590** | -0.00000596** | -0.00000686** | -0.000486** | -0.000484** | -0.000489** | -0.000565** | -0.000568** | -0.000567** |
| | (0.00000213) | (0.00000213) | (0.00000212) | (0.0000757) | (0.0000757) | (0.0000762) | (0.000128) | (0.000129) | (0.000130) |
| Adj hedonic reg error | 0.200* | 0.206* | 0.269** | -6.283$^+$ | -6.408$^+$ | -6.089$^+$ | -13.92* | -13.82* | -13.90* |
| | (0.0951) | (0.0952) | (0.0954) | (3.382) | (3.385) | (3.433) | (5.737) | (5.763) | (5.842) |
| Baseline price | 0.00409 | | | -0.0294 | | | -0.353* | | |
| | (0.00273) | | | (0.0970) | | | (0.165) | | |
| Predicted house price(t-1) | | 0.00884$^+$ | | | -0.145 | | | -0.104 | |
| | | (0.00522) | | | (0.186) | | | (0.316) | |
| Predicted house price(t-5) | | | 0.0123** | | | 0.0306 | | | -0.0329 |
| | | | (0.00284) | | | (0.102) | | | (0.174) |
| R-squared | 0.54 | 0.54 | 0.55 | 0.21 | 0.21 | 0.21 | 0.39 | 0.38 | 0.38 |

*N = 693.* $^+$significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.30 - Current-year predicted house prices - Owner-occupied properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Predicted house price | | 0.0133** | 0.00849** | | 0.0320 | 0.0263 | | 0.366** | 0.202** |
| | | (0.00105) | (0.00118) | | (0.0353) | (0.0452) | | (0.0509) | (0.0622) |
| Adjusted price variance | | 0.0282$^+$ | -0.0232 | | -2.001** | -3.108** | | -1.883* | -3.517** |
| | | (0.0159) | (0.0178) | | (0.533) | (0.683) | | (0.768) | (0.939) |
| Log square footage | | | 0.0359** | | | 0.324** | | | 0.202 |
| | | | (0.00302) | | | (0.116) | | | (0.160) |
| Age | | | 0.00183** | | | 0.0813** | | | 0.0968** |
| | | | (0.000224) | | | (0.00860) | | | (0.0118) |
| Age$^2$ | | | -0.0000123** | | | -0.000656** | | | -0.000889** |
| | | | (0.00000205) | | | (0.0000788) | | | (0.000108) |
| Adj hedonic reg error | | | 0.0710 | | | 4.689 | | | 7.319$^+$ |
| | | | (0.0813) | | | (3.128) | | | (4.302) |
| R-squared | | 0.19 | 0.51 | | 0.02 | 0.23 | | 0.09 | 0.34 |
| Predicted house price | 0.0121** | 0.00206 | 0.00557* | 0.292** | 0.112 | 0.256** | 0.469** | 0.248 | 0.392** |
| | (0.00216) | (0.00539) | (0.00255) | (0.0824) | (0.207) | (0.0979) | (0.114) | (0.285) | (0.135) |
| Adjusted price variance | -0.0223 | -0.0257 | -0.0294 | -3.045** | -3.074** | -2.624** | -3.453** | -3.499** | -3.119** |
| | (0.0177) | (0.0179) | (0.0184) | (0.676) | (0.688) | (0.704) | (0.935) | (0.946) | (0.972) |
| Log square footage | 0.0391** | 0.0352** | 0.0340** | 0.556** | 0.334** | 0.480** | 0.435* | 0.208 | 0.330$^+$ |
| | (0.00340) | (0.00308) | (0.00338) | (0.130) | (0.119) | (0.130) | (0.179) | (0.163) | (0.179) |
| Age | 0.00181** | 0.00183** | 0.00185** | 0.0802** | 0.0812** | 0.0795** | 0.0957** | 0.0968** | 0.0953** |
| | (0.000223) | (0.000224) | (0.000224) | (0.00852) | (0.00861) | (0.00859) | (0.0118) | (0.0118) | (0.0119) |
| Age$^2$ | -0.0000123** | -0.0000123** | -0.0000125** | -0.000655** | -0.000655** | -0.000645** | -0.000889** | -0.000889** | -0.000881** |
| | (0.00000204) | (0.00000205) | (0.00000205) | (0.0000780) | (0.0000788) | (0.0000785) | (0.000108) | (0.000108) | (0.000108) |
| Adj hedonic reg error | 0.0671 | 0.0776 | 0.0922 | 4.406 | 4.601 | 3.019 | 7.035 | 7.272$^+$ | 5.947 |
| | (0.0812) | (0.0815) | (0.0829) | (3.097) | (3.136) | (3.177) | (4.282) | (4.315) | (4.385) |
| Baseline price | -0.00520* | | | -0.378** | | | -0.380** | | |
| | (0.00258) | | | (0.0984) | | | (0.136) | | |
| Predicted house price(t-1) | | 0.00670 | | | -0.0893 | | | -0.0473 | |
| | | (0.00548) | | | (0.211) | | | (0.290) | |
| Predicted house price(t-5) | | | 0.00372 | | | -0.294** | | | -0.241 |
| | | | (0.00290) | | | (0.111) | | | (0.153) |
| R-squared | 0.52 | 0.51 | 0.51 | 0.25 | 0.23 | 0.24 | 0.35 | 0.34 | 0.35 |

*N = 693.* $^+$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.31 - Current-year predicted house prices - Renter-occupied properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Predicted house price | | 0.0275** | 0.0193** | | 0.414** | 0.347** | | 0.713** | 0.562** |
| | | (0.00186) | (0.00230) | | (0.0537) | (0.0697) | | (0.0734) | (0.0840) |
| Adjusted price variance | | 0.0184 | -0.0383* | | 1.432** | 1.737** | | 1.673** | 1.906** |
| | | (0.0112) | (0.0168) | | (0.323) | (0.508) | | (0.441) | (0.613) |
| Log square footage | | | 0.0263** | | | -0.179 | | | -0.851** |
| | | | (0.00513) | | | (0.155) | | | (0.189) |
| Age | | | -0.000462 | | | $0.0287^{+}$ | | | 0.0307 |
| | | | (0.000516) | | | (0.0156) | | | (0.0188) |
| $Age^2$ | | | 0.00000622 | | | $-0.000263^{+}$ | | | -0.000407* |
| | | | (0.00000469) | | | (0.000142) | | | (0.000171) |
| Adj hedonic reg error | | | 0.628** | | | -8.559 | | | -9.750 |
| | | | (0.220) | | | (6.646) | | | (8.031) |
| R-squared | | 0.24 | 0.39 | | 0.10 | 0.20 | | 0.13 | 0.40 |
| Predicted house price | 0.00250 | -0.0171 | -0.0133* | 0.348* | $0.683^{+}$ | 0.571** | 0.505** | 0.714 | 0.655** |
| | (0.00480) | (0.0124) | (0.00521) | (0.147) | (0.378) | (0.163) | (0.177) | (0.456) | (0.197) |
| Adjusted price variance | -0.0385* | -0.0427* | -0.0598** | 1.737** | 1.777** | 1.884** | 1.905** | 1.925** | 1.967** |
| | (0.0166) | (0.0167) | (0.0165) | (0.508) | (0.510) | (0.516) | (0.613) | (0.616) | (0.624) |
| Log square footage | 0.0173** | 0.0224** | 0.0110* | -0.179 | -0.144 | -0.0748 | -0.882** | -0.835** | -0.807** |
| | (0.00556) | (0.00526) | (0.00543) | (0.170) | (0.160) | (0.170) | (0.207) | (0.195) | (0.207) |
| Age | -0.000223 | -0.000296 | 0.000247 | $0.0287^{+}$ | $0.0271^{+}$ | 0.0238 | $0.0315^{+}$ | 0.0300 | 0.0287 |
| | (0.000514) | (0.000516) | (0.000509) | (0.0157) | (0.0157) | (0.0159) | (0.0190) | (0.0190) | (0.0192) |
| $Age^2$ | 0.00000514 | 0.00000507 | 0.00000138 | $-0.000263^{+}$ | $-0.000253^{+}$ | -0.000230 | -0.000411* | -0.000403* | -0.000394* |
| | (0.00000465) | (0.00000468) | (0.00000459) | (0.000142) | (0.000143) | (0.000144) | (0.000172) | (0.000172) | (0.000174) |
| Adj hedonic reg error | 0.610** | 0.656** | 0.820** | -8.558 | -8.819 | -9.873 | -9.811 | -9.871 | -10.29 |
| | (0.217) | (0.218) | (0.214) | (6.652) | (6.653) | (6.696) | (8.037) | (8.044) | (8.100) |
| Baseline price | 0.0229** | | | -0.00109 | | | 0.0777 | | |
| | (0.00574) | | | (0.176) | | | (0.212) | | |
| Predicted house price(t-1) | | 0.0382** | | | -0.353 | | | -0.159 | |
| | | (0.0128) | | | (0.390) | | | (0.470) | |
| Predicted house price(t-5) | | | 0.0407** | | | -0.278 | | | -0.117 |
| | | | (0.00588) | | | (0.184) | | | (0.222) |
| R-squared | 0.40 | 0.40 | 0.43 | 0.20 | 0.20 | 0.20 | 0.40 | 0.40 | 0.40 |

*N = 693.* $^{+}$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.32 - Unadjusted price variance - All properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0262** | 0.0274** | | 0.446** | 0.524** | | 1.006** | 1.175** |
| | | (0.00118) | (0.00201) | | (0.0567) | (0.100) | | (0.0730) | (0.121) |
| Price variance | | -0.0200** | -0.0413** | | 1.359** | 1.500** | | 1.392** | 1.544** |
| | | (0.00608) | (0.00823) | | (0.292) | (0.412) | | (0.376) | (0.496) |
| Log square footage | | | 0.00758* | | | -0.490** | | | -1.594** |
| | | | (0.00369) | | | (0.185) | | | (0.223) |
| Pct owner-occupied | | | -0.000583 | | | -0.480** | | | -0.327** |
| | | | (0.00133) | | | (0.0664) | | | (0.0800) |
| Age | | | 0.000887** | | | 0.0546** | | | 0.0520** |
| | | | (0.000254) | | | (0.0127) | | | (0.0153) |
| $Age^2$ | | | -0.00000413$^+$ | | | -0.000472** | | | -0.000535** |
| | | | (0.00000235) | | | (0.000118) | | | (0.000142) |
| Hedonic reg error | | | 0.311* | | | -24.72** | | | -27.82** |
| | | | (0.136) | | | (6.804) | | | (8.199) |
| R-squared | | 0.42 | 0.57 | | 0.13 | 0.29 | | 0.25 | 0.47 |
| Log house price | 0.00935** | 0.0184** | 0.0162** | 0.792** | 0.441** | 0.742** | 1.249** | 0.866** | 1.313** |
| | (0.00285) | (0.00291) | (0.00278) | (0.149) | (0.148) | (0.142) | (0.181) | (0.177) | (0.171) |
| Price variance | -0.0103 | -0.0383** | -0.0302** | 1.039* | 1.528** | 1.282** | 1.417** | 1.650** | 1.406** |
| | (0.00863) | (0.00816) | (0.00828) | (0.453) | (0.414) | (0.423) | (0.548) | (0.497) | (0.511) |
| Log square footage | 0.000373 | 0.00282 | 0.000794 | -0.383* | -0.534** | -0.358$^+$ | -1.565** | -1.757** | -1.510** |
| | (0.00361) | (0.00382) | (0.00380) | (0.189) | (0.194) | (0.194) | (0.229) | (0.232) | (0.235) |
| Pct owner-occupied | -0.00351** | -0.000956 | -0.00154 | -0.437** | -0.484** | -0.462** | -0.315** | -0.340** | -0.315** |
| | (0.00131) | (0.00131) | (0.00131) | (0.0685) | (0.0665) | (0.0667) | (0.0829) | (0.0799) | (0.0806) |
| Age | 0.00101** | 0.000820** | 0.000892** | 0.0527** | 0.0540** | 0.0545** | 0.0515** | 0.0497** | 0.0520** |
| | (0.000242) | (0.000251) | (0.000248) | (0.0127) | (0.0127) | (0.0127) | (0.0153) | (0.0153) | (0.0153) |
| $Age^2$ | -0.00000457* | -0.00000329 | -0.00000375 | -0.000465** | -0.000464** | -0.000479** | -0.000533** | -0.000506** | -0.000540** |
| | (0.00000224) | (0.00000233) | (0.00000230) | (0.000117) | (0.000118) | (0.000118) | (0.000142) | (0.000142) | (0.000142) |
| Hedonic reg error | 0.194 | 0.266* | 0.282* | -22.97** | -25.14** | -24.14** | -27.33** | -29.38** | -27.45** |
| | (0.130) | (0.135) | (0.133) | (6.819) | (6.828) | (6.791) | (8.250) | (8.198) | (8.203) |
| Baseline price | 0.0262** | | | -0.389* | | | -0.107 | | |
| | (0.00307) | | | (0.161) | | | (0.195) | | |
| Log house price(t-1) | | 0.0122** | | | 0.112 | | | 0.418* | |
| | | (0.00289) | | | (0.147) | | | (0.176) | |
| Log house price(t-5) | | | 0.0169** | | | -0.329* | | | -0.209 |
| | | | (0.00297) | | | (0.152) | | | (0.183) |
| R-squared | 0.61 | 0.58 | 0.59 | 0.30 | 0.29 | 0.30 | 0.47 | 0.47 | 0.47 |

*N = 693.* $^+$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.33 - Unadjusted price variance - All properties: new construction

| | Percent of properties newly built | | | Value of new construction | | | Square footage of new construction | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0912** | -0.000142 | | 0.920** | 1.169** | | 1.175** | 1.495** |
| | | (0.00900) | (0.0129) | | (0.102) | (0.186) | | (0.0958) | (0.171) |
| Price variance | | -0.155** | -0.0997+ | | 1.595** | 1.510* | | 1.510** | 1.718* |
| | | (0.0464) | (0.0531) | | (0.525) | (0.764) | | (0.488) | (0.687) |
| Log square footage | | | 0.0133 | | | -1.150** | | | -1.817** |
| | | | (0.0238) | | | (0.343) | | | (0.316) |
| Pct owner-occupied | | | -0.00292 | | | -0.764** | | | -0.501** |
| | | | (0.00855) | | | (0.123) | | | (0.111) |
| Age | | | -0.000563 | | | 0.0646** | | | 0.0539* |
| | | | (0.00163) | | | (0.0235) | | | (0.0220) |
| $Age^2$ | | | -0.00000201 | | | -0.000590** | | | -0.000534** |
| | | | (0.0000152) | | | (0.000219) | | | (0.000203) |
| Hedonic reg error | | | -0.530 | | | -32.54* | | | -35.25** |
| | | | (0.876) | | | (12.62) | | | (11.35) |
| R-squared | | 0.13 | 0.54 | | 0.13 | 0.25 | | 0.21 | 0.36 |
| Log house price | -0.0584** | 0.0250 | 0.00570 | 1.444** | 0.877** | 1.349** | 1.508** | 1.050** | 1.505** |
| | (0.0191) | (0.0190) | (0.0183) | (0.278) | (0.274) | (0.264) | (0.252) | (0.247) | (0.242) |
| Price variance | 0.000638 | -0.108* | -0.105+ | 1.037 | 1.611* | 1.331+ | 1.694* | 1.865** | 1.708* |
| | (0.0578) | (0.0532) | (0.0546) | (0.842) | (0.767) | (0.787) | (0.758) | (0.687) | (0.708) |
| Log square footage | -0.00995 | 0.0266 | 0.0168 | -1.041** | -1.305** | -1.041** | -1.811** | -2.057** | -1.811** |
| | (0.0242) | (0.0249) | (0.0251) | (0.353) | (0.359) | (0.361) | (0.326) | (0.329) | (0.332) |
| Pct owner-occupied | -0.0124 | -0.00188 | -0.00242 | -0.719** | -0.776** | -0.749** | -0.498** | -0.520** | -0.500** |
| | (0.00875) | (0.00855) | (0.00862) | (0.128) | (0.123) | (0.124) | (0.115) | (0.111) | (0.113) |
| Age | -0.000150 | -0.000375 | -0.000565 | 0.0627** | 0.0624** | 0.0645** | 0.0538* | 0.0498* | 0.0539* |
| | (0.00162) | (0.00164) | (0.00164) | (0.0236) | (0.0236) | (0.0235) | (0.0220) | (0.0219) | (0.0220) |
| $Age^2$ | -0.00000345 | -0.00000437 | -0.00000221 | -0.000583** | -0.000562* | -0.000596** | -0.000533** | -0.000484* | -0.000534** |
| | (0.0000150) | (0.0000152) | (0.0000152) | (0.000218) | (0.000219) | (0.000219) | (0.000203) | (0.000203) | (0.000204) |
| Hedonic reg error | -0.910 | -0.402 | -0.514 | -30.75* | -34.03** | -32.06* | -35.16** | -37.42** | -35.23** |
| | (0.871) | (0.878) | (0.877) | (12.69) | (12.65) | (12.63) | (11.42) | (11.34) | (11.36) |
| Baseline price | 0.0846** | | | -0.399 | | | -0.0203 | | |
| | (0.0206) | | | (0.299) | | | (0.270) | | |
| Log house price(t-1) | | -0.0341+ | | | 0.397 | | | 0.605* | |
| | | (0.0188) | | | (0.272) | | | (0.245) | |
| Log house price(t-5) | | | -0.00883 | | | -0.272 | | | -0.0159 |
| | | | (0.0196) | | | (0.282) | | | (0.256) |
| R-squared | 0.55 | 0.54 | 0.54 | 0.25 | 0.25 | 0.25 | 0.36 | 0.37 | 0.36 |

*N = 693.* +significant at 10%; *significant at 5%; **significant at 1%.

## Table 2.34 - Unadjusted price variance - All properties: existing construction

| | Percent of properties improved | | | Value of additions | | | Square footage of additions | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0218** | 0.0247** | | 0.101** | 0.203** | | 0.672** | 0.679** |
| | | (0.00109) | (0.00171) | | (0.0364) | (0.0647) | | (0.0656) | (0.109) |
| Price variance | | -0.0139* | -0.0323** | | 0.575** | 0.496$^+$ | | 0.833* | 0.884* |
| | | (0.00561) | (0.00699) | | (0.188) | (0.264) | | (0.338) | (0.445) |
| Log square footage | | | 0.00701* | | | -0.309** | | | -1.150** |
| | | | (0.00316) | | | (0.119) | | | (0.201) |
| Pct owner-occupied | | | 0.000369 | | | -0.126** | | | 0.0471 |
| | | | (0.00113) | | | (0.0427) | | | (0.0720) |
| Age | | | 0.00100** | | | 0.0573** | | | 0.0476** |
| | | | (0.000217) | | | (0.00818) | | | (0.0138) |
| Age$^2$ | | | -0.00000453* | | | -0.000462** | | | -0.000493** |
| | | | (0.00000201) | | | (0.0000759) | | | (0.000128) |
| Hedonic reg error | | | 0.252* | | | -8.290$^+$ | | | -12.45$^+$ |
| | | | (0.116) | | | (4.364) | | | (7.355) |
| R-squared | | 0.37 | 0.60 | | 0.03 | 0.21 | | 0.15 | 0.40 |
| Log house price | 0.0110** | 0.0162** | 0.0138** | 0.120 | 0.251** | 0.206* | 0.381* | 0.398* | 0.620** |
| | (0.00246) | (0.00248) | (0.00235) | (0.0965) | (0.0950) | (0.0916) | (0.162) | (0.160) | (0.154) |
| Price variance | -0.00870 | -0.0294** | -0.0216** | 0.640* | 0.479$^+$ | 0.493$^+$ | 1.398** | 0.981* | 0.942* |
| | (0.00743) | (0.00692) | (0.00699) | (0.292) | (0.265) | (0.272) | (0.490) | (0.445) | (0.458) |
| Log square footage | 0.00158 | 0.00253 | 0.000450 | -0.342** | -0.284* | -0.307* | -1.269** | -1.300** | -1.186** |
| | (0.00312) | (0.00326) | (0.00323) | (0.123) | (0.125) | (0.126) | (0.206) | (0.210) | (0.212) |
| Pct owner-occupied | -0.00186$^+$ | 0.0000211 | -0.000555 | -0.140** | -0.124** | -0.126** | -0.00134 | 0.0356 | 0.0421 |
| | (0.00113) | (0.00112) | (0.00111) | (0.0443) | (0.0428) | (0.0431) | (0.0744) | (0.0719) | (0.0727) |
| Age | 0.00110** | 0.000941** | 0.00101** | 0.0579** | 0.0577** | 0.0573** | 0.0497** | 0.0455** | 0.0476** |
| | (0.000209) | (0.000214) | (0.000210) | (0.00819) | (0.00820) | (0.00818) | (0.0138) | (0.0138) | (0.0138) |
| Age$^2$ | -0.00000486* | -0.00000373$^+$ | -0.00000416* | -0.000464** | -0.000466** | -0.000462** | -0.000501** | -0.000467** | -0.000491** |
| | (0.00000193) | (0.00000199) | (0.00000195) | (0.0000759) | (0.0000762) | (0.0000760) | (0.000127) | (0.000128) | (0.000128) |
| Hedonic reg error | 0.162 | 0.209$^+$ | 0.224* | -8.836* | -8.047$^+$ | -8.282$^+$ | -14.40$^+$ | -13.87$^+$ | -12.60$^+$ |
| | (0.112) | (0.114) | (0.112) | (4.388) | (4.380) | (4.371) | (7.369) | (7.353) | (7.364) |
| Baseline price | 0.0198** | | | 0.121 | | | 0.432* | | |
| | (0.00265) | | | (0.104) | | | (0.174) | | |
| Log house price(t-1) | | 0.0114** | | | -0.0652 | | | 0.381* | |
| | | (0.00246) | | | (0.0944) | | | (0.158) | |
| Log house price(t-5) | | | 0.0163** | | | -0.00469 | | | 0.0890 |
| | | | (0.00251) | | | (0.0978) | | | (0.165) |
| R-squared | 0.63 | 0.61 | 0.62 | 0.21 | 0.21 | 0.21 | 0.40 | 0.40 | 0.40 |

*N = 693.* $^+$significant at 10%; *significant at 5%; **significant at 1%.

