DEPARTMENT OF ECONOMICS
UNIVERSITY OF ALBERTA

Working Paper No. 2010-11

Residential Land Use Regulation and the US Housing Price Cycle Between 2000 and 2009

Haifang Huang
University of Alberta

Yao Tang
Bowdoin College

Revised November 2010

Residential Land Use Regulation and the US Housing Price Cycle Between 2000 and 2009

Haifang Huang* and Yao Tang†

This draft: November 2010

Abstract

In a sample covering more than 300 cities in the US between January 2000 and July 2009, we find that more restrictive residential land use regulations and geographic land constraints are linked to larger booms and busts in housing prices. The natural and man-made constraints also amplify price responses to the subprime mortgage-credit expansion in the decade, leading to greater price increases in the boom and subsequently bigger losses.

JEL classification: R3
Keywords: residential land use regulation; credit expansion; housing prices

1 Introduction

Large swings in asset prices are a concern for macroeconomic stability. The volatility of housing prices appears particularly destabilizing, as housing busts typically involve a larger loss in GDP than do equity busts.[1] In the housing market, an important factor in shaping the dynamics of price cycles is the supply conditions (Capozza et al., 2002; Malpezzi and Wachter, 2005; Glaeser et al., 2008). In this paper, we examine the relation between housing supply constraints and the magnitude of price

*Department of Economics, University of Alberta, HM Tory 8-14, Edmonton, AB T6G 2H4, Canada. Email address: haifang.huang@ualberta.ca.

†Department of Economics, Bowdoin College, 9700 College Station, Brunswick, Maine 04011-8497, USA. Email address: ytang@bowdoin.edu.

[1]Helbling and Terrones (2003) surveyed industrialized countries' experience of economic crises and found that output losses associated with housing busts were twice as large as those associated with equity busts (8% versus 4%).

swings in US local markets during the housing cycle between 2000 and 2009. We also ask whether supply inelasticity exacerbated the boom-bust consequences of the subprime mortgage-credit expansion during the decade.

While it is well documented that supply restrictions increase house prices' responses to positive demand shocks in booms, the evidence on the relation between supply inelasticity and price declines in busts is weaker. A recent study, Glaeser et al. (2008), reported that there was little correlation between geographic land scarcity and the fall in house prices during the bust over 1989-1996. Malpezzi and Wachter (2005), on the other hand, reported a positive relation between the standard deviation of price changes over 1979-1996 and a measure of regulatory restrictions in housing supply. Given the non-conclusiveness of the documented evidence, and that the destabilizing force of a housing cycle concentrates in the bust, this paper revisits the relation using data that include the three years of housing downturn from 2006 to 2009.

Our interest in the subprime mortgage expansion is motivated by the empirical study in Mian and Sufi (2008), which points to the extension of mortgage credit to borrowers of low credit quality as an important driver of the housing cycle in the last decade. In this paper, we interact local dependence on subprime mortgage credit with measures of supply constraints in the housing market to test whether the boom and bust consequences of the subprime expansion depended on housing-supply conditions.

We consider two types of supply restrictions: residential land use regulations and geographic land constraints. We are primarily interested in the former; the inclusion of geographic information acknowledges the possibility that land scarcity begets regulations.[2] Our findings suggest that both regulatory and geographic con-

[2]See Saiz (forthcoming) for discussions on the relation between land scarcity and regulation; see also Malpezzi et al. (1998).

straints contributed to the amplitude of price booms and busts between 2000 and 2009. During the downturn, the correlations between the two supply constraints and price declines are statistically significant and quantitatively substantial. We also find that supply inelasticity in the housing market interacted with the subprime expansion in the mortgage market to create greater booms and busts in house prices: an increase in local residents' dependence on subprime loans was particularly destabilizing in cities that face a high degree of supply restrictions, either from geography or from land use policies.

The structure of the paper is as follows: Section 2 reviews the literature. Section 3 describes the empirical model and data. Section 4 presents the results. Section 5 contains a series of robustness tests and a comparison between the 2006-2009 housing bust and the 1989-1996 bust. Section 6 concludes.

2 Literature review

The paper is related to the literature that studies housing markets through the perspective of supply, which has received less attention than housing demand. A special issue on the Journal of Real Estate Finance and Economics was intended to raise awareness of the sparseness of the literature (Rosenthal, 1999). Here we review some of the more recent contributions.

The literature has pointed to residential land use policy as an important aspect of housing supply (see Quigley and Rosenthal, 2005, for a review of empirical studies published before 2004). Glaeser et al. (2005) described the impact of government regulation on housing supply as a "man-made scarcity," and attributed the increase in US house prices since the 1970s to the increasing difficulty of obtaining approval for housing development. Their evidence included the combination of increases in housing prices and decreases in new construction, the increase in the ratios of house prices to construction costs, and the extra value for land that is bundled with the right to build. Quigley and Raphael (2005) constructed an index of regulatory stringency for California cities, and found that regulatory restrictions are correlated with higher housing prices and rents, and lower growth in housing stock. Green et al. (2005) found that stringent regulation is linked to lower estimates of metro-specific supply elasticities. Ihlanfeldt (2007) and Glaeser and Ward (2009) studied cities in Florida and the greater Boston area, respectively; both reported positive relations between regulatory restrictions and house prices.

In terms of measuring regulatory environments, the most recent work, which also has the largest scale, is Gyourko et al. (2008). It provides multidimensional measures on local land use control environments for more than 2,600 US cities, towns and villages. The underlying data source is a 2005 survey and other supplemental information. Other contributions include Pendall and Martin (2006), Xing, Hartzell, and Godschalk (2006) and Malpezzi (1996). In this paper we use the information from Gyourko et al. (2008) for its larger scale, smaller governmental units and because it is more recent.

