

# HOUSING PRICE FUNDAMENTALS THROUGH THE BUSINESS CYCLE

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## ABSTRACT

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We examine the fundamental determinants of nominal home price growth from 1995 to 2012 across 300 metropolitan areas in the U.S. This sample period provides a trough-to-trough time period that allows for analysis through a complete business cycle. By using a supply-to-demand ratio for home price appreciation, we identify a straightforward and powerful method for predicting home price appreciation across markets. We suggest an alternative and simple method for addressing endogeneity in house prices and include a comprehensive measure of human capital. We find five significant factors: home supply growth, personal income growth, human capital, an ocean dummy, and geographic constraint.

## KEY WORDS

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housing, real estate, house price forecasting

## JEL CODES

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R2, R31

## 1 INTRODUCTION

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For the past decade, much literature on housing markets and prices has focused on the housing bubble – its existence, its size, and its causes (e.g. see Gallin, 2006; Glaeser et al., 2008; Huang and Tang, 2012; Shiller, 2005; Akerlof and Shiller, 2009). As the housing market now stabilizes after an egregious boom and bust cycle in the 2000s, we can reexamine the fundamentals of housing prices with the

added benefit of hindsight. This paper examines factors that explain the home price growth disparity between cities in the U.S. through a complete business cycle.

In the long run, the literature suggests that regional home price growth is determined mainly by local fundamentals. Local fundamentals can be summarized into two categories: demand factors and supply factors. Demand

factors include mostly economic factors, such as income growth, employment growth, and population growth of a city, as well as non-economic factors, e.g. its amenities and climate. It is not surprising that when a city has a higher income, employment, and population growth, or has a more temperate climate, the home demand in the city will rise. Supply, summarized as the growth of building permits, is determined mainly by three factors: (1) the cost of land, which varies according to the availability of developable land (natural factor), (2) government regulations (man-made factor), and (3) physical building costs. In the following analysis, by and large, we assume that the growth of costs of building a home and its quality improvement does not vary significantly across the country.

While the literature on determinants of housing price is considerable, most of it is focused on either one or several demand-side or supply-side factors. Few have analyzed a comprehensive supply-and-demand framework. For instance, Malpezzi et al. (1998) find that income level and past income growth are positively related to housing prices and rents in 1990. Larger cities generally have higher housing prices. Changes in population are not a significant predictor. More stringent regulations predict higher housing prices and rents. Moretti (2004) summarizes the social return of human capital. He suggests that a city with high human capital will increase its productivity beyond an individual level, reduce criminal participation, improve voters' political behavior, and create land price premiums. Glaeser et al. (2005) suggest that since 1970, housing price appreciation has been accompanied by large reductions in residential development, mostly in coastal cities. The limited housing supply is driven mostly by the result of a changing regulatory regime that makes large-scale development increasingly difficult in expensive regions. Quigley and Raphael (2005) also find that the stringency of regulation is the main reason for the disparity of housing supply and housing prices across 407 cities in California.

In addition to regulation, Green et al. (2005) find that high population density predicts low supply elasticity. Saiz (2010) calculates the exact measurements of undevelopable land in cities, which could contribute to the supply inelasticity of a city.

Our study proposes a simple but holistic empirical model by using the latest period (1995–2012) of data. This paper provides three contributions to the literature. (1) By focusing on a cross-sectional analysis across 300 or so metropolitan areas over a long span of time rather than panel data (time series and cross section), our estimators will be largely free of the influences of non-fundamental factors that may have contributed to the housing bubble. These include psychological fads, panic, irrational expectations of future home prices, and subprime mortgage fiascos. Because of the wide range of our sample size, we propose a simple alternative partition method to improve the endogeneity problem. (2) We calculate a simple supply-to-demand ratio. The variable, which embodies the basic idea of supply elasticity, has significant explanatory prediction abilities. (3) We use a new measurement of human capital for metropolitan areas: the UCLA City Human Capital Index. This index represents the average educational attainment of residents in a city. As an educational/human capital factor, we suspect that this variable that we have constructed is more comprehensive and more representative than the variable that most of the literature has been using, i.e. the percentage of bachelor's degrees held by residents in a city.

We find five significant determinants of home price level and growth: home supply growth, personal income growth, human capital, an ocean dummy, and a measure of geographic constraint. The rest of the paper is organized as follows. Section 2 presents the data and the supply-to-demand ratio. Section 3 reports empirical results. Section 4 provides the robustness check. Section 5 handles the endogeneity problem. Section 6 discusses the human capital factor. Section 7 offers policy implications. Section 8 concludes.

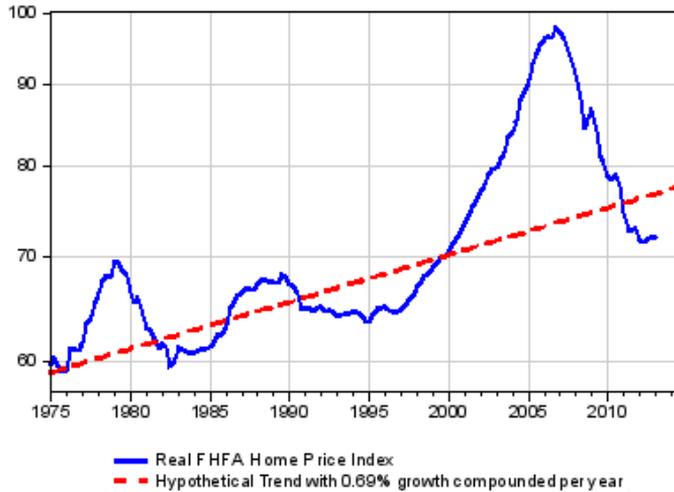


Fig. 1: FHFA single-family real home price index from 1975Q1 to 2012Q3 for the U.S.

