MERCATUS SPECIAL STUDY

REASSESSING THE ROLE OF SUPPLY AND DEMAND ON HOUSING BUBBLE PRICES

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ABSTRACT

The existing literature on price changes in the housing market between 2002 and 2010 has largely focused on temporary sources of demand—loosening and then tightening of credit markets or trend-following speculative activity. Using a new variable that quantifies the effect of inelastic supply on local prices, I estimate the relative scale of both supply- and demand-related factors on home prices.

The most important factors in changing home prices from 2002 to 2006 and from 2006 to 2010 were related to differences between metropolitan areas: (a) differences in regional demand for housing from factors like population growth, and (b) differences in housing supply elasticity. Much of the metropolitan area demand shifts were related to housing supply, because a lack of supply in some metropolitan areas caused families to migrate, increasing demand enough in other metropolitan areas to change home-price trends.

There was a credit boom and bust, but, from 2002 to 2006, the credit boom was associated with rising prices more in locations where price changes associated with supply constraints were moderate. Tightened lending standards after 2007 created pro-cyclical collapsing home prices in moderately priced regions while not addressing the supply constraints that were responsible for the most excessive price increases.

JEL codes: R310, G510

Keywords: housing, housing price determination, housing prices, housing supply, mortgage lending, regional housing market, residential real estate

The housing boom that ended in 2007 was very different from place to place. In many locations home prices remained relatively moderate, while in some regions prices skyrocketed. Research on the causes of the boom has focused on changes in demand. Demand for shelter itself should be rather slow to change; additional cyclical changes in housing demand can be the result of alterations in credit markets and buyer attitudes. These factors include the expansion of lending to less qualified borrowers, lax underwriting, new forms of financial products, or investor and speculator buying activity.

However, in retrospect, there is evidence that the pre-2007 housing market was primarily driven by location and basic demand for shelter.[1] Patterns in home prices created by inelastic supply were already in place before the peak housing-boom years, and changing home prices reflected a continuation and acceleration of those patterns. The problem of inelastic urban-housing supply has become binding enough that moderate shifts in demand for shelter can create volatile market activity without requiring a causal force of irrational or reckless lending or speculation.[2]

Researchers, such as the teams of Griffin, Kruger, and Maturana[3] and Atif Mian and Amir Sufi,[4] have frequently viewed explanations for rising home prices

1. See Gabriel Chodorow-Reich, Adam M. Guren, and Timothy J. McQuade, "The 2000s Housing Cycle With 2020 Hindsight: A Neo-Kindlebergerian View" (NBER Working Paper No. 29140, National Bureau of Economic Research, Cambridge, MA, August 2021), http://www.nber.org/papers/w29140.
2. Kevin Erdmann, *Shut Out* (London: Rowman & Littlefield, 2019). See also Kevin Erdmann, "Build More Houses: How an Incorrect Perception of Housing Supply Fueled the Great Recession and Slowed Recovery" (Mercatus Research Series, Mercatus Center at George Mason University, Arlington, VA, May 3, 2021).
3. John M. Griffin, Samuel Kruger, and Gonzalo Maturana, "What Drove the 2003–2006 House Price Boom and Subsequent Collapse? Disentangling Competing Explanations," *Journal of Financial Economics* 41, no. 3 (2021), 1007–35.
4. Atif Mian and Amir Sufi, "Household Debt and Defaults from 2000 to 2010: The Credit Supply View" (Kreisman Working Papers Series in Housing and Law Policy No. 28, University of Chicago Law School, Chicago, IL, June 2016).

as a debate between two schools of thought. First is the *credit-supply school*, which concluded that aggressive lending pressed capital into formerly credit-constrained neighborhoods. They argue that after controlling for regional differences, new aggressive forms of lending have been correlated with rising prices locally.

The *passive-credit school*, by contrast, concluded that speculative activity in general led to rising home prices. Over-optimistic buyers pushed up prices, so that increased use of credit was more of a facilitator or a result of speculative activity than a cause.

The debate remains unresolved, yet the debate rests on some shared maxims. Those include an agreement that construction activity and home-price appreciation both increased unsustainably, that the increase in activity and prices was triggered by unrealistic expectations, and that the eventual decline in activity and prices was generally an inevitable return to normalcy that confirms the unsustainability of the boom-era trends.

However, those premises are questionable. Increases in construction and home prices were based in fundamentals and were cross-sectionally correlated with rising rents. The increase in housing demand was moderate and was not unusually high compared to either past housing cycles in the United States or ongoing shifts in housing demand in other countries. Rising prices were primarily caused by highly inelastic housing supply in key metropolitan statistical areas (MSAs) (New York, Los Angeles, San Francisco, and Boston, primarily), which led to displacement of households out of those MSAs. The endemic problem of inadequate housing in those MSAs meant that moderate increases in the demand for housing per capita led to regional depopulation. The migration that resulted led to secondary housing booms in the regions that took in a large portion of those housing migrants (Florida, Arizona, Nevada, and inland California).

Those primary and secondary housing booms roughly correspond, respectively, to the MSAs where inelastic supply meant that high prices were not entirely unexpected and to MSAs where high prices developed in spite of more elastic local supply conditions. Eventually, the collapse in prices and construction activity was largely the result of monetary and lending policies that cut the moderate building boom short and ended the migration surge into the secondary boom cities.[5]

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5. Scott Sumner and Kevin Erdmann, "Housing Policy, Monetary Policy, and the Great Recession" (Mercatus Research Series, Mercatus Center at George Mason University, Arlington, VA, August 4, 2020). See also Erdmann, "Build More Houses," May 3, 2021. See also Gregor Schubert, "House Price Contagion and US City Migration Networks" (Joint Center for Housing Studies of Harvard University, Cambridge, MA, March 4, 2021), https://www.jchs.harvard.edu/research-areas/working-papers/house-price-contagion-and-us-city-migration-networks.

This description of events aligns more with the passive-credit school. But perhaps a third hypothesis should be considered: that both credit and speculative activity were largely passive or secondary factors driven by housing markets that were volatile because of fundamental supply issues. The basic trends in prices and construction can be adequately described with fundamentals rooted in supply and demand for shelter and location, particularly during the period when construction activity was rising.

Changes in price are, necessarily, a dual product of both supply and demand factors. Generally, in analysis of the causes of changing home prices, the demand factors estimated by both the credit-supply and the passive-credit schools are found to have had a much larger effect where supply is inelastic than where supply is elastic. Supply elasticity is usually treated as a control variable in this analysis. This creates a rhetorical tendency to attribute causality to the demand factors in question. The descriptive form typically is something like this—Source X of excess demand caused home prices to rise unsustainably, and it especially had that effect where supply was inelastic.

There is also, potentially, a second problem with this norm in research design. Supply elasticity is frequently accounted for by using fixed-effects variables for each region, usually at the metropolitan-area level or the county level. This requires the assumption that local fixed factors, such as supply elasticity, affect prices across the region uniformly.

What if regional prices aren't uniformly affected by changing demand under different conditions of supply? What if there are systematic differences across a given region, which will cause price changes to be more volatile in some neighborhoods than they are in other neighborhoods? If that is the case, then a uniform regional fixed effect could introduce bias to a model.

Mian and Sufi estimated the effect of subprime lending on housing markets at the ZIP code level, using county fixed effects. The reported standard deviation of annualized home-price changes from 2002 to 2005 between counties in their data was 7.8 percent, and the standard deviation within counties was 1.6 percent.[6] The variation between counties was much larger than the variation within them. That means that the vast majority of the variance in price changes is erased by controlling for regional differences. Furthermore, if fixed effects introduce even a small amount of bias, that bias could have as large an effect on regression output

6. Atif Mian and Amir Sufi, "The Consequences of Mortgage Credit Expansion: Evidence from the 2007 Mortgage Default Crisis. The Initiative on Global Markets," Table I, Panel A (National Initiative on Global Markets, University of Chicago, Graduate School of Business, May 2008), https://web-docs.stern.nyu.edu/salomon/docs/crisis/SUFI.pdf.

as local price differences have. And if that bias is correlated with the demand factor being estimated, then the bias could lead to a wrongly estimated effect of the demand factor.

Even before the boom years of 2002 to 2006, in MSAs with inelastic supply, there were systematic differences in home-price levels within regions. In recent analysis, I have found that within an MSA, inelastic housing supply has a greater proportional effect on low-tier parts of the market than on high-tier parts. The effect of inelastic supply is to force wealthier households toward the lower end of the market in search of affordable homes within the region. This puts undue pricing pressure on the more affordable neighborhoods in an MSA.

MSAs generally have a relatively linear systematic relationship between prices and local incomes. Where supply is inelastic, the price/income ratio becomes systematically higher as one moves to ZIP codes in the MSA characterized by lower incomes. This is an MSA's price/income slope. Among MSAs, a steeply negative price/income slope is correlated with several features of inelastic supply—such as negative net domestic migration, rising MSA average incomes, a slowing of the rate at which aging existing homes filter down to residents with lower incomes, or even a reversal of filtering in which aging homes filter up to residents with higher incomes.[7]

The price/income slope can be used as a proxy variable for supply elasticity. This can be an important tool for reconsidering the debates about the American housing bubble in the first decade of this century. This variable can help to add a third element to the debate for consideration—the degree to which inelastic supply was putting upward pressure on prices in a way that is distinct from forces of cyclical demand.

The difficulty of parsing these various potential causal elements is that many of them create similar outcomes. More aggressive lending at the extensive margin might push prices up, especially where incomes are lower, just as inelastic supply does. One way to think about these different forces is that loose lending may push up prices in a neighborhood because buyers matching the profile of the typical resident are more able to put a bid on a home. Where supply inelasticity pushes up the prices of more affordable homes, the fundamental demand pressure comes from households with greater financial means outside the neighborhood. Households with lower incomes are pressed into a declining portion of the MSA's housing stock when existing homes are claimed

7. Kevin Erdmann, "Price Is the Medium Through Which Housing Filters Up or Down: A Proposal for Price/Income as an Indicator of Housing Supply Elasticity" (Mercatus Policy Research, Mercatus Center at George Mason University, Arlington, VA, November 2022).

by households with higher incomes. Various facets of this process are frequently referred to as *gentrification*.

Migration patterns provide one reason to believe that inelastic supply was a more important factor in the housing boom and bust than either lending or speculation. When home prices were rising from 2002 to 2006, households, and especially households with lower-than-average incomes, were increasingly moving away from the most expensive cities. When home prices declined, the most expensive cities' net domestic migration remained negative but diminished. This suggests that a supply-constraint condition reached across both boom and bust. It also suggests that some rising prices associated with the boom were the result of an increase in gentrification demand that was triggered by a lack of adequate supply.[8]

Both before and after the housing boom of the first decade of the 21st century, inelastic supply in some MSAs had produced asymmetrical effects on prices—pushing up the prices of homes in ZIP codes with low incomes more than homes in ZIP codes with high incomes. This is a pattern that has persisted through several market regimes with different levels and types of demand. Home price appreciation negatively correlated with incomes is not necessarily the result of loose credit; it can also be the result of inelastic supply, regardless of credit conditions.

In the analysis that follows, I will

- use the price/income slope measure proposed in "Price Is the Medium Through Which Housing Filters Up or Down" to revisit the literature on the effects of speculation and credit supply on price trends within MSAs from 2002 to 2010;
- highlight a potential problem with income-control variables in analysis of changing home prices;
- demonstrate how large a proportion of price changes from 2002 to 2010 were due to regional differences and to income differences between ZIP codes;
- propose that unbiased regional fixed effects may require both a dummy variable and an income-interacted variable for each MSA to fully control for metropolitan-specific changes in demand and the effect of metropolitan-specific supply elasticity on prices;

8. Erdmann, *Shut Out*, chapter 5.

- further propose that, in analysis, the price/income slope can be used as a proxy for preexisting local supply constraints in attempts to attribute price changes to preexisting conditions (such as local credit constraints);
- extend that analysis by interacting various demand-side variables (proxies for credit supply and speculative activity) with the price/income slope supply variable;
- discuss the relative importance of various demand-side variables, the supply-elasticity variable, and metropolitan-area fixed effects in price changes from 2002 to 2006 and 2006 to 2010; and
- identify systematic correlations between regression residuals and ZIP code income within each metropolitan area in the period from 2006 to 2010.