Another factor that is thought to be an important determinant of housing supply is geographic constraint. Saiz (forthcoming) estimated, for 95 major US metropolitan areas, the percentage of land that is lost to water bodies, wetlands or slopes, and showed that a restrictive geography is a "strong predictor of housing price levels and growth for all metro areas during the 1970-2000 period." Rose (1989) constructed a similar measure of land constraint for a smaller number of cities.

Our paper differs from a large part of literature in that we focus on short-run fluctuations in house prices; we ask whether regulatory and geographic constraints are associated with greater booms and busts. In terms of the research question asked, the paper is close to Capozza et al. (2002), Malpezzi and Wachter (2005) and

Glaeser et al. (2008).[3]

Capozza et al. (2002) estimated the serial correlation and the mean reversion coefficients for the dynamics of housing prices in a panel of US metro areas. Among other findings, they reported that higher construction costs, which were interpreted as indicators of supply constraints, were associated with higher serial correlation and lower mean reversion, thus presenting conditions for overshooting of house prices.

Malpezzi and Wachter (2005) presented a model that features supply lags and speculative demand from adaptive expectations. In the model, markets with lower supply elasticity experience larger and more persistent price increases in response to a positive demand shock; the price movements then attract myopic actions, eventually leading to bigger busts in real estate prices. Empirically, the researchers reported a positive correlation between the stringency of regulation and the standard deviation of price changes between 1979 and 1996. Our paper will instead examine conditional responses to credit shocks.

Glaeser et al. (2008) constructed a model of housing bubbles that features irrational overoptimism and adaptive expectations. Because expectations are endogenous to past price movements and the latter are endogenous to supply conditions, housing bubbles are endogenous to supply conditions as well. The model predicts that inelastic supply leads to greater price increases in booms; it has ambiguous predictions on the relation between supply inelasticity and the size of post-bubble price corrections. On the one hand, supply constraints reduce new construction during the bubble; so the downward pressure on house prices in the bust from excessive stock is smaller. On the other hand, house prices increase by more in inelastic areas and in the process creates housing demand from adaptive expectations. Under some parameter conditions, supply inelasticity leads not just to a greater price increase,

[3]Other relevant contributions include Hwang and Quigley (2006) and Saks (2008).

but also to more construction (proposition 5 of the cited paper), a combination that will surely lead to a greater price bust after the bubble. Empirically, the researchers found little relation between the geographic land scarcity developed in Saiz (forthcoming) and the price declines over the 1989-1996 US housing bust; they did find a positive relation between the land constraint and the size of price booms over 1982-1989 and over 1996-2006. In this paper, our sample period covers the 2006-2009 housing bust that is not in Glaeser et al. (2008).

3 Empirical specification and data

3.1 The empirical specification

The paper studies the US housing cycle between 2000 and 2009, an episode widely believed to be driven by an expansion of subprime mortgage-credit supply in the early-to-mid 2000s. The model behind our empirical specification assumes that cities had different supply conditions in the housing market, and that the nationwide subprime expansion had different local impacts on housing demand, because some cities were more dependent on subprime credit than others. The first question we ask is whether supply inelasticity on average was associated with bigger price booms and busts. The second question is whether or not the impacts of the subprime expansion on the price cycle depended on supply conditions in the housing market.

The two measures of supply constraints we use are the land use regulation index from Gyourko et al. (2008) and the geographic constraint from Saiz (forthcoming). Following Mian and Sufi (2008), we proxy for the local impacts of subprime mortgage expansion using the rejection rates of mortgage applications in 1996. If a city had a higher level of rejection rate before the expansion, we assume that it had a greater share of residents who were subprime in the sense that their applications for loans were more likely to be rejected under the old lending standards. The subprime expansion lowered the standards, providing previously-unqualified borrowers access to mortgage loans. It will lead to a greater increase in housing demand in cities where the pool of low-quality borrowers was bigger, as inferred from a higher rejection rate before the expansion.[4] For robustness, we adopt an alternative proxy measuring the prevalence of risky mortgage loans during the housing boom, namely the share of mortgage loans that carried high interest-rate spreads during the boom.

Our empirical model, which also includes contemporaneous economic variables and other controls, is described by the following two equations:

$$\begin{aligned}
\Delta price_{i,boom} = {} & \alpha_0 + \alpha_c \cdot reject_i + \alpha_r \cdot regulation_i + \alpha_g \cdot geographic\ constraint_i \\
& + \alpha_{cr} \cdot reject_i \cdot regulation_i + \alpha_{cg} \cdot reject_i \cdot geographic\ constraint_i \\
& + \alpha_X \cdot X_{i,boom} + u_{i,boom} \\
\Delta price_{i,bust} = {} & \beta_0 + \beta_c \cdot reject_i + \beta_r \cdot regulation_i + \beta_g \cdot geographic\ constraint_i \\
& + \beta_{cr} \cdot reject_i \cdot regulation_i + \beta_{cg} \cdot reject_i \cdot geographic\ constraint_i \\
& + \beta_X \cdot X_{i,bust} + u_{i,bust},
\end{aligned}$$

where the subscript i indexes cities, and the subscript *boom* and *bust* indicate phases in the housing cycle. The vector of control variables, X_i, include percentage changes in employment and percentage changes in median household income (the latter is available only for the boom equation), as well as the city profile in the 2000 census, including population density, population size, the level of average household income, the share of urban population, the unemployment rate and the proportion of vacant housing units.