Sources: Federal Housing Finance Agency, and the consumer price index is from Bureau of Labor Statistics.

## 2 DATA AND THE SUPPLY-TO-DEMAND RATIO

Fig. 1 shows the real single-family home price index, based on the nominal home price index adjusted by the consumer price index, from the Federal Housing Finance Agency (FHFA) for all transactions in the U.S. With 20/20 hindsight, we can see three housing bubble and bust cycles over the past four decades. The first is in the late 1970s, the second in the late 1980s, and the third in the 2000s. During these periods, real home prices eventually return to an invisible, hypothetical trend<sup>1</sup> with some overshooting rolling below the trend. In other words, the mean-reverting home prices suggest that fundamental forces are in fact driving the home price appreciating trend in the long run and that the trend is not a random walk.

More importantly, Fig. 1 implies that the estimations of conventional fundamental analyses, either panel or time series analyses, on housing price dynamics might be contaminated by these bubble-bust cycles. Even though some studies explicitly investigate the bubble elements using fundamental factors, the difficulty of identifying the bubble and bust could bias their results. Fig. 1 also illuminates that 1995 and 2012 were the bottom of the housing price

cycles. The appreciation from 1995 to 2012 seems to be equal to the appreciation of the hypothetical fundamental trend (dotted line) from 1995 to 2012.

Following the 5-year housing boom period (2002 to 2006) and the 5-year slump period (2007 to 2011), 2012 is the beginning of the housing market recovery. As a result, we believe that 2012Q3 will be a reasonable ending point for our fundamental analysis. In other words, the home price change from 1995 to 2012 is not contaminated by non-fundamental factors such as psychological fad and panic, irrational expectation of future home prices, subprime mortgage fiascos, etc. Thus, we suggest that our sample period and our single period return will provide a more accurate estimation of fundamental determinants of housing price appreciation than most recent literature.

Fig. 2 displays the nominal single-family home price growth from 1995Q1 to 2012Q3 according to the FHFA for the 30 largest metropolitan statistical areas (MSAs) in the U.S. We can see that San Francisco has the highest home price growth – 142% (5% compounded growth per year) over the past 18

<sup>1</sup>In Fig. 1, we draw a hypothetical trend with a 0.69% growth compounded per year beginning with index 58 in 1975Q1.

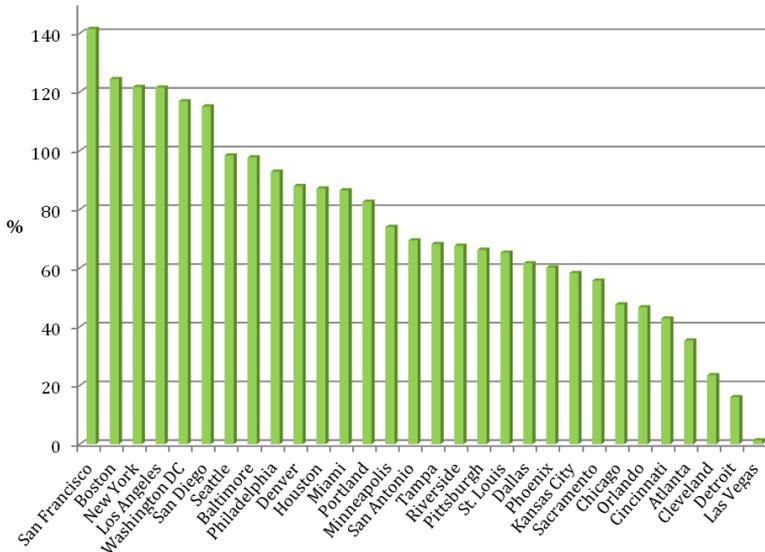


Fig. 2: Single-family home price growth from 1995Q1 to 2012Q3 for the 30 largest metropolitan areas  
Source: Federal Housing Finance Agency.

years, followed by Boston's 124%, New York's 122%, Los Angeles's 122%, and Washington D.C.'s 117%, down to Miami's 87%, Phoenix's 60%, Chicago's 48%, Atlanta's 35%, Detroit's 16%, and Las Vegas' barely 1%.<sup>2</sup> What explains this prodigious difference of home price growth across cities? In answering this, we can use the estimated coefficients from cross sections to forecast the long-term home price appreciation among cities within a time series context.

## 2.1 The Ratio of Building Permit Growth to Personal Income Growth

In theory, the gap between the growth of supply and the growth of demand in a city can predict long-term home price appreciation. Basic economic principles suggest that the bigger the gap between supply and demand, the smaller the home price appreciation. That is, if supply is rising more quickly than demand, home prices should fall; alternatively,

if demand is outpacing supply, home prices should rise. Additionally, when facing the same amount of positive demand shock, an inelastic housing supply will cause home prices to increase rapidly, while an elastic supply will prevent home prices from rising too much. For simplicity's sake, we use the personal income growth, which potentially includes all income, employment, and population growth of a city, as a representative variable of demand. By and large, we assume that the cost of building a home and its quality improvement does not vary significantly across the country.

Next, to understand the gap between supply and demand, we construct the ratio of total building permit growth to personal income growth:

$$\text{SDR} = \frac{\text{TBP}/\text{P}}{\text{PIG}},$$

where SDR is supply-to-demand ratio, TBP is total building permits issued 1995 to 2012, P is population in 2003, and PIG is personal income growth 1995 to 2011.