Table 2.35 - Unadjusted price variance - Owner-occupied properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0176** | 0.0194** | | 0.0721+ | 0.0360 | | 0.564** | 0.458** |
| | | (0.00113) | (0.00188) | | (0.0397) | (0.0747) | | (0.0560) | (0.103) |
| Price variance | | -0.0114 | -0.0879** | | -2.254** | -3.914** | | -1.323+ | -4.801** |
| | | (0.0152) | (0.0167) | | (0.531) | (0.664) | | (0.749) | (0.914) |
| Log square footage | | | 0.0179** | | | 0.279+ | | | -0.237 |
| | | | (0.00379) | | | (0.151) | | | (0.208) |
| Age | | | 0.00152** | | | 0.0829** | | | 0.0919** |
| | | | (0.000217) | | | (0.00864) | | | (0.0119) |
| $Age^2$ | | | -0.00000901** | | | -0.000671** | | | -0.000835** |
| | | | (0.00000201) | | | (0.0000798) | | | (0.000110) |
| Hedonic reg error | | | 0.283** | | | 8.532* | | | 14.31* |
| | | | (0.105) | | | (4.187) | | | (5.761) |
| R-squared | | 0.26 | 0.55 | | 0.03 | 0.24 | | 0.13 | 0.35 |
| Log house price | 0.00537+ | 0.0119** | 0.00837** | 0.0636 | 0.152 | 0.0747 | 0.513** | 0.534** | 0.468** |
| | (0.00321) | (0.00335) | (0.00298) | (0.130) | (0.134) | (0.121) | (0.179) | (0.184) | (0.166) |
| Price variance | -0.0473** | -0.0799** | -0.0698** | -3.994** | -4.036** | -3.978** | -4.958** | -4.880** | -4.818** |
| | (0.0180) | (0.0169) | (0.0169) | (0.732) | (0.674) | (0.682) | (1.008) | (0.928) | (0.939) |
| Log square footage | 0.0116** | 0.0151** | 0.0123** | 0.292+ | 0.322* | 0.299+ | -0.213 | -0.210 | -0.232 |
| | (0.00390) | (0.00391) | (0.00392) | (0.158) | (0.156) | (0.158) | (0.218) | (0.215) | (0.218) |
| Age | 0.00151** | 0.00148** | 0.00148** | 0.0830** | 0.0837** | 0.0831** | 0.0920** | 0.0924** | 0.0920** |
| | (0.000213) | (0.000217) | (0.000214) | (0.00865) | (0.00867) | (0.00866) | (0.0119) | (0.0119) | (0.0119) |
| $Age^2$ | -0.00000856** | -0.00000851** | -0.00000838** | -0.000672** | -0.000679** | -0.000673** | -0.000837** | -0.000840** | -0.000835** |
| | (0.00000197) | (0.00000201) | (0.00000198) | (0.0000799) | (0.0000801) | (0.0000800) | (0.000110) | (0.000110) | (0.000110) |
| Hedonic reg error | 0.237* | 0.248* | 0.285** | 8.622* | 9.070* | 8.523* | 14.48* | 14.66* | 14.31* |
| | (0.104) | (0.106) | (0.104) | (4.204) | (4.218) | (4.189) | (5.784) | (5.808) | (5.765) |
| Baseline price | 0.0183** | | | -0.0358 | | | -0.0708 | | |
| | (0.00341) | | | (0.139) | | | (0.191) | | |
| Log house price(t-1) | | 0.00908** | | | -0.139 | | | -0.0905 | |
| | | (0.00335) | | | (0.134) | | | (0.184) | |
| Log house price(t-5) | | | 0.0145** | | | -0.0509 | | | -0.0134 |
| | | | (0.00308) | | | (0.124) | | | (0.171) |
| R-squared | 0.57 | 0.56 | 0.57 | 0.24 | 0.24 | 0.24 | 0.35 | 0.35 | 0.35 |

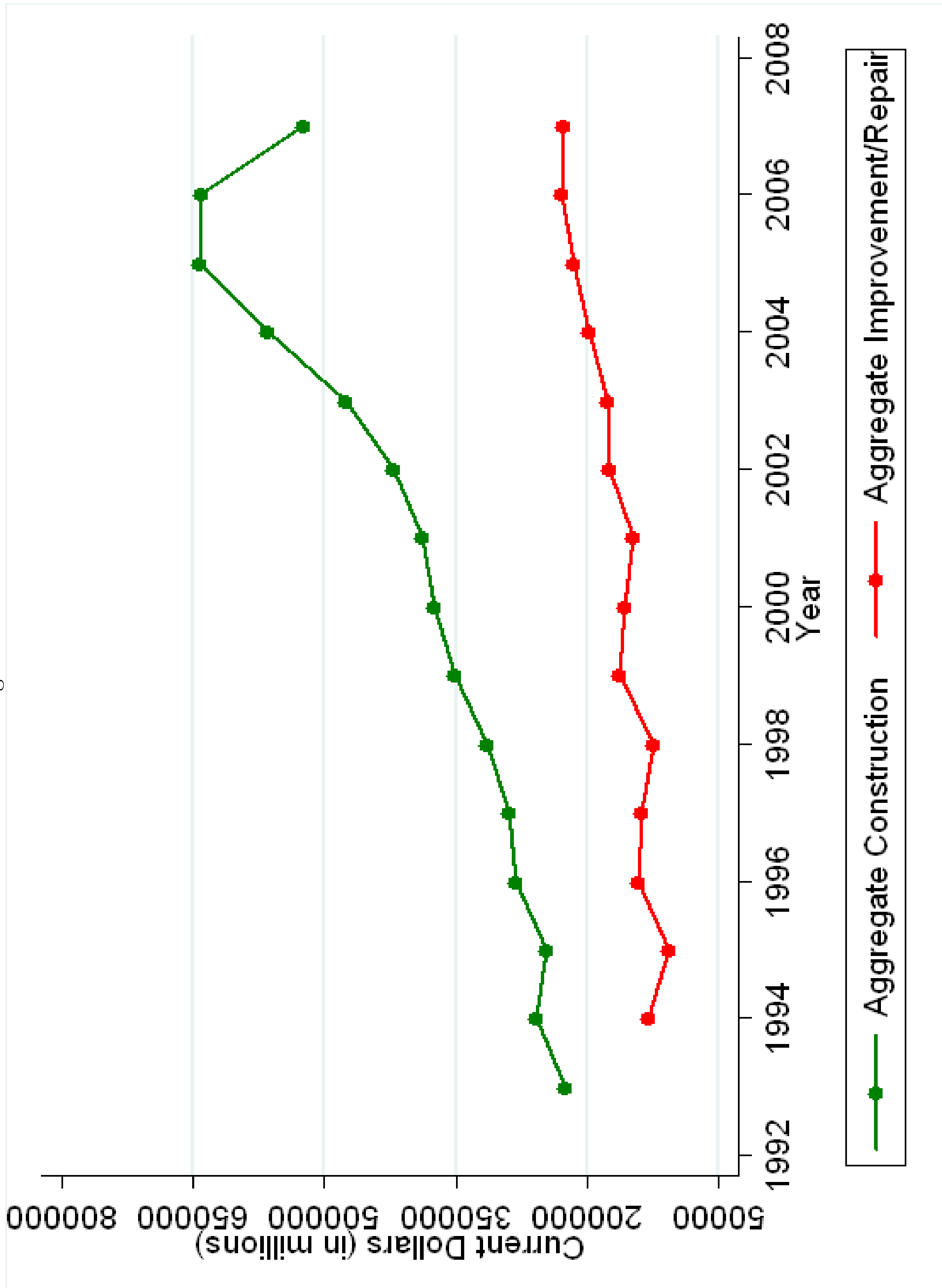
*N = 693.* +significant at 10%; *significant at 5%; **significant at 1%.

Table 2.36 Unadjusted price variance - Renter-occupied properties: all improvements

| | Percent of properties improved | | | Value of improvements | | | Square footage of improvements | | |
|---|---|---|---|---|---|---|---|---|---|
| Log house price | | 0.0431** | 0.0521** | | 0.558** | 0.426** | | 1.101** | 1.150** |
| | | (0.00197) | (0.00368) | | (0.0634) | (0.120) | | (0.0834) | (0.143) |
| Price variance | | -0.0343** | -0.0645** | | 1.025** | 2.256** | | 1.038* | 2.044** |
| | | (0.0105) | (0.0151) | | (0.336) | (0.492) | | (0.442) | (0.581) |
| Log square footage | | | -0.0103+ | | | -0.266 | | | -1.552** |
| | | | (0.00590) | | | (0.192) | | | (0.231) |
| Age | | | -0.000700 | | | 0.0257 | | | 0.0214 |
| | | | (0.000480) | | | (0.0157) | | | (0.0185) |
| $Age^2$ | | | 0.0000108* | | | -0.000228 | | | -0.000275 |
| | | | (0.00000439) | | | (0.000143) | | | (0.000170) |
| Hedonic reg error | | | 0.477+ | | | -33.61** | | | -34.75** |
| | | | (0.270) | | | (8.818) | | | (10.41) |
| R-squared | | 0.41 | 0.48 | | 0.13 | 0.20 | | 0.22 | 0.42 |
| Log house price | 0.0211** | 0.0359** | 0.0299** | 0.862** | 0.351+ | 0.591** | 1.311** | 0.839** | 1.234** |
| | (0.00593) | (0.00551) | (0.00546) | (0.198) | (0.182) | (0.182) | (0.236) | (0.215) | (0.217) |
| Price variance | -0.00781 | -0.0573** | -0.0401** | 1.455* | 2.290** | 2.073** | 1.748** | 2.184** | 1.951** |
| | (0.0170) | (0.0150) | (0.0155) | (0.569) | (0.496) | (0.514) | (0.675) | (0.584) | (0.608) |
| Log square footage | -0.0123* | -0.0168** | -0.0185** | -0.237 | -0.296 | -0.204 | -1.541** | -1.680** | -1.523** |
| | (0.00573) | (0.00607) | (0.00598) | (0.192) | (0.200) | (0.199) | (0.232) | (0.240) | (0.238) |
| Age | -0.000763 | -0.000801+ | -0.000752 | 0.0265+ | 0.0252 | 0.0260+ | 0.0217 | 0.0194 | 0.0215 |
| | (0.000466) | (0.000476) | (0.000470) | (0.0156) | (0.0157) | (0.0157) | (0.0185) | (0.0185) | (0.0185) |
| $Age^2$ | 0.0000125** | 0.0000123** | 0.0000122** | -0.000251+ | -0.000221 | -0.000238+ | -0.000284+ | -0.000247 | -0.000280+ |
| | (0.00000427) | (0.00000436) | (0.00000431) | (0.000143) | (0.000144) | (0.000144) | (0.000170) | (0.000170) | (0.000170) |
| Hedonic reg error | 0.183 | 0.385 | 0.387 | -29.45** | -34.03** | -32.93** | -33.21** | -36.53** | -34.41** |
| | (0.266) | (0.269) | (0.265) | (8.904) | (8.857) | (8.833) | (10.57) | (10.43) | (10.44) |
| Baseline price | 0.0384** | | | -0.543** | | | -0.201 | | |
| | (0.00588) | | | (0.197) | | | (0.233) | | |
| Log house price(t-1) | | 0.0210** | | | 0.0970 | | | 0.406+ | |
| | | (0.00539) | | | (0.178) | | | (0.209) | |
| Log house price(t-5) | | | 0.0298** | | | -0.223 | | | -0.113 |
| | | | (0.00552) | | | (0.184) | | | (0.218) |
| R-squared | 0.51 | 0.49 | 0.50 | 0.21 | 0.20 | 0.20 | 0.43 | 0.43 | 0.43 |

*N = 693.* +significant at 10%; *significant at 5%; **significant at 1%.

Figure 2.1:



Current Dollars (in millions)
50000
200000
350000
500000
650000
800000
1992
1994
1996
1998
2000
2002
2004
2006
2008
Year
Aggregate Construction
Aggregate Improvement/Repair

Figure 2.2:

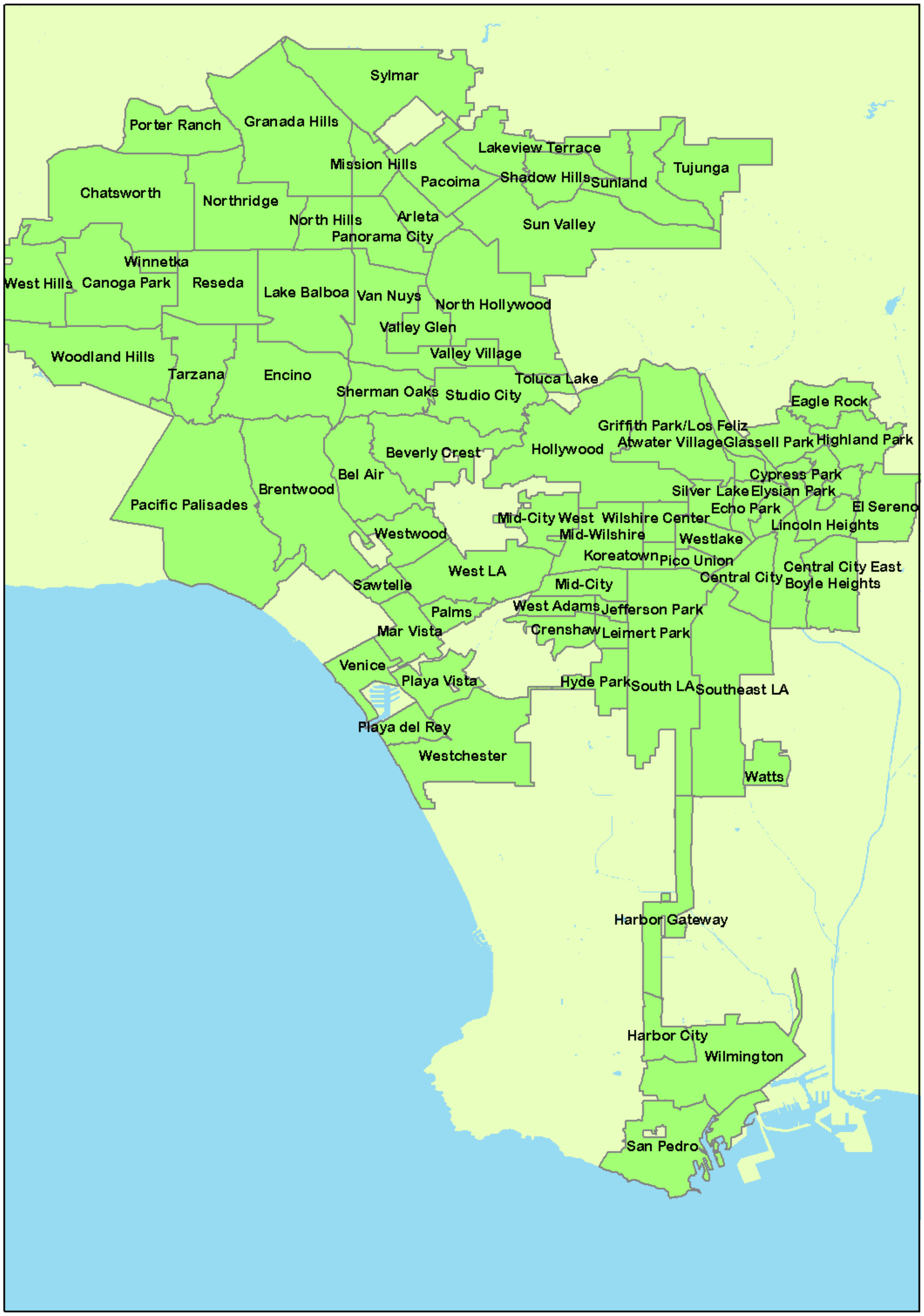

Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Tujunga
Mission Hills
Pacoima
Shadow Hills
Sunland
Chatsworth
Northridge
North Hills
Arleta
Panorama City
Sun Valley
Winnetka
West Hills
Canoga Park
Reseda
Lake Balboa
Van Nuys
North Hollywood
Valley Glen
Woodland Hills
Valley Village
Tarzana
Encino
Toluca Lake
Sherman Oaks
Studio City
Eagle Rock
Griffith Park/Los Feliz
Atwater Village
Glassell Park
Highland Park
Beverly Crest
Hollywood
Bel Air
Cypress Park
Brentwood
Silver Lake
Elysian Park
Pacific Palisades
Echo Park
El Sereno
Mid-City West
Wilshire Center
Lincoln Heights
Westwood
Mid-Wilshire
Westlake
Koreatown
Pico Union
West LA
Central City East
Central City
Sawtelle
Mid-City
Boyle Heights
Palms
West Adams
Jefferson Park
Mar Vista
Crenshaw
Leimert Park
Venice
Playa Vista
Hyde Park
South LA
Southeast LA
Playa del Rey
Westchester
Watts
Harbor Gateway
Harbor City
Wilmington
San Pedro

Figure 2.3:

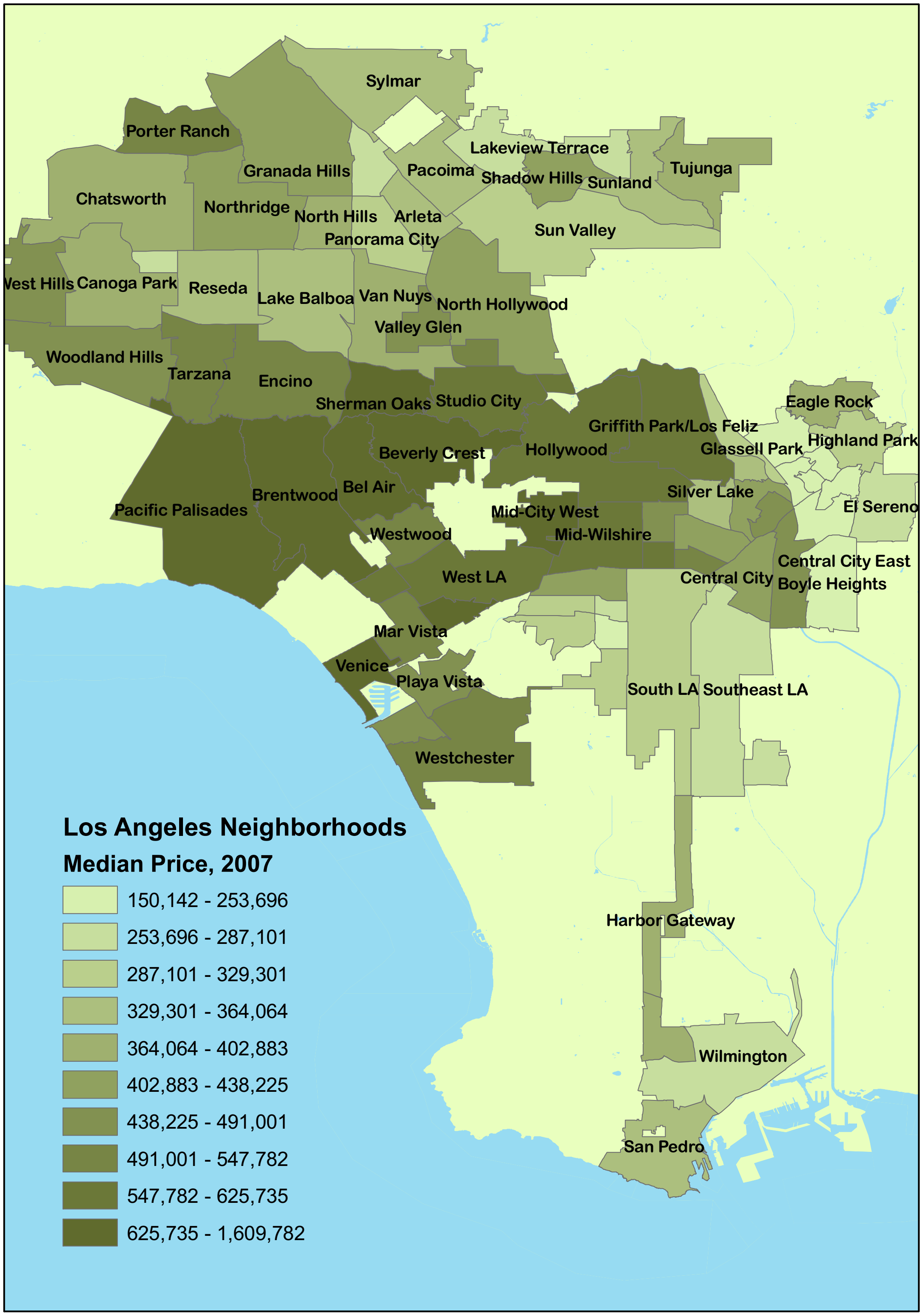

Sylmar
Porter Ranch
Lakeview Terrace
Granada Hills
Pacoima
Shadow Hills
Sunland
Tujunga
Chatsworth
Northridge
North Hills
Arleta
Panorama City
Sun Valley
West Hills
Canoga Park
Reseda
Lake Balboa
Van Nuys
North Hollywood
Valley Glen
Woodland Hills
Tarzana
Encino
Sherman Oaks
Studio City
Eagle Rock
Griffith Park/Los Feliz
Highland Park
Glassell Park
Beverly Crest
Hollywood
Bel Air
Brentwood
Silver Lake
Pacific Palisades
Mid-City West
El Sereno
Westwood
Mid-Wilshire
Central City East
West LA
Central City
Boyle Heights
Mar Vista
Venice
Playa Vista
South LA
Southeast LA
Westchester
Los Angeles Neighborhoods
Median Price, 2007
150,142 - 253,696
253,696 - 287,101
287,101 - 329,301
329,301 - 364,064
364,064 - 402,883
402,883 - 438,225
438,225 - 491,001
491,001 - 547,782
547,782 - 625,735
625,735 - 1,609,782
Harbor Gateway
Wilmington
San Pedro

Figure 2.4:

