The Evolution of House Price Capitalization and the Yield Curve

Stuart Gabriel
University of California-Los Angeles

Richard K. Green
University of Southern California

Christian Redfearn
University of Southern California

December 31, 2008
Preliminary and Incomplete

House prices have long been a subject of fascination. They have long been the stuff of both cocktail party conversation and academic research. Just the past twenty years have produced a long list of papers (e.g. Mankiw & Weil (1989), Peek & Wilcox (1991), Green & Hendershott (1996), Englehart & Poterba (1991), Gabriel et al., Malpezzi (1999), Glaeser, Gyourko, & Saks (2005), Hwang & Quigley (2006), Green, Malpezzi & Mayo (2005), some of which have been controversial, most notably, perhaps the Mankiw and Weil piece, which predicted a real decline in hosue prices of 47 percent between 1987 and 2007.

While real house prices actually rose considerably between 1987 and 2007, they have of course been falling nearly everywhere since then. These declines have contributed to the recent collapse in financial markets, making the evolution of housing prices now more interesting than ever.

We in this paper seek to do two things: to extend the user cost model of house prices to include the slope of the yield curve, and to investigate whether the development of exotic mortgages help explain the unprecedented increase in real house prices in some parts of the United States. While our results can be describes as only exploratory, they do appear to support the idea that the relaxation of "affordability constraints" through exotic products might be capitalized into house prices.

We begin by defining exotic mortgage products, and by looking at some stylized facts about the prevalence of exotic mortgages and house price movements. We then discuss the traditional user cost of capital model of house prices, and augment it by considering the slope of the yield curve and affordability constraints. We map this user cost discussion into an empirical strategy for estimating both the traditional user cost model and our augmented version of it for 135 Metropolitan Statistical Areas in the United States. We feature results for cities with stringent regulator constraints and for those not so constrained. We then relate capitalization to a number of characteristics, and report rolling regressions that investigate capitalization across time.

Exotic Mortgages

Between the Great Depression and the late 1970s, mortgages were a little like Model T Fords—you could have any kind you wanted, so long as it was fixed-rate, long term and self-amortizing. Fisher and Van Order (2008), in a history of mortgage market regulation, show that even the most ordinary of Adjustable Rate Mortgages—a One-Year Adjustable Rate mortgage whose rate was pegged to one-year treasuries plus a margin—was possible illegal before 1979 (check). Because financial institutions could offer only fixed-rate mortgages, and because the yield curve was sharply inverted (Figure 1), mortgage credit dried up between 1979 and 1982, with originations falling by xx percent.

In response to this, Congress passed the XX Act, which allowed for adjustable rate mortgages. The first of these products helped restart the mortgage market, and the market share of ARMS increased to 60 percent by 198X. Beyond the fact that the adjustable rate mortgage allowed financial intermediaries to match better their assets and liabilities, it also allowed lenders to provide borrowers relief from an affordability constraint, or "tilt." Even in the presence of an inverted yield curve, lenders were willing to provide mortgages to borrowers at low initial rates—or teaser rates. The teaser rates were still higher than the rates the lenders paid depositors, and under the institutional arrangements of the time, allowed borrowers to get access to credit. The hope was that the loans would ultimately adjust to a one-year Treasury plus a substantial margin. The assumptions behind this hope were (1) inflation would continue to cause nominal incomes to rise, meaning that borrowers would not be unduly stressed when their loans reset; (2) inflation would lead to higher nominal house prices, meaning that the incentive to default would remain low; and (3) that borrowers would not refinance a the time that their loan fully adjusted.

It turned out that none of these assumptions proved correct. The teaser rate ARM was particularly popular in California in the 1980s. Starting in 1989, California had its worst recession since the Great Depression, with a sharp uptick in unemployment and declines in *nominal* income (check). During the early 1990s, nominal house prices in Southern California fell by 21 percent (OFHEO). Finally, Green and Shilling (1997) provide some evidence that borrowers with teaser rate ARMS and high margins prepaid more rapidly than those with lower teasers and lower margins.

As we contemplate the events of the past nine or ten years, we may wish to consider the experience in California in the late 1980s and early 1990s. Green and Shilling (1994) used a bivariate tobit model to show that in the 1980s, teaser rates may well have been capitalized into house prices. The irony is that the instrument that was supposed to make ownership more affordable lost much of its effectiveness because it pushed up house prices.