This last point highlights the possible need to recognize the importance of novel and severe changes in credit access (even for prime borrowers) after 2007 as a factor affecting home prices during the housing-bust period of 2006 to 2010. This was not simply a reversal of boom-era lending standards.

Disentangling the Effects of Supply and Demand on Changing Prices

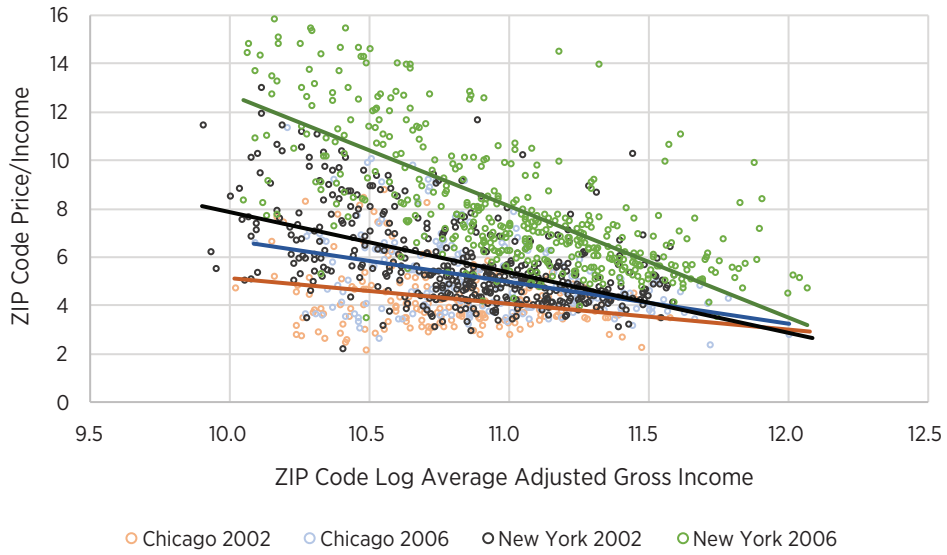
Figure 1 highlights how income-sensitive price patterns are persistently different in different MSAs.[9] The orange line represents the price/income line in Chicago in 2002, and the blue line represents the price/income line in Chicago in 2006. The black line is the price/income line in New York City in 2002, and the green line is the price/income line in New York City in 2006. These are simply the ordinary least squares regression lines of the median price/income ratio in each ZIP code against each ZIP code's average income.

The price/income lines in both MSAs have a fulcrum at the high end with a similar income and a similar price/income level, from which the price/income lines effectively swivel.[10] The price/income lines in both metropolitan areas swivel

9. See Appendix 1 for descriptions of data sources.

10. In Appendix 3 of "Price Is the Medium Through Which Housing Filters Up or Down," I outlined a framework for describing each MSA's housing market with three variables: (a) the price/income level of a fulcrum ZIP code at a given ZIP code income (which, in all cases, is higher than the metropolitan area average) where the price/income level is relatively stable and changes are not correlated with changes in the price/income slope, (b) the price/income slope that reflects the systematic relationship between a ZIP code's price/income level and its income relative to the fulcrum ZIP code (attributed to the relative scale of supply constraints in each metropolitan area), and (c) idiosyncratic differences in ZIP code price/income levels.

FIGURE 1. PRICE/INCOME IN CHICAGO AND NEW YORK CITY



around fulcrum points with a log income of just above 12 (about $160,000) and a price/income level of about 3.[11] In 2002, the price/income slope was steeper in New York City than it was in Chicago because supply in New York City is less elastic. Then, in both MSAs, the slope steepened from 2002 to 2006 so that the slope in Chicago in 2006 was nearly as steep as it had been in 2002 in New York City.

Here we can see the difficulty of disentangling the effects of supply and demand. In any case, a steeper slope is associated with a shift in the intersection of housing supply and demand at the MSA level. Differing local rates of building suggest that the difference between New York and Chicago in 2002 was largely due to less elastic supply in New York City compared to Chicago. The housing boom that coincided with the steepening from 2002 to 2006 in both MSAs suggests that the steepening over time was due to the demand curve shifting to the right in both MSAs.

This raises some questions. What is the sustainable price/income slope? Is the sustainable slope different in New York City than in Chicago? Was a price/income slope of –1.73 in Chicago in 2006 the result of an unsustainable demand

11. As in "Price Is the Medium Through Which Housing Filters Up or Down," I have removed ZIP codes with very high incomes. Above log income of about 12, price/income ratios tend toward a minimum level that creates concavity. Truncating the few ZIP codes with very high incomes helps to highlight the linear correlation between price/income and income among the remaining ZIP codes.

bubble? If so, then was the price/income slope of –2.48 in New York City in 2002 also unsustainable? The price/income slope in New York City has not been that low in any year since 2002.

The conventional intuition about housing markets from about 2002 to 2006 has been to identify the period as a credit-cycle boom and to associate rising prices in credit-constrained areas as unsustainable temporary effects of that boom. That intuition leads to an expectation that high prices at the beginning of the period can be attributed to locally inelastic supply and that rising prices in credit-constrained areas during the period might be attributed to changing credit conditions. The patterns highlighted above complicate that intuition. Inelastic supply is associated with higher prices in ZIP codes with low incomes regardless of whether the source of demand is cyclical, secular, credit-fueled, or a fundamental demand for shelter.

Testing Potential Causes of Rising Home Prices from 2002 to 2006

Regressions with different sets of regional controls can be informative when analyzing the relative importance of various factors that might influence home prices.

$$\text{Equation 1: } \Delta P = \beta(1) + \beta(2) \times D + \beta(\text{i}) \times C(\text{i}) + \varepsilon$$

In equation 1, ΔP is the log change in price/income ratio in a ZIP code over a period of time. In the analysis below, the period of change is 2002 to 2006. D is the housing-demand factor that is being tested as an influence on changing prices. Of course, various other control variables, $C(\text{i})$, can be added.

Because local differences in home-price changes have been so substantial, this basic regression has an omitted variable problem. The demand factor in question (subprime lending, speculative activity, etc.) could be correlated with expensive locations. Where home prices are more volatile, they might attract speculators, reckless lenders, and so on. To solve that problem, regional fixed effects can be added, along with other control variables.

$$\text{Equation 2: } \Delta P = \beta(1) + \beta(2) \times D + \left(\sum \beta(3)_{\text{MSA}} \times Dummy_{\text{MSA}}\right) + \beta(\text{i}) \times C(\text{i}) + \varepsilon$$

By controlling for regional fixed effects, one can isolate the effect of the *D* variable after accounting for changing conditions that affect an entire regional housing market. Other control variables, *C*(i), also account for various factors that might systematically influence home prices, such as local income.

In the Griffin, Kruger, and Maturana[12] review of several potential demand factors, they found that all seven factors that they tested correlated with rising prices across MSAs (without controlling for fixed effects). They included four credit-supply factors (subprime lender market share, non-core-deposit lender market share, originator-misreported second-lien mortgage activity, and private securitization activity) and three passive-credit, or speculation, factors (non-owner purchasing activity, out-of-town purchaser activity, and home-price growth preceding the test period).

Using an approach similar to Griffin, Kruger, and Maturana's, I used home prices at the ZIP code level. The data include 2,713 ZIP codes from the largest 28 MSAs with adequate data for ZIP code incomes, home prices, and lending activity. The dependent variable is the log change in the price/income ratio from 2002 to 2006. This is based on annual figures. Home prices for each year are an average of 12 monthly estimates. Control variables include residential density, ZIP code income, and MSA fixed effects.

Existing research has generally focused on price appreciation. Here changes in the price/income level are used instead, for three reasons. First, using income as a denominator creates a natural nominal adjustment that minimizes the effect of changes in nominal dollar-denominated variables over time that are unrelated to housing markets. Second, it helps to control for idiosyncratic local changes in income, so when home prices are rising in proportion to local incomes, they are differentiated from real local price changes that are unrelated to local income changes. Third, I will be using an independent variable that is a proxy for supply elasticity, which is defined using differences in price/income between ZIP codes.

The independent variables are based on preliminary conditions in 2002. There are two variables that may be proxies for credit supply—one is the share of mortgages that are Federal Housing Administration (FHA) loans, and the other is the denial rate of mortgage applications. Both of these measures should correlate with local credit constraints. Where FHA loans are more popular and where more mortgage applications are denied, demand should be sensitive to credit conditions.

12. Griffin, Kruger, and Maturana, "What Drove the 2003–2006 House Price Boom and Subsequent Collapse?"

I also report on two speculation variables—variables whose explanatory power aligns more with the passive-credit school. The first is the share of mortgage applications in 2002 to non-owner-occupiers. The second is the rate of price appreciation from 2001 to 2002. This could be a proxy for a number of factors, including herding behavior, but might simply reflect persistent idiosyncratic changing local conditions or sensitivity to the business cycle. For this reason, it could also be considered an important control variable.

In some specifications, the 2002 price/income slope line for each MSA was multiplied by relative ZIP code income; in others, income-interacted MSA fixed effects were used. The price/income slope variable may require some explanation. Like the FHA-share variable and the denial-rate variable, it will tend to have a positive coefficient during the 2002 to 2006 housing-boom time frame. Viewing figure 1 may add clarity. In New York City, in 2002, the price/income slope was –2.48 and in Chicago it was –1.08. If the price/income slope multiplied by the ZIP code income variable has a coefficient of 0.1, that means that a ZIP code that started the period with 1 percent lower income in New York City in 2002 was associated with an additional 0.248 percent increase in price/income from 2002 to 2006. An income 1 percent lower in Chicago in 2002 was associated with an additional 0.108 percent change in price/income from 2002 to 2006. This is an attempt to estimate the sensitivity to changing demand created by the preexisting level of supply inelasticity in each MSA. Generally, a higher positive coefficient means that prices increased more in ZIP codes that were located within MSAs with inelastic housing supply and that were more sensitive to supply inelasticity.

Table 1 highlights some foundational points. In column 1, no MSA fixed effects or control variables are included. Some of the independent variables are statistically significant, but on their own they explain an exceedingly small portion of changing prices from 2002 to 2006. A change in any of the independent variables of one standard deviation is generally associated with a percentage change in price/income levels in the low single digits, even when the results are highly statistically significant. During the 2002 to 2006 period, among the 2,713 ZIP codes here, the average log change in the price/income level was 0.24 points and the standard deviation was 0.22 points. The credit supply and speculation variables account for a small fraction of that.

This is not a function of this dataset. The relative scale and variance of price changes and the effect of the credit supply and speculation variables that Griffin, Kruger, and Maturana report, for instance, are also small relative to total changes.

TABLE 1. REGRESSIONS WITH DEPENDENT VARIABLE LOG CHANGE IN PRICE/INCOME, 2002–2006

FHA Share	−0.006	**0.044**	**0.072**		**0.030**
	0.005	0.004	0.003		0.003
Denial Rate	**0.038**	**0.045**	**0.034**		0.001
	0.006	0.004	0.003		0.002
Non-Owner-Occupied Share	**0.023**	−0.009	**−0.009**		**−0.018**
	0.004	0.004	0.003		0.003
2001–2002 Price Change		**0.140**	**0.042**	**0.025**	**0.032**
		0.004	0.005	0.004	0.004
2002 Income				**−0.089**	**−0.078**
				0.002	0.003
Control Variables & MSA Fixed Effects	No	No	Yes	Yes	Yes
Observations	2713	2713	2713	2713	2713
R^2	0.046	0.424	0.790	0.830	0.841

Note: Standard errors are shown below coefficients. Coefficients are standardized to reflect a change of 1 standard deviation in the independent variable. Boldface type designates *p* values of < 0.01. FHA = Fedral Housing Administration; MSA = metropolitan statistical area.

In column 2, the preboom trend variable of price changes from 2001 to 2002 is included. That variable alone is much more explanatory than the other independent variables. In column 3, MSA fixed effects are added. MSA fixed effects also improve the fit of the regression much more than the independent variables do.

In column 4, only control variables and MSA fixed effects are displayed, whereas in column 5 all independent variables, control variables, and fixed effects are shown. Some of the independent credit-supply and speculation variables have a statistically significant correlation with changing price/income, but on the whole, they have very little effect on the total fit.