<sup>2</sup>The other famous housing price index is the S&P/Case-Shiller Home Price Index, which considers home quality and a broader sampling but only covers 20 cities. Its home price appreciations for major cities are not significantly different from FHFA's as shown in column 2 of Tab. 1. For instance, according to the Case-Shiller index, the nominal home price appreciation between March 1995 and September 2012 is as follows: Boston: 123%, Los Angeles: 127%, Washington D.C.: 110%, Miami: 71%, Phoenix: 58%, Chicago: 36%, Atlanta: 19%, and Detroit: 9%.

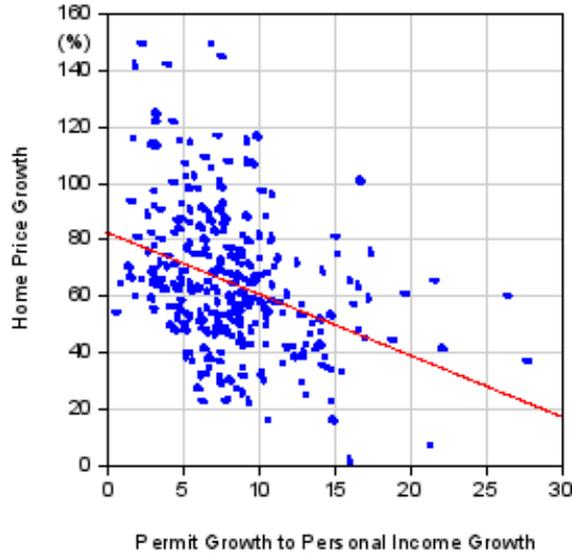


Fig. 3: The correlation between home price growth (1995–2012) and the ratio of permit growth to personal income growth (1995–2011)

Sources: Home prices are from the Bureau of Federal Housing Finance Agency, the permit number is from the U.S. Census, and the personal income growth and population is from the Bureau of Economic Analysis.

For the ratio of permit growth to personal income growth, the numerator is the total number of building permits issued from 1995 to 2012 over a metro's population in 2003<sup>3</sup> (middle point of the sample period), multiplied by 100. The denominator is the nominal total personal income growth from 1995 to 2011. If the ratio is very large, meaning that home supply outpaces demand, we expect a lower home price appreciation. If the ratio is very small, meaning that home supply does not catch up with demand, we expect a higher home price appreciation.

Fig. 3 presents a simple correlation between these two variables among 303 metropolitan areas<sup>4</sup> in the nation. The home price growth rate is calculated by the FHFA nominal single-family home index (all transactions) from 1995Q1 to 2012Q3. The scatter chart supports our simple theory. The downward-sloping line states an inverse relationship between the supply-to-demand ratio and home price growth. From the sample of 303 cities, the mean of the supply-to-demand ratio is 8.2 and the median is 7.7.

In Tab. 1, we list the 30 largest MSAs' home supply-to-demand ratio and the home price growth over this 18-year period. It is obvious that Northeastern and Coastal Californian cities have a less than accommodating home supply to meet their demand. As a result, they have higher home price growth and less affordable housing than other cities. Saiz (2010) uses the median home price, number of households, and physical and regulatory constraints from 1970 to 2000 to calculate the supply elasticity of metro areas, as shown in column 4 of Tab. 1.

If we run a simple OLS regression with the dependent variable as the nominal home price growth from 1995 to 2012 and the independent variables as our supply-to-demand ratio as well as Saiz's elasticity measurement. As shown in Tab. 2, we find that our simple supply-to-demand ratio has an  $R^2$  of 0.13, which is much higher than Saiz's elasticity with an  $R^2$  of 0.04. In other words, the supply-to-demand ratio seems to be a fairly easy barometer for home price appreciation. On the other hand, Saiz's

<sup>3</sup>Apparently, a bigger city will issue more building permits over time. To control for city size, we divide the total building permits issued from 1995 to 2011 by the city's population in 2003.

<sup>4</sup>There are 365 metropolitan statistical areas, but building permit data is available for only 303 metropolitan areas.

Tab. 1: Home price growth (1995–2012) and the supply-to-demand ratio for the 30 largest cities in the U.S.

	FHFA home price appreciation 1995–2012	Case-Shiller home price appreciation 1995–2012	Supply-to-demand ratio	Saiz (2010)'s supply elasticities
1 San Francisco	142	107	1.8	0.66
2 Boston	124	123	3.3	0.86
3 New York	122	108	4.4	0.76
4 Los Angeles	122	127	3.3	0.63
5 Washington DC	117	110	7.4	1.61
6 San Diego	115	117	4.7	0.67
7 Seattle	98	94	7.6	0.88
8 Baltimore	98	N/A	5.3	1.23
9 Philadelphia	93	N/A	4.9	1.65
10 Denver	88	92	9.3	1.53
11 Houston	87	N/A	7.9	2.30
12 Miami	87	71	6.9	0.60
13 Portland	83	78	7.2	1.07
14 Minneapolis	74	62	8.9	1.45
15 San Antonio	69	N/A	7.5	2.98
16 Tampa	68	55	10.6	1.00
17 Riverside	68	N/A	8.2	0.94
18 Pittsburgh	66	N/A	4.9	1.20
19 St. Louis	65	N/A	8.5	2.36
20 Dallas	62	N/A	9.1	2.18
21 Phoenix	60	58	11.9	1.61
22 Kansas City	58	N/A	9.6	3.19
23 Sacramento	56	N/A	8.6	N/A
24 Chicago	48	36	7.9	0.81
25 Orlando	47	N/A	13.4	1.12
26 Cincinnati	43	N/A	9.5	2.46
27 Atlanta	35	19	14.3	2.55
28 Cleveland	24	23	7.9	1.02
29 Detroit	16	9	10.6	1.24
30 Las Vegas	1	10	16.0	1.39

Source: Home price is from the Federal Housing Finance Agency, supply to demand ratio is calculated by the author, and supply elasticities are from Saiz (2010).

elasticity has much higher explanatory power on the log median home price level.