The teaser rate ARM of the 1980s was a vanilla product, however, compared with recent mortgage innovations. While mortgages had many permutations between 2001 and 2007, we may divide exotic mortgages into four types:

(1) Interest only mortgages. These mortgages made housing more affordable by reducing the payment required of borrowers early on in the life of the mortgage.

(2) Negative amortization mortgages. These mortgages went a step beyond interest only mortgages, and allowed borrowers to exchange low payments in the early years of the mortgage for increasing principal that would need to be repaid in the future.

(3) 2-28 and 3-27 mortgages. These mortgages were similar to the teaser rate mortgage of the 1980s, except that the teaser would last for either 2 or 3 years. However, these mortgages contained prepayment penalties to discourage borrowers from refinancing before the teaser expired.

(4) Stated income loans. These loans allowed borrowers to report their incomes and wealth without documentation, thus eliminating a barrier to mortgage credit.

One other feature that all these loans had in common was a low down payment requirement. Bostic and Wacter (????) have shown that the absence of a down payment has been a greater impediment to obtaining mortgage credit than insufficient income to make payments.

Exotic mortgage lenders of the past seven or eight years may well have been making the same assumptions of the teaser-rate lenders of the 1980s: that incomes would rise; that house prices would rise; the borrowers would not ruthlessly refinance. The United States is in a recession with falling employment and income, house prices are falling at a rate last seen in the 1930s, and according to Loan Performance data, borrowers that could refinance out of exotic mortgages did refinance.

We may get a flavor of the impact of all this by looking at two maps. The first (figure 2) shows the change in the use of "exotic financing" between 2002-2005. The change ranges from an increase of 8.8 percentage points in Mississippi to 57.7 percent in Nevada. The second (figure 3) shows the change in house price by state, based on the Office of Federal Housing Enterprise Oversight repeat sales series. The state with the highest increase is again Nevada, where prices rose an at annualized rate in excess of 17 percent over the four year period. That said, the state with the smallest price increase, Utah, was above average in its increase in subprime lending. Nevertheless, the correlation coefficient between the change in subprime lending and change in house prices was .59. A simple bivariate regression of change in house price on change in use of interest-only and negative amortization mortgages produces an R^2 of 0.36.

An investigation of the relationship between the change in exotic market share presents us with a problem of causality. Expensive house prices could induce the use of exotic products, so that borrowers who would otherwise not qualify for a mortgage could do so. Conversely, the development of exotic mortgages could be a demand shifter for housing, and as such could induce higher house prices.

Our strategy for establishing at least one direction of causality will be to investigate the effect of the yield curve on house prices. Because exotic mortgages are overwhelmingly adjustable rate mortgages, their rates will be influenced by the short end of the yield curve. The yield curve is arguably exogenous with respect to house prices.[1] We will therefore use the slope of the yield curve, along with a measure of long-term interest rates, in order to explain house prices.

$$\begin{aligned} UC &= CC + OC - TS \\ &= r + E[\pi] - g + m + d + t + \alpha - \tau\,(r + E[\pi] + t) \\ &= (1 - \tau)(r + E[\pi] + t) - g + m + d + \alpha \end{aligned}$$

where

UC ≡ user cost

CC ≡ cost of capital

OC ≡ occupancy cost

TS ≡ tax savings

r ≡ weighted average real cost of capital

pi ≡ inflation rate

g ≡ expected rent growth

t ≡ property tax rate

m ≡ maintenance as a fraction of value

d = depreciation

alpha ≡ a risk premium

In the standard equilibrium model of house prices, prices are just rent divided by user cost. Because we will be focusing on changes in the user cost equation, many of the right hand side variables difference out. For instance, while marginal tax rates do change somewhat differently from state to

[1] We take the word of the Federal Reserve that it did not use monetary policy to inflate or deflate assets values.

state, they changes are slow and relatively small.[2] But both g and α can change dramatically and quickly across time.

The use cost framework does assume that house prices are in equilibrium. The events of the past ten years or do begs the question as to whether house prices generally are in equilibrium. While Mayer (200x) has argued that the user cost model had explained house prices his view—that house prices rose expect expected house price growth was high—is also consistent with a bubbly story. Blackley and Follain (1996) moreover argue that the user cost framework has been disappointing in its ability to explain house prices nationally. They note:

> "Although the results [of the user cost model] are generally consistent with expectations...the estimates fail to identify a strong relationship between rent and user costs."