[4] We should note that the level of aggregation in Mian and Sufi (2008) is geographically finer than ours, as they aggregated the rejection rates at the census-tract level and use them in zip-code level regressions, while we use the rejection rates at the city level. Nevertheless, the summary statistics in Table 1 indicate that there are large variations in the rejection rates across cities. Finally, there are direct measures of mortgage expansion at local levels such as changes in the volume of mortgage loans, but the loan volume is an equilibrium outcome and cannot be used to explain house prices.

The important features of the specification are that we break the price movements between 2000 and 2009 into two phases: an initial boom and a bust afterward. The price changes in the two periods are the dependent variables. City profile and contemporaneous changes in economic conditions are control variables, while the focus is on the two supply constraints, the variables proxying for the local impacts of the subprime mortgage credit expansion, and the interactions between the supply constraints and the subprime variables; we use the interaction terms to test whether supply inelasticity has turned the subprime expansion into bigger booms and busts.

3.2 Data and descriptive statistics

We have two different indices for housing prices. The main results are based on the index from Zillow.com, because it is available at sub-metropolitan level, same as the land use regulation index. The second index, used for robustness checks, is the House Price Index from the Federal Housing Finance Agency (formerly known as the OFHEO House Price Index), which is available only at the level of metropolitan areas. Zillow provides estimates of prices for individual houses in US urban areas, using mostly public data such as county records and information on local housing market conditions. The estimates have been shown to have good accuracy by the media and academic literature.[5] We are primarily interested in changes in the price aggregated at the city level. We check the quality of the data by comparing it to the Federal Housing Finance Agency house price index at the metropolitan level. We aggregate the Zillow prices to metropolitan areas using populations as weights.

[5]The Wall Street Journal on line (February 14, 2007) tests the accuracy of Zillow estimates with a sample of 1,000 homes in seven states, and found a median margin of error of 7.8%, and an equal split between overestimates and underestimates. The equal split suggests that the price data must have better accuracy at aggregated levels. We use the aggregated index at city levels. On this front the Zillow data has good accuracy as well. Mian and Sufi (2008) uses Zillow data at the zip code level for robustness checks. They find from 2,248 zip codes that house price changes from the Zillow's index and the Fiserv Case Shiller Weiss index have a correlation coefficient of 0.91 (page 10 of the cited paper).

The largest overlapped sample from the two sources has 210 metropolitan areas. We then calculate, from each index, the price gain in the boom period over 2000-2006 and the price loss in the bust period over 2006-2009. The correlation coefficient between the two sources is 0.93 for the gain and 0.90 for the loss.

The index for regulatory land restriction is the Wharton Residential Land Use Regulatory Index (WRLURI) developed by Gyourko et al. (2008). The index is based on a nationwide survey of local land use controls in 2005. The survey reports information about local jurisdictions' regulatory processes and rules on residential land use, such as binding limits on new construction, minimum lot size, affordable housing requirements, open space dedications, and developers' payment for infrastructure. It also provides information about the outcomes of the regulatory process such as change in cost of lot development and change in review time. The survey is supplemented by information on the legal, legislative and executive actions regarding land use policies. The WRLURI itself is the first factor from a factor analysis of eleven subindexes; a higher value indicates a more restrictive environment.

The data on geographic land scarcity is from Saiz (forthcoming), who estimate the proportion of undevelopable land that is lost to water bodies, wetlands and slopes within 50-kilometer radii from metropolitan central cities. The estimates are available for 95 major Metropolitan Statistical Areas (MSA). We assign to each city the value associated with the MSA where it locates.

The mortgage rejection rate in 1996 is from the Loan Application Register (LAR) of the Home Mortgage Disclosure Act (HMDA), which is believed to cover a large majority of mortgage loans sold in the US.[6] The percentage of high-cost loans, defined as mortgage loans sold between 2004 and 2006 that had a rate spread 3 percentage points above the Treasury security of comparable maturity, was compiled by

[6] Avery et al. (2007) reported that HMDA-covered lenders together account for approximately 80% of all home lending nationwide.

the US Department of Housing and Urban Development (HUD) for forecasting local foreclosure risks; the data was also derived from the HMDA database, which reports the rate-spread information only starting from 2004.[7] There is a high correlation between the two subprime variables (the correlation coefficient > 0.7).

Among the control variables, the changes in employment and median household income are from the Local Area Unemployment Statistics program of the Bureau of Labor Statistics and the USA Countries data files, respectively. We use the information at the county level for better coverage and because the income variable is available only at the county level. Replacing the county-level employment information with city-level counterparts does not change our main results, but it reduces the sample size substantially. For the boom regression, we control for both the employment and income changes. For the bust regression, we have only the employment changes, because the income information after 2007 is not yet available at its source. Other control variables are from the 2000 census at the city level.

The paper's definition of city corresponds to *incorporated places* in the US census. The sample excludes cities with fewer than 10,000 residents in the 2000 census.[8] The use of multiple datasets imposes a multi-level filtering process: Zillow's data does not include 15 states that are less densely populated; the regulation data is from a survey with incomplete responses;[9] the geographic information in Saiz (forthcoming) covers only the biggest 95 metropolitan areas. The final sample consists of 327 cities from 28 states.[10] It covers areas where 47 million Americans

[7]See "Neighborhood Stabilization Program Data, Methodology and Data Dictionary for HUD Provided Data" available on the HUD website.

[8]The mortgage information, namely the rejection rate and the percentage of high-cost loans, are aggregated to the city level using census tract-level population as weights.

[9]According to Gyourko et al. (2008), the jurisdictions that responded to the survey account for 60% of the population being surveyed.