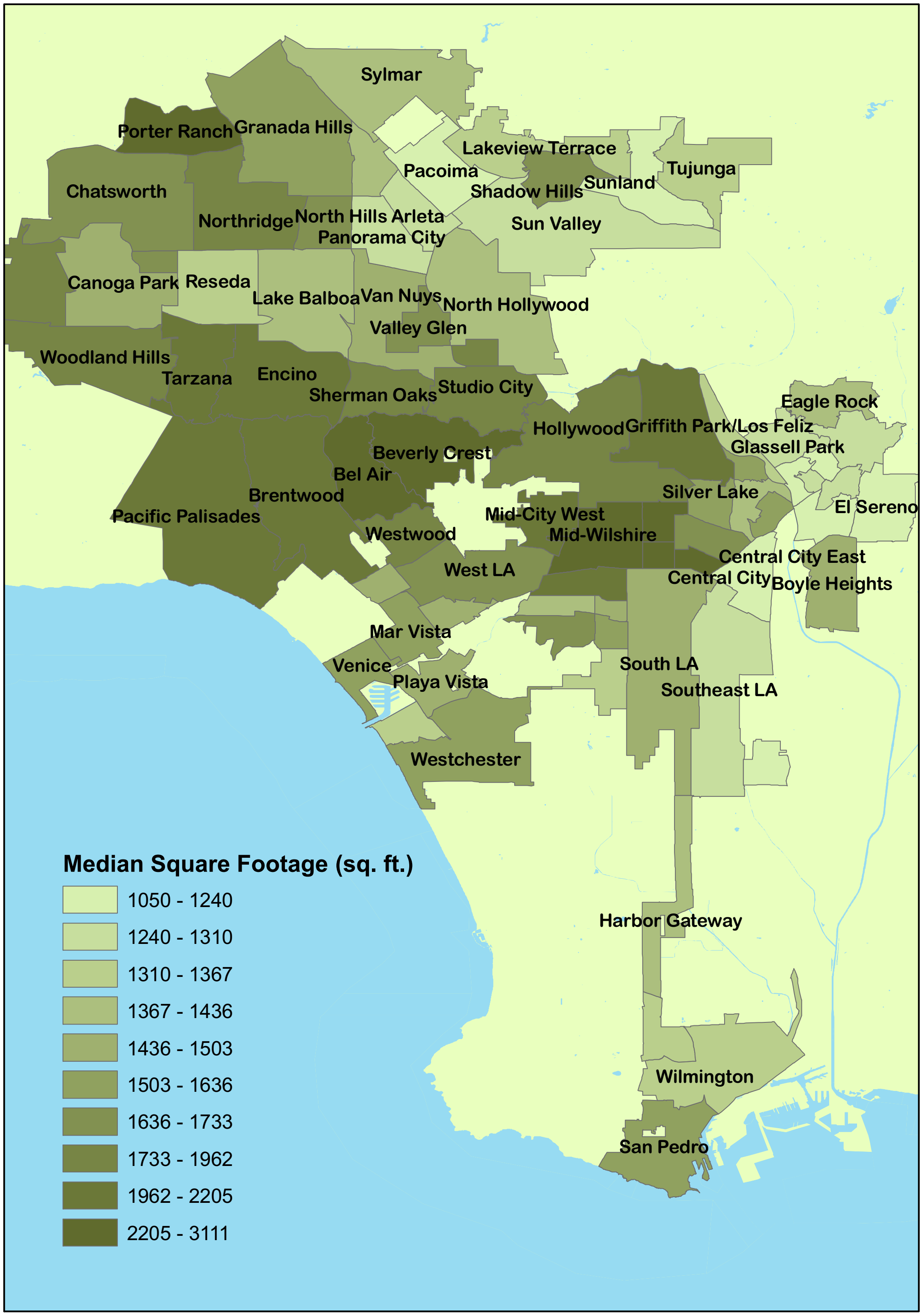
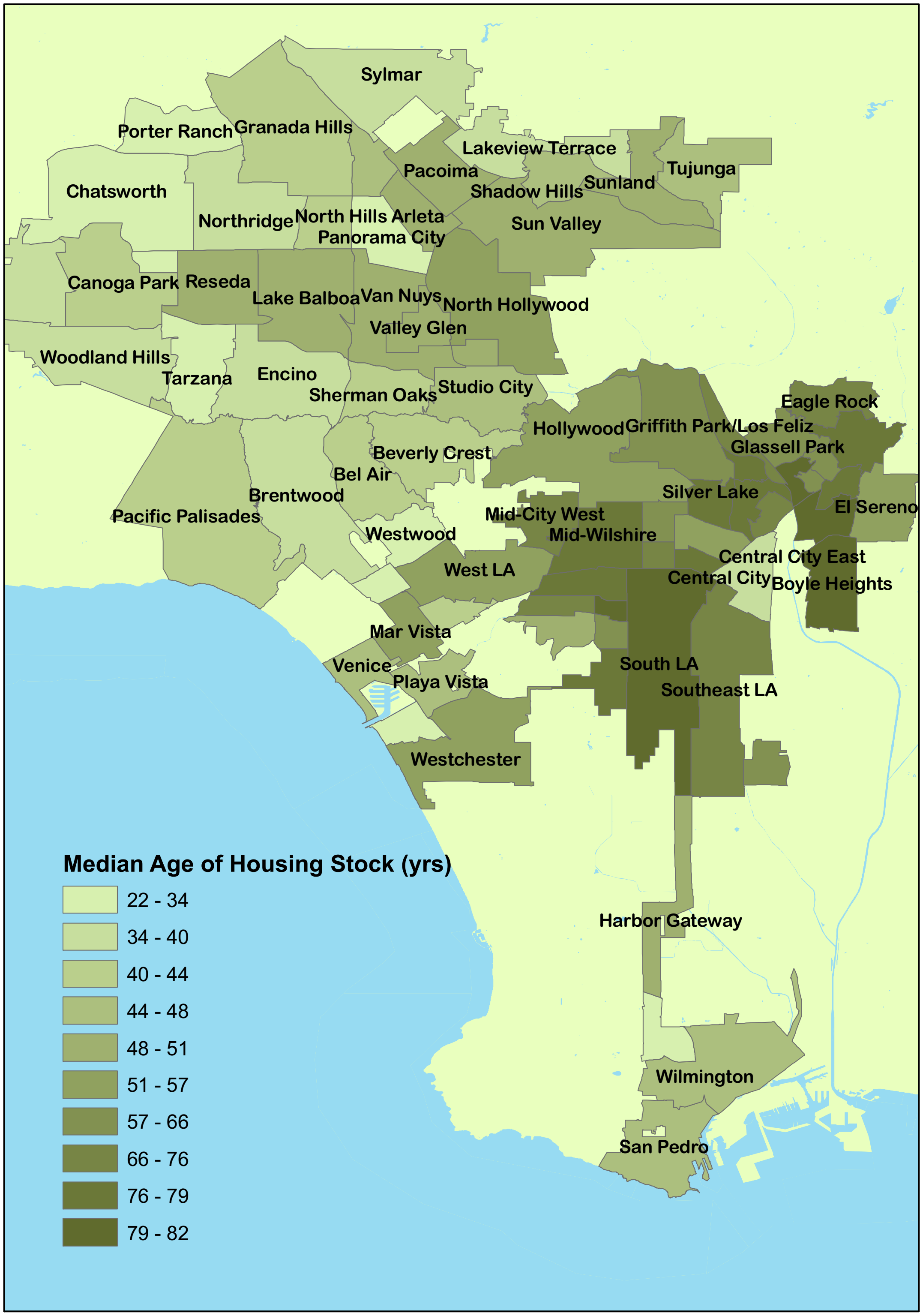

Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Tujunga
Pacoima
Sunland
Shadow Hills
Chatsworth
Northridge
North Hills
Arleta
Panorama City
Sun Valley
Canoga Park
Reseda
Lake Balboa
Van Nuys
North Hollywood
Valley Glen
Woodland Hills
Tarzana
Encino
Sherman Oaks
Studio City
Eagle Rock
Hollywood
Griffith Park/Los Feliz
Glassell Park
Beverly Crest
Bel Air
Brentwood
Silver Lake
El Sereno
Pacific Palisades
Mid-City West
Westwood
Mid-Wilshire
Central City East
West LA
Central City
Boyle Heights
Mar Vista
Venice
South LA
Playa Vista
Southeast LA
Westchester
Median Square Footage (sq. ft.)
1050 - 1240
1240 - 1310
1310 - 1367
1367 - 1436
1436 - 1503
1503 - 1636
1636 - 1733
1733 - 1962
1962 - 2205
2205 - 3111
Harbor Gateway
Wilmington
San Pedro

Figure 2.5:



Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Tujunga
Pacoima
Sunland
Shadow Hills
Chatsworth
Sun Valley
Northridge
North Hills
Arleta
Panorama City
Canoga Park
Reseda
Lake Balboa
Van Nuys
North Hollywood
Valley Glen
Woodland Hills
Tarzana
Encino
Sherman Oaks
Studio City
Eagle Rock
Hollywood
Griffith Park/Los Feliz
Glassell Park
Beverly Crest
Bel Air
Silver Lake
Brentwood
El Sereno
Pacific Palisades
Mid-City West
Mid-Wilshire
Westwood
Central City East
West LA
Central City
Boyle Heights
Mar Vista
Venice
South LA
Playa Vista
Southeast LA
Westchester
Median Age of Housing Stock (yrs)
22 - 34
34 - 40
40 - 44
44 - 48
48 - 51
51 - 57
57 - 66
66 - 76
76 - 79
79 - 82
Harbor Gateway
Wilmington
San Pedro

Figure 2.6:

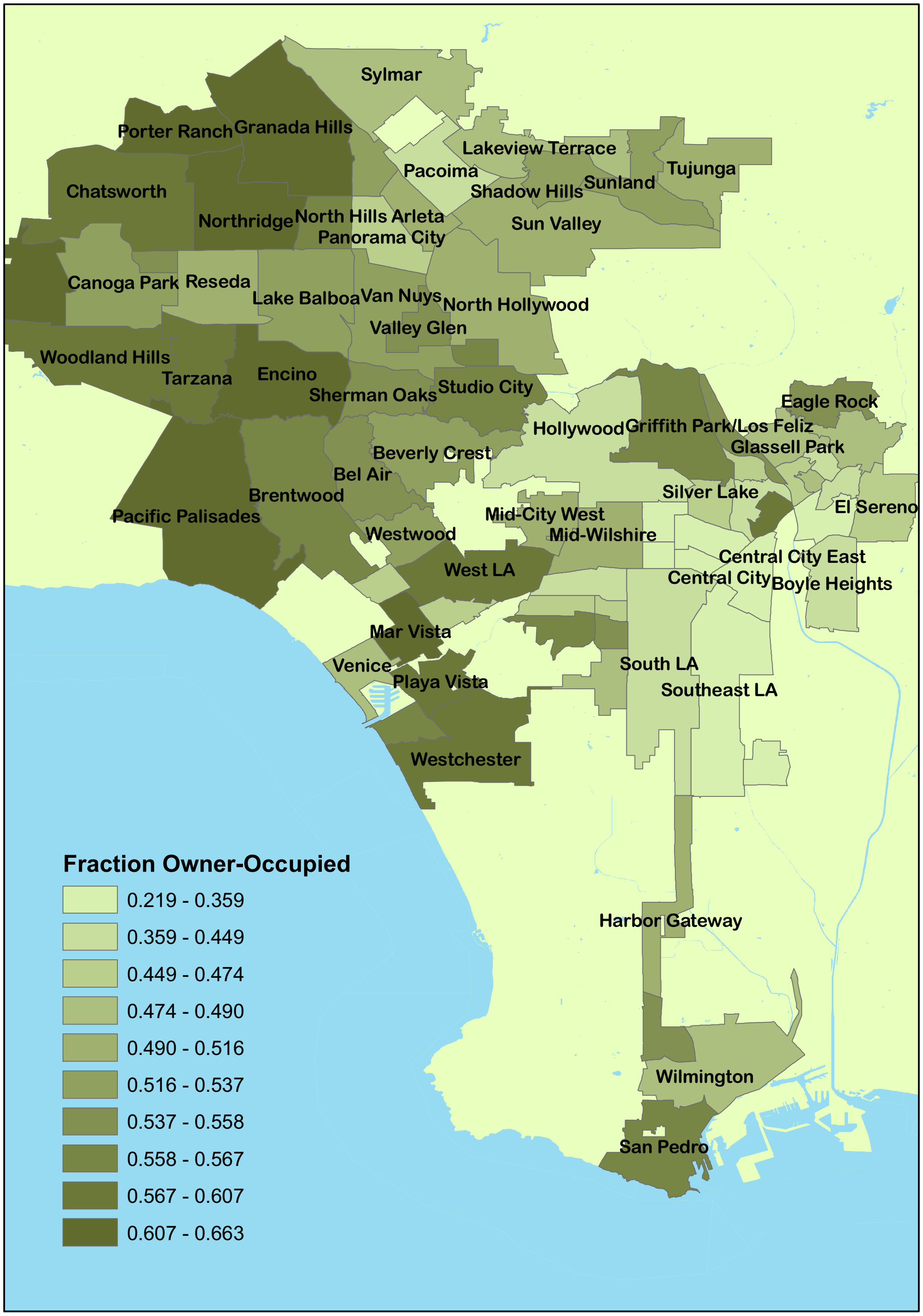

Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Tujunga
Pacoima
Sunland
Shadow Hills
Chatsworth
Northridge
North Hills
Arleta
Sun Valley
Panorama City
Canoga Park
Reseda
Lake Balboa
Van Nuys
North Hollywood
Valley Glen
Woodland Hills
Tarzana
Encino
Sherman Oaks
Studio City
Eagle Rock
Hollywood
Griffith Park/Los Feliz
Glassell Park
Beverly Crest
Bel Air
Silver Lake
Brentwood
El Sereno
Pacific Palisades
Mid-City West
Westwood
Mid-Wilshire
Central City East
West LA
Central City
Boyle Heights
Mar Vista
Venice
South LA
Playa Vista
Southeast LA
Westchester
Fraction Owner-Occupied
0.219 - 0.359
0.359 - 0.449
0.449 - 0.474
0.474 - 0.490
0.490 - 0.516
0.516 - 0.537
0.537 - 0.558
0.558 - 0.567
0.567 - 0.607
0.607 - 0.663
Harbor Gateway
Wilmington
San Pedro

Figure 2.7:

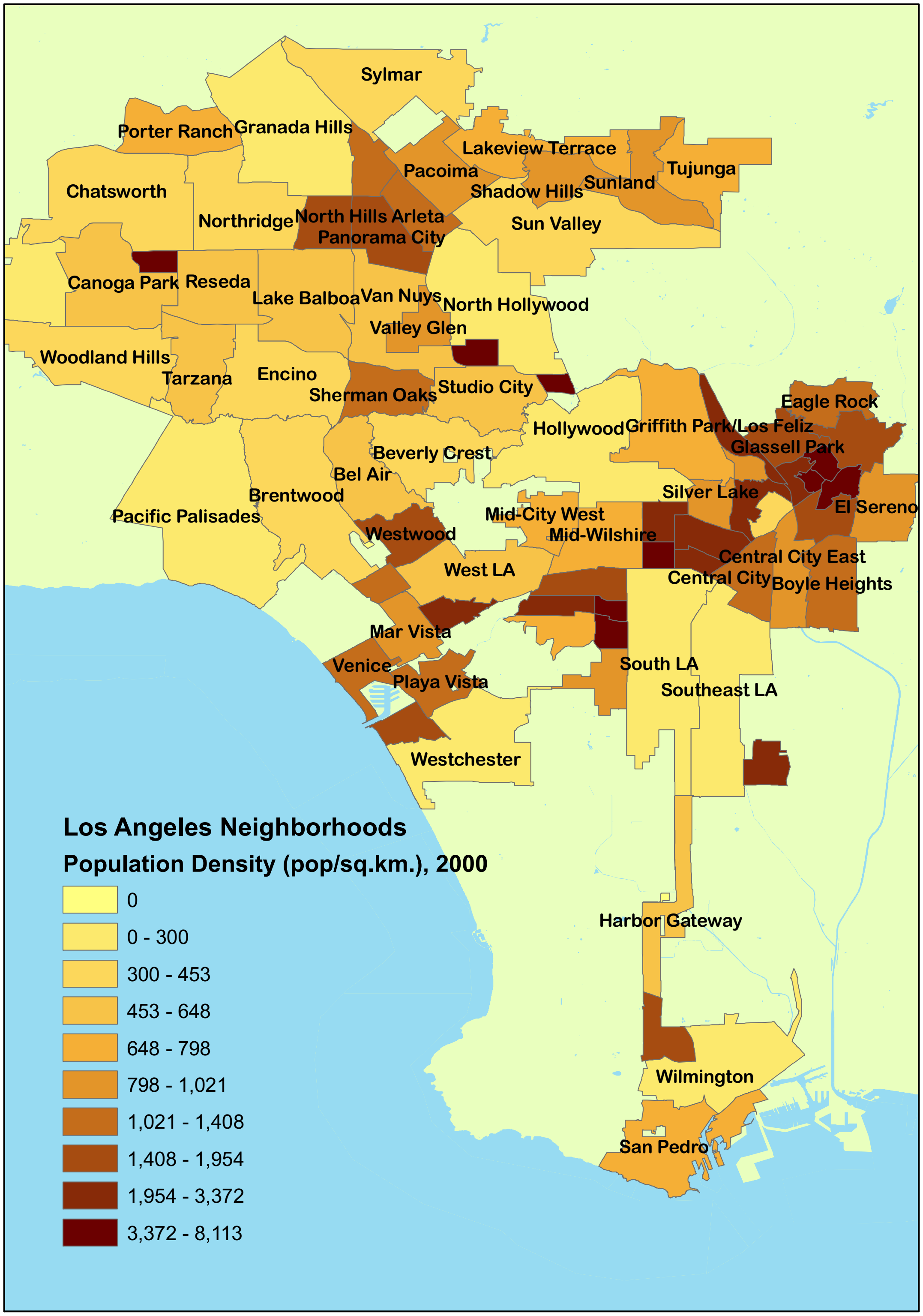

Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Tujunga
Pacoima
Chatsworth
Shadow Hills
Sunland
Northridge
North Hills
Arleta
Panorama City
Sun Valley
Canoga Park
Reseda
Lake Balboa
Van Nuys
North Hollywood
Valley Glen
Woodland Hills
Tarzana
Encino
Sherman Oaks
Studio City
Eagle Rock
Hollywood
Griffith Park/Los Feliz
Beverly Crest
Glassell Park
Bel Air
Silver Lake
Brentwood
El Sereno
Pacific Palisades
Mid-City West
Westwood
Mid-Wilshire
Central City East
West LA
Central City
Boyle Heights
Mar Vista
Venice
South LA
Playa Vista
Southeast LA
Westchester
Los Angeles Neighborhoods
Population Density (pop/sq.km.), 2000
0
0 - 300
300 - 453
453 - 648
648 - 798
798 - 1,021
1,021 - 1,408
1,408 - 1,954
1,954 - 3,372
3,372 - 8,113
Harbor Gateway
Wilmington
San Pedro

Figure 2.8:

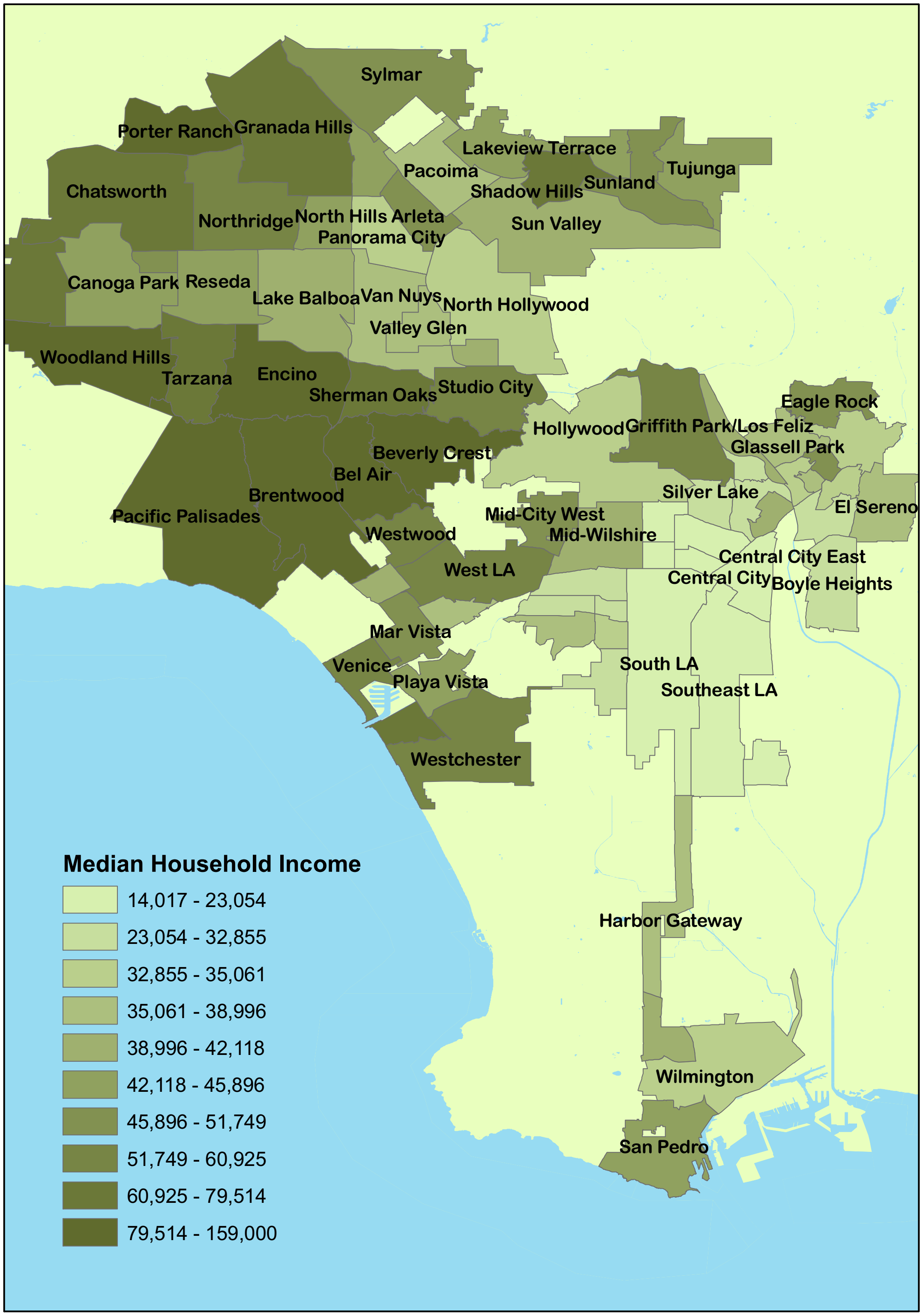

Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Tujunga
Pacoima
Sunland
Shadow Hills
Chatsworth
Northridge
North Hills
Arleta
Panorama City
Sun Valley
Canoga Park
Reseda
Lake Balboa
Van Nuys
North Hollywood
Valley Glen
Woodland Hills
Tarzana
Encino
Sherman Oaks
Studio City
Eagle Rock
Hollywood
Griffith Park/Los Feliz
Glassell Park
Beverly Crest
Bel Air
Brentwood
Silver Lake
Pacific Palisades
Mid-City West
El Sereno
Westwood
Mid-Wilshire
Central City East
West LA
Central City
Boyle Heights
Mar Vista
Venice
Playa Vista
South LA
Southeast LA
Westchester
Median Household Income
14,017 - 23,054
23,054 - 32,855
32,855 - 35,061
35,061 - 38,996
38,996 - 42,118
42,118 - 45,896
45,896 - 51,749
51,749 - 60,925
60,925 - 79,514
79,514 - 159,000
Harbor Gateway
Wilmington
San Pedro

Figure 2.9:

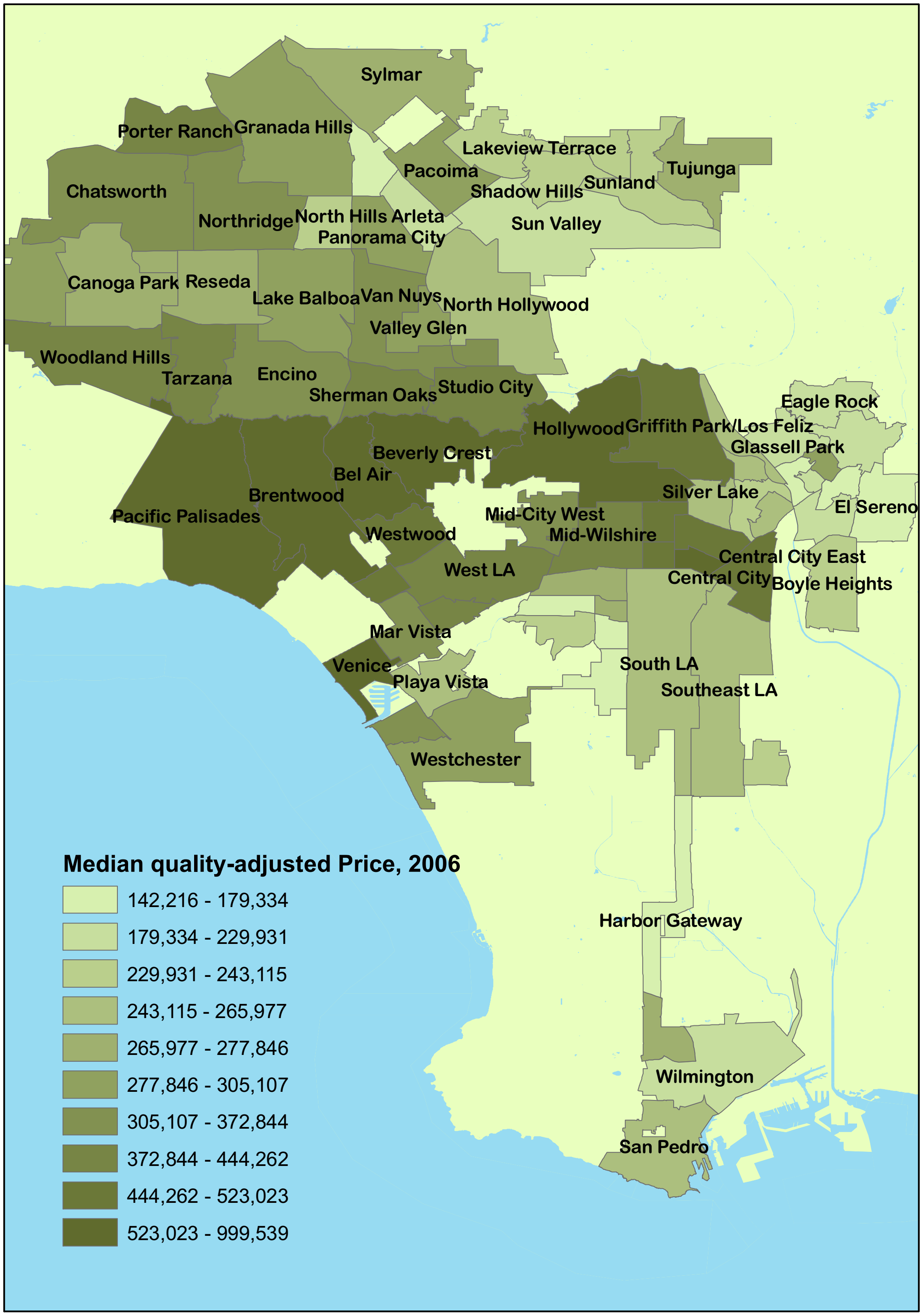

Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Tujunga
Pacoima
Chatsworth
Shadow Hills
Sunland
Northridge
North Hills
Arleta
Sun Valley
Panorama City
Canoga Park
Reseda
Lake Balboa
Van Nuys
North Hollywood
Valley Glen
Woodland Hills
Tarzana
Encino
Sherman Oaks
Studio City
Eagle Rock
Hollywood
Griffith Park/Los Feliz
Glassell Park
Beverly Crest
Bel Air
Silver Lake
Brentwood
Mid-City West
El Sereno
Pacific Palisades
Westwood
Mid-Wilshire
Central City East
West LA
Central City
Boyle Heights
Mar Vista
Venice
South LA
Playa Vista
Southeast LA
Westchester
Median quality-adjusted Price, 2006
142,216 - 179,334
179,334 - 229,931
229,931 - 243,115
243,115 - 265,977
265,977 - 277,846
277,846 - 305,107
305,107 - 372,844
372,844 - 444,262
444,262 - 523,023
523,023 - 999,539
Harbor Gateway
Wilmington
San Pedro