And

> "About half of any increase in user costs is ultimately passed along as higher rent. The adjustment process takes a long time...one-third of the long-run effect within 10 years."

While the Blackley and Follain results are interesting, they do not necessarily reject the user cost model. It is possible that rents are set in the urban land market, and that prices are then determined by the capitalization of those rents. We would especially expect this to be true in land constrained markets.

Nevertheless, there are models (Hendershott and Abraham 1994 and Capoza, Hendershott and Mack 2004) that suggest strongly that the user cost framework does not adequately explain the evolution of house prices. On the other hand, Capozza, Green and Hendershott (1996) show that differences is rent-to-price ratios across a panel of metropolitan areas can be explained largely by differences in after tax interest rates and property tax rates.

Part of the reason that the user cost framework has had mixed result in explaining house prices might be that institutional arrangements prevent households from making tenure choice decisions based entirely on the after-tax difference in cost between owning and renting. In the first place, there is some evidence that the owner and renter markets are segmented. At the crudest level of analysis, the American Housing Survey shows that xx percent of multifamily housing is renter occupied, whereas only xx percent of detached single-family housing is owner-occupied. This may be because individuals have an advantage at managing detached houses, while there are economies

[2] In static cross-sections, marginal tax rates vary quite a lot across states and are important in explaining differences in rent to price ratios, See Capozza, Green and Hendershott (1996).

of scale to managing multi-family housing.

Perhaps more important, the ability of households to obtain a mortgage involved much more than the relative user costs of owning and renting. With the possible exception of the period 2002-2007, households faced fairly rigid nominal affordability constraints, or underwriting constraints.

Consider that when a household bids for a house, they finance it with debt and equity, do that

$$H = E + M$$

Where H is the bid for the house, E is the equity (or down payment), and M is the size of the mortgage. Lenders usually will not permit borrowers from having payments that are larger than some fraction of income, so that

$$m = \psi * y$$

where m is the mortgage payment, y is income, and ψ is the maximum fraction of income that the lender will allow to be allocated to a mortgage payment. We may approximate the size of the resulting mortgage with

$$M \approx \frac{m}{r}$$

where m is the mortgage payment and r is the mortgage interest rates. Finally,

$$E = d * H$$

where d is the required downpayment ratio, and H is the amount bid for the house. Rearrainging, the nominal affordability constraint is

$$H = \min\left(\frac{E}{d}, \frac{\psi y}{r}\right)$$

This gives us straightforward comparative statics about the relationships among income, interest rates, the affordability constraint, and households' ability to bid for a house. Specifically:

$$\frac{\partial H}{\partial r} = -\frac{\psi y}{r^2}$$

$$\frac{\partial H}{\partial y} = \frac{\psi}{r}$$

$$\frac{\partial H}{\partial \psi} = \frac{y}{r}$$

$$\frac{\partial H}{\partial d} = -\frac{E}{d^2}$$

So as interest nominal interest rates fall, affordability constraints become less binding, and households may bid more for houses. Similarly, as the downpayment constraint falls, the ability to bid more for a house rises.

Empirical Strategy

The question, then, is this: is there a stable relationship between interest rates and house prices? Is there one rate that matters to households across different housing markets? The user-cost model includes one rate, which is largely held to be the interest rate on the standard 30-year fixed rate, conforming mortgage. The user-cost model has not been very successful at explaining housing prices, however, and it may be that a more nuanced model is required that incorporates other features of housing markets, especially those of recent years. In years prior to recent innovations in mortgage markets, there existed a binary choice between fixed- and adjustable-rate mortgages. Even during this period of relative debt instrument simplicity, it is easy to see how a household that *ceteris paribus* expected house prices to rise might pick the mortgage with the lower interest rate so that it could qualify for a larger mortgage, increasing its leverage and expected returns. It would appear that expectations would then play a role of the choice between these two mortgages and would which rate to include in the user cost model. This effect was clear over the last years of the most recent housing bubble. During this era of mortgage innovation, the variety of interest rates available to households were legion, and households could pick from a set of several based upon expected holding period, risk tolerance, etc. In addition to expectations, another key issue in determining household choice may have been affordability: households picked interest rates from the short end of the yield curve because those rates qualified them to make bids that they may have not been able to make based on the long end of the curve. For these households, the relevant rate may differ from households for which affordability is not binding.