Note that in this paper we use only the single-family home price because of the data availability. However, for the building permits issued, we include both single and multi units.

We assume that even the number of multi-unit permits will have an impact on the single-family home price growth. That is because when the supply of multi units is abundant, it will ease the demand for single units, therefore reducing the price appreciation of single-family homes.

Tab. 2: OLS estimations with dependent variable: home price growth between 1995 and 2012

Dependent variable	Home price growth (1995–2012)		
Supply-to-demand ratio	−2.17*** (0.32)		−2.37*** (0.36)
Saiz’s (2010) elasticity		−3.43*** (1.06)	−3.88*** (1.00)
<i>N</i>	303	249	241
Adjusted <i>R</i> <sup>2</sup>	0.13	0.04	0.18

Note: The numbers in the parentheses indicate standard errors, \* indicates a 10% significance level, \*\* indicates a 5% significance level, and \*\*\* indicates a 1% significance level.

### 3 ESTIMATIONS

In the previous sections, we use a single variable – supply-to-demand ratio – to explain the difference of home price growth across cities. This ratio will be able to explain 13% (adjusted  $R^2$ ) of variation of home price appreciation across cities. Now, we take a broader view to see how all of the major factors predict home price appreciation across cities from 1995 to 2012. The baseline OLS model is Equation (1) and estimation results are shown in Tab. 3.

$$\begin{aligned}
 \text{Home price growth} = & \alpha + \\
 & + \beta_1 \cdot \text{Home supply} + \\
 & + \beta_2 \cdot \text{Economy} + \\
 & + \beta_3 \cdot \text{Human capital} + \\
 & + \beta_4 \cdot \text{Climate} + \\
 & + \beta_5 \cdot \text{Ocean} + \\
 & + \beta_6 \cdot \text{City size} + \\
 & + \beta_7 \cdot \text{Household size} + \\
 & + \beta_8 \cdot \text{Geography} + \\
 & + \beta_9 \cdot \text{Regulation} + \epsilon \quad (1)
 \end{aligned}$$

The dependent variable is the nominal FHFA home price growth from 1995Q1 to 2012Q3. Here we examine and explain the estimation of all these potential factors:

(1) Home supply: total building permits from 1995–2012 over the 2003 population. In order to consider home supply from existing homes due to the out-migration occurring in cities such as Detroit, we include those declining populations divided by average household size (2.6 people) as additional home supply.

(2) Economy: nominal personal income growth from 1995–2011. In Model 1 of Tab. 3, two major factors – supply (building permits/population) and demand (personal income growth) – account for 24% of the variation ( $R^2$ ). Both variables are statistically significant at a 1% level. As predicted, home supply has the negative coefficient, which means a larger home supply will result in lower home price appreciation.

(3) Human capital: We use the UCLA City Human Capital Index in 2008. This index is computed based on the average educational attainment of adult residents in an area. We discuss the construction of this variable in more detail in Section 6 below. We suspect that a more educated city will create a home price premium for reasons such as safety and better school districts. In Model 2, human capital is statistically significant at a 1% level. More importantly, the human capital factor boosts the  $R^2$  from 0.24 (Model 1) to 0.37, which demonstrates that it is an important determinant.

(4) Climate: the average temperature in January. It is well known that a migration from the Snow Belt to the Sun Belt has been occurring since technology advancements such as air conditioning have come into play. It is of interest to see if the weather still plays a role in affecting home price growth. In Model 3, it is statistically significant at a 5% level. But considering the fact that the  $R^2$  increased only from 0.37 to 0.38, it does not add too much explanatory power.

Tab. 3: Multiple regression estimations with dependent variable: home price growth between 1995 and 2012

Model	1	2	3	4	5	6	7
Home supply growth (1995–2012)	−2.06*** (0.33)	−2.36*** (0.38)	−2.48*** (0.39)	−2.47*** (0.31)	−2.57*** (0.30)	−2.68*** (0.32)	−2.70*** (0.32)
Personal income growth (1995–2011)	0.42*** (0.05)	0.45*** (0.05)	0.42*** (0.05)	0.43*** (0.05)	0.50*** (0.05)	0.53*** (0.06)	0.53*** (0.06)
Human capital 2008		1.56*** (0.25)	1.79*** (0.29)	1.23*** (0.24)	0.64** (0.27)	0.57* (0.31)	0.64* (0.33)
Climate			0.25** (0.05)	−0.07 (0.10)	−0.05 (0.10)	−0.20* (0.12)	−0.20* (0.12)
Ocean				23.58*** (3.66)	22.60*** (4.08)	17.01*** (4.31)	15.88*** (4.61)
City size 2003 (millions of people)					1.60*** (0.60)	1.94*** (0.64)	1.95*** (0.64)
Household size					−28.50*** (7.67)	−31.40*** (8.33)	−29.90*** (8.93)
Geography						0.37*** (0.07)	0.38*** (0.07)
Regulation index							−1.58 (1.75)
<i>N</i>	303	303	303	303	303	245	245
Adjusted <i>R</i> <sup>2</sup>	0.24	0.37	0.38	0.46	0.50	0.57	0.57

Note: The numbers in the parentheses indicate standard errors, \* indicates a 10% significance level, \*\* indicates a 5% significance level, and \*\*\* indicates a 1% significance level.