Figure 2.10:

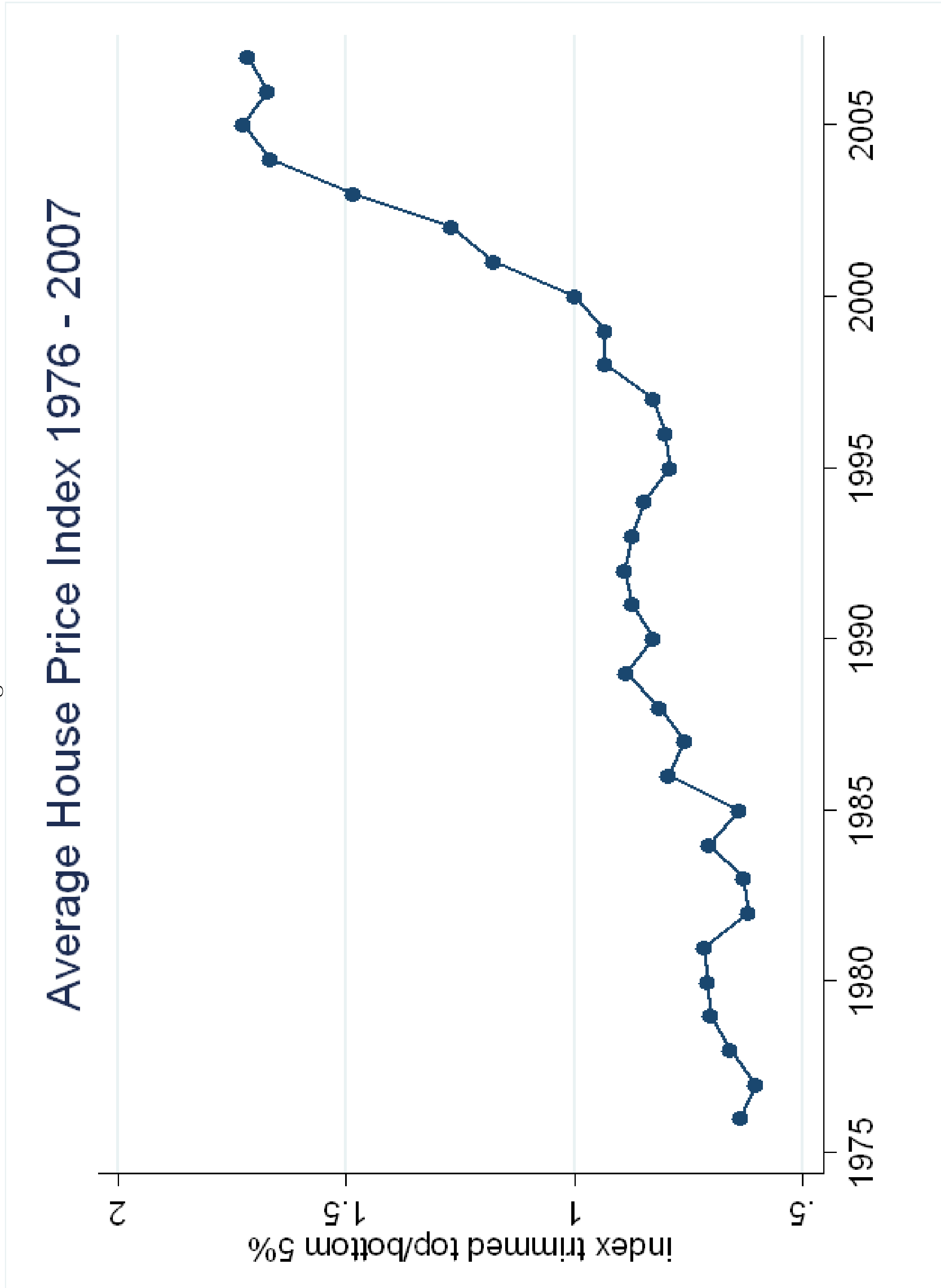
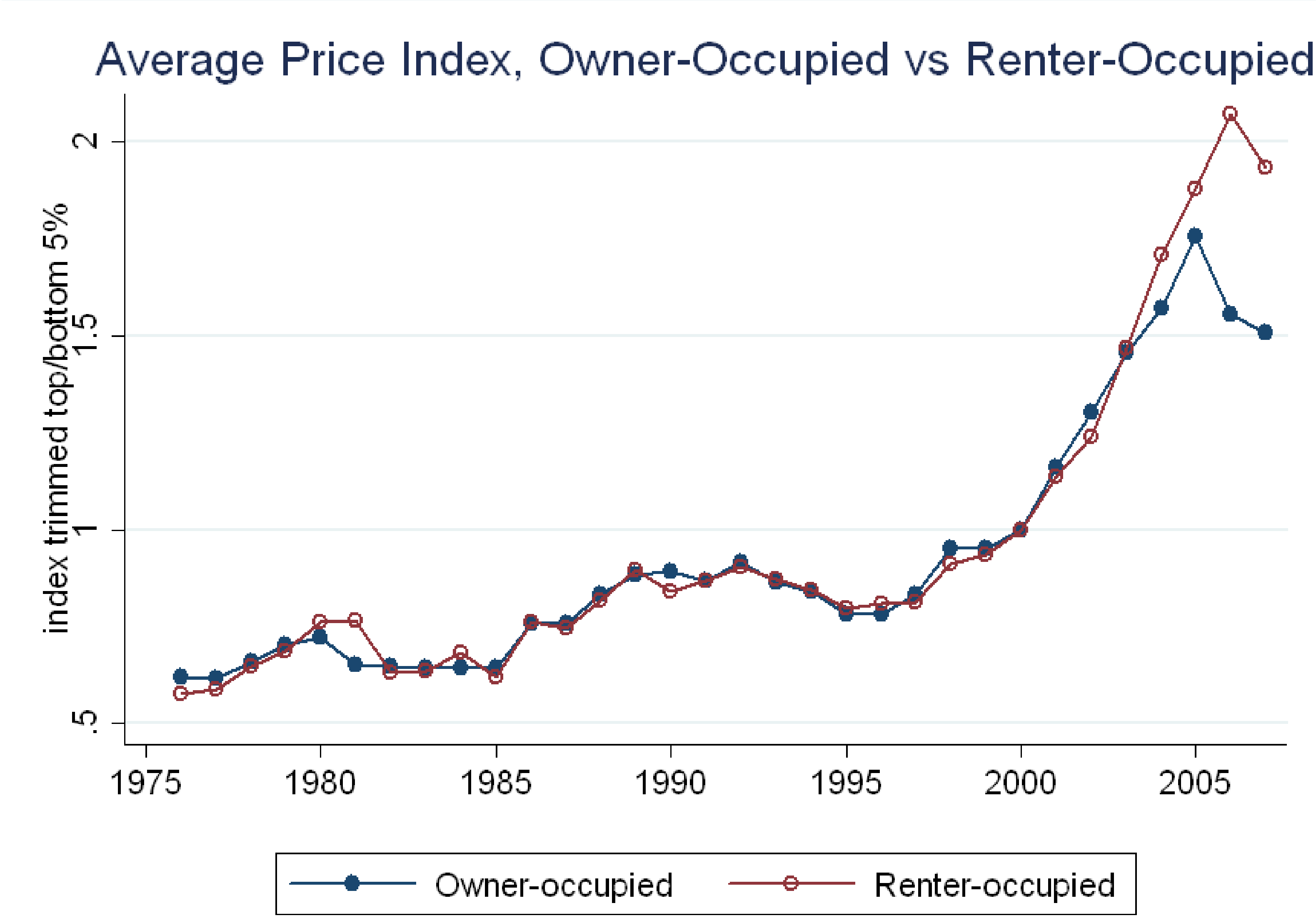

Average House Price Index 1976 - 2007
index trimmed top/bottom 5%
.5
1
1.5
2
1975
1980
1985
1990
1995
2000
2005

Figure 2.11:



Average Price Index, Owner-Occupied vs Renter-Occupied
index trimmed top/bottom 5%
2
1.5
1
.5
1975
1980
1985
1990
1995
2000
2005
Owner-occupied
Renter-occupied

Figure 2.12:

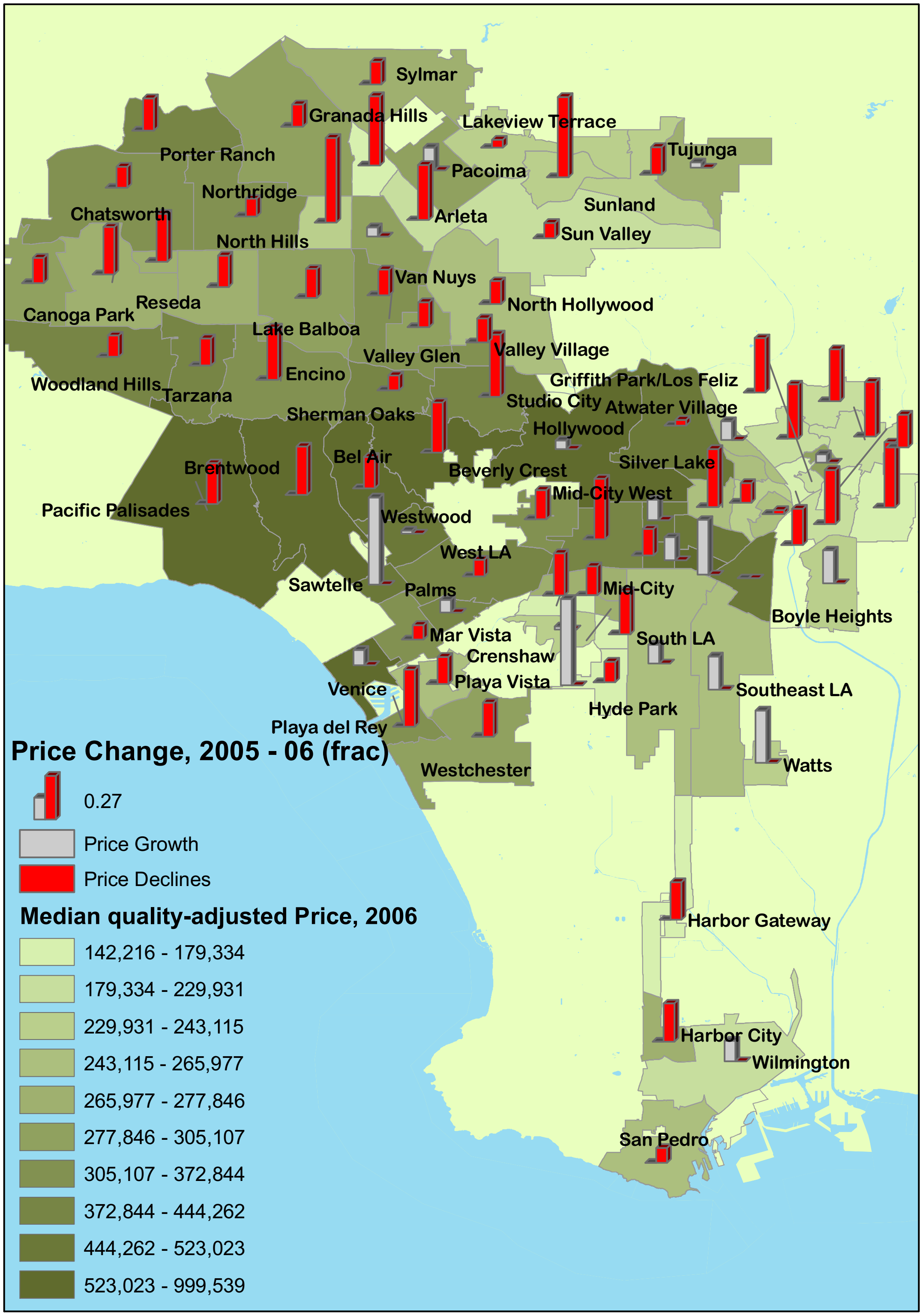

Sylmar
Granada Hills
Lakeview Terrace
Tujunga
Porter Ranch
Pacoima
Northridge
Sunland
Chatsworth
Arleta
Sun Valley
North Hills
Van Nuys
North Hollywood
Reseda
Canoga Park
Lake Balboa
Valley Village
Valley Glen
Encino
Griffith Park/Los Feliz
Woodland Hills
Tarzana
Studio City
Atwater Village
Sherman Oaks
Hollywood
Silver Lake
Bel Air
Brentwood
Beverly Crest
Mid-City West
Pacific Palisades
Westwood
West LA
Sawtelle
Palms
Mid-City
Boyle Heights
Mar Vista
South LA
Crenshaw
Playa Vista
Venice
Southeast LA
Hyde Park
Playa del Rey
Westchester
Watts
Harbor Gateway
Harbor City
Wilmington
San Pedro
Price Change, 2005 - 06 (frac)
0.27
Price Growth
Price Declines
Median quality-adjusted Price, 2006
142,216 - 179,334
179,334 - 229,931
229,931 - 243,115
243,115 - 265,977
265,977 - 277,846
277,846 - 305,107
305,107 - 372,844
372,844 - 444,262
444,262 - 523,023
523,023 - 999,539

Figure 2.13:

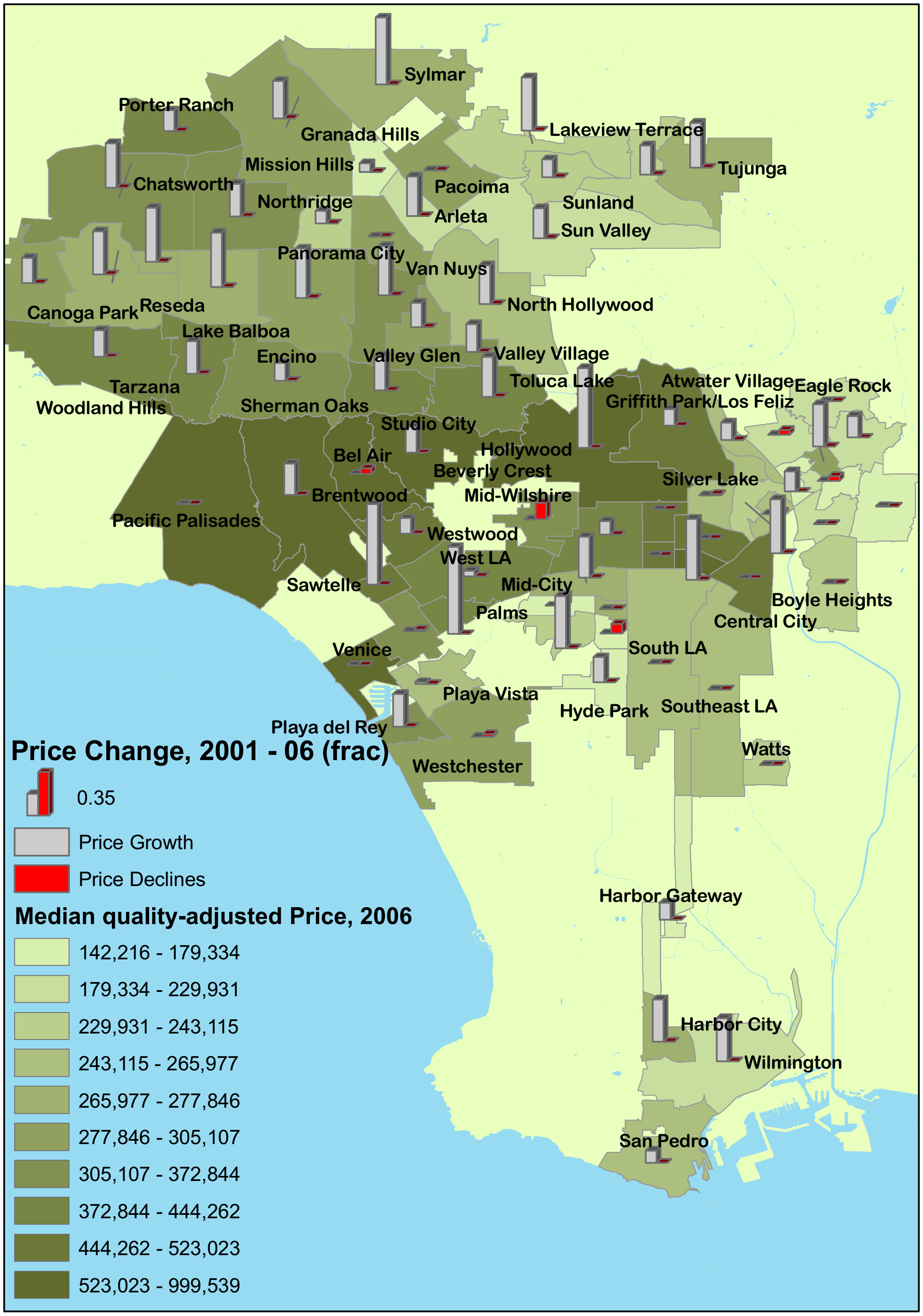
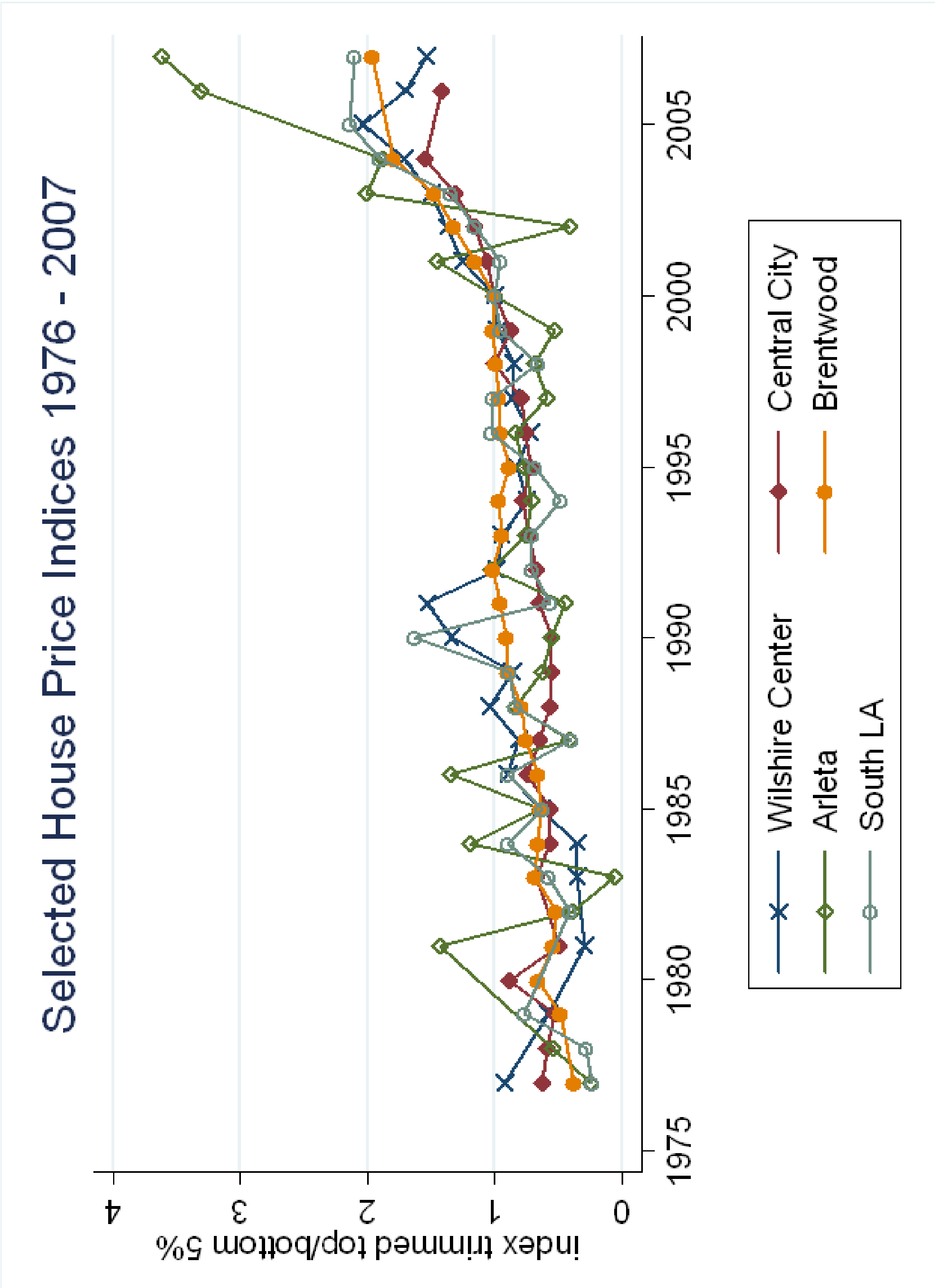
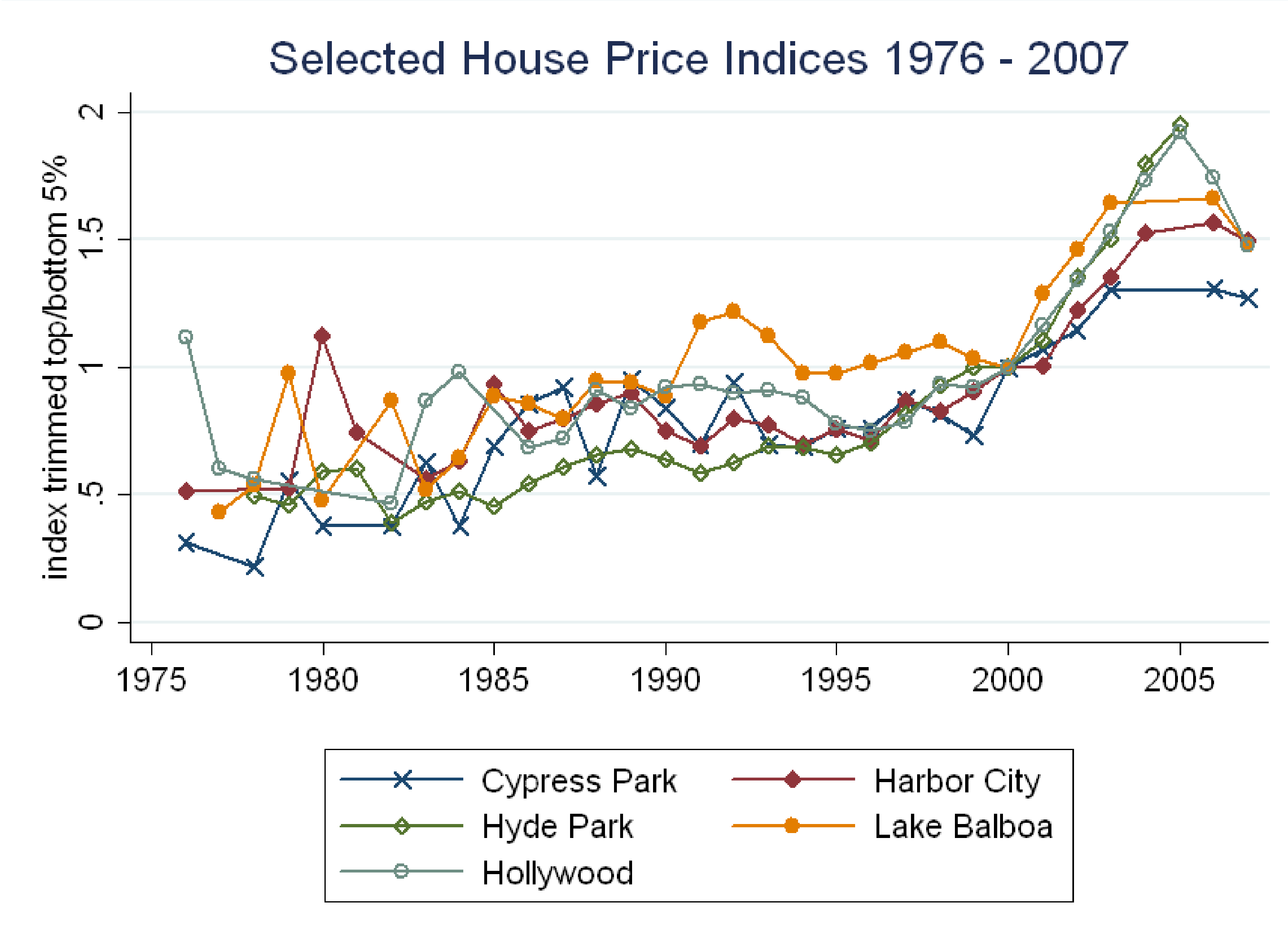

Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Tujunga
Mission Hills
Chatsworth
Pacoima
Northridge
Sunland
Arleta
Sun Valley
Panorama City
Van Nuys
North Hollywood
Canoga Park
Reseda
Lake Balboa
Encino
Valley Glen
Valley Village
Toluca Lake
Atwater Village
Eagle Rock
Griffith Park/Los Feliz
Tarzana
Woodland Hills
Sherman Oaks
Studio City
Hollywood
Bel Air
Beverly Crest
Silver Lake
Brentwood
Mid-Wilshire
Pacific Palisades
Westwood
West LA
Sawtelle
Mid-City
Boyle Heights
Central City
Palms
Venice
South LA
Playa Vista
Hyde Park
Southeast LA
Playa del Rey
Watts
Westchester
Harbor Gateway
Harbor City
Wilmington
San Pedro
Price Change, 2001 - 06 (frac)
0.35
Price Growth
Price Declines
Median quality-adjusted Price, 2006
142,216 - 179,334
179,334 - 229,931
229,931 - 243,115
243,115 - 265,977
265,977 - 277,846
277,846 - 305,107
305,107 - 372,844
372,844 - 444,262
444,262 - 523,023
523,023 - 999,539

Figure 2.14:



Selected House Price Indices 1976 - 2007
index trimmed top/bottom 5%
0
1
2
3
4
1975
1980
1985
1990
1995
2000
2005
Wilshire Center
Central City
Arleta
Brentwood
South LA

Figure 2.15:



Selected House Price Indices 1976 - 2007
index trimmed top/bottom 5%
0
.5
1
1.5
2
1975
1980
1985
1990
1995
2000
2005
Cypress Park
Harbor City
Hyde Park
Lake Balboa
Hollywood

Figure 2.16:

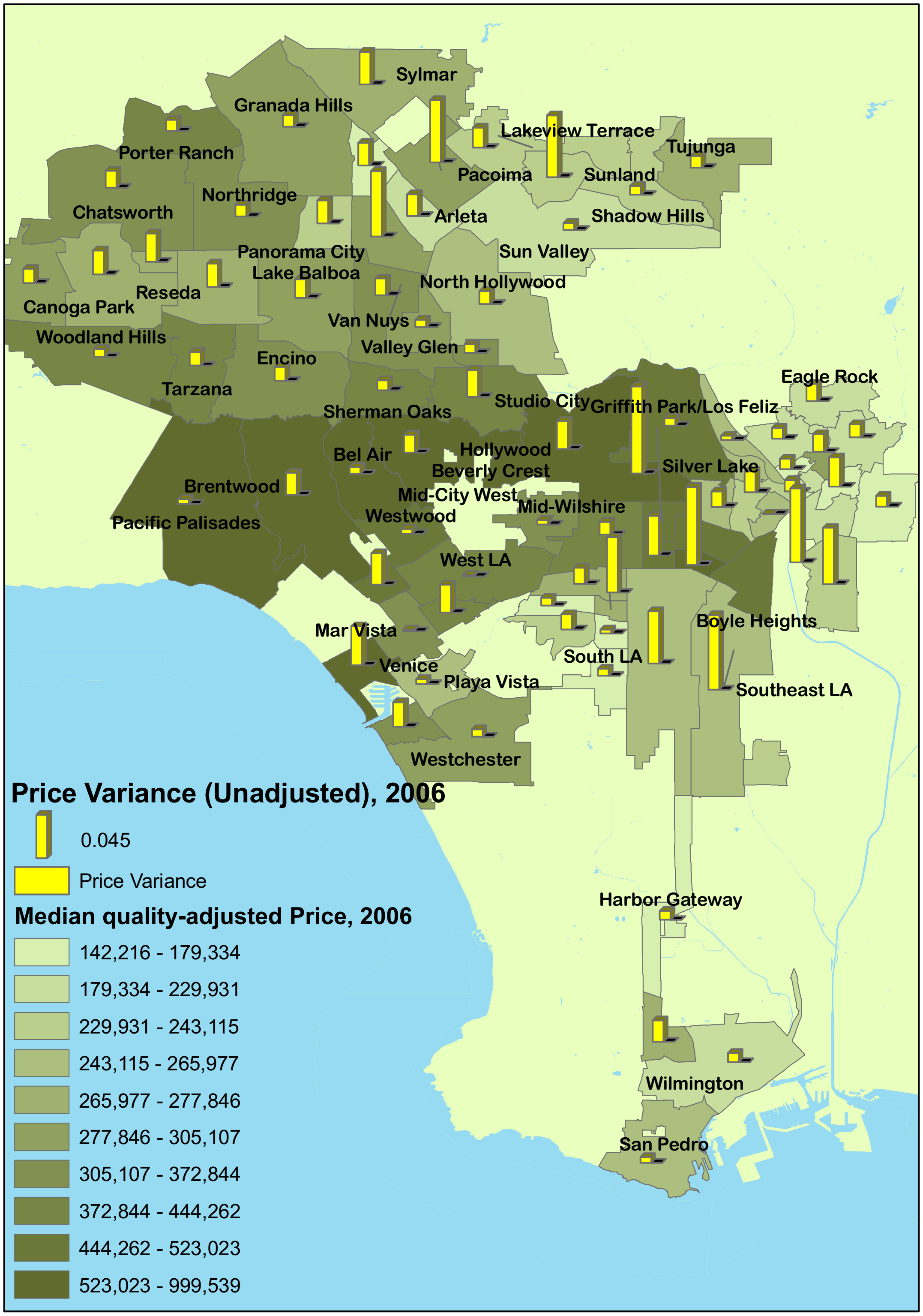

Sylmar
Granada Hills
Lakeview Terrace
Tujunga
Porter Ranch
Pacoima
Sunland
Northridge
Chatsworth
Arleta
Shadow Hills
Panorama City
Sun Valley
Lake Balboa
Reseda
North Hollywood
Canoga Park
Van Nuys
Woodland Hills
Valley Glen
Encino
Eagle Rock
Tarzana
Studio City
Griffith Park/Los Feliz
Sherman Oaks
Hollywood
Bel Air
Beverly Crest
Silver Lake
Brentwood
Mid-City West
Mid-Wilshire
Westwood
Pacific Palisades
West LA
Boyle Heights
Mar Vista
South LA
Venice
Playa Vista
Southeast LA
Westchester
Price Variance (Unadjusted), 2006
0.045
Price Variance
Median quality-adjusted Price, 2006
142,216 - 179,334
179,334 - 229,931
229,931 - 243,115
243,115 - 265,977
265,977 - 277,846
277,846 - 305,107
305,107 - 372,844
372,844 - 444,262
444,262 - 523,023
523,023 - 999,539
Harbor Gateway
Wilmington
San Pedro

Figure 2.17:

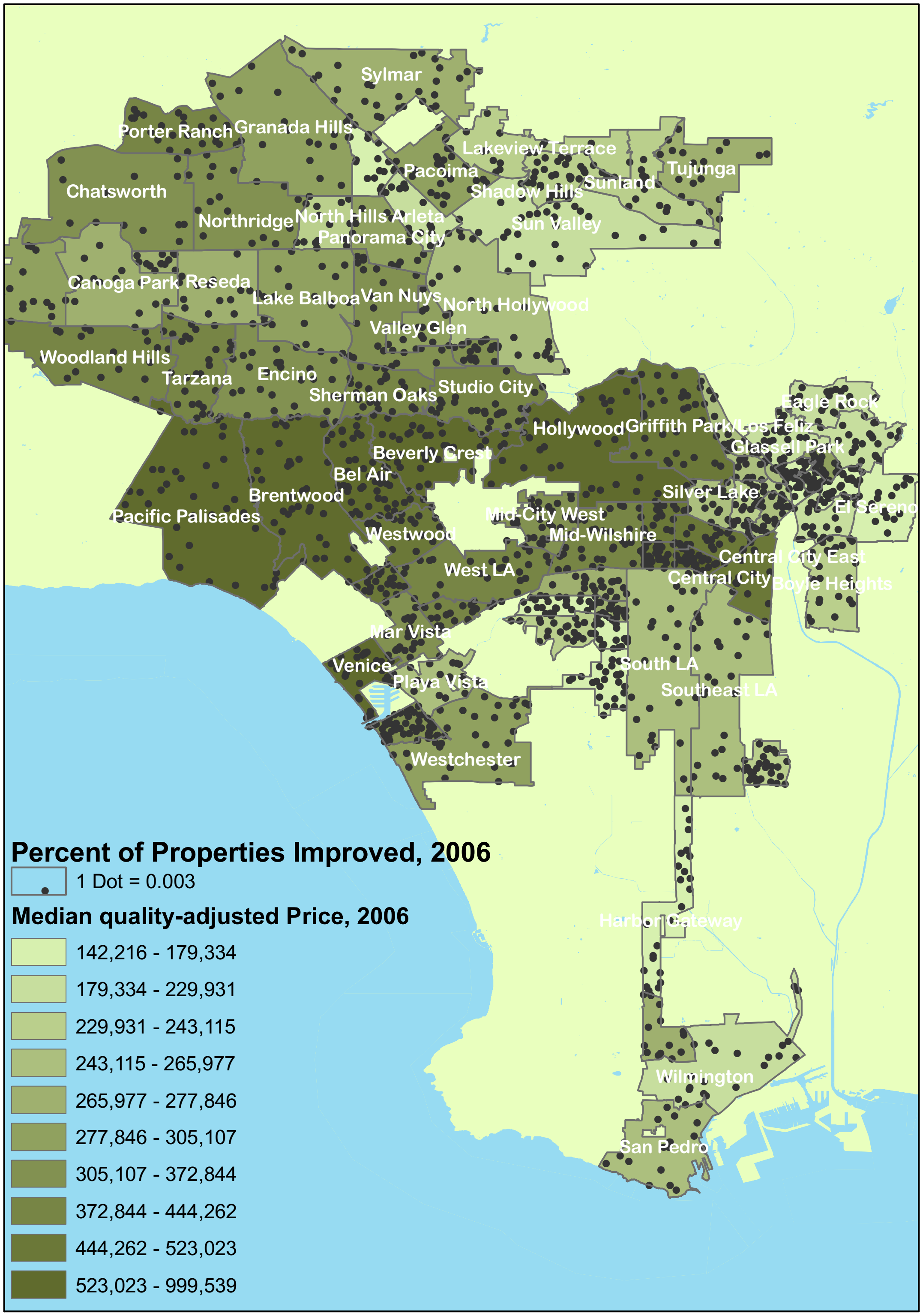

Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Tujunga
Pacoima
Sunland
Shadow Hills
Chatsworth
Northridge
North Hills
Arleta
Sun Valley
Panorama City
Canoga Park
Reseda
Lake Balboa
Van Nuys
North Hollywood
Valley Glen
Woodland Hills
Tarzana
Encino
Sherman Oaks
Studio City
Eagle Rock
Hollywood
Griffith Park
Los Feliz
Glassell Park
Beverly Crest
Bel Air
Brentwood
Silver Lake
Pacific Palisades
Mid-City West
El Sereno
Westwood
Mid-Wilshire
Central City East
West LA
Central City
Boyle Heights
Mar Vista
Venice
Playa Vista
South LA
Southeast LA
Westchester
Harbor Gateway
Wilmington
San Pedro
Percent of Properties Improved, 2006
1 Dot = 0.003
Median quality-adjusted Price, 2006
142,216 - 179,334
179,334 - 229,931
229,931 - 243,115
243,115 - 265,977
265,977 - 277,846
277,846 - 305,107
305,107 - 372,844
372,844 - 444,262
444,262 - 523,023
523,023 - 999,539

Figure 2.18:

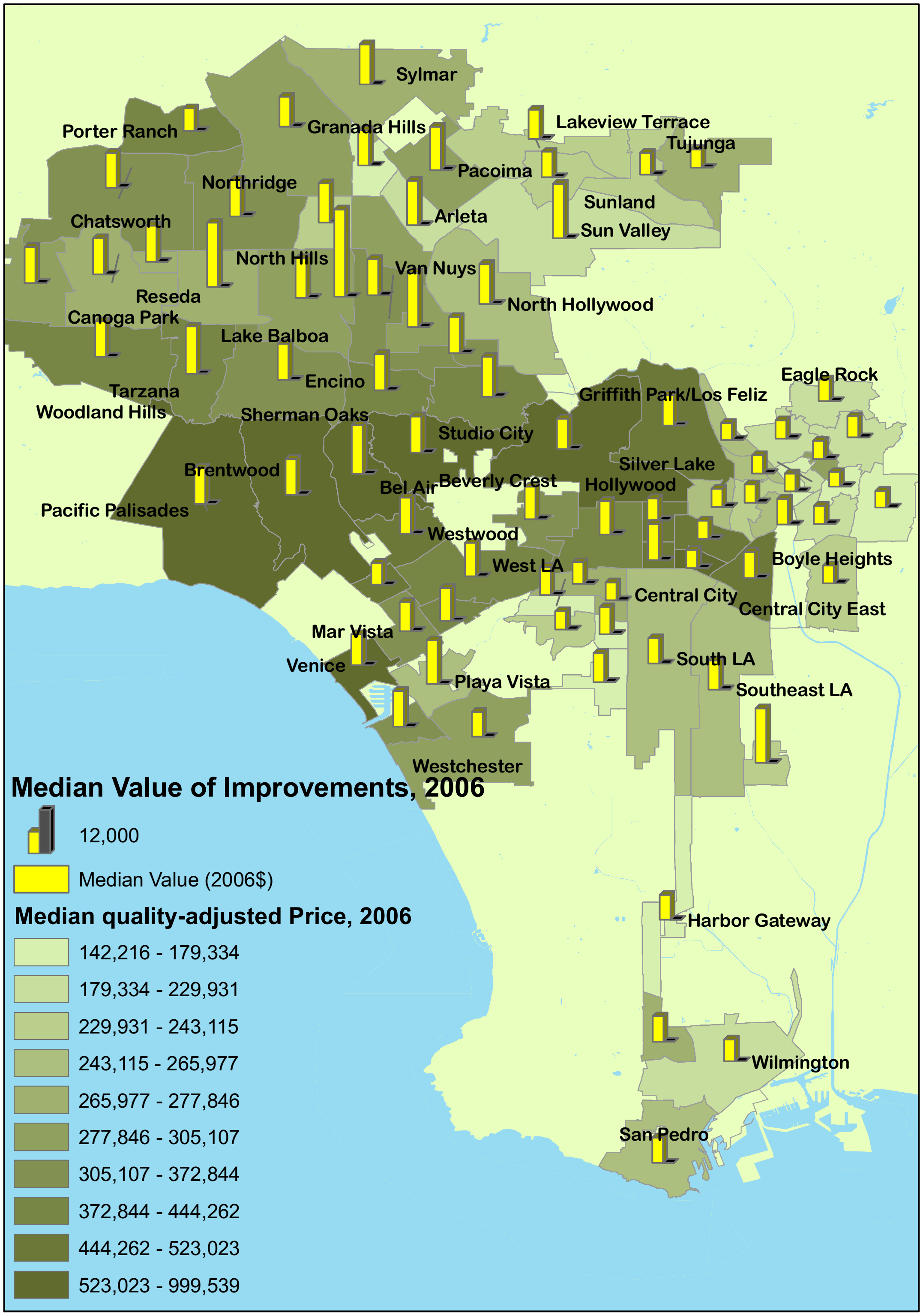

Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Tujunga
Pacoima
Northridge
Arleta
Sunland
Chatsworth
Sun Valley
North Hills
Van Nuys
Reseda
North Hollywood
Canoga Park
Lake Balboa
Encino
Eagle Rock
Tarzana
Griffith Park/Los Feliz
Woodland Hills
Sherman Oaks
Studio City
Silver Lake
Brentwood
Bel Air
Beverly Crest
Hollywood
Pacific Palisades
Westwood
West LA
Boyle Heights
Central City
Central City East
Mar Vista
Venice
South LA
Playa Vista
Southeast LA
Westchester
Median Value of Improvements, 2006
12,000
Median Value (2006$)
Median quality-adjusted Price, 2006
142,216 - 179,334
179,334 - 229,931
229,931 - 243,115
243,115 - 265,977
265,977 - 277,846
277,846 - 305,107
305,107 - 372,844
372,844 - 444,262
444,262 - 523,023
523,023 - 999,539
Harbor Gateway
Wilmington
San Pedro

Figure 2.19:

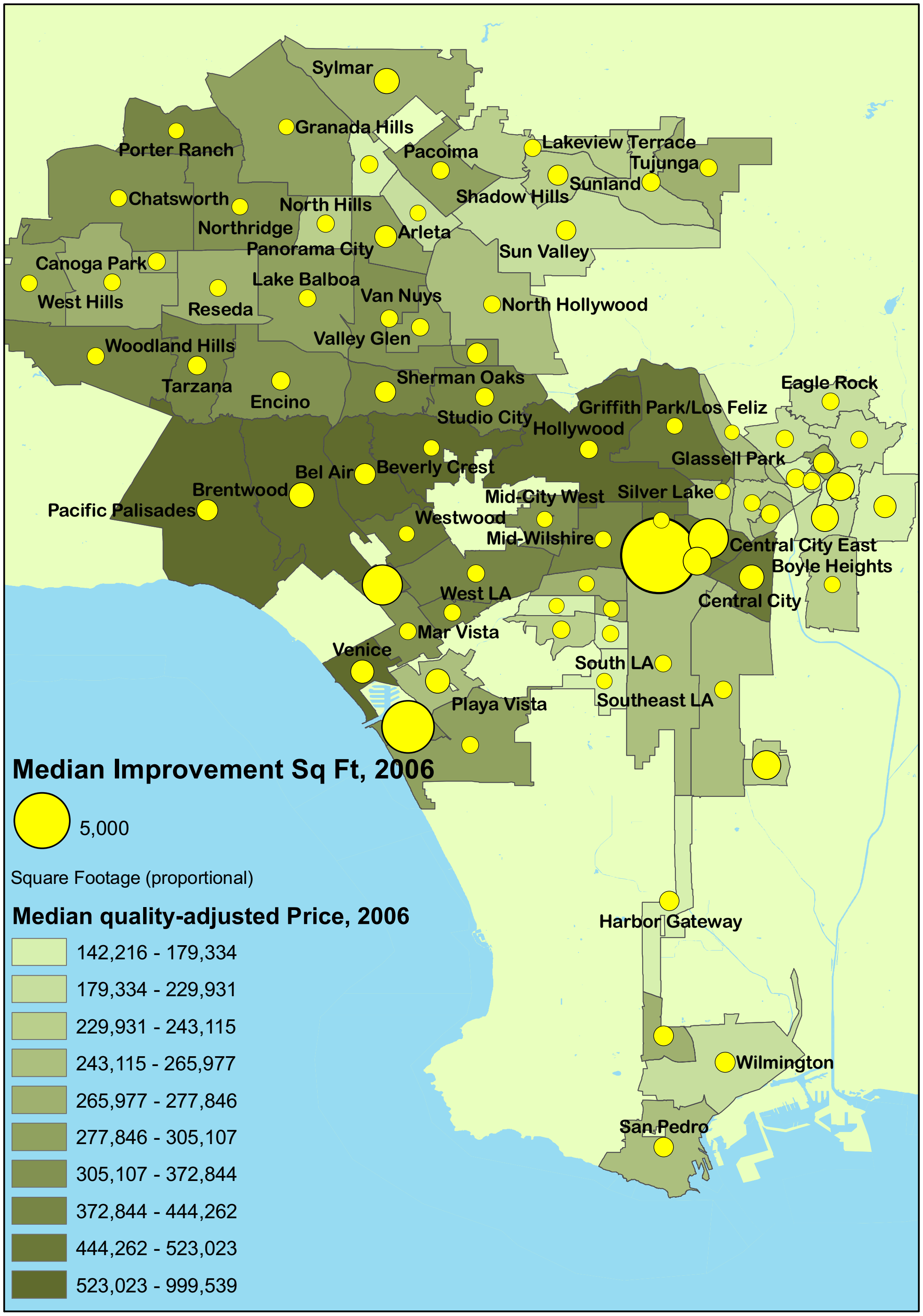

Sylmar
Granada Hills
Porter Ranch
Pacoima
Lakeview Terrace
Tujunga
Sunland
Shadow Hills
Chatsworth
North Hills
Northridge
Arleta
Panorama City
Sun Valley
Canoga Park
Lake Balboa
West Hills
Reseda
Van Nuys
North Hollywood
Valley Glen
Woodland Hills
Tarzana
Sherman Oaks
Encino
Eagle Rock
Studio City
Griffith Park/Los Feliz
Hollywood
Glassell Park
Bel Air
Beverly Crest
Brentwood
Mid-City West
Silver Lake
Pacific Palisades
Westwood
Mid-Wilshire
Central City East
Boyle Heights
West LA
Central City
Mar Vista
Venice
South LA
Southeast LA
Playa Vista
Median Improvement Sq Ft, 2006
5,000
Square Footage (proportional)
Median quality-adjusted Price, 2006
142,216 - 179,334
179,334 - 229,931
229,931 - 243,115
243,115 - 265,977
265,977 - 277,846
277,846 - 305,107
305,107 - 372,844
372,844 - 444,262
444,262 - 523,023
523,023 - 999,539
Harbor Gateway
Wilmington
San Pedro