It is here that we think previous user cost analysis is perhaps inadequate. Generally, past work has focused on but one rate: either the ten-year treasury rate or some version of the 30-year fixed rate mortgage rate.[3] Recent years have made clear that this is not the only relevant rate; for example, 75.3% of new home purchases in San Diego in 2005 were made with negative amortization or interest only mortgages – financial instruments tied to the short end of the yield curve. Our innovation is to allow the data to reveal which portion of the yield curve was relevant to movements in aggregate housing prices. We do so by estimating the nominal affordability constraint outlined above, looking both for stable relationships and those that appear and disappear with changes in expectations.

In order to examine the nominal affordability constraint directly, we estimate the model:

$$\text{(X)} \qquad \ln(H_t) = \beta^{mtg}\ln(r_t^{mtg}) + \beta^{d}\ln(d) + \beta^{\psi}\ln(\psi) + \beta^{y}\ln(y_t)$$

For the mortgage rate, we will specify it by using the ten-year treasury rate and the slope of the yield curve between the one and ten-year treasuries. Income, y, is the per capita income for whichever geography is used – US, state, or metropolitan area. We are confident that ψ and d changed over time – particularly in recent years, with the advent of low-down payment mortgages. However, we can't measure them precisely because there is no readily available and uniform data on down payment requirements and payment ratios. We omit these variables, in effect assuming that they remain constant. This misspecifiction will affect the coefficients on the rates variables and the income variable to the extent that they are correlated. [Add national numbers on downpayment trends/income ratio trends/and rate correlations – weak].

Thus the model we estimate is:

$$\ln(H_{it}) = \alpha + \beta_i^{mtg}\ln(r_t^{mtg}) + \beta_i^{slope}\ln(\Delta_t) + \beta_i^{y}\ln(y_{it}) + \varepsilon_{it}$$

where i subscripts metropolitan areas and t subscripts time. We use this model to examine the capitalization of income, long and short-term interest rates for aggregate U.S. house prices and across 135 Metropolitan Statistical Areas (MSAs). We also look at how capitalization evolves across time, how these temporal patterns vary across MSAs, and how capitalization varies between constrained and unconstrained metropolitan areas.

Data

We use two sources to generate our house price series. To generate quality-controlled nominal prices, we use the National Association of Realtors Median house price index for the first quarter of 2006. We then use the Office of Federal Housing Enterprise Oversight repeat sales

---

[3] The Freddie Mac survey of 30-year fixed rate mortgage would be an example of such a rate. See freddiemac.com/XXX

indices for the U.S. and for the metropolitan areas to generate nominal house price levels over time. These sources produce data for 135 MSAs. We collect Income and Population data for each MSA from the Bureau of Economic Analysis. Our interest rate series – the 10-year and one-year Treasury yields and the 30-year fixed rate mortgage rates, are taken from the Federal Reserve Bank of St. Louis' FRED II database.

Using these data, we run two types of regressions: static and "dynamic" regressions. The static regressions look for stable relationships among the data. We estimate these models for the full sample and for two subsamples: before and after 1997, a date we use to mark the break between traditional mortgage lending and a period of rapid innovation and pronounced change in borrowing behavior. The second type of regression is a dynamic "running" regression in which the model described in Equation X is estimated on a running basis over time with observations taken from a temporal window of 5 years, with the a coefficient for date *t* is estimated using data from 10 quarters before and after *t*. This type of regression reveals temporal patterns in the capitalization of rates and income into house prices.

Results

US Regressions

We begin with time series regressions using aggregated data for the entire United States. That is, we use national-level house prices and national per capita income; the rate series are inherently national. We estimate Equation X for the full 1975 to 2007 sample period as well as two subsamples, before and after 1997. Our findings (Table 1: Model 1) for two of our three coefficients are not unsurprising: rising nominal income and falling mortgage rates result in higher nominal house prices. There is no measured effect of the rate spread on house prices. Nothing in Model 1 conflicts with the user cost model.

When we divide the pooled time-series into two epochs, we get more complex results. Models 2 and 3 in Table 1 (using pre- and post-1997 samples, respectively) provide only weak evidence that the shape of the yield curve matters. Only one of two coefficients on the spread variable is significant. Moreover, the sign on the significant coefficient is negative, suggesting that as short-rates drop relative to long-rates (i.e., the spread increases), house prices fall. This appears to contradict a simple story about affordability, in which dropping short-rates allow households that would other not qualify to obtain a mortgage. In this case, it may be that the negative sign captures expectations, with lower expectations associated with economic weakness as the Federal Reserve cuts short rates.