[10]They are Alaska, Arkansas, Arizona, California, Colorado, Delaware, Florida, Georgia, Illinois, Kentucky, Massachusetts, Maryland, Michigan, Minnesota, North Carolina, Nebraska, New Jersey, Nevada, New York, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Virginia, Washington, and Wisconsin.

resided as of the 2000 census; this is 28% of our targeted population universe (urban population living in incorporated places with at least 10,000 residents).

To separate the housing cycle into the boom and the bust phases, we examine the average house prices in the sample. The peak is June of 2006. We thus define the price boom as the percentage change in house prices from January 2000 to June 2006, and the price bust as the change from June 2006 to July 2009.

Table 1 provides summary statistics. The average increase of real housing prices, adjusted with the Consumer Price Index excluding shelters, is 56.54%. The average price bust is 24.94%. The index of housing regulation has a mean of 0.14 and a standard deviation of 0.87 in our sample. Because the index is standardized nationally to have a mean of 0 and a standard deviation of 1, our sample of cities is slightly more regulated than the average city in the nation and more homogeneous than the nation as a whole. On average, the cities in the sample have 30.76% of land that is not suitable for housing development. On average 26.41% of mortgage-loan applications were rejected in 1996. The standard deviation of the rejection rate is 12.30%, indicating large variations in the initial credit conditions. Among the mortgage loans originated between 2004 and 2006, 26.13% were classified as high-cost loans.

Table 2 tabulates the changes in house prices by regulation index, geographic constraint and the mortgage rejection rate. It shows that cities that are more regulated or have less developable land experienced larger booms and larger busts in the prices. The same was true for cities that had higher rejection rates in mortgage applications in 1996, and those that were sold proportionally more high-interest loans between 2004 and 2006.

4 Regression Results

Table 3 presents the regression results. Each column in the table corresponds to one estimation. The variables shown on the top row are dependent variables. Due to the presence of interactive terms, we removed the means from right-hand side variables before interacting them with one another. This way we can interpret the coefficients on non-interaction terms as measuring the marginal effects at the sample mean. Columns (1) and (3) are the boom and bust equations, respectively; they using the 1996 mortgage rejection rate to measure local dependence on subprime credit. Column (2) and (4) use the share of high-interest loans instead, but are otherwise identical counterparts to (1) and (3), respectively.

The estimates show that a more restrictive geographic or regulatory constraint on housing supply is associated with bigger booms and bigger busts in house prices, all with statistical significance at conventional levels. If the a regulation score increases by one standard deviation (in its nationwide scale) and all other variables remain at the sample averages, the estimates in columns (1) and (3) suggest that the price boom will be 5.64% greater and the bust 4.55% deeper. If the share of undevelopable land rises by one-standard deviation (19.38%), all else remaining at the averages, the price boom will be 9.30% greater and the bust 5.04% deeper. Quantitatively similar observations are made in column (2) and (4).

Local dependence on subprime mortgage credit (as proxied for by the 1996 rejection rates of mortgage applications and, alternatively, the share of high-cost mortgages during the boom) is associated with greater swings in house prices. In cities that have average supply conditions, a one-standard deviation (12.3%) increase in the rejection rate leads to a 1.35% greater boom and a 5.29% deeper bust. The picture is markedly different if we take into account the interactions between the subprime variables and the supply constraints in the housing market. The interaction terms, all attracting statistically significant coefficients, indicate that the subprime dependence had greater boom-and-bust consequences in cities with inelastic housing supply. In cities where the regulation constraint is one standard-deviation higher than the average, the impacts of a one-standard deviation increase in the rejection rate are 7.5% for the boom and -9.1% for the bust. In cities where the share of undevelopable land is one-standard deviation (19.38%) greater, the impacts are 10.89% in the boom and -6.96% in the bust. Quantitatively similar observations are made using the share of high-cost mortgages to measure subprime dependence.[11]

5 Robustness checks and further discussions

We first address an endogeneity concern. We recognize that, although more stringent regulation in housing supply is associated with bigger price booms and busts, the causation between the regulation and price movements can run in both directions. Unlike in the case of geography, cities can change their residential land use policies, and their decisions may be a response to the level of and the changes in house prices (see Saiz, forthcoming). The survey behind the WRLURI was conducted in 2005. The regulatory environment at the time might have been influenced by the gains in house prices before 2005. For robustness, we estimate the models using the two sub-indices of the WRLURI at the state-level: the state political involvement index (SPII) and the state court involvement index (SCII), both developed by Foster and Summers (2005). The SPII measures the extent to which the executive and legislative arms of a state promote greater state-wide land use restrictions. The SCII measures the tendency of the judicial system of a state to uphold municipal

[11]Specifically, in cities with average supply conditions, a one-standard deviation (11.51%) increase in the share of high-cost mortgages raise the price boom by 4.14% and deepens its bust by 4.37%. In cities where the regulation index is one-standard deviation higher, the impacts are 7.60% and -8.17%, respectively. In cities where the share of undevelopable land is one standard deviation higher, the impacts are 13.07% and -5.49%, respectively.

land use regulations; it reflects the court's deference to municipal land controls. The state-level indexes are likely to be exogenous to city-level movements in house prices, particularly so with SCII, since the courts are unlikely to judge based on movements in house prices.

Table 4 reports the tests when local dependence on subprime mortgages is measured by the pre-expansion rejection rate of mortgage applications. In columns (1) and (3) of Table 4, we replace the overall index with the SPII. In column (2) and (4), we use the SCII instead. In all cases, results are similar to Table 3: the two state-level indices are correlated with the greater booms and greater busts; their interactions with the credit variable mostly retain their signs and significance; the biggest departure is that the interaction between the SCII and the mortgage rejection rates now has an essentially-zero coefficient in the boom equation. Results are similar when the alterative subprime variable, namely the prevalence of high-cost loans, is used; for space reasons those estimates are reported in the appendix.