Figure 2.20:

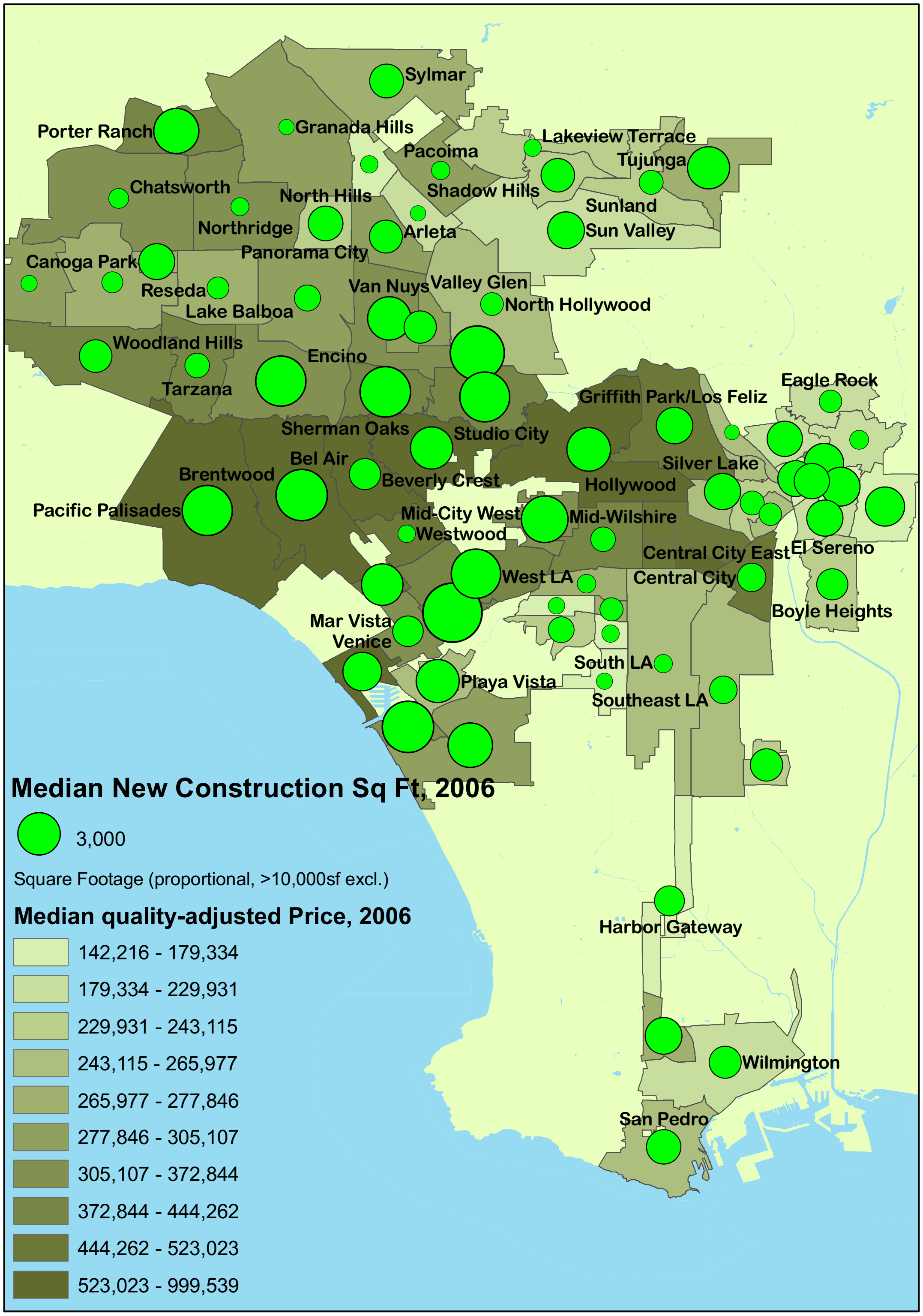

Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Pacoima
Tujunga
Chatsworth
North Hills
Shadow Hills
Sunland
Northridge
Arleta
Sun Valley
Panorama City
Canoga Park
Reseda
Van Nuys
Valley Glen
North Hollywood
Lake Balboa
Woodland Hills
Encino
Tarzana
Eagle Rock
Griffith Park/Los Feliz
Sherman Oaks
Studio City
Bel Air
Silver Lake
Brentwood
Beverly Crest
Hollywood
Pacific Palisades
Mid-City West
Mid-Wilshire
Westwood
Central City East
El Sereno
West LA
Central City
Boyle Heights
Mar Vista
Venice
South LA
Playa Vista
Southeast LA
Median New Construction Sq Ft, 2006
3,000
Square Footage (proportional, >10,000sf excl.)
Median quality-adjusted Price, 2006
142,216 - 179,334
179,334 - 229,931
229,931 - 243,115
243,115 - 265,977
265,977 - 277,846
277,846 - 305,107
305,107 - 372,844
372,844 - 444,262
444,262 - 523,023
523,023 - 999,539
Harbor Gateway
Wilmington
San Pedro

Figure 2.21:

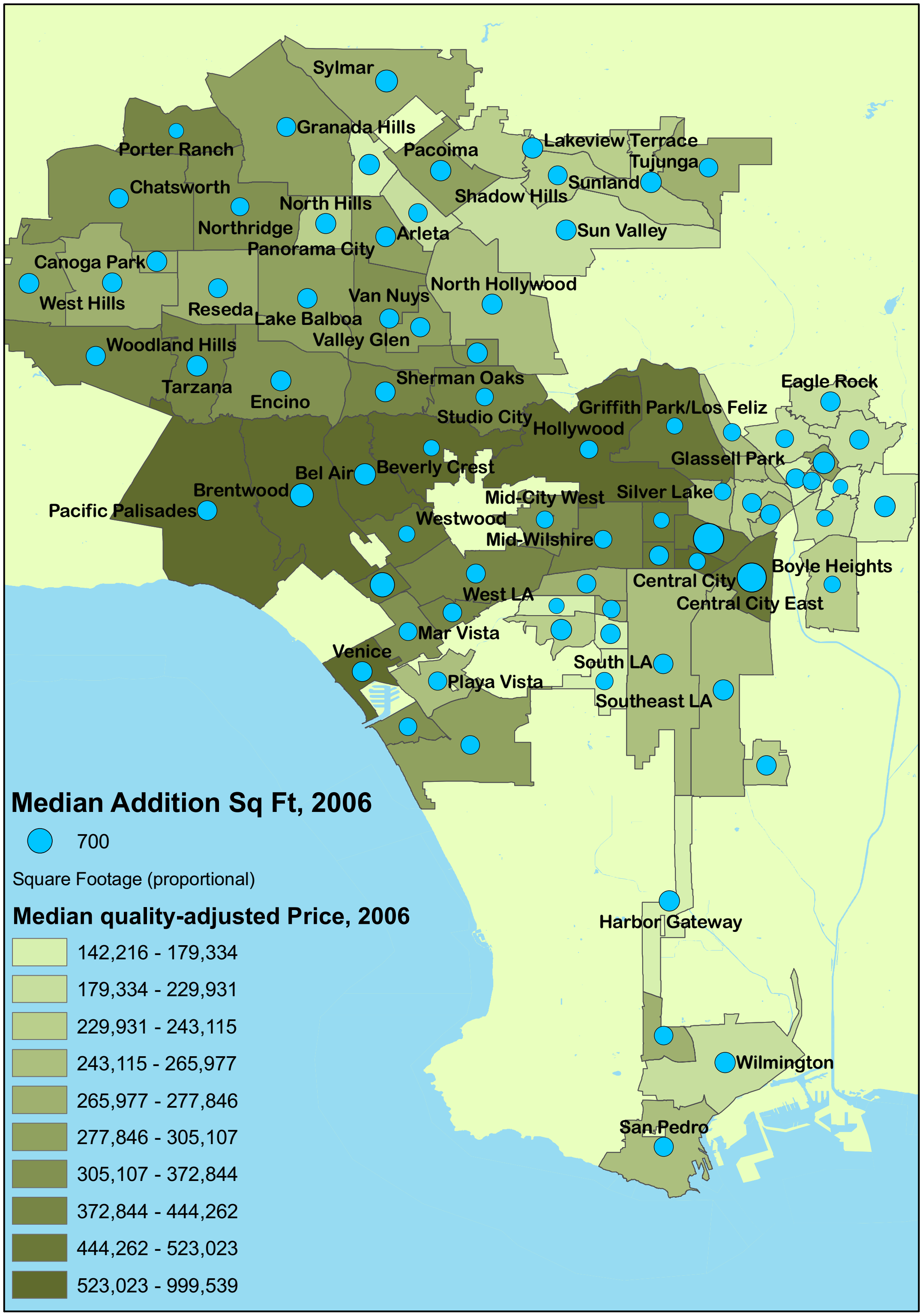
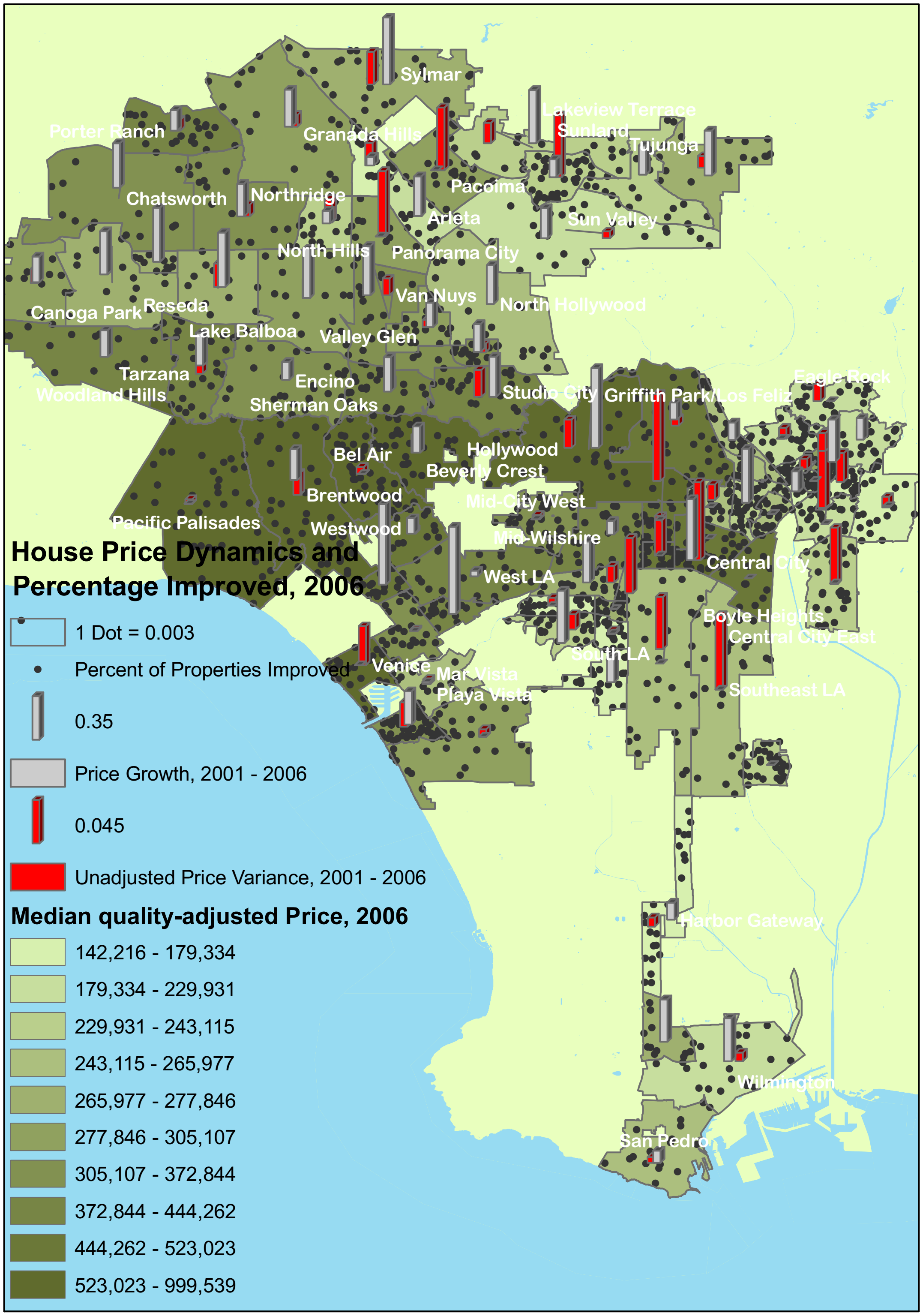

Sylmar
Granada Hills
Porter Ranch
Pacoima
Lakeview Terrace
Tujunga
Sunland
Shadow Hills
Chatsworth
North Hills
Northridge
Arleta
Sun Valley
Panorama City
Canoga Park
West Hills
Reseda
Van Nuys
North Hollywood
Lake Balboa
Valley Glen
Woodland Hills
Tarzana
Encino
Sherman Oaks
Eagle Rock
Studio City
Griffith Park/Los Feliz
Hollywood
Glassell Park
Bel Air
Beverly Crest
Brentwood
Pacific Palisades
Mid-City West
Silver Lake
Westwood
Mid-Wilshire
Boyle Heights
Central City
West LA
Central City East
Mar Vista
Venice
South LA
Playa Vista
Southeast LA
Median Addition Sq Ft, 2006
700
Square Footage (proportional)
Median quality-adjusted Price, 2006
142,216 - 179,334
179,334 - 229,931
229,931 - 243,115
243,115 - 265,977
265,977 - 277,846
277,846 - 305,107
305,107 - 372,844
372,844 - 444,262
444,262 - 523,023
523,023 - 999,539
Harbor Gateway
Wilmington
San Pedro

Figure 2.22:


House Price Dynamics and Percentage Improved, 2006
1 Dot = 0.003
Percent of Properties Improved
0.35
Price Growth, 2001 - 2006
0.045
Unadjusted Price Variance, 2001 - 2006
Median quality-adjusted Price, 2006
142,216 - 179,334
179,334 - 229,931
229,931 - 243,115
243,115 - 265,977
265,977 - 277,846
277,846 - 305,107
305,107 - 372,844
372,844 - 444,262
444,262 - 523,023
523,023 - 999,539
Sylmar
Porter Ranch
Granada Hills
Lakeview Terrace
Sunland
Tujunga
Chatsworth
Northridge
Pacoima
Arleta
Sun Valley
North Hills
Panorama City
Canoga Park
Reseda
Van Nuys
North Hollywood
Lake Balboa
Valley Glen
Tarzana
Encino
Woodland Hills
Sherman Oaks
Studio City
Griffith Park/Los Feliz
Eagle Rock
Bel Air
Hollywood
Beverly Crest
Brentwood
Mid-City West
Pacific Palisades
Westwood
Mid-Wilshire
West LA
Central City
Boyle Heights
Central City East
Venice
Mar Vista
Playa Vista
South LA
Southeast LA
Harbor Gateway
Wilmington
San Pedro

# Chapter 3

# Building "Boom" and Building "Bust" during the 2000s: New York City as a Case Study

## 3.1 Introduction

During the first decade of the 21st century, American economic expansion was driven in large part by two sectors of the economy: the residential real estate industry and the financial services industry. As the nation's financial hub and most populous residential center, New York City and the surrounding metropolitan area was a major center of this economic activity. For this reason, New York City (hereafter referred to as "the City") is an ideal location to analyze the causes and consequences of the most recent boom, and bust, in residential real estate development.

This chapter provides an overview of residential development activity in New York City during the years 2000 - 2008. In this analysis, I hope to address a number of questions relevant to the experience of all metropolitan housing markets during this decade using the City as a case study, to describe the effects of this real estate "boom" on the housing market in New York City during these years, and to characterize the long-term effects of the "boom" and subsequent "bust" in residential development on the composition of the City's housing stock.

What were the economic factors contributing to the "boom" and "bust" pattern of New York City's residential real estate development? Economic theories of investment predict that real estate markets will exhibit cyclicality in general due to a number of factors, including the effects of macroeconomic cyclicality on the demand for housing, the irreversibility of housing investment, the time lag between housing investment decisions and the completion of development, and the tendency of rents and prices to remain fixed due to the long-term nature of rental contracts and residential tenure.

How did patterns of residential development over time and geography during the 2000s in New York City compare to those in other cities during the decade, and to previous periods of housing market expansion in the City? As some of the factors contributing to the cyclicality of housing investment - in particular, macroeconomic conditions and irreversibility - are shared across housing markets, we should expect to see somewhat similar patterns of residential development across cities. However, New York City's housing market has several distinctive features, including a larger share of development in multi-unit rental buildings, scarce developable land, high construction costs, and a complicated regulatory environment, that dampen the supply response to changes in housing demand.

As such, building activity in the City is less volatile than in other cities with fewer supply constraints, such as Las Vegas and Miami. Comparing the most recent real estate cycle in New York City and surrounding areas to the City's previous building boom of the mid-1980s, the growth and decline of residential construction over time appears to be driven by changes in the federal tax schedule disfavoring the construction of multi-unit rental buildings in the earlier period, and by changes in the macroeconomic environment in the later period.

What was the effect of the building boom on New York City's housing market, and on the City's stock of residential housing? I provide a general overview of the timing and nature of residential development in the City during the years 2000 - 2008 using data on certificates of occupancy issued by the New York City Department of Buildings, and information on these buildings from the New York City Department of Finance's Real Property Assessment Database. I analyze the effect of this development on the housing market by combining this information on new buildings with information on residential sales, using a proprietary dataset compiled by the Furman Center for Real Estate and Urban Policy at New York University.

I explore the relationship between development and the local environment by identifying a set of housing market conditions, socioeconomic characteristics, and geographic features that are predicted to affect the incidence of housing investment in previous theoretical and empirical work. As development activity increased, regulatory constraints and government subsidies seem to have become less important to the decision to invest, relative to market conditions. Finally, I comment briefly on the potential future consequences of cycle-driven building in the City during the boom, by documenting the prevalence of unfinished projects and newly completed unsold buildings.

## 3.2 Economic factors contributing to cyclicality in real estate development

The most simple explanation for cyclicality - periods of high building activity followed by periods of little activity - in residential real estate markets is that the demand for residential housing is closely tied to household incomes and economic growth in general, which is also cyclical. However, construction activity and residential real estate values are far more volatile than household income and other categories of household consumption. Another simple explanation is that developers do not anticipate future declines in real estate prices when making investment decisions. A model of real estate cycles outlined by Wheaton (1999) incorporating investor myopia finds that myopic behavior leads to boom and bust patterns of development. However, relying on economically suboptimal behavior by investors is a somewhat unsatisfying approach to the issue.

In his analysis of the determinants of real estate cycles, Grenadier (1995) discusses two additional commonly identified sources of cyclicality of in real estate markets. The first is the long lag between the decision to invest in real estate and the completion of the project. Grenadier's study employs a model of real options in housing investment to explain that even if developers can accurately predict the length of this lag, and have accurate predictions of expected future housing values, the fixed costs and irreversibility of capital investment, along with uncertainty in future housing prices and the long-term nature of rental contracts, imply that building will be delayed even as market conditions improve, and that new units will continue to enter the market even as market conditions deteriorate.

The second source of cyclicality in housing markets which Grenadier identifies (but subsequently discounts) is the prevalence of nonrecourse lending in real estate development. While differences in mortgage structure cannot explain why certain markets, particularly those in coastal cities such as New York, tend to follow a boom and bust pattern more than others, robust credit markets are a significant contributor to building activity.

Credit availability is closely related to household income and economic growth, at the national and local levels. However, a recent paper by Mian and Sufi (2008) finds that zip codes that experienced large increases in mortgage lending between 2001 and 2005 also had high levels of house price growth during this period, even as income and employment declined in some of these zip codes relative to others with more moderate house price growth. A related paper by Arsenault and Peng (2009), using quarterly data on commercial real estate values and the supply of mortgage credit, documents a positive feedback loop between previous price growth and the current supply of mortgage credit, and between current mortgage fund flows and real estate values.

## 3.3 Comparing the current real estate cycle in New York City to other cities and cycles

What was the pattern of growth and decline in residential housing construction in New York City during this decade, and how does this pattern compare to activity in other cities and to previous real estate cycles in New York? Following the theories outlined above, there are a number of reasons why patterns of development might differ between New York and other cities. A far larger share of residential development in New York City than in other cities is in multi-unit buildings, which require a larger capital investment, take longer to complete, and are less frequently traded than single-family homes. The problem of long-term rental contracts is a larger issue for investors in rental property than for owner-occupiers, and New York's rent control ordinances are likely to exacerbate this problem. These factors imply that residential real estate investment might be more cyclical in New York than in other cities.

However, geographic and regulatory constraints on development, as well as high construction costs, lead to a lower elasticity of housing supply in New York than in a city with more open space and fewer regulations on what can be built and where building can take place. Also, developers of large projects may be more likely to correctly forecast the future trajectory (both upwards and downwards) of real estate values than builders of single-family homes. These factors may mitigate the impact of New York City's housing composition on the cyclicality of housing investment.

Figure 3.1 graphs the annual percentage change in the housing stock between 2001 and 2008 for the New York City metropolitan area and for 9 other metropolitan areas (which together comprise the 10 city sample for the Case-Shiller national metropolitan house price index). All of these cities experienced growth during this period. As predicted by theory, cities with more residential stock in apartment buildings, less vacant land available for development, and higher construction costs, such as San Francisco, Boston, and New York, had the smallest year-to-year percent increases in the housing stock. In contrast, metropolitan areas such as the Washington DC metro area (which includes rural counties in Maryland and Virginia), Miami, and Las Vegas (whose percentages were beyond the scale of the graph) not only had higher percentage growth during the boom, but experienced a larger decline in annual growth relative to more supply-constrained cities towards the end of the decade.

Economic theories of real estate cycles also predict differences in building trends over time between the most recent building boom in New York City and the last boom, which occurred between 1982 and 1987. In both episodes, the rapid growth and collapse of incomes in the financial and legal services industries fueled demand for residential housing in the City, and changes in the structure of mortgage markets allowed developers and buyers greater access to credit. However, in contrast with the previous cycle, the mayoral administration in the City actively encouraged private residential development during this decade, through a series of residential rezonings and numerous public-private partnerships. Thus, we might expect to see higher levels of building during the 2000s than during the 1980s.