(5) Ocean dummy: For cities facing either the Atlantic Ocean or the Pacific Ocean, we assign them as 1<sup>5</sup>. Otherwise, 0. As Rappaport and Sachs (2003) point out, there might be two premiums for cities adjacent to the ocean. First are amenities, and the second is higher productivity and convenience of international trade and traveling. In Model 4, the ocean dummy is statistically significant at a 1% level. And it increases explanatory power from 0.38 to 0.46. However, the January temperature becomes insignificant after the ocean factor is added. This implies that the Sun Belt premium we used to see may have been fading away during the period of 1995 to 2012. The ocean factor is a more appropriate candidate for natural amenities in terms of the demand of homes.

(6) City size: the 2003 population. We suspect that the size of a city could partly represent its amenities, e.g. a more diversified lifestyle and a more public infrastructure. In Model 5, it is statistically significant at a 1% level.

(7) Household size: Given the same population, the larger the household size, the lower the demand of homes will be. Therefore, we suspect that the household size has an inverse relationship with home price growth. In Model 5, indeed it has a negative sign and is statistically significant at a 1% level.

(8) Geographic constraint: Saiz (2010) constructs a land unavailability index for cities in the U.S. based on the mountainous areas and internal waters of cities. The index is presented as the percentage of undevelopable area within a 50-km radius of a metro center. As a supply-side factor, we suspect that a higher value in the index will increase the building cost and therefore home price growth over time. In Model 6, it is statistically significant at a 1% level. It is unclear why this determinant, which is fixed and is easily known, will still produce the expected returns. This seems to contradict the efficient market theory. One possible reason is that facing uncertain demand, the scarcity

<sup>5</sup>We consider coastal cities as those cities whose centers are within 80 km of the Atlantic or Pacific Ocean. We do not consider cities along the Great Lakes or the Gulf of Mexico (except cities in Florida) because the main underlying implication is their amenities.

will create more volatility of home price growth. And this high volatility will need to be compensated for by higher expected return (higher home price appreciation in the long run).

(9) Regulation: As mentioned earlier, studies have shown that environmental and zoning regulations could defer permit and home construction and increase building costs. We suspect that it could explain the higher home price appreciation, which cannot be captured by the

home supply factor. For the proxy of regulation, here we adopt the Wharton Residential Urban Land Regulation Index, created by Gyourko et al. (2008). In Model 7, the variable is not statistically significant.

In summary of these seven models, we find that, except for climate (January temperature) and regulation, all other factors are persistently significant and their coefficients are relatively stable.

## 4 ROBUSTNESS CHECK

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In the previous section, we use the nominal FHFA housing price index as the dependent variable. Here, as a robustness check, we use the nominal log median housing prices of MSAs as the alternative dependent variable from American Community Survey of 2010. Tab. 4 presents the estimation results. Comparing Tab. 3 and 4, we find most of the results are consistent. For instance, home supply growth, personal income growth, human capital, an ocean dummy, city size, and geographic constraint are mostly statistically significant at a 1% level. It is worth noting that in Tab. 3, we focus on the home price growth in the past two decades (1995 to 2012). In Tab. 4, we could say we focus on the infinite home price growth because the home price level in 2010 is the accumulative result of all previous home price appreciations in MSAs.

The difference is as follows: (1) Household size has an expected negative impact on home price growth between 1995 and 2012 as shown in Tab. 3 while it has an unexpected positive impact on home price level in 2010 as shown in Tab. 4. The reason is unclear. (2) Regulation is not statistically significant on home price growth (Tab. 3) while it is statistically significant on the price level (Tab. 4). This could imply that a more stringent regulation indeed boosts the building costs and prices in MSAs prior to 1995. But that impact fades away during the period of 1995 to 2012. (3) Earthquakes<sup>1</sup> are not statistically significant on home price growth while they are statistically significant on the price level. Model 14 in Tab. 4 has an  $R^2$  of 0.74. Combining Tab. 3 and 4, we could conclude our models and partial correlation inferences are robust and reliable.

## 5 ENDOGENEITY PROBLEM

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The preceding analysis is useful for in-sample forecasting, but drawing inferences for real-time policy use or out-of-sample forecasting requires further investigation. In particular, in Tab. 3 and 4, our results may be biased because some of right-hand-side variables are endogenous. For instance, home supply growth, personal income growth, human capital level, and city size will be affected by home price growth. To resolve the endogenous problem, the literature usually uses instrumental variables. However, due to the lack

of valid instrumental variables, we propose two alternative methods to refine our estimation.