The appendix also reports other robustness tests. In one of them, we interact the variables of subprime dependence (the 1996 rejection rate or the share of high-cost loans) with all the city-level census variables in 2000; the purpose is to see if the interactive terms between the credit variables and the two supply constraints retain the signs and significance of their coefficients after the inclusion of those many interactive terms. The answer is yes: all estimates retain their signs; most (6 out of 8) retain their significance. In another test, we include MSA dummies in all regressions. The interactions between the geographic land constraint and the two measures of subprime dependence continue to attract negative and significant coefficients in the bust equation, indicating that the subprime expansion was particularly destabilizing in cities that are limited by geography in land supply. Other estimates, however, become statistically insignificant, suggesting that inter-MSA differences are the driving force behind the findings reported in Table 3.

We now compare our findings to those from Glaeser et al. (2008). Table 3 shows that cities with a greater geographic constraint experienced a greater decline in price between June 2006 and July 2009. This finding is different from those in Glaeser et al. (2008), which reported that there was "little correlation between price declines during the bust [from 1989 to 1996] and the degree of elasticity [measured by the share of developable land]." (p. 213). Here we show that the differences in the two set of findings are due to different episodes. For this purpose, we conduct a comparison between the two episodes of housing busts using the same price index, same set of geographic areas and the same model specification, leaving sample periods as the only source of differences.

Because Zillow's price index is not available before 2000, we have to switch to the Federal Housing Finance Agency's (FHFA) House Price Index that was used in Glaeser et al. (2008). The index is available only at the MSA level, so the analysis has to switch to the MSA level as well. In the years between the two busts, the US Office of Management and Budget changed the area composition of MSAs. This creates difficulty in comparisons over time because the geographic land variable from Saiz (forthcoming) is measured for MSAs defined under the old federal standard, while the FHFA index is now published under the new standard. To bypass the problem, our analysis includes only areas that were largely not affected by the change, which we define as areas where more than 90% of residents belong to the same MSA before and after the change (even if the name of the MSA changed). Our final sample consists of 59 MSAs.

We first regress the price changes over the 1989-1996 housing bust on the share of undevelopable land, the changes in employment and a constant.[12] The coefficient

[12]The data currently available on the BLS State and Area Employment, Hours and Earnings (SM) program does not go back before 1990. So the change in employment for the earlier episode

on the land variable is -0.06[stderr= 0.08]. From an identical regression for the 2006-2009 bust, the coefficient rises to -0.21[0.05]. Since sample periods are the only source of differences, the two estimates present a stark contrast between the recent episode and the earlier one.

Our efforts to identify the source of differences between the two episodes of busts turned out inconclusive. We first examine new construction in booms that preceded the busts. Glaeser et al. (2008) shows that during the course of a housing bubble, inelastic housing supply, combined with adaptive expectation, can theoretically lead to more construction in addition to a greater jump in house prices, a combination that certainly will lead to greater bust in house prices after the bubble. Has this theoretical possibility played out in the 2000-2006 boom but less so in the 1982-1989 boom? Simple correlation statistics do not support the hypothesis. In the MSA sample, the correlation between the share of undevelopable land and new construction (number of housing permits normalized by the initial housing stock) is more negative in the recent boom than it was in the earlier one.[13] For an alternative explanation, we test whether land constraints have forced new construction to peripheries farther away from metro centers in the boom, and the excessive construction in such fringes had led to a greater bust for the whole area.[14] We use the increases in average commute time to work, obtained from the censuses and the American Community surveys, to measure the expansion of MSAs.[15] We did not find significant correlations between the changes in commute time and the land variable in either one of the two booms.

is defined as the change from 1990 to 1996, instead of from 1989 to 1996.

[13]The regressions in Glaeser et al. (2008) show a similar pattern of difference (tables 3 and 7), which disappears in their regressions after controlling for climate, income and other variables.

[14]This possibility was pointed out to us by an anonymous referee.

[15]For the 1982-1989 boom, we compute the increase in commute time as the difference in average commute time between the 1980 and the 1990 censuses (data source: Missouri Census Data Centre). For the 2000-2006 housing boom, we take the difference between the mean travel time to work reported in the 2005-2007 American Community Surveys and that reported in the 1999-2001 surveys.

A potential source of the difference is that land constraint has become more responsible for the increases in house prices during the recent boom. In Glaeser et al. (2008), the variable of land availability attracts a substantially larger coefficient in explaining price appreciations over the 1996-2006 boom than it does over the 1982-1989 episode (more than twice as big without covariates and 40% bigger with control variables; in its Tables 3 and 7). The larger price increases from supply inelasticity in the more recent cycle might have exposed inelastic areas to greater downward pressures in the bust.

6 Conclusion

Using data from over 300 US cities, we examine how residential land use regulation, geographic land scarcity and subprime mortgage credit expansion were related to the amplitude of housing price cycle between January 2000 and July 2009. We find that cities that are more regulated or have less developable land experienced greater price gains between January 2000 and June 2006, and greater price declines between June 2006 and July 2009. Furthermore, the supply constraints in the housing market amplified the boom-and-bust consequences of the subprime expansion in the mortgage market: an increase in local borrowers' reliance on subprime mortgages was associated with greater price booms and busts in cities that are more supply restricted, either by geography or by land use policies.