Figure 3.2 graphs two series: the number of residential building permits issued in New York State between 1980 and 2008, and the number of certificates of occupancy issued in New York City between 1990 and 2008. As annual summary statistics on certificates of occupancy or building permits in the City are currently not available before 1990, we use state-level aggregate data as an alternate measure. The increase in building activity between 1982 and 1987 in New York State was far more rapid and dramatic than the increase between 1995 and 2005, and the trend in City certificates of occupancy closely follows that of statewide building permits (with a one-year lag).

One reason for this unexpected result may be changes to an alternate regulatory incentive to construction: the federal tax code. The Tax Reform Act of 1986, which substantially reduced the tax benefits associated with multifamily rental housing, has been linked to declines in renter-occupied residential construction during the 1980s in previous work (for an overview, see Follain, Leavens, and Velz, 1993). As rental housing represents a large share of residential housing in New York City, construction may have precipitously declined after 1987 in response to this increase in the cost of development.

## 3.4 Building activity in New York City, 2000 - 2008

Table 3.1 reports the number of residential units completed in the City between 2000 and 2008, by year of completion and borough of location. Information on completed buildings is compiled using data on certificates of occupancy issued by the City Department of Buildings. After a building undergoes a final inspection by the Department to ensure that the construction complies with building codes and standards of habitability, a certificate is issued.

Building activity in the City grew slowly in the first half of this time period, and more quickly after 2003, peaking in 2006 at a level of 25,208 units completed and falling to 22,713 units completed in 2008. Manhattan added the most units during these years, followed by Brooklyn and Queens. Staten Island and Manhattan experienced more growth towards the middle of the time period, while building activity in Brooklyn and the Bronx peaked in 2007 and 2008, respectively.

By linking each building's certificate of occupancy to its property tax record from the Real Property Assessment Database, we can obtain more information on the building, including its assessed value, building and lot square footage, and building type. Table 3.2 uses this information to estimate the number of residential units completed in each year by building type - single-family, 2-4 family, 5-plus units, condominium, or cooperative ownership - and Table 3.3 reports estimates of the number of units completed in each borough between 2000 and 2008 by building type.

Although the popular media tends to focus on condominium construction (along with the substantial advertising that accompanies this type of development), the majority of new residential units completed in the City between 2000 and 2008 were in 5-plus unit rental-occupancy buildings. About 47 percent of new units were in this type of building, 31 percent were in 2-4 family buildings, 8 percent were single-family homes, 14 percent were condominiums, and a very small percentage of new units were in co-op or mixed use buildings.[1]

Completions of 5-plus unit buildings grew steadily during this time period, while development of other building types, and of condominiums in particular, declined substantially in 2008. In Manhattan, Brooklyn, and the Bronx, most units built between 2000 and 2008 were located in 5-plus unit rental occupancy buildings, while 2-4 family buildings were the most common type of development in Queens and single-family homes were most common in Staten Island.

What were the effects of this new development on the total stock of residential housing, and the composition of the residential housing market, in New York City? By using data on certificates of occupancy to measure building activity, we can ensure an accurate tally of new residential units that are added to the housing stock in each year, as opposed to using data on building permits, which might include projects that are never started, or are started and stalled, possibly multiple times. Unfortunately, neither measure indicates whether a new building represents a new contribution to the housing stock, or a replacement structure that might even have fewer units than the previously existing building.

In lieu of a precise count of annual changes in the total number of residential units between years, Table 3.4 reports the number of residential units completed between 2000 and 2008 in each year as a percentage of the existing number of units. The total number of units in each borough, in each year, is measured using property tax records from the Real Property Assessment Database. Although Staten Island gained the fewest new units in absolute terms, the borough added the largest percentage (almost 12 percent) to the housing stock during this time period. Manhattan gained the second most units in percentage terms (slightly over 6 percent), with the remaining boroughs adding between 4 and 5 percent.

Table 3.5 reports a measure of the effect of new development on the stock of residential housing for sale: the share of residential sales that were sales of newly completed buildings and condominium units, in each year and borough, between 2000 and 2008. Due to the relatively large amount of new construction in Staten Island, a substantial percentage of residential sales during this time period were sales of new buildings and units, reaching a high of 18 percent in 2007. New buildings and units also represented a significant share of housing market activity in the Bronx and Queens, and a smaller share in Brooklyn and Manhattan. The share of residential sales that were sales of new buildings and units grew through the end of this time period in all boroughs except Manhattan.

[1] Even under an alternate method of linking certificates of occupancy to property tax records, the percentage of new residential units completed during this time period that were condominiums was estimated at 24 percent, compared to 34 percent for 5-plus unit rental buildings. Details on the two methods for linking property records, as well as information on new building type using the alternate methodology, are in the final tables in this chapter.

## 3.5 Correlates of building activity in New York City neighborhoods

Traditional models of housing development in the urban economics literature exploit differences in location-based amenities across properties, and changes in demand for these amenities, to predict patterns of housing investment. The foundational model in this literature is the monocentric city model of urban development, developed by Alonso (1964), Mills (1967), and Muth (1969), and outlined in a summary article by Brueckner (1987). In this model, costs of commuting from the urban fringe to the city center must be offset by lower prices per square foot of housing and land rents, which results in larger houses being constructed at the urban fringe. An extension to this model by Braid (2001), and Brueckner and Rosenthal (2005), exploits patterns of urban growth over time from the city center outwards to predict where urban redevelopment will occur, based on the age of the housing stock, the population and income growth rates, and the growth rate of commuting costs.

Preferences over other neighborhood-level characteristics, such as the socioeconomic composition of the population, can also have striking effects on patterns of residential investment. Schelling (1971), and Card, Mas, and Rothstein (2008), propose and empirically demonstrate that social interactions in racial preferences can generate "tipping point" levels of racial diversity above which new housing construction declines significantly.

An example of a study in this category focused primarily on estimating a model of housing supply is Mayer and Somerville's (2000) empirical analysis of new housing investment, which is based explicitly on the monocentric city model. In their model, an increase in demand to live in a given city leads to an influx of new residents and an increase in the city size. As a result, the land prices of all properties in the city (except for those at the urban fringe) increase, because commuting costs for properties at the urban fringe have increased and spatial equilibrium requires that price differences across properties reflect differences in commuting costs.

Mayer and Somerville use this model to propose that housing investment should depend on changes in prices and not on differences in price levels per se, because differences in price levels can exist in a spatial equilibrium where the amount of new construction is zero. Using aggregate data on housing starts, house prices, and construction costs, the authors estimate a positive relationship between quarterly house price growth and new construction, and also find that lagged values of house price growth (up to 2 previous quarters) are positively related to housing investment. While their incorporation of the spatial aspects of housing markets into a model of housing supply is innovative, it seems not to be incorporated in the empirical analysis as their estimation is based on national-level data.

There are a number of studies exploring the determinants of neighborhood redevelopment that focus on differences in neighborhood-level attributes within an urban area to predict where neighborhood change will occur. While many studies of this type, such as Brueckner and Rosenthal (2005), and Kolko (2007), are primarily concerned with gentrification as defined by changes in the socioeconomic composition of a previously low-income neighborhood, other studies focus on housing investment as an outcome of gentrification. One of the most detailed studies in this latter group is Helms' (2003) analysis of home improvement decisions in Chicago. Helms' model of housing renovation is based on a utility-maximizing household determining their optimal amount of housing consumption. Households make improvements to their properties if their desired housing consumption is higher than the existing stock of housing.

Helms also incorporates a wide range of building attributes and neighborhood-level demographic, spatial, and economic characteristics in his analysis, and finds that older houses in neighborhoods with older housing stock and a moderate number of multi-unit buildings are most likely to be improved. Other important neighborhood characteristics include proximity to the central business district, accessibility of public transportation, and the presence of green space and shoreline, while the presence of public housing projects discourages investment.

Earlier papers taking a similar approach to Helms yield inconsistent results. Focusing on the effects of neighborhood-level characteristics on housing investment, Melchert and Naroff (1987) estimate the relationship between these outcomes at the Census block level and the probability that the Census block was identified as "gentrified" by the Boston Redevelopment Authority. In another city-specific analysis, Neil Mayer (1981) collected data from Berkeley landlords on subjective measures of neighborhood quality and linked these records to other neighborhood-level characteristics and building permit activity to estimate their effect on housing improvement.

Both studies include information on the age of the housing stock, distance to the central business district, the density and condition of the housing stock, and socioeconomic characteristics of the neighborhood. However, Mayer's study also included building-level characteristics such as age, size, and owner-occupied status, which he found to be the only statistically significant predictors of improvement activity. Melchert and Naroff, like Helms, found that proximity to downtown, green space, and age of the housing stock were positively related to the probability that a Census block gentrified over the next decade.

What were the correlates of development activity across neighborhoods in New York City during the most recent building boom? Table 3.6 reports the correlation between the number of units built in a City community district (adjusted for the population of the district) and a set of housing market and socioeconomic characteristics of the district: the median value of a housing unit in 2000, and growth in housing prices between 1996 and 2004, rough measures of demand for housing in the neighborhood; the neighborhood's median household income in 2000; the percent of neighborhood residents who were nonwhite race in 2000; the rate of felonies per capita in 2000; and the percent of students in neighborhood schools performing at grade level on statewide math examinations in 2000.

The amount of development is positively correlated with housing values at the beginning of the decade, recent house price growth, median household income, and school performance, and negatively correlated with the percent of neighborhood residents who are nonwhite. Although these results cannot be interpreted causally, the correlations confirm our expectations of the relationships between demand for neighborhood amenities, neighborhood housing values, and development activity.

Figure 3.3 displays the geographic distribution of buildings built between 2000 and 2008 across the City. While development is concentrated in traditionally robust areas such as Midtown, Lower Manhattan, and adjoining neighborhoods in Brooklyn, the map highlights the large amount of new construction that also took place in the South Bronx, Central Harlem, and the Flatbush neighborhood of Brooklyn.

One feature apparent to New Yorkers from this map is that new development follows subway lines. As predicted by other empirical analyses of the determinants of local development, proximity to transit and green space was a relevant factor for much of the building that took place during the boom. Table 3.7 reports that over one-third of new development was located within a quarter-mile walk of a subway station in Brooklyn, with an even higher percentage located near transit in Manhattan. Three-quarters of new units in Queens and Staten Island, and almost all new units in Brooklyn and Manhattan, were located within a quarter mile of a park.

Perhaps the single most important factor contributing to the decision to build is the cost of development. Although New York City represents a single labor market and regulatory environment, building regulations vary widely across boroughs, community districts, zoning districts, and even building lots on the same block.

According to zoning regulations, each City lot has a restriction on how large of a building can be built on the land: the maximum floor area ratio (or FAR) of building square footage to lot square footage. One of the ongoing projects of the Furman Center at NYU documents rezoning activity in New York City between 2003 and 2007. The resulting dataset includes, for each lot, the floor area ratio of existing construction in 2003 and defines an underdeveloped, or "soft", site as a lot that is built to less than 50 percent of maximum permitted FAR. Soft sites may be more likely to experience building activity than sites that are not soft because it may be less costly to remove the existing construction, and increasing the size of the building on the lot is less likely to require changes in the zoning for that lot.

Tables 3.8, 3.9, and 3.10 explore the relationship between a lot's status as a soft site and subsequent building activity. Table 3.8 reports the percentage of sites that were soft in 2003 that subsequently experienced construction that increased the FAR by over ten percent. Table 3.9 reports the percent of sites that were soft in 2003 that were subsequently associated with a new certificate of occupancy, in each year and borough, between 2004 and 2008. The percent of soft sites that were subsequently issued new certificates of occupancy is smaller than the percent that experienced building permitting activity in general because not all construction activity results in a new certificate being issued. The largest share of soft sites, 4.2 percent, were (re)developed in Staten Island, followed by Queens and Brooklyn.

Table 3.10 reports the percent of units that were built on sites that were soft in 2003, by year and borough. In Brooklyn and the Bronx, nearly half of the units built between 2004 and 2008 were built on sites that were soft in 2003. In contrast, only one-fifth of units built in Manhattan during these years were built on sites that were previously soft, which suggests that rezoning may be a more important element of the development process in Manhattan than in the outer boroughs. In general, a majority of new units were built on sites that were not soft in 2003, which suggests that zoning restrictions may not have been a severe impediment to development in New York City during the most recent building boom.

New York City's Department of Housing Preservation and Development, in conjunction with state and federal governments, administers a wide array of programs designed to encourage the development of affordable housing. These programs affect the cost of development by providing subsidies, tax credits and abatements, and by facilitating lending to affordable housing projects. Table 3.11 reports the percent of new units in developments participating in a selection of these programs: new developments owned by the City, new developments participating in other subsidy programs, and new buildings receiving tax abatements under the 421-a or J51 programs.[2]

The share of units built between 2000 and 2008 that are City-owned or receiving other subsidies is highest in Brooklyn, the Bronx, and Manhattan, reflecting the central location and higher density

[2]Information on participation in the 421-b program, which provides tax abatements for single- and two-family homes, is not made publicly available by the Department of Finance.

of public housing developments. Similarly, the share of units receiving tax abatements under the 421a and J51 programs is high in Manhattan and in the Bronx, but is also high in Queens. The recorded share of properties receiving public subsidies is lowest in Staten Island, but this likely reflects the omission of the 421-b program from the data on tax abatements.

The share of properties across the City receiving public subsidies increased between 2001 and 2002, but declined steadily thereafter as private development accelerated and the scope of subsidy programs was restricted. One interesting element of this shift is the evolution of the 421-a program. The 421-a tax abatement program, which was created in a period of low demand for housing in New York City and originally provided long-term tax abatements for a large share of City developments, was severely curtailed in late 2006. The modifications, which took effect in June 2008, restricted the geographic scope of the program and set a limit on the amount of assessed value exempt from taxation.

As a result, participation in the tax abatement programs in Manhattan fell by over 75 percent between 2007 and 2008, from 18 percent of units to 4 percent. In contrast, participation in Brooklyn and Queens, which had been declining up to 2007, increased as developers moved to complete projects in areas that would no longer be included in the program before the new regulations took effect. An unintended consequence of the regulatory changes may have been an over-reaction by developers to take advantage of the expiring tax provisions, resulting in a flood of new units being completed in concentrated geographic areas just as demand for new residential housing softened.

## 3.6 Effects of the "building bust" in New York City

As in 1987, the popular press is currently awash in articles lamenting the end of New York City's building boom. Titles such as "The Billyburg Bust" and "Fighting Eyesores Before They Start" suggest that boom and bust patterns of residential development can have negative consequences not just for developers' solvency, but also for neighborhoods with concentrations of unfinished, abandoned, or unsold developments.

Table 3.12 reports counts of buildings and condo units that were issued a certificate of occupancy between 2000 and 2008, but were not recorded with a sale in the Real Property Assessment Database during that time. The largest numbers of unsold properties were located in Staten Island, which is even more striking considering that this borough added the fewest units during this time period. Queens and Brooklyn (the subject of the above-mentioned "Billyburg" article) each also had around 5,000 unsold properties. These properties will tend to have a negative effect on sales prices by increasing the supply of units on the market.

Unfinished developments might also have a negative impact on local housing values, by decreasing the quality of life in the surrounding area through their effect on streetscapes, vermin, and crime. This problem has become of such concern in the City that the Department of Buildings created a task force in February 2009 to address concerns. The task force developed a system where neighborhood residents could report unsafe conditions at stalled sites, and in conjunction with the City Council and mayor's office, passed legislation to enable developers who provide a safety plan and submit to ongoing inspection to obtain extensions of up to four years on their building permits (which normally expire after 12 months of inactivity).

Table 3.13 reports the number of stalled sites in each borough as of November 2009, and Table 3.14 highlights the 5 community districts with the largest numbers of stalled sites. The problem of stalled construction seems to be worst in Brooklyn, which has the most stalled sites, and Queens, where two of the five neighborhoods with the most stalled sites are located. However, the Financial District, Soho, and Washington Heights - areas in Manhattan which experienced rapid growth during the building boom - are also among the top 5. These sites - durable reminders of the decade's wild ride - can come to represent the potential for future growth if the City's management strategies are effective.

## 3.7 Conclusion

As building activity in New York City (and across the country) slows and the list of "stalled sites" continues to grow, some observers might wonder if developers failed to realize that prices were likely to fall. Cyclicality in real estate markets is a well-known phenomenon, and many of the developers currently active in the City were also active during the last building boom and bust. Although builders may have anticipated price declines in the near future, economic theories of cyclicality in real estate markets outlined in this chapter show that uncertainty over the exact timing of price declines, coupled with a long development lag, can lead to buildings being completed and new units entering the market even as prices are declining. In spite of the City's higher inherent constraints on new residential development, and the many years of experience that most City developers have, building activity in the City still tends to follow a boom-and-bust pattern.

Taking this into account, what were the effects of the most recent building boom and bust on residential housing in New York City? While condominium development garners much attention during building booms, data from certificates of occupancy show that the majority of new units were added in multifamily rental buildings. Building in the City was likely more geographically dispersed than in the previous boom. However, many units were still located near subway stations and public parks, and neighborhoods with higher levels of amenities - better schools, less crime, and higher housing values - experienced more growth in residential housing supply.

A stated goal of Mayor Bloomberg's strategic plan for New York City, "PlaNYC", was to build 265,000 new residential units in the City between 2007 and 2030. Although certain public subsidies for residential development were severely curtailed, regulatory barriers to development seemed to be less of an issue as the boom progressed. Currently, fewer housing units are being built than at the height of the boom. However, if we take into account the inherently cyclical nature of real estate development, and we view the current stock of "stalled sites" not as failures but as future opportunities, reaching this goal seems eminently feasible.

**Table 3.1: Number of Residential Units Completed in NYC 2000-2008, by Year and Borough**

| Year | Bronx | Brooklyn | Manhattan | Queens | Staten Island | All Boros |
|---|---|---|---|---|---|---|
| 2000 | 1165 | 1465 | 5125 | 2016 | 3224 | 12995 |
| 2001 | 1289 | 2241 | 5893 | 1532 | 2625 | 13580 |
| 2002 | 1477 | 2169 | 7142 | 2188 | 1753 | 14729 |
| 2003 | 1379 | 4289 | 4197 | 2794 | 3150 | 15809 |
| 2004 | 2933 | 4211 | 7266 | 2533 | 2119 | 19062 |
| 2005 | 2957 | 4811 | 6397 | 4655 | 1893 | 20713 |
| 2006 | 4068 | 6037 | 7435 | 5793 | 1875 | 25208 |
| 2007 | 4214 | 6744 | 7456 | 5270 | 1443 | 25127 |
| 2008 | 4175 | 7172 | 4793 | 5552 | 1021 | 22713 |
| Total | 23657 | 39139 | 55704 | 32333 | 19103 | 169936 |

**Table 3.2: Number of Residential Units Completed in NYC 2000-2008, by Year and Type**

| Year | Single-family | 2-4 family | 5-plus family | Condo | Coop | Mixed-use | Total units | Total units (%) |
|---|---|---|---|---|---|---|---|---|
| 2000 | 2297 | 3527 | 6461 | 624 | 4 | 82 | 12995 | 7.6% |
| 2001 | 1718 | 4288 | 5069 | 2447 | 16 | 42 | 13580 | 8.0% |
| 2002 | 1220 | 4067 | 6707 | 2224 | 410 | 101 | 14729 | 8.7% |
| 2003 | 1961 | 5528 | 5958 | 2139 | 107 | 116 | 15809 | 9.3% |
| 2004 | 1655 | 5547 | 8704 | 3039 | 4 | 113 | 19062 | 11.2% |
| 2005 | 1277 | 7065 | 8583 | 3669 | 0 | 119 | 20713 | 12.2% |
| 2006 | 1192 | 8476 | 10952 | 3809 | 595 | 184 | 25208 | 14.8% |
| 2007 | 1058 | 7832 | 11813 | 4053 | 124 | 247 | 25127 | 14.8% |
| 2008 | 774 | 6444 | 13494 | 1691 | 89 | 221 | 22713 | 13.4% |
| Total units by type | 13152 | 52774 | 77741 | 23695 | 1349 | 1225 | 169936 | |
| Total (%) | 7.7% | 31.1% | 45.7% | 13.9% | 0.79% | 0.72% | | |

**Table 3.3: Number of Residential Units Completed in NYC 2000-2008, by Borough and Type**

| Borough | Single-family | 2-4 family | 5-plus family | Condo | Coop | Mixed-use | Total units by borough | Total units (%) |
|---|---|---|---|---|---|---|---|---|
| Bronx | 285 | 9876 | 12839 | 510 | 0 | 147 | 23657 | 13.9% |
| Brooklyn | 1287 | 15186 | 16230 | 6060 | 46 | 330 | 39139 | 23.0% |
| Manhattan | 18 | 776 | 38592 | 14986 | 1283 | 49 | 55704 | 32.8% |
| Queens | 1915 | 17965 | 9706 | 2111 | 3 | 633 | 32333 | 19.0% |
| Staten Island | 9647 | 8971 | 374 | 28 | 17 | 66 | 19103 | 11.2% |
| Total units by type | 13152 | 52774 | 77741 | 23695 | 1349 | 1225 | 169936 | |
| Total units (%) | 7.7% | 31.1% | 45.7% | 13.9% | 0.79% | 0.72% | | |

**Table 3.4: Number of Residential Units Completed in NYC 2000-2008, by Year and Borough, as a percentage of existing stock**

| Year | Bronx | Brooklyn | Manhattan | Queens | Staten Island | All Boros |
|---|---|---|---|---|---|---|
| 2000 | | | | | | |
| 2001 | | | | | | |
| 2002 | 0.31% | 0.24% | 0.79% | 0.28% | 1.10% | 0.46% |
| 2003 | 0.29% | 0.47% | 0.49% | 0.36% | 1.95% | 0.49% |
| 2004 | 0.60% | 0.45% | 0.80% | 0.32% | 1.27% | 0.58% |
| 2005 | 0.59% | 0.51% | 0.69% | 0.59% | 1.12% | 0.62% |
| 2006 | 0.81% | 0.63% | 0.81% | 0.60% | 1.10% | 0.71% |
| 2007 | 0.84% | 0.68% | 0.79% | 0.64% | 0.84% | 0.73% |
| 2008 | 0.79% | 0.69% | 0.45% | 0.66% | 0.56% | 0.62% |
| Total (as % of 2002 stock) | 4.93% | 4.27% | 6.13% | 4.18% | 11.97% | 5.25% |

**Table 3.5: Share of Residential Sales that are from New Construction 2000-2008, by year and borough**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|
| NYC | 3.7% | 4.4% | 3.2% | 3.8% | 4.7% | 4.9% | 5.6% | 5.7% | 6.9% |
| Bronx | 1.8% | 4.4% | 3.1% | 3.9% | 3.7% | 4.3% | 5.3% | 7.1% | 12.9% |
| Brooklyn | 2.2% | 2.8% | 2.4% | 2.1% | 3.5% | 3.8% | 4.3% | 4.6% | 5.3% |
| Manhattan | 3.0% | 2.0% | 1.5% | 1.1% | 0.7% | 1.2% | 1.0% | 0.4% | 0.3% |
| Queens | 2.0% | 2.8% | 2.6% | 3.3% | 3.4% | 3.5% | 4.9% | 5.6% | 7.5% |
| Staten Island | 12.0% | 12.0% | 7.9% | 10.6% | 15.2% | 17.9% | 17.7% | 18.1% | 17.7% |

**Table 3.6: Correlations of Neighborhood-Level Characteristics with Number of Units Built, 2000-2008**

| | Median price of housing unit, 2000 | Pct change in prices, 96-04 | Median household income, 2000 | Percent nonwhite, 2000 | Felony crime rate, 2000 | Pct students at grade level (math), 2000 |
|---|---|---|---|---|---|---|
| Units per capita | 0.36001 | 0.19473 | 0.24675 | -0.25734 | 0.04745 | 0.25344 |
| Pr(\|r\|) < 0 | 0.0051 | 0.1394 | 0.0596 | 0.0491 | 0.7284 | 0.0528 |

Notes: Analysis is at the community district level for number of units built per capita, *N=59.* Pearson correlation coefficients, Pr(|r|) < 0 is under H0: rho=0.)