Even at this broad level of aggregation, it is clear that there is no stable relationship between house prices and interest rates and income. For the period 1975-1997 (Table 1: Model 2), we find that income is the primary driver of house prices, but with the elasticity of price less than one – a percent increase in per capita income yield house prices that are higher by 0.862%. This suggests a relatively elastic supply response in the provision of dwellings. The same is distinctly not true for the epoch from 1998 to 2007:II (Table 1: Model 3). Here the price elasticity of income is 1.911, twice that of the earlier period. Similarly, the coefficients on mortgage rates, while consistently significant and negative, change substantially in magnitude between the two epochs.

Table 1 - U.S. House Price Regressions

Variable	Model 1	Model 2	Model 3
r-Squared	0.969	0.994	0.983
Observations	131	89	42
Intercept	2.131	1.988	-0.784
	(15.92)	(44.18)	(2.34)
log(Mortgage Rate)	-0.114	-0.069	-0.370
	(2.94)	(3.35)	(5.12)
log(Rate) Spread	-0.036	0.010	-0.046
	(1.22)	(0.63)	(3.13)
log(Per Capita Income)	0.918	0.862	1.911
	(44.28)	(110.97)	(29.64)

The high explanatory power of per capita income could be explained as reflecting the impact of inflation on both house prices and incomes; one might also explain it by noting that national house prices models may just not be very satisfactory. To address this, an analogous set of three regressions are estimated using MSA-level data (MSA house prices and incomes; national rates). The results of these regressions are reported in Table 2. (MSA fixed-effects are included in all three regressions but are not reported.) With regards to explanatory power, the two sets of models are similar as are the patterns in the capitalization of per capita income. However, rather than the expected coefficients on mortgage rates, the estimated parameter is significant and positive for the full series and the earlier of the two epochs. Only in the post 1997 subsample is the expected sign obtained and here the same curious sign on the spread variable returns. From these two sets of regressions, two stable patterns arise. First, and not surprising, per capita income is the primary driver of house prices. Second, there appears to be a sharp break in regimes, with none of the parameters stable across the pre- and post-1997 break in the sample.

Table 2 - Pooled MSA House Price Regressions			
(MSA fixed-effects included, but not reported)			
Variable	Model 1	Model 2	Model 3
r-Squared	0.914	0.919	0.930
Observations	13,560	7,769	5,791
Intercept	1.354	1.828	1.620
	(22.32)	(24.87)	(18.50)
log(Mortgage Rate)	0.039	0.049	-0.568
	(2.93)	(3.37)	(28.17)
log(Rate) Spread	-0.002	0.007	-0.082
	(0.57)	(0.91)	(19.18)
log(Per Capita Income)	1.032	0.859	1.300
	(97.41)	(60.74)	(77.60)

"Unconstrained" MSAs

Modern models of urban economics, including Capozza and Helsely (1989) and DiPasquale and Wheaton (199x), imply that cities with elastic housing supply should see little long-run capitalization. This is because once prices rise above replaement cost, developers should enter the market and supply housing until the price falls back to replacement cost. The process should happen far more quickly in unconstrained markets than in constrained markets. In our models, we would expect to see capitalization of income above one where markets are constrained – where additional incomes results in rents accrued to the relatively scarce supply of housing. In contrast, we would expect markets that readily accommodate higher demand to have income capitalization of less than one.

To explore this, we feature results from six "unconstained" MSAs in Table 3: Buffalo, Indianapolis, Oklahoma City, Omaha, Pittsburgh, and Wichita. In these MSAs, income continues to be an important predictor, but with a coefficient of substantially less than one, meaning that increases in per capita income do not flow one-for-one into nominal house prices. The balance of the coefficients are not easily interpreted. Mortgage rates get capitalized with the expected sign in Pittsburgh and Buffalo, but with an unexpected sign in Oklahoma City. In the other three MSAs, mortgage rates appear to have no significant average effect. None of the six MSA house prices series appears to be consistently influenced by the spread. Note that the source of being "unconstrained" can arise in two ways. First, there can be large amounts of readily developed land within the metropolitan area, as in Oklahoma City, Omaha, and Wichita. Alternatively, Pittsburgh and Buffalo are "unconstrained" because they are losing population and housing is a durable good – the housing supplies are inelastic (they don't decline as rapidly as decreases in population). This is consistent with Glaeser and Gyourko (200x).