This also is similar to the results from Griffin, Kruger, and Maturana. In each type of regression they describe, the R^2 figure is similar regardless of which credit supply or speculation variables they include. Almost all of the fit between estimated price changes and measured price changes is due to the fixed effects and control variables.[13]

13. See Griffin, Kruger, and Maturana, "What Drove the 2003–2006 House Price Boom and Subsequent Collapse?," table 3.

In order of importance, the factors influencing changing home prices are (a) the MSA that the ZIP code is in, (b) the income level of the ZIP code, (c) the preboom trend of prices in the ZIP code, and (d) the other credit-supply and speculation variables. The debate about credit supply versus speculation has been a controversy about an exceedingly small portion of the mystery. This is somewhat justified if the local factors and controls are neutral or arbitrary factors that do not convey much cyclical information. However, as I have outlined above, embedded within those local fixed effects and controls is valuable information about the effect of supply elasticity on home prices. The power of the control variables and MSA fixed effects is evident in the results of the various regressions. Identifying the signal that inelastic supply creates within an MSA's housing market provides an opportunity to carve out some useful information from those variables, with the goal of adding an additional type of independent variable—a supply-elasticity variable—to compare to the credit-supply and speculation variables. By adding a variable scaled to each MSA's price/income slope, two additional factors can be added to the fundamental drivers of changing home prices from 2002 to 2006. In addition to credit-supply and speculation variables, (a) the effects of housing-supply elasticity and (b) other sources of changing demand that are uniform across individual MSAs can be estimated.

The coefficients for the preboom trend (2001–2002) price-change variable in table 1 reflect the relative importance of the factors at play in the period from 2002 to 2006. With no controls or MSA fixed effects, price changes from 2002 to 2006 were highly correlated with price changes from 2001 to 2002. In fact, each 1 percent increase in price from 2001 to 2002 was associated with a 3 percent increase in the price/income ratio in a given ZIP code—nearly a 1:1 persistence in annual price trends. (Table 1 coefficients are scaled to standard deviations of the independent variables, so the 0.140 coefficient is the four-year change associated with a 0.047 one-year pretrend change.) Adding in MSA fixed effects (column 3 from table 1) reduces the effect by about two-thirds. In other words, most of the persistence in price trends was related to the MSA the ZIP code was located in.

Adding the income-control variable to the equation further weakens the effect of the preboom trend price change. The coefficient of the 2001–2002 price-change variable declines further from 0.042 to 0.025 (compare column 3 to column 4). So, after accounting for the trends of different MSAs, nearly half of the remaining correlation between 2001 to 2002 price changes and changes in 2002 to 2006 price/income levels is related to ZIP code income. As the coefficients of

the income variable make clear, income has been an important factor in relative home-price appreciation, and some of that was a continuation of preexisting trends.

The coefficients of the other variables also change with the various specifications. The market share of non-owner-occupied mortgages has a positive coefficient when MSA fixed effects are not applied, but the coefficient turns negative when they are applied. Similarly, the coefficient on the denial rate of mortgage applications is positive without MSA fixed effects but is weakened when controls are applied. FHA market share has the opposite pattern: it is insignificant without MSA fixed effects but strengthens with fixed effects, though it weakens when an income variable is included. These patterns are somewhat similar to the patterns found by Griffin, Kruger, and Maturana, who found that speculative variables tended to have strong correlations with price increases in general but not within MSAs. On the other hand, some credit-supply variables were significantly and positively correlated with price appreciation within MSAs.

The income variable here signals something important. The coefficients are negative. In other words, systematically, ZIP codes with lower incomes experienced higher home-price appreciation during the 2002 to 2006 boom period. Mian and Sufi identified this as strong evidence in support of the credit-supply thesis: "The primary counter-argument to our supply interpretation is that high latent demand zip codes experience relative mortgage origination and house price growth from 2001 to 2005 because of relative improvements in demand conditions such as credit quality or productivity. However, a number of facts dispute this concern. First, high latent demand zip codes experience negative relative income, wage, employment, and establishment growth from 2001 to 2005."[14]

Because the dependent variable here is price/income, it is especially sensitive to the trends Mian and Sufi identified. On the other hand, average prices and average price changes of different MSAs were positively correlated with income growth from 2002 to 2006. ZIP codes that had low incomes or low income growth compared to other *local* ZIP codes did not necessarily have low incomes or low income growth compared to ZIP codes in other MSAs, so correlations between income, income growth, and price changes were at least partially due to controlling for regional differences.[15] Furthermore, some research that supports non-credit sources of demand has found that while prices increased in areas with

14. Mian and Sufi, "The Consequences of Mortgage Credit Expansion," 2.
15. Erdmann, *Shut Out*, chapter 3, and "Price Is the Medium," appendix 3.

lower incomes, the average buyers were generally qualified with improving economic prospects.[16]

If one assumes that rising prices in ZIP codes with low incomes are driven by housing demand from the existing residents, then it is reasonable to conclude that some perverse elements of credit expansion were important. But in supply-constrained MSAs, the demand for housing comes from the unwillingness of local municipalities to expand housing to accommodate new residential growth. The amount of local housing supply available to residents with low incomes actually shrinks as a result of those supply pressures, so rising housing costs for the residents who choose to remain in spite of low incomes is not necessarily the result of rising demand from the residents with low incomes, in spite of initial appearances. Residents with low incomes from expensive MSAs were moving away from those MSAs at a fast clip from 2002 to 2006. They were not a likely source of rising housing demand in the ZIP codes they were moving away from. Each ZIP code is not an island. Substitutions within the housing market of a given MSA are important. Newspapers in housing-constrained cities are filled with articles complaining about gentrification—a stark reminder of very localized encroachment of housing demand as a result of inadequate supply. Perhaps considering prices in four quadrants (table 2) can help clarify the sources of rising prices.

TABLE 2. WHAT MIGHT CAUSE RISING HOME PRICES?

		MSAs	
		Low Income	High Income
ZIP Codes	Low Income	Credit Supply	Inelastic Supply
	High Income		Speculation

16. See Manuel Adelino, Antoinette Schoar, and Felipe Severino, "Loan Originations and Defaults in the Mortgage Crisis: The Role of the Middle Class" (Tuck School of Business Working Paper No. 2546427, Duke I&E Research Paper No. 15-8, March 2016); see also Christopher L. Foote, Lara Loewenstein, and Paul Willen, "Cross-Sectional Patterns of Mortgage Debt During the Housing Boom: Evidence and Implications" (NBER Working Paper No. w22985, National Bureau of Economic Research, Cambridge, MA, December 2016), https://www.nber.org/papers/w22985; and Stefania Albanesi, Giacomo De Giorgi, and Jaromir Nosal, "Credit Growth and the Financial Crisis: A New Narrative" (NBER Working Paper No. w23740, National Bureau of Economic Research, Cambridge, MA, August 2017), http://www.nber.org/papers/w23740.

When home prices are rising the most where incomes are lower, it is reasonable to infer that aggressive supply of credit is a fundamental cause. In a market in which home prices are rising the most where incomes are higher, it is reasonable to infer that trend-following, speculation, herding behavior, and so on are causes, or at least are factors.

This is, more or less, the source of debate between the credit-supply school and the passive-credit school. If one controls for differences between MSAs so that only differences within MSAs are measured, then it is possible to isolate evidence that prices are rising faster in ZIP codes with low incomes. This is what the credit-supply school finds. But as the regression results in table 1 demonstrate, most of the variance in price appreciation from 2002 to 2006 was determined by the MSA the home was in, and those were generally MSAs with higher beginning prices and higher incomes. This aligns with the passive-credit school.

However, the peculiar market where prices are rising the most in ZIP codes with low incomes that are located in MSAs with high incomes is the result of localized supply inelasticity. It could be that the evidence that seems to support the credit-supply thesis and the evidence that seems to support the speculative theses are both measuring facets of a third potential causal factor: localized inelastic supply. Both of those schools could be "feeling different parts of the elephant," so to speak. Of course, it could also be possible—in fact, it is quite likely—that each of these factors was in play from 2002 to 2006. Isolating the three types of market trends can shed light on the relative importance of each factor.

MSA Fixed Effects with an Income Interaction

Equation 3 details one way to account for the regional price patterns described above.

$$\text{Equation 3: } \Delta P = \beta(1) + \beta(2) \times D + (\Sigma\, \beta(3)_{\text{MSA}} \times Dummy_{\text{MSA}}) + (\Sigma\, \beta(4)_{\text{MSA}} \times I \times Dummy_{\text{MSA}}) + \beta(\text{i}) \times C(\text{i}) + \varepsilon$$

The new variable, *I*, is the log income in a given ZIP code. This replaces a uniform income-control variable. Assigning each MSA a coefficient on the basis of a dummy variable and a coefficient that interacts with income will control for both a uniform change in prices in each MSA and the change in each MSA's unique price/income slope.

Income is one of the variables that is commonly controlled for in one way or another, but controlling for income uniformly cannot capture the effect

described above. Home prices are sensitive to incomes to a different degree in every MSA, depending on local supply conditions. The relationship between income and home prices is not uniform. In some MSAs, price/income ratios vary widely across the MSA, while in others they do not vary much at all, so a simple control for income does not capture most of the interaction between income and home prices. The relationship between income and home prices is not constant; it is sensitive to local supply elasticity.

Referencing Chicago and New York City in figure 1 once again, a uniform control for the correlation between prices and incomes would overestimate the correlation between income and price/income ratios in Chicago ZIP codes and underestimate the correlation in New York City ZIP codes.

Table 3 displays the results of specifications based on equation 3. As with the simpler specifications in table 1, almost all of the fit of the regressions comes from the control variables and fixed effects, so all three columns have a similar r-squared value.

However, I am surprised to see that when the independent variables are included (shown in column 2) along with both types of MSA fixed effects, their scale and statistical significance does not weaken, compared to column 5 of table 1. (The market share of non-owner-occupiers is associated with a slightly less negative change in prices in table 3, but if speculation is driving prices higher, that coefficient should be positive.) On the basis of the analysis above, I had expected these more comprehensive MSA fixed-effects controls to lower the correlation of the independent variables. My intuition was that an expensive city with inelastic supply would tend to have both higher price appreciation and ZIP codes with more signals of credit constraints. By controlling more fully for the effects of inelastic supply, I expected those correlations to decline.

But the way those correlations are strengthened is intriguing. In table 3, column 3, in addition to using both dummy and income-interacted fixed effects, I have interacted each independent variable with income. Including the interactions increases the scale and significance of the FHA market-share variable even more, and the interaction between FHA market share and income is positive. In other words, FHA market share is a more important influence on prices in ZIP codes where FHA market share and incomes are both higher than average. This is an odd interaction if FHA market share is a signal of credit constraints and if expanding credit is associated with prices rising the most where incomes are lower.

Yet not too much reliance should be placed on the outcomes shown in table 3. Using both dummy MSA fixed effects and income-interacted MSA fixed effects puts a great deal of power in the controls. Both fixed-effects variables

TABLE 3. REGRESSIONS WITH DEPENDENT VARIABLE LOG CHANGE IN PRICE/INCOME, 2002–2006

FHA Share		**0.036** 0.003	**0.041** 0.004
Denial Rate		0.001 0.003	0.002 0.003
Non-Owner-Occupied Share		**–0.014** 0.003	**–0.013** 0.003
2001–2002 Price Change	**0.028** 0.005	**0.034** 0.005	**0.032** 0.005
FHA Share x Income			**0.015** 0.004
Denial Rate x Income			0.002 0.006
Non-Owner-Occupied Share x Income			–0.007 0.006
2001–2002 Price Change x Income			–0.004 0.009
Control Variables & MSA Dummy & Income-Interacted Fixed Effects	Yes	Yes	Yes
Observations	2713	2713	2713
R^2	0.840	0.852	0.853

Note: Standard errors are shown below coefficients. Coefficients are standardized to reflect a change of 1 standard deviation in the independent variable. Boldface type designates *p* values of < 0.01. FHA = Fedral Housing Administration; MSA = metropolitan statistical area.

can pick up the effects of changes that happened after 2002 so that changes in lending activity that correlate negatively with incomes might be captured by the income-interacted fixed effects rather than by the independent variables. Even though the coefficients of the credit variables are strengthened when the interacted fixed effects are included, they might still be understated.