**Table 3.7: New Construction 2000-2008 Access to Parks and Transit, by Borough**

| Borough | Pct New Construction within 1/4 mile of park | Pct New Construction within 1/4 mile of subway |
|---|---|---|
| Brooklyn | 90.85% | 33.16% |
| Manhattan | 95.31% | 44.87% |
| Queens | 74.79% | 14.95% |
| Staten Island | 75.22% | 6.41% |

**Table 3.8: Percent of 2003 "Soft Sites" that subsequently experienced construction activity between 2004 and 2007, by borough**

| Borough | Number of underdeveloped lots | Number redeveloped, 2003 - 2007 | Redevelopment Rate |
|---|---|---|---|
| Bronx | 30480 | 1794 | 5.89% |
| Brooklyn | 68406 | 4684 | 6.85% |
| Manhattan | 6875 | 713 | 10.37% |
| Queens | 56005 | 4698 | 8.39% |
| Staten Island | 29901 | 2666 | 8.92% |
| Total | 191667 | 14555 | 7.59% |

**Table 3.9: Percent of 2003 "Soft Sites" associated with a new Certificate of Occupancy, by year and borough**

| Year | Bronx | Brooklyn | Manhattan | Queens | Staten Island | All Boros |
|---|---|---|---|---|---|---|
| 2004 | 0.23% | 0.27% | 0.28% | 0.29% | 0.58% | 0.32% |
| 2005 | 0.35% | 0.62% | 0.39% | 0.72% | 1.03% | 0.67% |
| 2006 | 0.69% | 0.97% | 0.50% | 1.07% | 1.10% | 0.96% |
| 2007 | 0.80% | 0.81% | 0.54% | 0.92% | 0.89% | 0.84% |
| 2008 | 0.63% | 0.70% | 0.58% | 0.94% | 0.60% | 0.74% |
| Total | 2.71% | 3.37% | 2.30% | 3.94% | 4.20% | 3.53% |

**Table 3.10: Percent of Units Built between 2004-2008 that were built on sites that were soft in 2003, by year and borough**

| Year | Bronx | Brooklyn | Manhattan | Queens | Staten Island | All Boros |
|---|---|---|---|---|---|---|
| 2004 | 11.9% | 21.6% | 4.5% | 16.7% | 12.0% | 11.9% |
| 2005 | 36.6% | 32.9% | 20.7% | 39.6% | 28.2% | 30.8% |
| 2006 | 58.8% | 53.2% | 26.3% | 37.1% | 33.6% | 41.0% |
| 2007 | 63.6% | 44.1% | 20.5% | 42.0% | 30.2% | 39.1% |
| 2008 | 58.2% | 50.7% | 29.0% | 42.7% | 29.9% | 44.6% |
| Total | 48.7% | 42.5% | 19.6% | 37.8% | 25.9% | 34.5% |

**Table 3.11: Percent of New Residential Units receiving 421-a tax abatement/other NYC subsidies in NYC 2000-2008, by Year and Borough**

| | Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | *Boro Total 2000-2008* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bronx* | % City Owned | 6.8% | 6.6% | 13.7% | 8.7% | 16.2% | 5.5% | 1.4% | 0.0% | 0.5% | 5.1% |
| | % Other Subsidy | 44.6% | 6.6% | 28.0% | 17.4% | 16.2% | 14.7% | 6.5% | 4.1% | 0.5% | 11.1% |
| | % 421-a/J51 | 18.7% | 12.2% | 29.2% | 23.0% | 30.2% | 24.4% | 36.8% | 35.1% | 18.6% | 27.4% |
| | *% Subsidized* | 70.1% | 25.4% | 70.9% | 49.1% | 62.7% | 44.6% | 44.6% | 39.2% | 19.5% | 43.6% |
| *Brooklyn* | % City Owned | 1.8% | 10.3% | 10.2% | 17.7% | 12.0% | 5.7% | 1.1% | 2.2% | 0.0% | 5.7% |
| | % Other Subsidy | 5.9% | 10.3% | 13.9% | 18.0% | 14.2% | 6.0% | 3.8% | 2.6% | 0.1% | 6.9% |
| | % 421-a/J51 | 12.9% | 20.0% | 9.6% | 16.3% | 13.7% | 10.1% | 10.9% | 10.8% | 11.1% | 12.3% |
| | *% Subsidized* | 20.6% | 40.6% | 33.8% | 52.1% | 39.9% | 21.8% | 15.8% | 15.7% | 11.2% | 24.8% |
| *Manhattan* | % City Owned | 2.4% | 4.0% | 17.0% | 7.6% | 3.1% | 4.8% | 4.7% | 0.0% | 1.4% | 5.1% |
| | % Other Subsidy | 8.2% | 4.7% | 21.5% | 10.0% | 3.1% | 6.2% | 4.7% | 0.0% | 1.4% | 6.6% |
| | % 421-a/J51 | 53.4% | 40.1% | 36.3% | 66.8% | 34.8% | 25.1% | 12.5% | 18.1% | 4.0% | 30.7% |
| | *% Subsidized* | 64.1% | 48.8% | 74.7% | 84.4% | 41.0% | 36.1% | 22.0% | 18.1% | 6.9% | 42.4% |
| *Queens* | % City Owned | 0.0% | 0.1% | 0.0% | 1.0% | 4.3% | 0.9% | 0.7% | 0.2% | 0.0% | 0.7% |
| | % Other Subsidy | 0.2% | 0.1% | 0.2% | 1.1% | 4.5% | 1.1% | 2.3% | 1.9% | 0.1% | 1.4% |
| | % 421-a/J51 | 32.4% | 28.9% | 36.9% | 26.7% | 30.8% | 36.9% | 16.8% | 15.1% | 19.0% | 24.7% |
| | *% Subsidized* | 32.6% | 29.0% | 37.1% | 28.8% | 39.6% | 38.9% | 19.8% | 17.2% | 19.2% | 26.8% |
| *Staten Island* | % City Owned | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | % Other Subsidy | 0.1% | 0.0% | 0.3% | 0.1% | 0.1% | 0.0% | 0.2% | 0.1% | 0.3% | 0.1% |
| | % 421-a/J51 | 0.1% | 0.8% | 0.0% | 0.2% | 0.0% | 0.0% | 4.2% | 0.8% | 0.0% | 0.6% |
| | *% Subsidized* | 0.2% | 0.8% | 0.3% | 0.3% | 0.1% | 0.0% | 4.3% | 1.0% | 0.3% | 0.7% |
| *Annual Total* | % City Owned | 1.8% | 4.1% | 11.1% | 7.8% | 6.9% | 3.8% | 2.0% | 0.6% | 0.4% | 3.8% |
| | % Other Subsidy | 8.0% | 4.4% | 15.3% | 9.3% | 7.4% | 5.7% | 3.9% | 1.8% | 0.5% | 5.6% |
| | % 421-a/J51 | 29.3% | 25.3% | 27.4% | 28.9% | 25.0% | 21.9% | 16.4% | 17.4% | 12.4% | 21.5% |
| | *% Subsidized* | 39.0% | 33.7% | 53.9% | 45.9% | 39.4% | 31.3% | 22.4% | 19.8% | 13.3% | 30.9% |

**Table 3.12: Number of Unsold Buildings and Condo Units as of 12/2008, by Year Certificate of Occupancy was issued and Borough**

| Year | Bronx | Brooklyn | Manhattan | Queens | Staten Island | All Boros |
|---|---|---|---|---|---|---|
| 2000 | 159 | 334 | 52 | 267 | 1124 | 1936 |
| 2001 | 277 | 301 | 63 | 229 | 907 | 1777 |
| 2002 | 280 | 304 | 100 | 253 | 678 | 1615 |
| 2003 | 229 | 738 | 69 | 360 | 1363 | 2759 |
| 2004 | 386 | 564 | 91 | 447 | 796 | 2284 |
| 2005 | 325 | 761 | 85 | 774 | 557 | 2502 |
| 2006 | 366 | 913 | 78 | 808 | 378 | 2543 |
| 2007 | 412 | 1004 | 50 | 878 | 343 | 2687 |
| 2008 | 377 | 870 | 40 | 864 | 304 | 2455 |
| Total | 2811 | 5789 | 628 | 4880 | 6450 | 20558 |

**Table 3.13: Stalled Construction Sites (as of 11/29/2009)**

| | Number of sites |
|---|---|
| Bronx | 24 |
| Brooklyn | 237 |
| Manhattan | 80 |
| Queens | 140 |
| Staten Island | 34 |
| Total | 515 |

**Table 3.14: Top 5 Community Districts: Number of Stalled Sites**

| | Number of sites |
|---|---|
| Financial District (CD 301) | 79 |
| Jamaica/Hollis (CD 412) | 26 |
| Greenwich Village/Soho (CD 302) | 20 |
| Flushing/Whitestone (CD 407) | 20 |
| Washington Heights/Inwood (CD 312) | 18 |

**Table 3.15: Number of Residential Units Completed in NYC 2000-2008, by Year and Type (alternate matching methodology)**

| Year | Single-family | 2-4 family | 5-plus family | Condo | Coop | Mixed-use | Total units | Total units (%) |
|---|---|---|---|---|---|---|---|---|
| 2000 | 2297 | 3545 | 5569 | 1498 | 4 | 82 | 12995 | 7.6% |
| 2001 | 1718 | 4294 | 4434 | 3076 | 16 | 42 | 13580 | 8.0% |
| 2002 | 1220 | 4080 | 4995 | 3923 | 410 | 101 | 14729 | 8.7% |
| 2003 | 1961 | 5555 | 5430 | 2640 | 107 | 116 | 15809 | 9.3% |
| 2004 | 1655 | 5574 | 7561 | 4155 | 4 | 113 | 19062 | 11.2% |
| 2005 | 1277 | 7128 | 6853 | 5336 | 0 | 119 | 20713 | 12.2% |
| 2006 | 1192 | 8543 | 7211 | 7483 | 595 | 184 | 25208 | 14.8% |
| 2007 | 1058 | 7926 | 7451 | 8321 | 124 | 247 | 25127 | 14.8% |
| 2008 | 774 | 6497 | 11401 | 3731 | 89 | 221 | 22713 | 13.4% |
| Total units by type | 13152 | 53142 | 60905 | 40163 | 1349 | 1225 | 169936 | |
| Total (%) | 7.7% | 31.3% | 35.8% | 23.6% | 0.79% | 0.72% | | |

**Table 3.16: Number of Residential Units Completed in NYC 2000-2008, by Borough and Type (alternate matching methodology)**

| Borough | Single-family | 2-4 family | 5-plus family | Condo | Coop | Mixed-use | Total units by borough | Total units (%) |
|---|---|---|---|---|---|---|---|---|
| Bronx | 285 | 9876 | 12065 | 1284 | 0 | 147 | 23657 | 13.9% |
| Brooklyn | 1287 | 15499 | 10909 | 11068 | 46 | 330 | 39139 | 23.0% |
| Manhattan | 18 | 810 | 28714 | 24830 | 1283 | 49 | 55704 | 32.8% |
| Queens | 1915 | 17982 | 8921 | 2879 | 3 | 633 | 32333 | 19.0% |
| Staten Island | 9647 | 8975 | 296 | 102 | 17 | 66 | 19103 | 11.2% |
| Total units by type | 13152 | 53142 | 60905 | 40163 | 1349 | 1225 | 169936 | |
| Total units (%) | 7.7% | 31.3% | 35.8% | 23.6% | 0.79% | 0.72% | | |

**Figure 3.1:**
**Annual Percentage Change in Housing Stock, 2001-2008: Selected Cities**

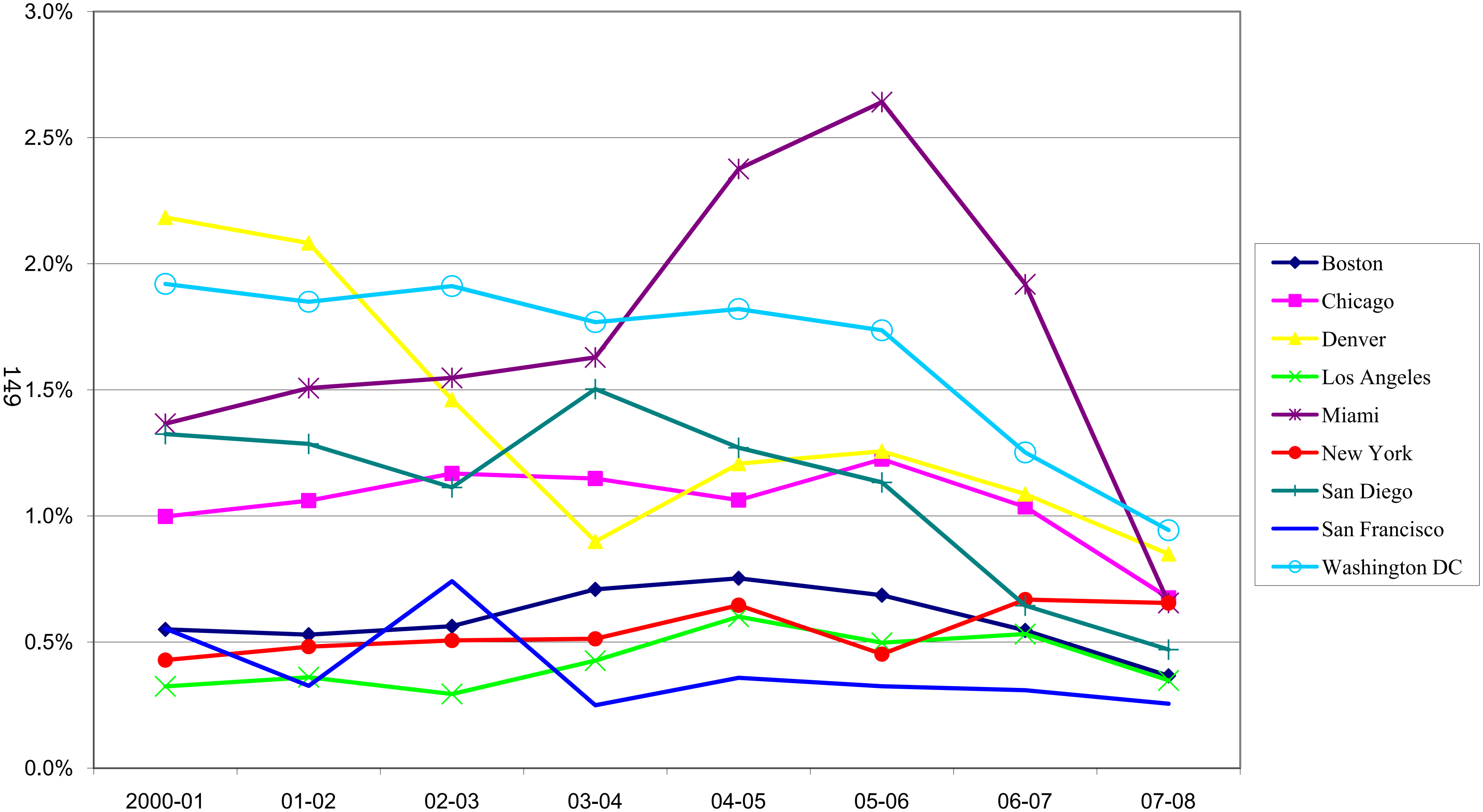
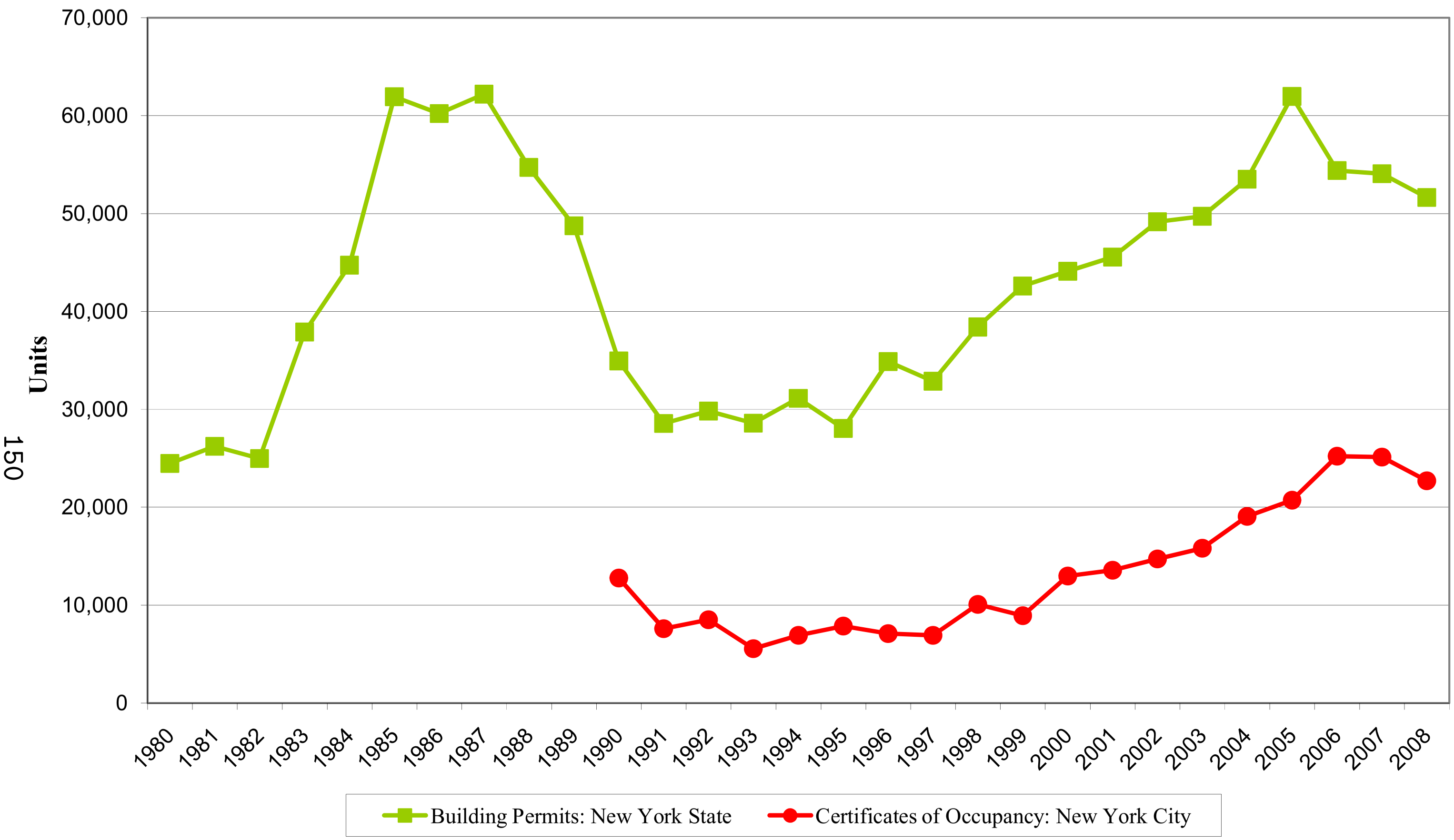


**Figure 3.2:**
**Building Activity: New York City and New York State, 1980-2008**



## 3.8 Data Sources for Chapter 3

Figure 3.1: Cross-city building statistics are measured at the Metropolitan Statistical Area (MSA) level using data on annual estimates of housing units, by county, from the Census Bureau, available at: http://www.census.gov/popest/housing/HU-EST2008-4.html

Figure 3.2: Data on residential building permits authorized in the State of New York are from the Census Bureau, Division of Mining, Manufacturing, and Construction Statistics, Series C40, available at: http://www.census.gov/const/www/C40/annualhistorybystate.pdf

Table 3.1: Data on Certificates of Occupancy are recorded by the New York City Department of Buildings, and made available through the Department's Building Information System, available at: http://www.nyc.gov/html/dob/html/bis/bis.shtml

Tables 3.2 - 3.4; Figure 3.3: Data on Certificates of Occupancy are recorded by the New York City Department of Buildings, and additional information on new buildings is obtained by linking certificates of occupancy to property records from the New York City Department of Finance's Real Property Assessment Database, available at:
http://www.nyc.gov/html/dof/html/property/property_val_valuation.shtml
Properties in both of these datasets are identified by the borough, block, and lot numbers (the "BBL" numbers), which together provide a unique identifier for each property in New York City.

In general, this identifier is consistent over time, even if the building on the lot changes. However, there are some situations where the BBL number for a given property can change, and the BBL number recorded on the certificate of occupancy is different from the BBL number recorded in the tax assessment database. The most common situations where this occurs are:

- Tax lots are merged, split, or altered, and the resulting lots are assigned new BBL numbers;
- New construction on a newly created lot is issued a certificate of occupancy before a BBL number is assigned;
- A new condominium building is associated with the previous BBL number, or assigned a new BBL number, on its certificate of occupancy. When the condo units are assessed for taxation, each unit is assigned its own unique BBL.

In our sample of 38,270 certificates of occupancy, 2,510 (approximately 6.5 percent) observations do not match to a record in the tax assessment database using BBL numbers. We employ two methods of assigning property type categories to these records:

Method 1: Assign buildings with 1 unit and 2-4 units to the single-family and 2-4 family building types, respectively.

For buildings with 5-plus units, check to see if the block on which the building is located includes a condominium lot.

If the block includes a condo lot, assign the building as a condo.

If the block does not include a condo lot, assign shares of units in the building as condos and rental units in 5-plus family buildings based on the distribution of building types among unmatched buildings in the sample. This distribution was derived from a 5 percent sample of unmatched buildings that were matched by hand using physical records from the Building Information System. (Only 5 buildings/74 units were in this category.)

Method 2: Match buildings to tax assessment records by borough, block, and number of units (plus or minus one).

Because the second method matches certificates of occupancy to tax records (rather than just assigning buildings to categories), we use the second matching method in the analysis. Figures for shares of residential units by type using the first matching method are reported in Tables 3.15 and 3.16 located at the end of the chapter.

Table 3.5: Data on Certificates of Occupancy are recorded by the New York City Department of Buildings, and data on property sales are from the New York City Automated City Register Information System (ACRIS), available at: http://www.nyc.gov/html/dof/html/jump/acris.shtml

Tables 3.6 - 3.7: Community district-level information on housing values, household income, racial composition, crime activity, and school performance are compiled from a range of sources (including the Census, ACRIS, and the New York City Department of Education), and are available from the Furman Center for Real Estate and Urban Policy's NYC Housing and Neighborhood Information System, available at: http://www.nychanis.com

Tables 3.8 - 3.10: Information on lot-level zoning is a current project of the Furman Center, and will be made publicly available at a future date.

Table 3.11: Details on the vast array of subsidy programs administered by New York City's Housing Preservation Department, and information on building participation in these programs, is available at: http://www.nyc.gov/html/hpd/html/developers/developers.shtml

Table 3.12: Data on Certificates of Occupancy are recorded by the New York City Department of Buildings, and data on property sales are from the New York City Automated City Register Information System (ACRIS).

Tables 3.13 - 3.14: The NYC Department of Building's list of stalled construction sites is available at: http://www.nyc.gov/html/dob/html/guides/snapshot_report.shtml

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