It should be noted that even here, in these relatively stable MSAs, the pre- and post-1997 relationships are not stable. We report the same regressions as those in Table 3a, for the 1975-1997 time period in Table 3b and for the 1998-2007:II period in Table 3c. In both Tables 3b and 3c, income continues to be the primary driver of house prices, but again there is a sharp increase in the rate of its capitalization between the two periods. In the earlier period, the odd pattern of mortgage rate and rate spread capitalization in the earlier epoch continues as it did in the national regressions. However, in the later period, something resembling the expected pattern appears. Higher mortgage rates are associated with lower house prices. Spread remains a puzzle, with no clear pattern emerging.

Table 3a -- "Unconstrained" Metropolitan Area House Price Regressions 1975-2007:II

Variable	Buffalo	Indianapolis	Okla. City	Omaha	Pittsburgh	Wichita
r-Squared	0.961	0.990	0.823	0.963	0.986	0.947
Observations	119	122	122	118	125	124
Intercept	2.159	1.972	1.722	2.338	2.698	2.542
	(11.40)	(24.81)	(7.90)	(13.18)	(32.80)	(21.88)
log(Mortgage Rate)	-0.159	-0.002	0.261	-0.051	-0.218	-0.003
	(3.53)	(0.09)	(4.83)	(1.19)	(9.89)	(0.09)
log(Rate) Spread	-0.024	0.001	0.005	-0.021	-0.017	0.009
	(0.98)	(0.07)	(0.14)	(0.97)	(1.19)	(0.46)
log(Per Capita Income)	0.798	0.773	0.715	0.717	0.669	0.595
	(24.05)	(60.27)	(18.29)	(24.75)	(51.14)	(30.01)

Table 3b -- "Unconstrained" Metropolitan Area House Price Regressions 1975-1997						
Variable	Buffalo	Indianapolis	Okla. City	Omaha	Pittsburgh	Wichita
r-Squared	0.956	0.984	0.669	0.957	0.976	0.945
Observations	77	80	80	76	83	82
Intercept	2.068	1.941	1.910	2.591	2.728	2.582
	(11.23)	(25.37)	(9.50)	(22.91)	(34.84)	(34.95)
log(Mortgage Rate)	-0.226	0.026	0.392	-0.004	-0.201	0.081
	(5.00)	(1.24)	(7.26)	(0.15)	(8.67)	(3.80)
log(Rate) Spread	-0.031	-0.084	0.049	-0.046	-0.076	-0.055
	(0.58)	(3.23)	(0.66)	(1.51)	(2.55)	(1.97)
log(Per Capita Income)	0.897	0.764	0.522	0.580	0.646	0.508
	(23.81)	(52.81)	(11.14)	(26.34)	(44.56)	(33.95)

Table 3c -- "Unconstrained" Metropolitan Area House Price Regressions 1998-2007:II						
Variable	Buffalo	Indianapolis	Okla. City	Omaha	Pittsburgh	Wichita
r-Squared	0.970	0.992	0.977	0.996	0.993	0.982
Observations	42	42	42	42	42	42
Intercept	1.996	1.933	2.142	1.417	1.594	1.729
	(8.43)	(19.97)	(10.86)	(17.76)	(13.63)	(11.25)
log(Mortgage Rate)	-0.278	-0.109	-0.242	-0.070	-0.212	-0.042
	(5.38)	(5.47)	(4.67)	(3.97)	(7.83)	(1.19)
log(Rate) Spread	-0.050	0.011	-0.040	-0.005	0.001	0.039
	(5.02)	(2.81)	(3.81)	(1.36)	(0.24)	(5.37)
log(Per Capita Income)	0.905	0.845	0.889	0.997	0.981	0.861
	(19.84)	(44.86)	(25.94)	(67.66)	(46.35)	(30.29)

"Constrained" MSAs

We now turn to six "constrained" MSAs: Boston, Los Angeles, New York, San Francisco, San Jose, and Seattle. These are MSAs in which capitalization of income is greater than one in both epochs. In Table 4a, it is clear that these metropolitan areas were "constrained" by this definition well before mortgage innovation began in earnest at the beginning of the housing cycle in 1998. Indeed, the average income capitalization is twice that of the unconstrained MSAs in Table 3b. And though they were constrained before the last run up in prices began, their relative increase in capitalization exceeded that of the unconstrained MSAs by a factor of two. That is, one percent of additional per capita income resulted in even larger increases in house prices in the constrained MSAs.