Adding a Supply-Elasticity Variable

In order to test these effects without adding that bias, equation 4 can be used.

$$\text{Equation 4: } \Delta P = \beta(1) + \beta(2) \times D + \beta(3) \times Price/Income\ Slope_{2002,\text{MSA}} \times I \times Dummy_{\text{MSA}} + [\Sigma\, \beta(4)_{\text{MSA}} \times Dummy_{\text{MSA}}] + \beta(\text{i}) \times C(\text{i}) + \varepsilon$$

Instead of adding another fixed effect, equation 4 adds another independent variable that is a proxy for the preexisting MSA supply elasticity. As described above, where housing supply is inelastic, it has a systematic, income-sensitive effect on home prices. In inelastic MSAs, homes in ZIP codes with lower incomes have higher price/income levels. Since this effect scales with income, this variable is multiplied by the ZIP code's relative average income to estimate the scale of the effect on each ZIP code.

Whereas equation 3 attributes all of the income-sensitive change in prices to the income-interacted fixed-effect variable, equation 4 only attributes income-sensitive changes that are proportional across all MSAs to the preexisting price/income slopes in 2002. In other words, again referencing figure 1, equation 4 only attributes price changes to supply constraints where the price/income slope in New York steepens 2.3 times more than in Chicago from 2002 to 2006, and likewise proportionately to the 2002 price/income slopes of the other 26 MSAs in the dataset.

In most MSAs, especially those with inelastic supply, the price/income slope is negative, so a positive coefficient means that prices rose higher in ZIP codes with lower incomes (a negative slope multiplied by a negative difference in income).

Again, as with the results in table 3, the independent variables have more positive coefficients with this specification than they did in column 5 of table 1 using a simple income-control variable.

In column 2 of table 4, both of the credit-supply variables—FHA market share and mortgage denial rate—now have a statistically significant positive correlation with rising price/income levels. (So does the 2001–2002 price preboom trend variable.) In fact, a one-standard-deviation increase in FHA market share has a stronger association with rising prices than any of the variables tested by Griffin, Kruger, and Maturana when they include MSA fixed effects.[17]

And, again, as shown in column 3, when interaction variables are added, the coefficient on the credit-supply variables rise. Here, an interaction variable has been included between all the demand-related independent variables (both the credit supply and speculation variables) and the supply-related price/income slope variable. This is intended to capture the interaction between the demand triggers and supply triggers. Where supply is inelastic, we should expect increased supply of credit or increased speculative activity to have a stronger effect on prices than where supply is elastic. Yet here, again, the effect is the opposite. By including the interactions, both the credit-supply variables and the

17. See Griffin, Kruger, and Maturana, "What Drove the 2003–2006 House Price Boom and Subsequent Collapse?," table 4, panel A.

TABLE 4. REGRESSIONS WITH DEPENDENT VARIABLE LOG CHANGE IN PRICE/INCOME, 2002–2006

FHA Share		**0.058** 0.003	**0.059** 0.004
Denial Rate		**0.013** 0.003	**0.020** 0.004
Non-Owner-Occupied Share		−0.006 0.003	0.000 0.004
2001–2002 Price Change	**0.021** 0.005	**0.033** 0.005	**0.016** 0.007
2002 MSA PI Slope x Income	**0.173** 0.006	**0.124** 0.007	**0.154** 0.014
FHA Share x 2002 MSA PI Slope x Income			−0.008 0.004
Denial Rate x 2002 MSA PI Slope x Income			**−0.025** 0.007
Non-Owner-Occupied Share x 2002 MSA PI Slope x Income			**−0.018** 0.006
2001–2002 Price Change x 2002 MSA PI Slope x Income			**0.035** 0.009
Control Variables & MSA Fixed Effects	Yes	Yes	Yes
Observations	2713	2713	2713
R^2	0.788	0.825	0.830

Note: Standard errors are shown below coefficients. Coefficients are standardized to reflect a change of 1 standard deviation in the independent variable. Boldface type designates *p* values of < 0.01. FHA = Fedral Housing Administration; MSA = metropolitan statistical area.

supply-elasticity variable are strengthened, and the interactions between the credit-supply variables and the supply-elasticity variable have negative coefficients. That means that increased credit supply had a stronger effect on prices where incomes were higher and where supply was more elastic.

This may seem counterintuitive, but in this particular housing boom, added demand in the most expensive cities was moderated by a rise of outmigration. Credit may have been facilitating migration to more affordable cities at least as much as it was facilitating more demand in the expensive cities. It may be useful to think of housing-demand elasticity in terms of three conditions—elastic/inelastic/elastic.

As housing supply becomes constrained, demand becomes more inelastic because, as rising costs increasingly force compromises on the more essential elements of housing consumption, households are willing to spend more to maintain those essentials. However, at some point, the cost becomes untenable for a portion of a city's population, so that marginal new increases in cost induce some households to have more elastic housing demand, in terms of the local market. They finally leave the city altogether because of a lack of tenable options. Prices may continue to rise in cities that are in that condition, but they rise mainly as the result of compositional changes in the city's population due to housing-induced migration. Credit access could be associated with rising prices for cities where rents are rising and net migration is still neutral or positive. At some point, however, the net result of new marginal price increases is that families with relatively low incomes, who would be more likely to use FHA loans or to be denied mortgages, move away.[18]

Adding the third element of housing-supply elasticity to this analysis leads to at least three conclusions: (a) The effect of credit supply may have been stronger than models without the housing-supply factor have been able to measure; (b) in spite of that, inelastic housing supply was still a much stronger factor pushing prices higher from 2002 to 2006; and (c) credit supply may have had a stronger effect where price/income ratios were more moderate. Where supply was inelastic, prices may have been increasing not because of the direct effects of new credit access to buyers with low incomes, but rather because of the ability of buyers with higher incomes to accelerate the price pressures created by inelastic supply. On net, rising prices in ZIP codes with low incomes in cities with inelastic housing supply may have been related to the driving away of households with lower incomes rather than to unsustainable mortgage funding that allowed them to remain.

In short, this evidence suggests that the housing boom of 2002 to 2006 was associated with an acceleration of the process whereby demand driven by outsiders with higher incomes drives households with lower incomes out of MSAs that lack adequate housing. That conclusion matches the migration patterns of

18. For recent literature on this, see Rebecca Diamond and Enrico Moretti, abstract, "Where is Standard of Living the Highest? Local Prices and the Geography of Consumption" (NBER Working Paper, July 2021), https://www.nber.org/papers/w29533; Stan Veuger, Philip G. Hoxie, and Daniel Shoag, "Moving to Density: Half a Century of Housing Costs and Wage Premia from Queens to King Salmon" (AEI Economic Policy Working Paper Series, American Enterprise Institute, Washington, DC, April 2022), https://www.aei.org/research-products/working-paper/moving-to-density-half-a-century-of-housing-costs-and-wage-premia-from-queens-to-king-salmon/; and David Card, Jesse Rothstein, and Moises Yi, "Location, Location, Location" (Center for Economic Studies Working Paper No. CES 21-32, Washington, DC, October 2021), 41, https://www2.census.gov/ces/wp/2021/CES-WP-21-32.pdf.

the time. Where supply was inelastic and prices were high, endemic patterns of economically triggered outmigration increased during the period from 2002 to 2006. That outmigration may have helped mitigate further price appreciation.

Figure 2 and figure 3 are graphs of the change in price/income for each ZIP code predicted by the last specification in column 3 of table 4 and of the actual measured change in price/income in each ZIP code. Atlanta, Detroit, Los Angeles, and Phoenix are highlighted here; these are typical of all 28 MSAs in the dataset. The model provides a relatively accurate and unbiased estimate of price/income changes from 2002 to 2006. Next are the various effects on prices for each ZIP code, broken out as follows:

1. Credit supply (2002 FHA market share, 2002 denial rate, and the interactions of those two variables with the housing-supply variable)
2. Speculation (2001–2002 pretrend price change, 2002 non-owner-occupier market share, and the interactions of those two variables with the housing-supply variable)
3. Housing-supply elasticity (the 2002 MSA price/income slope × the 2002 ZIP code income variable)

FIGURE 2. 2002–2006 MEASURED CHANGES IN PRICE/INCOME VS. CHANGES ESTIMATED WITH REGRESSION

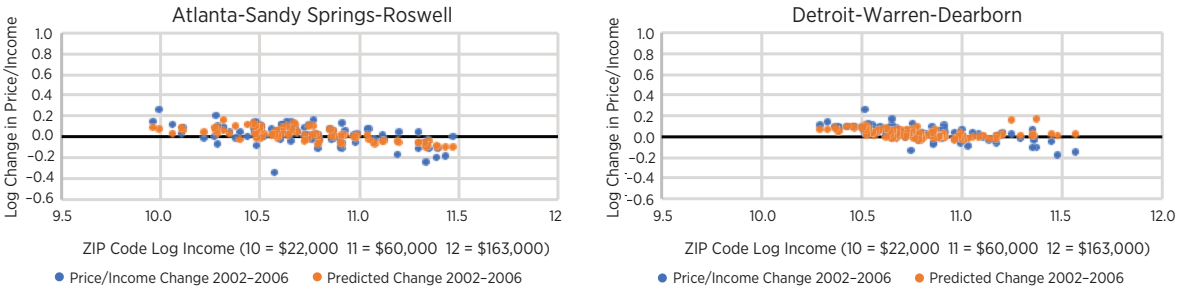
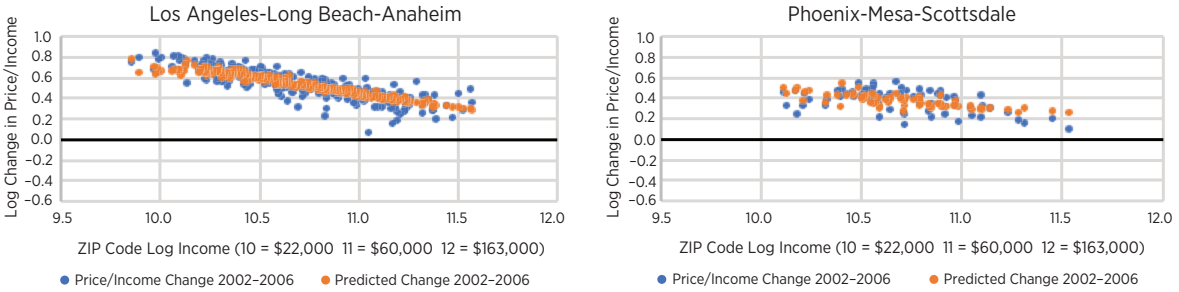


FIGURE 3. 2002–2006 MEASURED CHANGES IN PRICE/INCOME VS. CHANGES ESTIMATED WITH REGRESSION



4. Controls and MSA fixed effects (ZIP code density and the dummy MSA fixed-effects variable)
5. Residuals (changes in price/income that are not correlated with these variables)

The variable that clearly jumps out in figure 4 and figure 5 is that of price changes in Los Angeles correlated with the preexisting price/income slope in 2002 (the gray plots). This model attributes little of the rise in prices in Los Angeles to either uniform MSA price appreciation or to credit supply. There is a moderate amount of price appreciation associated with speculation or continuation of pre-2002 price trends, but overall Los Angeles tells a stark story of supply inelasticity.

In the other MSAs shown in figure 4 and figure 5 that are not dominated by that single factor, there are some interesting things going on. The strength of the credit-supply variables in all three of the other MSAs is surprising. In each case, there were ZIP codes that appear to have experienced as much as a 20 percent price appreciation associated with changing credit constraints.