References

Avery, R. B., Brevoort, K. P., Canner, G. B., 2007. Opportunities and issues in using hmda data. Journal of Real Estate Research 29 (4), 351–380.

Capozza, D. R., Hendershott, P. H., Mack, C., Mayer, C. J., Oct. 2002. Determinants of real house price dynamics. NBER Working Papers 9262, National Bureau of Economic Research, Inc.

Foster, D. D., Summers, A. A., September 2005. Current state legislative and judicial profiles on land-use regulations in the u.s. Working Paper 512, Wharton Real Estate Center, The Wharton School, University of Pennsylvania.

Glaeser, E. L., Gyourko, J., Saiz, A., September 2008. Housing supply and housing bubbles. Journal of Urban Economics 64 (2), 198–217.

Glaeser, E. L., Gyourko, J., Saks, R. E., May 2005. Why have housing prices gone up? American Economic Review 95 (2), 329–333.

Glaeser, E. L., Ward, B. A., May 2009. The causes and consequences of land use regulation: Evidence from greater boston. Journal of Urban Economics 65 (3), 265–278.

Green, R. K., Malpezzi, S., Mayo, S. K., May 2005. Metropolitan-specific estimates of the price elasticity of supply of housing, and their sources. American Economic Review 95 (2), 334–339.

Gyourko, J., Saiz, A., Summers, A., 2008. A New Measure of the Local Regulatory Environment for Housing Markets: The Wharton Residential Land Use Regulatory Index. Urban Studies 45 (3), 693–729.

Helbling, T., Terrones, M., 2003. When bubbles burst. Chapter II, World Economic Outlook.

Hwang, M., Quigley, J. M., 2006. Economic fundamentals in local housing markets: Evidence from u.s. metropolitan regions. Journal of Regional Science 46 (3), 425–453.

Ihlanfeldt, K. R., May 2007. The effect of land use regulation on housing and land prices. Journal of Urban Economics 61 (3), 420–435.

Malpezzi, S., 1996. Housing prices, externalities, and regulation in u.s. metropolitan areas. Journal of Housing Research 7 (2), 209 – 241.

Malpezzi, S., Chun, G. H., Green, R. K., 1998. New place-to-place housing price indexes for u.s. metropolitan areas, and their determinants. Real Estate Economics 26 (2), 235–274.

Malpezzi, S., Wachter, S. M., 2005. The role of speculation in real estate cycles. Journal of Real Estate Literature 13 (2), 143 – 164.

Mian, A., Sufi, A., April 2008. The consequences of mortgage credit expansion: Evidence from the 2007 mortgage default crisis. Working Paper 13936, National Bureau of Economic Research.

Pendall, Rolf, R. P., Martin, J., 2006. From traditional to reformed: A review of the land use regulations in the nations 50 largest metropolitan areas. Metropolitan Policy Program, The Brookings Institution.

Quigley, J., Rosenthal, L., 2005. The effects of land-use regulation on the price of housing: What do we know? what can we learn? Cityscape: A Journal of Policy Development and Research 8 (1), 69–110.

Quigley, J. M., Raphael, S., May 2005. Regulation and the high cost of housing in california. American Economic Review 95 (2), 323–328.

Rose, L. A., November 1989. Topographical constraints and urban land supply indexes. Journal of Urban Economics 26 (3), 335–347.

Rosenthal, S. S., January 1999. Housing supply: The other half of the market a note from the editor. The Journal of Real Estate Finance and Economics 18 (1), 5–7.

Saiz, A., forthcoming. The geographic determinants of housing supply. Quarterly Journal of Economics.

Saks, R. E., 2008. Job creation and housing construction: Constraints on metropolitan area employment growth. Journal of Urban Economics 64 (1), 178 – 195.

Xing, X., Hartzell, D. J., Godschalk, D. R., 2006. Land use regulations and housing markets in large metropolitan areas. Journal of Housing Research 15 (1), 55–79.

Table 1: Summary statistics for key variables

Variable	Mean	Standard deviation	Min	Max	Obs.
Housing price change between Jan 2000 and June 2006 (%)	56.54	57.93	-49.09	454.89	327
Housing price change between June 2006 and July 2009 (%)	-24.94	16.52	-65.25	30.88	327
Wharton Residential Land Use Regulatory Index	0.14	0.87	-1.94	3.46	327
Proportion of undevelopable area in Saiz (2008) (%)	30.76	19.38	1.04	79.64	327
Proportion of mortgage applications denied in 1996 (%)	26.41	12.30	4.77	65.13	327
Proportion of high-cost mortgage loans between 2004 and 2006 (%)	26.13	11.51	5.39	70.32	327

Table 2: Housing price boom and bust in subsamples

Subsamples with	Average price gain 2000-2006	Average price loss 2006-2009	Obs.
more stringent regulation	65.95	-29.19	164
	(4.25)	(1.15)	
less stringent regulation	47.07	-20.65	163
	(4.70)	(1.34)	
more undevelopable area	79.64	-28.58	166
	(4.30)	(1.17)	
less undevelopable area	32.72	-21.18	161
	(3.98)	(1.35)	
more mortgage rejections	73.14	-26.42	164
in 1996	(4.67)	(1.46)	
less mortgage rejections	39.84	-23.44	163
in 1996	(3.99)	(1.08)	
more high-interest loans	69.95	-26.10	164
between 2004 and 2006	(5.32)	(1.53)	
less high-interest loans	43.04	-23.76	163
between 2004 and 2006	(3.25)	(0.99)	

Note: the numbers in the parentheses are the standard errors of means.