First, we change the sample periods of those endogenous variables to the earlier years or periods. Instead of using the home supply growth and personal income growth from 1995 to 2012, we only use the home supply growth and personal income growth from 1995 to 2003. Although there is an overlapping period (1995 to 2003) for dependent variables and endogenous variables, it is less likely that the

Tab. 4: Multiple regression estimations with dependent variable: log median home price 2012

Model	8	9	10	11	12	13	14
Home supply growth (1995–2012)	−0.00 (0.01)	−0.01** (0.00)	−0.01*** (0.01)	−0.01*** (0.00)	−0.01*** (0.00)	−0.01*** (0.00)	−0.01*** (0.00)
Personal income growth (1995–2011)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Human capital 2008		0.03*** (0.00)	0.04*** (0.01)	0.03*** (0.00)	0.04*** (0.01)	0.04*** (0.01)	0.03* (0.01)
Climate			0.01*** (0.00)	0.00 (0.00)	0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)
Ocean				0.46*** (0.06)	0.41*** (0.05)	0.22*** (0.06)	0.16*** (0.05)
City size 2003 (millions of people)					0.02*** (0.01)	0.03*** (0.01)	0.03*** (0.00)
Household size					0.73*** (0.14)	0.70*** (0.18)	0.58*** (0.17)
Geography						0.01*** (0.00)	0.01*** (0.00)
Regulation index							0.12*** (0.02)
Earthquake							0.14 (0.03)
<i>N</i>	304	304	304	304	304	246	246
Adjusted $R^2$	0.05	0.29	0.33	0.46	0.58	0.66	0.74

Note: The numbers in the parentheses indicate standard errors, \* indicates a 10% significance level, \*\* indicates a 5% significance level, and \*\*\* indicates a 1% significance level.

Tab. 5: Multiple regression estimations with dependent variable: home price growth between 1995 and 2012

Model	1	2	3	4	5	6
Home supply growth (1995–2003)	−3.24*** (0.63)	−3.25*** (0.64)	−3.38*** (0.64)	−3.24*** (0.58)	−3.19*** (0.59)	−3.78*** (0.65)
Personal income growth (1995–2003)	0.84*** (0.16)	0.70*** (0.15)	0.64*** (0.15)	0.61*** (0.14)	0.60*** (0.15)	0.78*** (0.18)
Human capital 1990		1.22*** (0.26)	1.42*** (0.28)	0.92*** (0.24)	0.90*** (0.24)	0.88*** (0.26)
Climate			0.24 (0.11)	−0.04 (0.10)	−0.05 (0.10)	−0.20* (0.12)
Ocean				23.28 (3.66)	22.49*** (3.89)	16.39*** (4.86)
City size 1998 (millions of people)					0.72 (0.79)	1.03 (0.80)
Geography						0.29*** (0.08)
<i>N</i>	300	300	300	300	300	244
Adjusted $R^2$	0.16	0.23	0.24	0.33	0.33	0.43

Note: The numbers in the parentheses indicate standard errors, \* indicates a 10% significance level, \*\* indicates a 5% significance level, and \*\*\* indicates a 1% significance level.

Tab. 6: Multiple regression estimations with dependent variable: log median home price 2012

Model	8	9	10	11	12	13	14
Home supply growth (1995–2003)	−0.02*** (0.01)	−0.02** (0.01)	−0.03*** (0.01)	−0.02*** (0.01)	−0.02*** (0.01)	−0.03*** (0.01)	−0.02*** (0.01)
Personal income growth (1995–2003)	0.02*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01** (0.00)	0.01*** (0.00)	0.01*** (0.00)
Human capital 1990		0.04*** (0.01)	0.04*** (0.01)	0.03*** (0.00)	0.03*** (0.01)	0.03*** (0.00)	0.03*** (0.00)
Climate			0.01** (0.00)	0.00 (0.00)	0.00 (0.00)	−0.00** (0.00)	−0.00*** (0.00)
Ocean				0.42*** (0.06)	0.37*** (0.06)	0.18*** (0.05)	0.19*** (0.05)
City size 1998 (millions of people)					0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)
Geography						0.01*** (0.00)	0.01*** (0.00)
Earthquake							0.12*** (0.03)
<i>N</i>	301	301	301	301	301	245	245
Adjusted $R^2$	0.21	0.44	0.47	0.58	0.60	0.69	0.71

Note: The numbers in the parentheses indicate standard errors, \* indicates a 10% significance level, \*\* indicates a 5% significance level, and \*\*\* indicates a 1% significance level.

Tab. 7: Multiple regression estimations with dependent variable: home price growth between 2004 and 2012

Model	1	2	3	4	5	6
Home supply growth (1995–2003)	−1.41*** (0.36)	−1.41*** (0.36)	−1.41*** (0.32)	−1.43*** (0.32)	−1.50*** (0.40)	−1.47*** (0.49)
Personal income growth (1995–2003)	0.00 (0.10)	−0.01 (0.11)	−0.01 (0.12)	−0.01 (0.12)	0.01 (0.12)	0.08 (0.15)
Human capital 1990		0.03 (0.18)	0.03 (0.22)	0.10 (0.23)	0.14 (0.24)	0.16 (0.23)
Climate			−0.01 (0.10)	0.04 (0.11)	0.04 (0.11)	−0.04 (0.10)
Ocean				−3.48 (2.83)	−2.31 (2.98)	−1.35 (3.68)
City size 1998 (millions of people)					−1.06 (0.75)	−0.72 (0.67)
Geography						−0.05 (0.06)
<i>N</i>	301	301	301	301	301	245
Adjusted $R^2$	0.09	0.08	0.08	0.08	0.09	0.09

Note: The numbers in the parentheses indicate standard errors, \* indicates a 10% significance level, \*\* indicates a 5% significance level, and \*\*\* indicates a 1% significance level.

home price appreciation between 1995 and 2012 will cause the growth of personal income or home supply between 1995 and 2003. For the human capital level, we use the data in 1990 instead of 2008. This would be sufficiently exogenous. For city size (population), we use 1998 instead of 2003. Since we do not have the

data of regulation in the earlier year, we exclude it in the regression.