FIGURE 4. 2002–2006 CHANGE IN PRICE/INCOME ASSOCIATED WITH EACH EFFECT

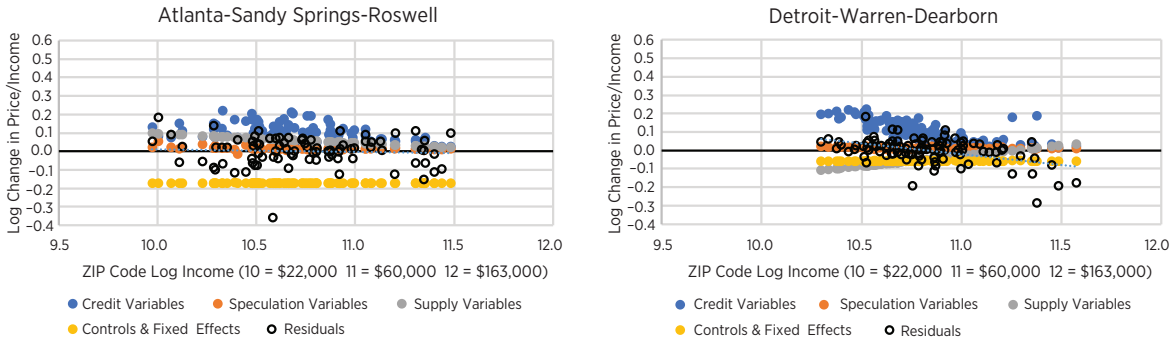
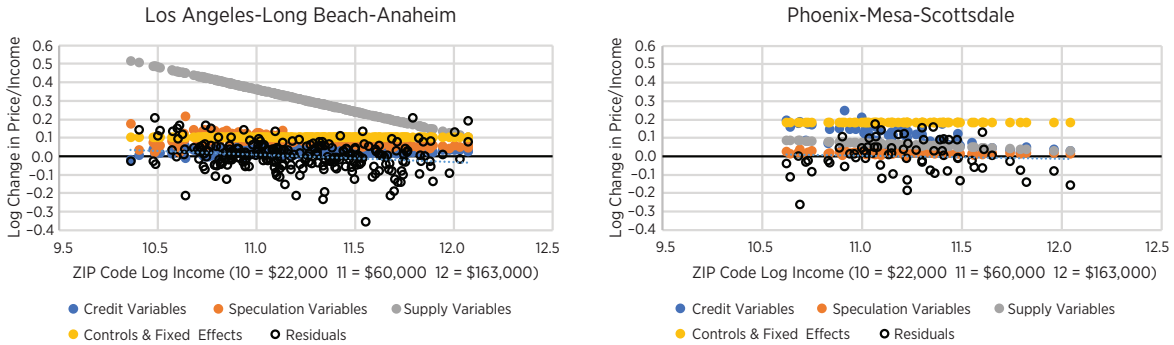


FIGURE 5. 2002–2006 CHANGE IN PRICE/INCOME ASSOCIATED WITH EACH EFFECT



Comparing Factors in 2002 to 2006 and 2006 to 2010

In the Griffin, Kruger, and Maturana[19] study, the authors used a two-step logical approach in their comparison of these factors. First, if a factor continued to show statistically significant correlation with home prices from the end of 2002 to the end of 2006 after applying MSA-level fixed effects, this supported a conclusion that it was an important causal factor in rising home prices. Subprime-lender market share and misreported second-lien originations both were significant at the 1 percent level after controlling for MSA fixed effects.

Second, they measured the correlation between each factor and the resulting decline in prices from the end of 2006 to the end of 2010. If these factors had led to excessive buying or building activity during the boom years, then they would be correlated with a sharper decline in prices during the bust years. Their four credit-supply variables had significant correlations with declining prices at the 1 percent level. None of their speculation variables did.

Having performed well under both tests, subprime lending and misreported originations seem to be the most likely candidates for factors that created unsustainably volatile housing markets from 2002 to 2010. The authors also applied a variety of other tests of this conclusion. They noted, "The results are consistent with the interpretation that excess credit supply fueled both speculation and demand for housing more generally. Like most of the literature, our analysis is subject to traditional concerns regarding omitted variables and endogeneity. Although we use the leading variables proposed over the last decade of research, it is possible that speculation variables are less able to capture the underlying theories that motivate them than variables for credit supply are."[20]

I believe that there is an omitted variable in their analysis, which is the effect of supply inelasticity and the related filtering, migration, and price patterns that such inelasticity sets in place. By including the initial price/income slopes in the specifications, the effect of supply elasticity can be more comprehensively accounted for. This also applies to analysis of the following 2006 to 2010 period. Figure 6 and figure 7 visually present the disaggregated factors for Atlanta, Detroit, Los Angeles, and Phoenix for the 2006 to 2010 period.

There does appear to be a strong reversal in the effect of all variables on home prices from 2006 to 2010. Supply inelasticity was still important, though

19. Griffin, Kruger, and Maturana, "What Drove the 2003–2006 House Price Boom and Subsequent Collapse?"

20. Griffin, Kruger, and Maturana, "What Drove the 2003–2006 House Price Boom and Subsequent Collapse?," 5.

FIGURE 6. 2006–2010 CHANGE IN PRICE/INCOME ASSOCIATED WITH EACH EFFECT

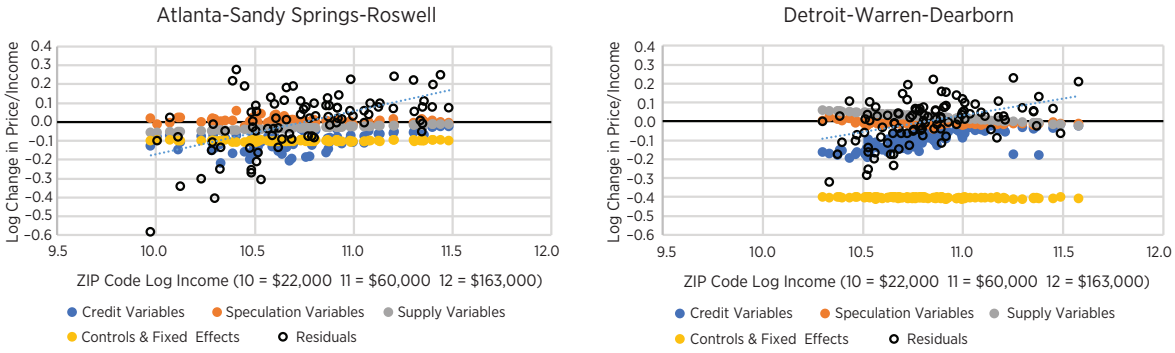
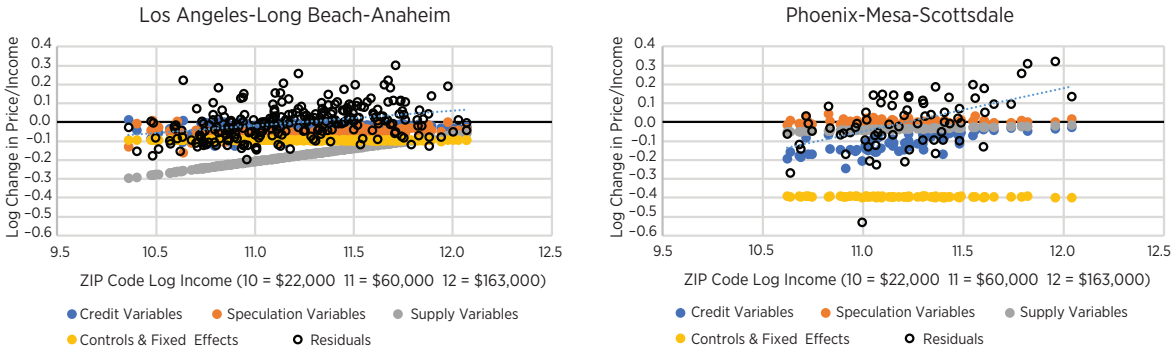


FIGURE 7. 2006–2010 CHANGE IN PRICE/INCOME ASSOCIATED WITH EACH EFFECT



less important than it had been from 2002 to 2006, and MSA dummy fixed effects were especially strong—and negative—in Phoenix and Detroit from 2006 to 2010.

Table 5, column 1, displays the normalized coefficients for the period from 2006 to 2010. This analysis appears to confirm the conclusion of Griffin et al. that an increase in the supply of credit played a role in the rising prices from 2002 to 2006, which then reversed in 2006 to 2010. However, the addition of the housing-supply variable provides a better basis for understanding the scale of all these factors in the broader event of the boom and bust. Even though credit supply was an important factor, it was less important than either the problem of inelastic supply or the idiosyncratic forces of demand that applied to individual MSAs. Applying five categories of factors across all 2,713 ZIP codes in all 28 MSAs in this dataset, and attributing all of the interaction effects to the credit and speculation variables, the standard deviation of their estimated effects on changing price/income ratios from 2002 to 2006 and from 2006 to 2010 is shown in table 6.

TABLE 5. LOG CHANGE IN PRICE/INCOME

	2006–2010	2002–2006	2006–2010
FHA Share	**–0.053** 0.004	**0.064** 0.004	**–0.029** 0.004
Denial Rate	**–0.018** 0.004	0.09 0.05	**–0.014** 0.004
Non-Owner-Occupied Share	**0.013** 0.004	0.009 0.006	**0.021** 0.006
2001–2002 Price Change	**–0.024** 0.006	**0.149** 0.008	**–0.085** 0.006
2002 MSA PI Slope x Income	**–0.088** 0.015	**0.124** 0.012	**–0.069** 0.012
MSA Population Trend Change		**0.046** 0.005	**0.101** 0.004
FHA Share x 2002 MSA PI Slope x Income	–0.009 0.005	**–0.041** 0.005	0.003 0.005
Denial Rate x 2002 MSA PI Slope x Income	0.024 0.009	**0.062** 0.010	0.016 0.009
Non-Owner-Occupied Share x 2002 MSA PI Slope x Income	0.010 0.006	**–0.040** 0.010	**–0.035** 0.009
2001–2002 Price Change x 2002 MSA PI Slope x Income	–0.018 0.010	**–0.058** 0.014	**0.037** 0.011
Control Variables	Yes	Yes	Yes
MSA Fixed Effects	Yes	No	No
Observations	2713	2713	2713
R^2	0.715	0.503	0.408

Note: Standard errors are shown below coefficients. Coefficients are standardized to reflect a change of 1 standard deviation in the independent variable. Boldface type designates *p* values of < 0.01. FHA = Fedral Housing Administration; MSA = metropolitan statistical area.

TABLE 6. EFFECT OF ONE STANDARD DEVIATION CHANGE IN VARIABLES ON PRICE/INCOME ACROSS 2,713 ZIP CODES

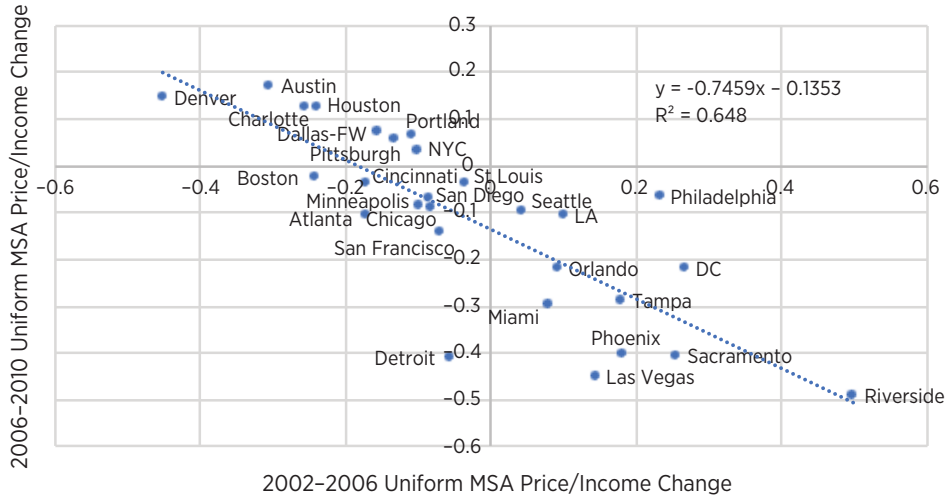
	2002–2006	2006–2010
Control Variables & MSA Fixed Effects	0.175	0.155
Supply Variable	0.154	0.088
Residuals	0.092	0.101
Credit Variables	0.070	0.065
Speculation Variables	0.037	0.036

Supply elasticity and differences between MSAs level changes were the most important factors from 2002 to 2006. The credit-supply variables used here were somewhat important, though to a lesser extent; speculation variables had the smallest effect. The results were similar for 2006 to 2010 except that supply elasticity became less important, though still it was correlated with price changes of a larger scale than the credit-supply variables.

While the reversal of credit supply was undoubtedly an important element in the rise and fall of housing markets, it is visually clear in figure 6 and figure 7 that from 2006 to 2010, regional differences became very important. In Detroit and Phoenix, factors that pushed down prices uniformly across the MSA accounted for a decline in price/income levels of about 0.40 log points. Regardless of the role changing credit markets played, this is an outrageous scale of change that demands the primary focus of any analysis of the boom and bust.