Table 3: Main results

Variables	$\frac{P_{2006}-P_{2000}}{P_{2000}}$ (1)	$\frac{P_{2006}-P_{2000}}{P_{2000}}$ (2)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (3)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (4)
regulation	5.64 (2.08)***	4.98 (2.10)**	-4.55 (0.92)***	-4.66 (0.9)***
undevelopable land (%)	0.48 (0.13)***	0.5 (0.12)***	-.26 (0.04)***	-.29 (0.04)***
rejection (%)	0.11 (0.24)		-.43 (0.1)***	
regulation*rejection	0.5 (0.15)***		-.31 (0.08)***	
undevelopable land*rejection	0.04 (0.009)***		-.007 (0.004)**	
high interest loans (%)		0.36 (0.24)		-.38 (0.1)***
regulation*high interest loans		0.3 (0.16)*		-.33 (0.07)***
undevelopable land*high interest loans		0.04 (0.008)***		-.005 (0.003)*
Δ employment 2000-2006 (%)	1.08 (0.36)***	0.99 (0.35)***		
Δ median HH income 2000-2006 (%)	3.85 (0.36)***	4.15 (0.38)***		
Δ employment 2006-2009 (%)			1.28 (0.22)***	1.02 (0.23)***
population density in 2000	0.67 (0.47)	0.58 (0.46)	-.24 (0.14)*	-.24 (0.14)*
population in 2000	-.007 (0.003)**	-.005 (0.003)*	0.001 (0.0007)**	0.0008 (0.0007)
mean HH income in 2000	0.03 (0.08)	0.05 (0.09)	-.12 (0.04)***	-.11 (0.04)***
proportion of urban population (%)	0.46 (0.5)	0.42 (0.5)	-.11 (0.31)	-.12 (0.29)
unemployment rate (%)	2.64 (1.30)**	1.95 (1.21)	0.31 (0.4)	0.11 (0.38)
proportion of vacant housing units (%)	0.006 (0.78)	-.55 (0.7)	-.34 (0.26)	-.16 (0.3)
Const.	56.89 (2.01)***	57.93 (2.10)***	-25.32 (0.79)***	-25.81 (0.82)***
Obs.	327	327	327	327
R^2	0.62	0.63	0.33	0.32
F statistic	79.53	68.52	12.68	14.01

Notes: (1) The variables shown on the top row are dependent variables, measured in percents. (2) The numbers in the parentheses are robust standard errors. (3) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Table 4: Robustness checks with state level indices

Variables	$\frac{P_{2006}-P_{2000}}{P_{2000}}$ (1)	$\frac{P_{2006}-P_{2000}}{P_{2000}}$ (2)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (3)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (4)
state political involvement index	8.30 (1.98)***		-5.98 (0.86)***	
state court involvement index		13.95 (2.86)***		-7.39 (1.65)***
undevelopable land (%)	0.46 (0.13)***	0.43 (0.14)***	-.23 (0.04)***	-.23 (0.05)***
rejection (%)	0.06 (0.24)	-.15 (0.26)	-.37 (0.1)***	-.25 (0.11)**
state political involvement*rejection	0.35 (0.17)**		-.27 (0.08)***	
state court involvement index*rejection		0.02 (0.24)		-.41 (0.12)***
undevelopable land*rejection	0.04 (0.009)***	0.04 (0.009)***	-.007 (0.004)**	-.005 (0.004)
Δ employment 2000-2006 (%)	1.09 (0.34)***	1.11 (0.35)***		
Δ median HH income 2000-2006 (%)	3.64 (0.37)***	3.60 (0.37)***		
Δ employment 2006-2009 (%)			1.33 (0.22)***	1.31 (0.21)***
census profile in 2000	included	included	included	included
Const.	55.45 (1.97)***	56.11 (2.10)***	-24.31 (0.75)***	-24.00 (0.82)***
Obs.	327	327	327	327
R^2	0.63	0.63	0.37	0.35
F statistic	89.5	105.88	17.29	19.91

Notes: (1) The variables shown on the top row are dependent variables, measured in percents. (2) The numbers in the parentheses are robust standard errors. (3) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels. (4) The census profile variables are from the 2000 census and include the following: population size, population density, the level of average household income, the share of urban population, the unemployment rate and the proportion of vacant housing units.

Appendix to "Residential Land Use Regulation and the US Housing Price Cycle Between 2000 and 2009"

November 17, 2010

Table A.1: Robustness checks: including extra interactive terms for the subprime variables

Variables	$\frac{P_{2006}-P_{2000}}{P_{2000}}$ (1)	$\frac{P_{2006}-P_{2000}}{P_{2000}}$ (2)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (3)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (4)
regulation	5.71	4.75	-4.09	-3.77
	(2.17)***	(2.15)**	(0.94)***	(0.9)***
undevelopable land (%)	0.41	0.47	-.24	-.27
	(0.12)***	(0.11)***	(0.04)***	(0.04)***
rejection (%)	0.22		-.54	
	(0.22)		(0.11)***	
regulation*rejection	0.48		-.25	
	(0.14)***		(0.08)***	
undevelopable land*rejection	0.04		-.008	
	(0.008)***		(0.003)**	
high interest loans (%)		0.71		-.70
		(0.24)***		(0.13)***
regulation*high interest loans		0.15		-.20
		(0.16)		(0.08)***
undevelopable land*high interest loans		0.04		-.003
		(0.008)***		(0.003)
Δ employment 2000-2006 (%)	1.03	0.92		
	(0.32)***	(0.34)***		
Δ median HH income 2000-2006 (%)	3.85	4.16		
	(0.35)***	(0.39)***		
Δ employment 2006-2009 (%)			1.46	1.15
			(0.22)***	(0.22)***
census profile in 2000	included	included	included	included
census profile in 2000*rejection	included		included	
census profile in 2000*high interest loans		included		included
Const.	60.46	62.53	-27.52	-29.57
	(2.86)***	(2.89)***	(1.03)***	(1.20)***
Obs.	327	327	327	327
R^2	0.64	0.64	0.37	0.37
F statistic	71.44	50.45	11.38	12.8