The estimation results are displayed in Tab. 5. By and large, we get a similar result as that in Tab. 3. Home supply growth, personal income growth, human capital levels in 1990, the ocean dummy and geographic constraints

are all statistically significant at a 1% level. The only difference is the city size in 1998, which becomes statistically insignificant.

In Tab. 6, following Tab. 5 for adjusting the sample periods of endogenous variables, we use the log median home price as the dependent variable. The results in Tab. 6 are consistent with those in Tab. 4. Again, this proves that our determinants' predictions are robust and more likely exogenous. It is worth noting that we use the human capital level of 1990, and it still can predict home price growth from 1995 to 2012 as well as the median home price in 2010. Not only do we know that human capital is an important determinant of home price premium, but also that it is a good long-term predictor because of its persistence.

## 6 HUMAN CAPITAL

One contribution of this paper is that we use the UCLA Human Capital Index, which calculates the mean of residents' education attainments, rather than the percentage of bachelor's degree or higher used by all the literature, if they use any related variable at all. In other words, our variable is a more comprehensive indicator of human capital in MSAs than the simple percentage of higher educated residents.

We compute the index based on three parts with corresponding population percentages as follows. We do not consider the migration factor of human capital because there is no available data.

(1) For those residents who are above 25 years of age, we calculate the CHCI by assigning the attained schooling years using the following categories:

- Category 1: Less than 9th grade: we assign 5 schooling years (50 CHCI points) for this percentage of residents.
- Category 2: 9th to 12th grade: we assign 10 schooling years.
- Category 3: High school graduate: we assign 12 schooling years.
- Category 4: Some college, no degree: we assign 13 schooling years.

In Tab. 7, we extend our alternative method to an extreme. We change our sample period of the home price growth to the period of 2004 to 2012. In this case, we exclude any possibility of endogeneity. The results, however, are not appealing. First, the  $R^2$  is low (around 0.09). Second, only home supply growth is statistically significant while all other variables become insignificant. One possible reason for this result is that the second half of the sample period (2004 to 2012) experienced the swift housing price bubble and bust. Thus this period is not an ideal sample period for the long-term fundamental analysis.

- Category 5: Associate's degree: we assign 14 schooling years.
- Category 6: Bachelor's degree: we assign 16 schooling years.
- Category 7: Graduate or professional degree: we assign 18 schooling years.

(2) For those residents who are between 18 and 24 years of age, we estimate the CHCI by assigning the schooling year with the following categories:

- Category 1: less than high school graduate: we assign  $X$  schooling years, in which  $X$  is estimated by the CHCI average of Categories 1 and 2 from Part (1) in the same region.
- Category 2: High school graduate: we assign 12 schooling years.
- Category 3: Some college or associate's degree: we assign  $Y$  schooling years, in which  $Y$  is estimated by the weighted average of Categories 4, 5, 6, and 7 from Part (1) in the same region.
- Category 4: Bachelor's degree or higher: we assign 16 schooling years.

(3) For those residents who are between 5 and 17 years of age, we forecast their future potential CHCI based on the CHCI average of

Tab. 8: Multiple regression estimations with dependent variable: home price growth between 1995 and 2012

Dependent variable	Home price growth 1995 to 2012		Log median home price 2010		Home price growth 1995 to 2012		Log median home price 2010	
	The whole sample		The whole sample		The earlier period of year		The earlier period of year	
Endogenous variable								
Model	(7)		(14)		(6)		(14)	
Home supply growth	-2.70*** (0.32)	-2.69*** (0.32)	-0.01*** (0.00)	-0.01*** (0.00)	-3.78*** (0.65)	-3.68*** (0.64)	-0.02*** (0.01)	-0.02*** (0.01)
Personal income growth	0.53*** (0.06)	0.50*** (0.06)	0.00*** (0.00)	0.00*** (0.00)	0.78*** (0.18)	0.68*** (0.18)	0.01*** (0.00)	0.01*** (0.00)
City human capital index	<b>0.64*</b> (0.33)		<b>0.03*</b> (0.01)		<b>0.88***</b> (0.26)		<b>0.03***</b> (0.00)	
Bachelor's degree		<b>0.64***</b> (0.21)		<b>0.02***</b> (0.00)		<b>1.21***</b> (0.22)		<b>0.03***</b> (0.00)
Climate	-0.20* (0.12)	-0.19* (0.11)	-0.00 (0.00)	-0.00*** (0.00)	-0.20* (0.12)	-0.19* (0.11)	-0.00*** (0.00)	-0.01*** (0.00)
Ocean	15.88*** (4.61)	15.89*** (4.36)	0.16*** (0.05)	0.16*** (0.04)	16.39*** (4.86)	16.32*** (4.47)	0.19*** (0.05)	0.21*** (0.05)
City size (millions of people)	1.95*** (0.64)	1.65** (0.66)	0.03*** (0.01)	0.02*** (0.01)	1.03 (0.80)	0.55 (0.85)	0.04*** (0.01)	0.04*** (0.01)
Household size	-29.90*** (8.93)	-31.70*** (6.63)	0.58*** (0.17)	0.22* (0.11)				
Geography	0.38*** (0.07)	0.38*** (0.06)	0.01*** (0.00)	0.00*** (0.00)	0.29*** (0.08)	0.31*** (0.07)	0.01*** (0.00)	0.01*** (0.00)
Regulation index	-1.58 (1.75)	-2.31 (1.66)	0.12*** (0.02)	0.11*** (0.02)				
Earthquake			0.14*** (0.03)	0.15*** (0.03)			0.12*** (0.03)	0.13*** (0.03)
<i>N</i>	245	245	246	303	244	245	245	245
Adjusted $R^2$	0.57	0.58	0.74	0.78	0.43	0.47	0.71	0.74