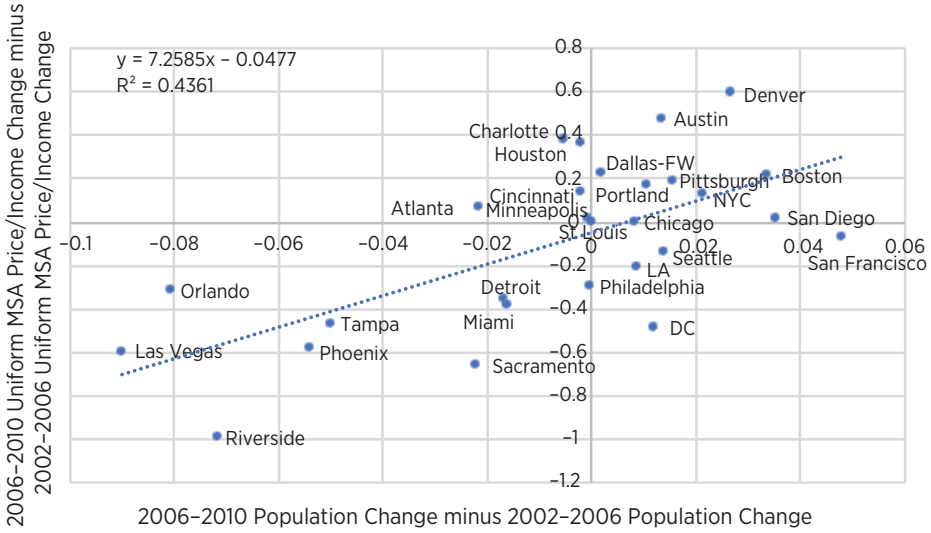
The fixed-effects coefficients during the bust tended to reflect a reversal of the boom, similar to the independent variables. The reversal of the housing market was intensely regional. Figure 8 compares the 2002 to 2006 MSA price changes to the 2006 to 2010 MSA price changes (roughly, the level of the yellow plots for each metropolitan area from figure 4 through figure 7) for each MSA. The reversal of lending standards was little different in Austin than it was in Phoenix, yet the difference in the bust-era price shifts between those two MSAs was about 0.6 log points.

FIGURE 8. THE HOUSING BUST REVERSED REGIONAL TRENDS



Furthermore, these differences were highly correlated with population shifts. Figure 9 tracks the shift in population growth (on the *x*-axis) and the change in uniform MSA price/income changes. For each 1 percent decline in population growth in 2006 to 2010 compared to 2002 to 2006, there was a 7 percent decline in the trend of an MSA price/income level. Gregor Schubert at Harvard looked deeply at this issue and found that convulsions of migration flows and economic contagion between various metropolitan areas was very important.[21] The whiplash of migration trends is largely unmentioned in most of the literature.

FIGURE 9. MIGRATION WAS A KEY COMPONENT OF THE HOUSING BUST



In order to further check this issue, in table 5, columns 2 and 3, I removed the MSA fixed effects and added a variable for MSA population trend shift. The population trend change used in the table in column 2 is the population-growth rate from 2002 to 2006 minus the population-growth rate of the previous four years (as an independent variable testing home-price changes from 2002 to 2006) and in column 3 is the change in the population-growth rate from 2006 to 2010 compared to 2002 to 2006 (to test against price changes from 2006 to 2010). Since population change is only one component of the potential sources of regional variations, the fit of these regressions is lower than for the regressions with MSA fixed effects. However, the coefficients of the independent vari-

21. See Gregor Schubert, "House Price Contagion and US City Migration Networks."

ables are similar to the other results. In the boom period of 2002 to 2006, the coefficient of the trend change in population growth is 0.057 log points—a little lower than the effect associated with the credit-supply variables. In the period from 2006 to 2010, the coefficient for the population-growth trend is larger than for all the other variables, including the housing-supply variable.

Population growth was a moderately important factor in MSA fixed effects during the boom, but it was the primary factor during the bust. In the specifications with MSA fixed effects, one standard deviation change in fixed effects was associated with a 0.15 point change in log price/income levels from 2006 to 2010. In the specification with the population trend variable, a one-standard-deviation change in population-growth trend was associated with a 0.10 point change in log price/income levels.[22] Population trends were a powerful force driving most of the MSA fixed effects during the bust.

The Scale of Each Set of Factors in Boom and Bust

Table 7 compares the estimated scale of the four factors from table 5 over each period and the sum of the two periods from 2002 to 2010 for the average ZIP code. (By construction, the average effect of residuals is zero.) For the entire period, price changes associated with credit and speculation roughly reversed from boom to bust. Price/income changes associated with supply inelasticity only partially reversed, so that homes in markets driven by inelastic supply were an average of 6 percent higher in 2010 than in 2002. The average change in price/income levels not associated with either credit, speculation, or inelastic supply

22. Some existing research, such as Davidoff's 2013 paper listed below, attributes differences in demand to regionally differing credit conditions. A focus on population changes and migration flows should add clarity to this discussion. While there could be some endogeneity problems where loose lending drives population flows, renters make up an inordinate portion of movers. Furthermore, although it is difficult to determine the direction of causality (does demand drive lending standards, or do lending standards drive demand?), in 2011, Ferreira and Gyourko (cited below) found that credit expansion generally lagged price increases. In more general analysis, in *Building from the Ground Up*, I noted that according to data from the New York Federal Reserve Bank, most of the rise in per capita debt in Florida, Nevada, and Arizona, relative to the rest of the country, was between 2005 and 2007. Housing starts were already declining by the end of 2005, and the population flows had already begun to reverse by 2006, so it is unlikely that these population shifts were driven by credit conditions. See Thomas Davidoff, "Supply Elasticity and the Housing Cycle of the 2000s," *Real Estate Economics* 41, no. 4 (2013): 793–813. See also Kevin Erdmann, *Building from the Ground Up* (New York: Post Hill Press, 2022) and Fernando Ferreira and Joseph Gyourko, "Anatomy of the Beginning of the Housing Boom: US Neighborhoods and Metropolitan Areas, 1993–2009" (NBER Working Paper No. 17374, National Bureau of Economic Research, Cambridge, MA, August 2011), https://www.nber.org/papers/w17374. Finally, see New York Federal Reserve Center for Microeconomic Data Household Debt and Credit Report (2019, quarter 4), "Total Debt Balance per Capita by State," 32.

TABLE 7. AVERAGE OF EFFECTS ACROSS 2,713 ZIP CODES

	2002–2006	2006–2010	Sums
Control Variables & MSA Fixed Effects	–0.026	–0.081	–0.108
Supply Variable	0.149	–0.085	0.063
Credit Variables	0.079	–0.080	–0.001
Speculation Variables	0.042	–0.027	0.016
Sums	0.244	–0.273	–0.030

was negative in both periods. For the full eight-year period, the average ZIP code price/income level declined by 11 percent before accounting for changes related to housing supply, credit, and speculation.

Taken as a whole, these results suggest that the key factors over this period were secular, not cyclical. On balance, the country's stock of housing was bifurcating into housing in markets with elastic or inelastic supply. The housing where supply was inelastic was persistently diverging to higher prices (especially for residents with lower incomes), while prices of housing elsewhere declined relative to incomes. A credit boom may have temporarily sped up the process of migration, filtering, and economic segregation driven by inelastic supply. Then when the credit boom reversed, the process slowed down.

The debate between credit supply and speculation that has not adequately focused on housing supply has lent itself to the presumption that, whatever the causes, this was a story of a bubble and its reversal. As table 7 highlights, that framework for thinking about the period misses some of the most important facets of the changing housing market. One complication to consider is that a primary motivation for the credit boom was to escape the expensive housing-deprived cities.

As I argued in "Price Is the Medium Through Which Housing Filters Up or Down," when there is a lack of adequate supply, a tremendous number of intra-market substitutions are made that systematically transmit the higher costs of inelastic supply throughout an MSA. Rising costs in ZIP codes with low incomes are not the result of rising demand from the households with low incomes as much as they are the result of households with higher incomes claiming the existing supply when new supply is suppressed and pressing the financially marginalized households into an ever-shrinking remnant of the existing stock of homes. This, in turn, forces many to migrate away. In short, the especially high-rising prices in housing-deprived ZIP codes come not from rising demand of the existing residents with low incomes but from the systematic process of housing

filtering up to a demographically shifting urban population. Where homes are filtering up, one can think of the low-income housing market as having a stationary demand curve but a supply curve that keeps being pushed to the left.

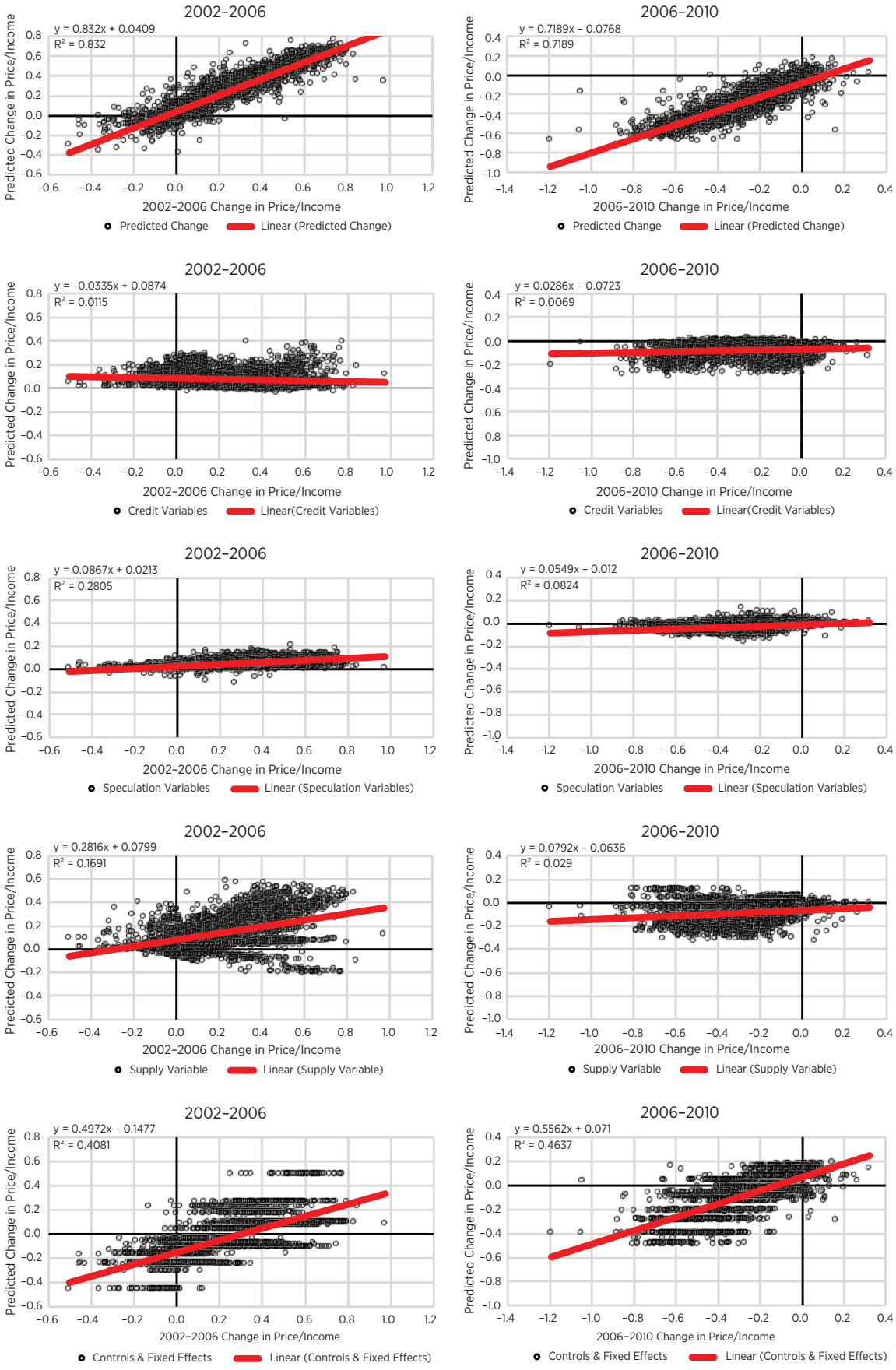
The credit boom was associated with an acceleration of that process. The particular rise in home prices in credit-constrained parts of the housing-deprived MSAs is more accurately described as an increase in the leftward push of the local supply curve for families with low incomes than as a rightward shift in their demand. The migration event that was triggered out of those cities quite strongly lends itself to this alternative conclusion. Credit supply may have been operating in two different ways. First, in the cities with inelastic supply, credit supply may possibly have increased the demand for housing for the households for which homes were within reach. Second, it may have facilitated migration to less expensive MSAs for those who were faced with the leftward-shifting local supply curve for existing low-income residents. So, looking again at table 7, the rise in price/income levels associated with credit supply was mitigated by the decline in price/income levels in MSAs with elastic housing supply. In other words, regarding the credit boom, there may have been little need for prices to reverse on net. Where homes were filtering up, the demographic shift was a secular trend that was only accelerated by cyclical factors. Where homes were filtering down, the net result of the boom was not associated with rising price/income levels.