Notes: (1) The variables shown on the top row are dependent variables, measured in percents. (2) The numbers in the parentheses are robust standard errors. (3) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Table A.2: Robustness checks: including MSA fixed effects

Variables	$\frac{P_{2006}-P_{2000}}{P_{2000}}$ (1)	$\frac{P_{2006}-P_{2000}}{P_{2000}}$ (2)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (3)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (4)
regulation	-3.19 (3.47)	-3.12 (3.42)	-.25 (0.58)	-.26 (0.57)
rejection (%)	-.12 (0.17)		-.06 (0.06)	
regulation*rejection	-.006 (0.16)		0.004 (0.05)	
undevelopable land*rejection	0.01 (0.01)		-.005 (0.003)**	
high interest loans (%)		-.04 (0.19)		-.14 (0.07)**
regulation*high interest loans		0.05 (0.19)		-.01 (0.06)
undevelopable land*high interest loans		0.02 (0.01)		-.008 (0.003)***
Δ employment 2000-2006 (%)	-.14 (0.27)	-.15 (0.26)		
Δ median HH income 2000-2006 (%)	-.66 (0.96)	-.68 (0.92)		
Δ employment 2006-2009 (%)			-.53 (0.38)	-.53 (0.36)
population density in 2000	-1.15 (0.78)	-1.08 (0.78)	0.23 (0.24)	0.19 (0.22)
population in 2000	0.002 (0.002)	0.002 (0.002)	0.0006 (0.0006)	0.0004 (0.0006)
mean HH income in 2000	-.07 (0.06)	-.04 (0.06)	0.006 (0.02)	-.02 (0.02)
proportion of urban population (%)	-.81 (0.39)**	-.79 (0.38)**	0.12 (0.12)	0.11 (0.12)
unemployment rate (%)	2.68 (0.88)***	2.54 (0.9)***	-.33 (0.29)	-.17 (0.28)
proportion of vacant housing units (%)	-.25 (0.65)	-.19 (0.67)	0.27 (0.14)*	0.27 (0.14)*
MSA fixed effects	included	included	included	included
Const.	56.43 (1.53)***	56.93 (1.38)***	-24.87 (0.36)***	-25.11 (0.36)***
Obs.	327	327	327	327
R^2	0.81	0.81	0.88	0.89
F statistic	1.8	2.21	1.77	2.26

Notes: (1) The variables shown on the top row are dependent variables, measured in percents. (2) The numbers in the parentheses are robust standard errors. (3) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Table A.3: Robustness checks: tests using state-level regulation indices and the share of high-cost loans

Variables	$\frac{P_{2006}-P_{2000}}{P_{2000}}$ (1)	$\frac{P_{2006}-P_{2000}}{P_{2000}}$ (2)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (3)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (4)
state political involvement index	8.01 (1.76)***		-5.97 (0.77)***	
state court involvement index		16.32 (2.68)***		-9.12 (1.51)***
undevelopable land (%)	0.48 (0.12)***	0.42 (0.12)***	-.26 (0.04)***	-.25 (0.04)***
high interest loans (%)	0.35 (0.22)	0.34 (0.23)	-.36 (0.1)***	-.36 (0.1)***
state political involvement*high interest loans	0.23 (0.13)*		-.18 (0.07)***	
state court involvement Index*high interest loans		0.08 (0.26)		-.39 (0.15)***
undevelopable land*high interest loans	0.04 (0.007)***	0.05 (0.008)***	-.009 (0.003)***	-.009 (0.003)***
Δ employment 2000-2006 (%)	0.96 (0.32)***	0.81 (0.32)**		
Δ median HH income 2000-2006 (%)	3.95 (0.39)***	3.90 (0.38)***		
Δ employment 2006-2009 (%)			1.03 (0.23)***	1.11 (0.22)***
census profile in 2000	included	included	included	included
Const.	57.19 (2.00)***	57.38 (2.00)***	-25.04 (0.73)***	-25.04 (0.74)***
Obs.	327	327	327	327
R^2	0.64	0.64	0.36	0.37
F statistic	71.36	101.16	18.82	19.38

Notes: (1) The variables shown on the top row are dependent variables, measured in percents. (2) The numbers in the parentheses are robust standard errors. (3) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels.

Table A.4: Compare the 2006-2009 bust to the 1989-1996 bust

Variables	$\frac{P_{1996}-P_{1989}}{P_{1989}}$ (1)	$\frac{P_{2009}-P_{2006}}{P_{2006}}$ (2)
undevelopable land (%)	-.06	-.21
	(0.08)	(0.05)***
Δ employment 1990-1996 (%)	0.59	
	(0.21)***	
Δ employment 2006-2009 (%)		2.19
		(0.40)***
Const.	.32	-15.7
	(1.97)	(1.23)***
Obs.	59	59
R^2	0.16	0.62
F statistic	6.93	67.10

Notes: (1) The variables shown on the top row are dependent variables, measured in percents. (2) The numbers in the parentheses are robust standard errors. (3) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels. (4) The data currently available on the BLS State and Area Employment, Hours and Earnings (SM) program does not go back before 1990. So the change in employment for the earlier episode is defined as the change from 1990 to 1996, instead of from 1989 to 1996.