Note: The numbers in the parentheses indicate standard errors, \* indicates a 10% significance level, \*\* indicates a 5% significance level, and \*\*\* indicates a 1% significance level.

the CHCI of residents from Part (1) in the same region with the following weighted adjustment of their current school enrollment rate:

- Category 1: 5 to 9 years old: if the area's enrollment rate is, say 94%, 94% will be assigned CHCI calculated from Part (1) and 6% of this area's residents will be assigned as 2 schooling years.
- Category 2: 10 to 14 years old: if the area's enrollment rate is  $Z$ ,  $Z$  will be assigned CHCI calculated from Part (1), and  $1 - Z$  of this area's residents will be assigned as 7 schooling years.
- Category 3: 15 to 17 years old: if the area's enrollment rate is  $Z$ ,  $1 - Z$  of this area's residents will be assigned as 11 schooling years.

Does our human capital index provide more value than the traditional measurement of human capital? Surprisingly, based on the results in Tab. 8, the answer is no. The percentage of bachelor's degree seems to (1) have a higher  $R^2$  by 0.04 on average than city human capital index, and (2) have larger  $t$ -statistics. The possible reasons are twofold: First, the percentage of bachelor's degree has a higher standard deviation while the city human capital index has a lower standard deviation because it is calculated based on the average number of schooling years. Second, the average number of schooling years of residents could be more correlated to other variables, such as household size. Nevertheless, both human capital index and bachelor's degrees provide equivalently insightful inferences on housing price appreciation.

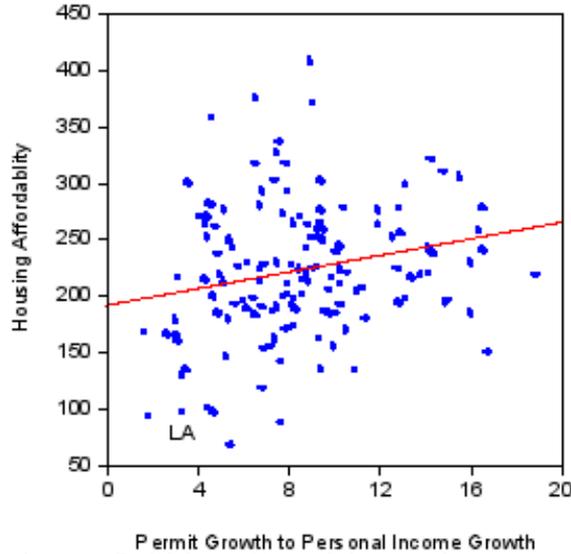


Fig. 4: The correlation between housing affordability in 2011 and the ratio of permit growth to personal income growth (1995–2011)

Sources: Housing affordability is from the National Association of Realtors, permit numbers are from the U.S. Census, and the personal income growth and population is from the Bureau of Economic Analysis.

## 7 POLICY IMPLICATIONS

This paper has an important practical use for policymakers concerned with housing affordability through its emphasis on distinguishing between cyclical fluctuations in housing prices and long-term, though-the-cycle trends. Most demand-side factors are broader in nature than housing-policy specific factors. For instance, if regional home price growth is driven by demand factors, such as income growth, employment growth, population growth, or human capital enhancement (educated workers migration or local school improvement), it is a symbol of the vibrant and resilient trend or cycle. Residents should embrace the situation and celebrate with the steadily rising home prices.

Yet, if the regional home price growth is driven by the supply factor, which means that a limited number of building permits is driving up the home price, then we suggest that it will hamper a city's growth. Less affordable housing will increase the cost for renters and immigrants who may come to the city. As a result, it will also increase the cost of businesses

as employers offer higher wages to compensate for the higher cost of living that employees are facing. Fig. 4 shows the correlation between our simple supply-to-demand ratio and the housing affordability index. An adequate number of construction and building permits in line with the demand of homes in a city is more likely to temper home price appreciation and to provide affordable housing.

Policymakers must distinguish between cyclical and trend factors in constructing housing policy. Our simple supply-demand ratio can be valuable in this task. Many macroeconomic demand-side factors, such as income growth, are drivers of housing demand, and it would be inappropriate to respond at a local level to cyclical fluctuations in income growth with active policy. Rather, policymakers should seek to balance supply and demand through the business cycle, by ensuring that supply is allowed to keep up with long-term trends rather than cyclical fluctuations.

## 8 CONCLUSIONS

Based on the FHFA nominal home price growth from 1995 to 2012 and the Census nominal median home price in 2010 for MSAs, this paper identifies several determinants to predict the home price growth and home price level: (1) Home supply growth, measured by the total permit growth. (2) Personal income growth, which captures a region's growth of population, employment, and income. (3) Human capital level, measured by the city human capital index and the percentage of residents holding a bachelor's degree or higher. (4) Ocean dummy, which demonstrates the amenities provided by facing the Atlantic or Pacific Oceans. (5) Geographic constraints, measured by Saiz (2010)'s percentage of undevelopable area in a city.

This paper provides three contributions to the literature: (1) The selection of our single sample period could avoid the complex issues that accompany housing bubbles and busts. Moreover, we propose a simple sample partition method to improve the endogeneity problem. (2) We calculate a simple supply-to-demand ratio, as a proxy of supply elasticity, which could be an easy measurement to determine whether or not a city has an adequate home supply to fit its demand in the long run. (3) We provide an alternative measurement for a city's human capital and verify the importance of education and a skilled workforce to a city's housing market.

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