During the bust, both factors (credit supply and MSA fixed effects) were associated with significant price declines. Consequently, the bust was especially damaging to the markets where it hit, and it was made worse by contracting credit markets, even though in most MSAs, prices had not been driven to unsustainably high levels by loosened credit.

Figure 10 helps to highlight this issue. The top panels compare the measured change in price/income ratios (on the *x*-axis) to the changes predicted by equation 4 (on the *y*-axis). The left panels are for 2002 to 2006; the right panels are for 2006 to 2010. Below there are separate graphs comparing the measured change in price/income ratios to the estimated effects of each individual set of factors (credit supply, speculation, supply inelasticity, and MSA fixed effects).[23] As suggested by the results reported above, the scale of the supply elasticity and MSA fixed effects are much greater than the scale of the credit supply and speculation variables.

23. This includes the interactions shown in table 4, column 3, and in table 5, column 1. The panels for credit supply and speculation in figure 10 include the interactions.

FIGURE 10. CHANGE IN PRICE/INOCME ASSOCIATED WITH EACH EFFECT VS. ACTUAL CHANGE



But, more subtly, notice the correlation between credit-supply effects and measured changes in price/income. There is no correlation between the effect of credit supply and measured changes in price/income during the boom. The increase in credit supply is associated with an average increase in price/income ratios of about 9 percent, all else held equal, but it was negatively correlated with measured changes in price/income levels. It was likely to be associated with a more than 9 percent price appreciation where price/income levels were otherwise declining, and a somewhat less than 9 percent price appreciation where price/income levels had risen the most. This is because credit supply was associated with the biggest price increases in ZIP codes where the aggregate effect of other variables was negative. In other words, there was a credit boom and bust, but it was orthogonal to the more significant boom and bust motivated by inadequate supply.

This presents a bit of a statistical paradox. Credit conditions undoubtedly loosened from 2002 to 2006 and boosted demand that had a positive effect on prices. Yet, home prices in the average ZIP code with high FHA market share and high denial rates increased by less than they did in the average ZIP code that had low FHA market share and low denial rates.

The motivation to squash a housing bubble is rooted in the fear that prices in a bubble become increasingly unsustainable. There were places where home prices may have become unsustainable, and these fall into two categories. Both categories were motivated fundamentally by a lack of supply. The first category is cities that took on large waves of migration, like Phoenix. As shown above, home prices in those cities rose substantially and then reversed. The level of migration associated with their housing booms was likely to decline in any case. In 2008, a federal monetary and fiscal policymaking regime focused on stability rather than bubble-busting may have minimized the declines, but those markets were vulnerable to reversals in any scenario because of the price spikes in 2002 to 2006.

The second category where home prices became unsustainable was the ZIP codes with low incomes in cities with inadequate housing—the cities with steep price/income ratios. The unsustainability of those prices did ebb and flow cyclically, from 2002 to 2010, but the unsustainability itself was not cyclical. The unsustainability was the result of the lack of adequate building. Because families resist moving away from their home cities, housing costs in those places need to become unsustainable in order to induce those families to move away.

Creating a recession and greatly limiting access to mortgage credit after 2007 relieved the pressure on those families by reducing the ability of families

with greater financial means to claim the limited housing in the expensive cities. But the unsustainability of prices in those markets is and will be a permanent fixture, with varying degrees of scale, as long as homebuilding is obstructed in those MSAs. Slowing down the process by lowering the incomes and mortgage access of households across the country was obviously not an optimal solution to the problem, and it has become clear more recently that it was only a temporary solution.

Novel Changes in Credit Access After 2007

Inelastic supply and changes that uniformly affected whole MSAs drove the boom and bust. Simultaneously, there was a credit boom that may have been mitigating the market trends created by those factors as much as it was aggravating them.[24]

Looking back at figures 6 and 7, the residuals in some MSAs are correlated with ZIP code incomes. In the aggregate data, there is no correlation between residuals and ZIP code income, but in figure 6 and figure 7, the upward slope of the residuals across incomes within some MSAs during the bust is noticeable. In the 2002 to 2006 period, the bias of the residuals within MSAs was generally reduced by using the price/income slope variable, because price/income levels generally increased in proportion to each MSAs initial supply conditions. However, there remains a bias in residuals in the 2006 to 2010 period within MSAs, correlated with incomes. And the scale of the bias in each MSA is correlated with MSA fixed effects. Where the coefficient on MSA fixed effects was very negative, as in Detroit and Phoenix, the residuals tended to have a positive correlation with ZIP code incomes in the period from 2006 to 2010.

The reversal in credit supply was much stronger than the increase in credit supply had been during the boom. The change in credit scores on originated mortgages, tracked by the New York Federal Reserve, suggests that this was the case. The median credit score on originated mortgages had fluctuated around 720 before and during the boom, and then from 2007 to 2009 it shot up to around 760, where it has generally remained.[25]

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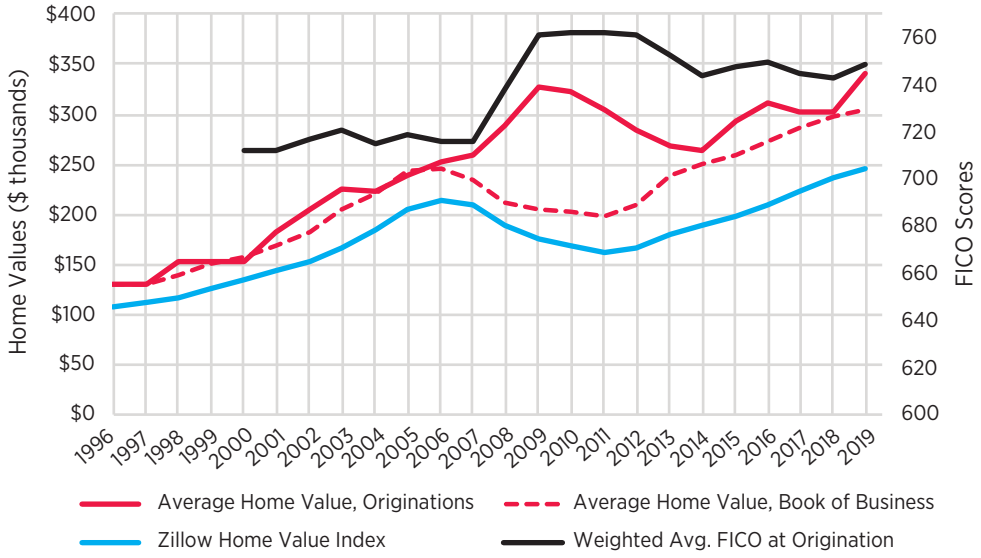
24. It could be that some other variables meant to capture credit-supply changes, such as dubious lending or subprime market share, will have different results than FHA market share and denial rates have. Further research could help to shed light on the differences.

25. Federal Reserve Bank of New York, Center for Microeconomic Data, "Household Debt and Credit Report," 2022 (2nd quarter), https://www.newyorkfed.org/microeconomics/hhdc.html.

Data from Fannie Mae also point to extreme shifts in credit supply.[26] Figure 11 presents several relevant measures. First, the black line is the average credit score on newly originated mortgages each year. The average Fannie Mae mortgage followed the same pattern as mortgages across the market during this time. The average score at Fannie Mae fluctuated around 710 until 2008, when it shot up to 740 or more and remained elevated.

FIGURE 11. FANNIE MAE FICO SCORES AND HOME VALUES



The graph also illustrates the current average market price of homes with existing Fannie Mae mortgages from previous years (dashed red line). The solid red line is the average market price of homes that received new Fannie Mae mortgages that year. Notice that from 2000 to 2007, while credit scores at Fannie Mae remained stable, the average price of homes with new mortgages was roughly tracking the average price of homes with existing mortgages. In other words, until 2008, Fannie Mae was making loans to the same types of borrowers in the same types of homes as before the housing boom, but then Fannie Mae retreated from the low-end market. From 2007 to 2009, the average current mar-

26. Median home value is the Zillow Home Value Index (ZHVI) reported at www.zillow.com /research/data. Average home values and weighted average FICO at origination were taken from Fannie Mae annual 10-K SEC filings. Average home values were inferred from average loan-to-value percentages and average mortgage size for both originations and book of business.

ket price of existing Fannie Mae homes declined, along with homes across the country (estimated here with the Zillow median US home price). However, at the same time the average price of homes receiving new Fannie Mae mortgages shot up from around $250,000 to more than $300,000. The fact that credit scores at Fannie Mae followed the same trends as credit scores across the market in all mortgage types suggests that these momentous shifts reflect trends in the broader market.

The contraction of credit was deep, reaching well into prime and conventional borrowers, so it is not surprising that there may have been additional declines in home prices in ZIP codes with lower incomes—declines that were unrelated to relaxed credit constraints or speculative activities that had happened there before 2006 and that were consequently not captured by the credit-access variables. This is another area in which the existing literature should be reexamined. The reversal of home prices in credit-constrained ZIP codes has been taken as a confirmation of the unsustainability of lending during the boom and thus as a confirmation of the explanatory power of credit supply in driving that boom. But much of the decline in home prices in ZIP codes that are sensitive to credit constraints may have been related to new tightening in credit markets that was not a reversal of boom-era activity.

Quantifying the role of contracting credit access beyond a reversal of boom-era lending would be a useful extension of the existing literature, but it is beyond the scope of this paper. The evidence already described suggests that new credit access had little to do with unsustainably high prices during the boom—that it was mostly associated with rising prices in areas where prices were moderate. But in the period from 2006 to 2010, the reversal of credit norms plus novel new changes in lending standards (effective after 2006) now became procyclical. In the bust period, places that were experiencing a reversal of the migration surge and places where regional price trends had been relatively negative in both the boom and bust now faced an additional headwind of tight credit. During the bust, tight credit hit the most financially vulnerable ZIP codes in the most financially vulnerable MSAs especially hard—both because of the reversal of boom-era credit trends and because of the imposition of new forms of tightening standards.

The popular notion that the bust was an unavoidable product of a credit bubble was an especially cruel misunderstanding. It led to a sharp, targeted wealth shock whose victims were frequently owners in markets that had little to do with the motivating trends that created excessively high home prices.

CONCLUSION

In "Price Is the Medium Through Which Housing Filters Up or Down," I developed a measure for estimating the effect of supply inelasticity on MSA home prices. I proposed that, empirically, the housing market in each MSA in the United States can be roughly represented by a single line (the price/income line) that functions like a lever. The fulcrum of the lever rests at a ZIP code with some relatively high income, which has a price/income level that is not sensitive to the slope of the price/income line. The slope of that line rises and falls over time because of both systematic shared changes across MSAs and idiosyncratic changes within MSAs. There is a systematic process of the filtering of the existing housing stock, either down to families with lower incomes as homes age (where supply is more elastic) or up to families with higher incomes (where supply is inelastic and demand for local shelter is high). Where supply is inelastic, the reversal of the filtering process operates through changing prices. The large number of discretionary substitutions within the housing market across an MSA distributes the costs of displacement across the MSA. Measured across ZIP code incomes, inelastic supply causes the average price/income ratio to rise more where incomes are low as residents with higher incomes substitute into lower-tier parts of the market in search of more affordable homes.

By using this new metric, the factors that were associated with changing home prices from 2002 to 2010 can be more comprehensively reviewed. The analysis that follows covers five potential sources of price variation during that period in a dataset of 2,713 ZIP codes in 28 MSAs:

1. Housing-supply constraints, estimated with each MSA's price/income slope in 2002.
2. Credit supply, estimated with FHA market share and the mortgage-application denial rate in each ZIP code in 2002.
3. Speculation, estimated with the price change from 2001 to 2002 and the share of mortgage applications by non-owner-occupiers in 2002 in each ZIP code.
4. MSA fixed effects, which estimate changes in housing demand over the periods in question that uniformly affected home prices within each MSA.
5. Residuals, representing the remaining unexplained factors.

In order of importance, MSA fixed effects were associated with about one-third of the price volatility from 2002 to 2010. After accounting for the effects of supply inelasticity and credit supply, the price/income ratio in the average ZIP code declined in both the boom period of 2002 to 2006 and the bust period of 2006 to 2010, declining nearly 11 percent over the entire period. However, the variation was very high between MSAs—some MSAs experienced very high price increases during the boom period that were more than reversed during the bust period. That rise and reversal was highly correlated with whiplash in population and migration flows. MSAs with very large downshifts in trends of migration inflows and population growth saw substantial price shocks across the region, especially during the bust period (2006–2010).

Much of those migration shifts were a secondary effect of supply inelasticity in a few major areas. MSAs constrained by limited supply present a peculiar pattern of price increases, and where this was the case, in MSAs like Los Angeles, housing-supply inelasticity was overwhelmingly the factor driving up home prices. Supply inelasticity was associated with about a quarter of the price volatility from 2002 to 2010. The price/income of the average ZIP code associated with inelastic supply increased by about 15 percent from 2002 to 2006 and then partially reversed by 9 percent from 2006 to 2010. But, as with MSA fixed effects, there was wide variation in this effect across the country. It was minimal in many MSAs, but overwhelmingly high in the few MSAs where supply inelasticity was a key problem. That heterogeneity is what drove the migration patterns that transmitted the rising prices out to other MSAs, where it was captured by MSA fixed effects. In other words, constrained supply lowered the quantity of housing demanded in Los Angeles, and that in turn increased the demand for housing in Phoenix.

Residual factors not captured by this analysis were associated with about 20 percent of price changes; credit supply was associated with about 14 percent of price volatility during this time. An increase in the price/income of the average ZIP code of about 8 percent during the boom and a decrease of about 8 percent during the bust was associated with changes in credit supply. ZIP codes the most sensitive to credit supply increased and then decreased by more than 20 percent in the boom and bust, which is a stronger effect than was found previously by some other researchers. However, the effect was still much smaller than the factors described above. Nonetheless, the decline in credit access led to disastrous procyclical declines in home prices during the housing bust. Price appreciation associated with credit access was negatively correlated with price appreciation

associated with other factors during the boom, so while its reversal led to disastrous loss of wealth during the bust, it was neither a useful nor a necessary remedy to the excesses of the boom. Finally, this analysis finds only minor effects from speculation during the period.

In summary, there was a significant credit boom from 2002 to 2006, which was reversed from 2006 to 2010. However, it is incorrect to identify it as the central driving force behind the extreme valuation changes that created economic upheaval. Supply inelasticity and the secondary effects of it were the primary drivers of volatile home prices. While there was a boom and bust, the fundamental effects of supply inelasticity remain in place, and the net result of all of these factors from 2002 to 2010 was that the country's housing stock was increasingly bifurcated between housing with declining price/income levels where supply was elastic and housing with rising price/income levels where supply was inelastic.

Where supply is inelastic, that bifurcation plays out also at a more granular level within MSAs. Inelastic supply has an inordinate effect on low-income neighborhoods in supply-constrained MSAs, regardless of the source of rising demand. That problem is not solved by retracting credit access to the households that are financially stressed because of that supply constraint. Credit access may be an important mechanism for relieving those stresses. Credit access facilitates the production of housing in other regions so that, at least, the painful second-best option of migration is more widely available to families who are the most acute victims of inelastic urban housing supply. Thus, it is important to avoid overestimating the role of credit in changing prices. The focus on reducing credit access has not solved this real supply-constraint problem, which is the fundamental driver of rising home prices in ZIP codes with low incomes in housing-constrained MSAs, and it may have made the problem more severe over the long run. A reassessment of the period and its aftermath, with a focus on housing-supply inelasticity, is necessary.

APPENDIX 1: DATA

Median Home Price is from https://www.zillow.com/research/data/, using Zillow Home Value Index (ZHVI) for all homes.

Median Rent is from https://www.zillow.com/research/data/, using Zillow Observed Rent Index (ZORI) for all homes.

Average Income is from https://www.irs.gov/statistics/soi-tax-stats-individual-income-tax-statistics-zip-code-data-soi, using the average adjusted gross

income (AGI) of all returns. The data are available for 1998, 2001, 2002, and 2004 to 2019.

2002 FHA market share, denial rates, and non-owner-occupied market share compiled from Table 1—Applications by Tract for each MSA from https://www.ffiec.gov/hmdaadwebreport/aggwelcome.aspx

	Average	Standard Deviation
2002 FHA Share	0.16	0.15
2002 Denial Rate	0.14	0.07
2002 Non-Owner-Occupied Share	0.17	0.09
2001–2002 Price Change	0.09	0.05
2002 Price/Income Attributed to P/I Slope:	1.38	1.42
2002–2006 Log P/I Change	0.24	0.22
2006–2010 Log P/I Change	–0.27	0.19

APPENDIX 2: ADDING A PROPERTY TAX CONTROL

In Appendix 4 of "Price Is the Medium Through Which Housing Filters Up or Down," an adjustment was added for the effect of different property taxes on home prices in each ZIP code. Controlling for property taxes created generally minor changes to the relative level of the price/income slopes in various MSAs, but it did reduce the residuals in some MSAs that have especially high variance in property-tax rates, and it produced better linearity in some MSAs. So I have reproduced the analysis above by using the alternative 2002 MSA price/income slopes that have been adjusted for property-tax effects, as reported in that paper.

Table A2.1 shows the results of the regression using property-tax-adjusted prices; column 1 is comparable to column 3 of table 4 and column 2 is comparable to column 1 of Table 5.

Also, below are the averages and standard deviations across the dataset ZIP codes of the scale of each type of factor. Table A2.2 is comparable to table 6 (changes are generally minor), and table A2.3 is comparable to table 7.

Figure A2.1 is similar to figure 4 and figure 5, charting the estimated effect of each type of factor on each ZIP code. The main visible difference is that the effect of credit access in ZIP codes with lower incomes in Atlanta and Detroit

TABLE A2.1. LOG CHANGE IN PRICE/INCOME

	2002–2006	2006–2010
FHA Share	**0.058**	**–0.049**
	0.005	0.005
Denial Rate	**0.016**	**–0.015**
	0.004	0.005
Non-Owner-Occupied Share	0.000	**0.020**
	0.005	0.005
2001–2002 Price Change	**0.017**	**–0.021**
	0.007	0.006
2002 MSA PI Slope x Income	**0.138**	**–0.078**
	0.012	0.012
FHA Share x 2002 MSA PI Slope x Income	–0.011	–0.004
	0.005	0.005
Denial Rate x 2002 MSA PI Slope x Income	–0.017	0.007
	0.019	0.009
Non-Owner-Occupied Share x 2002 MSA PI Slope x Income	**–0.020**	–0.004
	0.007	0.007
2001–2002 Price Change x 2002 MSA PI Slope x Income	**0.029**	–0.019
	0.009	0.009
Control Variables & MSA Fixed Effects	Yes	Yes
Observations	2713	2713
R^2	0.829	0.721

Note: Standard errors are shown below coefficients. Coefficients are standardized to reflect a change of 1 standard deviation in the independent variable. Boldface type designates *p* values of < 0.01. FHA = Fedral Housing Administration; MSA = metropolitan statistical area.

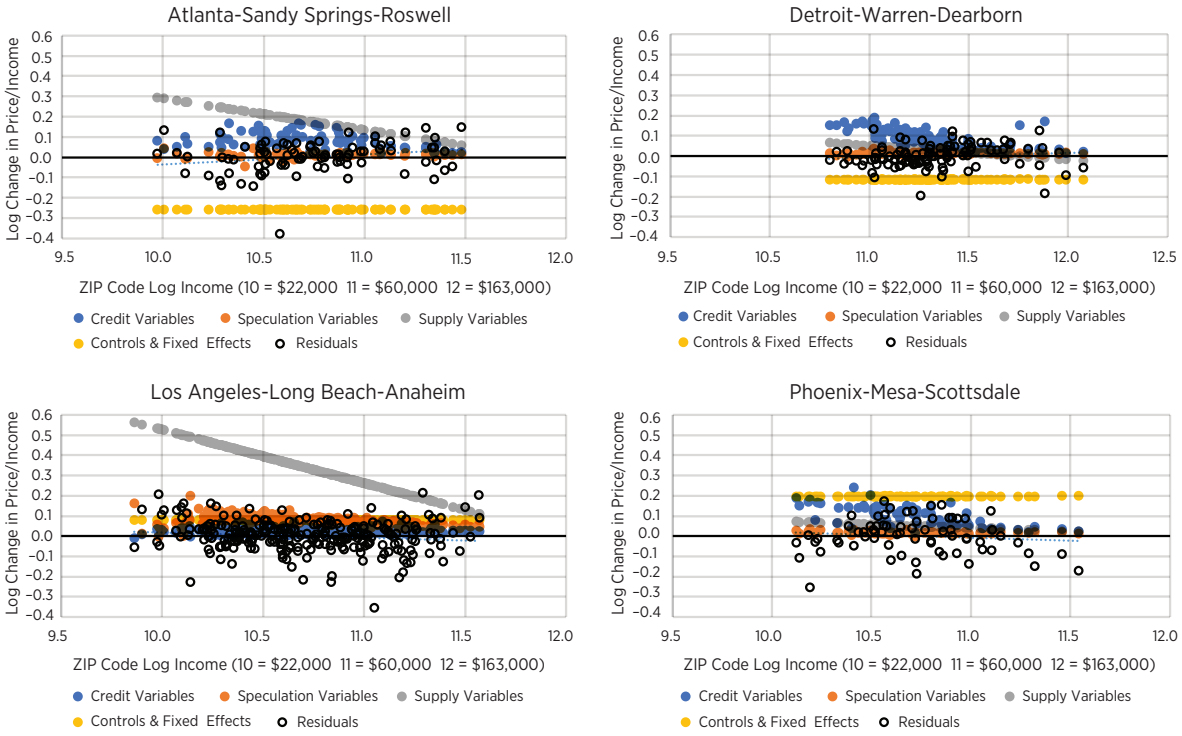
TABLE A2.2. STANDARD DEVIATION OF EFFECTS ACROSS 2,713 ZIP CODES

	2002–2006	2006–2010
Control Variables & MSA Fixed Effects	0.178	0.155
Supply Variable	0.138	0.078
Residuals	0.092	0.099
Credit Variables	0.059	0.057
Speculation Variables	0.034	0.040

TABLE A2.3. AVERAGE OF EFFECTS ACROSS 2,713 ZIP CODES

	2002–2006	2006–2010	Sums
Control Variables & MSA Fixed Effects	–0.045	–0.082	–0.127
Supply Variable	0.180	–0.101	0.079
Credit Variables	0.070	–0.068	0.001
Speculation Variables	0.039	–0.022	0.017
Sums	0.244	–0.273	–0.030

FIGURE A2.1 . 2002–2006 CHANGE IN PROPERTY TAX ADJUSTED PRICE/INCOME ASSOCIATED WITH EACH EFFECT



is a bit lower; more of the change in prices in those cities is attributed to some supply inelasticity.

After adjusting for property taxes, the net average loss of –3 percent in home price/income levels from 2002 to 2010 represents an even stronger bifurcation between supply-constrained regions and affordable regions, with the baseline ZIP code losing 13 percent from its 2002 price/income level but with supply constraints adding 8 percent to the average price/income level.

ABOUT THE AUTHOR

Kevin Erdmann is a senior affiliated scholar at the Mercatus Center at George Mason University. He has engaged in research with Mercatus about housing finance, land-use restrictions, and monetary policy. His first book, titled *Shut Out: How a Housing Shortage Caused the Great Recession and Crippled Our Economy* (Rowman & Littlefield, 2019), offers a contrarian theory on the causes of the housing boom and bust and details a number of ways in which obstacles to housing supply affect the American economy. Reviews of *Shut Out* have appeared in the *Economic Record*, *Regulation*, and the *Washington Examiner*. His second book, *Building from the Ground Up: Reclaiming the American Housing Boom*, reconsiders the policy decisions that led to the Great Recession and brought the housing market to the condition it is in today. Erdmann's work has appeared in the *Wall Street Journal*, *Barron's*, *National Review*, *USA Today*, and *Politico*, and it has been featured on C-SPAN. Erdmann was a small business owner for 17 years and holds a master's degree in finance from the University of Arizona.

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