Table 4a -- "Constrained" Metropolitan Area House Price Regressions 1975-1997						
Variable	Boston	Los Angeles	New York	San Francisco	San Jose	Seattle
r-Squared	0.914	0.947	0.948	0.951	0.951	0.958
Observations	77	88	86	87	86	86
Intercept	0.723	0.847	1.060	1.260	1.444	1.538
-	(2.01)	(4.29)	(4.75)	(6.16)	(7.28)	(9.34)
log(Mortgage Rate)	0.103	0.087	0.010	-0.039	0.001	-0.054
-	(1.09)	(1.35)	(0.14)	(0.60)	(0.02)	(1.04)
log(Rate) Spread	-0.047	0.024	0.039	-0.088	-0.067	-0.106
-	(0.42)	(0.28)	(0.41)	(1.00)	(0.79)	(1.55)
log(Per Capita Income)	1.255	1.340	1.242	1.293	1.220	1.111
-	(19.91)	(36.52)	(34.73)	(37.22)	(36.95)	(39.26)

For the earlier period from 1975 to 1997 (Table 4a), the results are disappointing from the perspective of the literal use of the user-cost model – there is no interest rate capitalization at all, of either mortgage rates or the spread between long and short rates. In the second period, from 1998 to 2007:II (Table 4b), the expected relationship appears in all the six sample MSAs. In each, the coefficient on mortgage rates is negative and significant – higher mortgage rates imply lower house prices. The spread variable remains without a clear pattern. The scattered nature of the results prompts us to think that capitalization is not a stable phenomenon. We will demonstrate this further later in the paper.

Table 4b -- "Constrained" Metropolitan Area House Price Regressions 1998-2007:II						
Variable	Boston	Los Angeles	New York	San Francisco	San Jose	Seattle
r-Squared	0.978	0.980	0.976	0.960	0.884	0.899
Observations	42	42	42	42	42	42
Intercept	-1.226	-3.893	-3.526	-1.551	1.088	-2.794
-	(2.75)	(6.08)	(6.01)	(2.55)	(1.28)	(2.73)
log(Mortgage Rate)	-0.593	-0.680	-0.573	-0.589	-1.355	-0.456
-	(5.96)	(4.80)	(4.93)	(4.34)	(7.09)	(2.53)
log(Rate) Spread	0.064	-0.136	-0.008	0.027	-0.062	-0.179
-	(3.00)	(4.82)	(0.32)	(0.87)	(1.26)	(4.90)
log(Per Capita Income)	2.122	3.134	2.775	2.291	2.007	2.548
-	(26.79)	(26.51)	(25.23)	(21.49)	(11.99)	(12.18)

"Bubble" Markets

Thus far the exercise has been exploratory in nature, motivated by a desire to understand the nature of the relationship between house prices and income, mortgage rates, and the spread between long and short rates. Thus far it is clear that no one relationship exists, but several regularities have been apparent. Among others, income is the only clear and consistent driver of house prices, though the magnitude of the capitalization has been higher in the later period than the earlier. Furthermore, there is a general pattern that the role of mortgage rates is more what might be expected during these later years. Of course, it was during this period that the latest housing bubble formed. House prices rose in MSAs even where it appeared that they should not be constrained. It may be useful to examine the results from so-called "bubble" MSAs. We select another six MSAs by the growth in their capitalization of income: El Paso, Jacksonville, Las Vegas, Miami, Phoenix, and Riverside. In each of these six MSAs an additional percent of income results in greater than three times the increase in house price in the later period relative to the earlier period. These results are reported in Tables 5a and 5b.

Table 5a -- "Bubble" Metropolitan Area House Price Regressions 1975-1997

Variable	El Paso	Jacksonville	Las Vegas	Miami	Phoenix	Riverside
r-Squared	0.824	0.977	0.924	0.955	0.959	0.894
Observations	58	75	76	85	80	83
Intercept	3.664	2.091	2.158	1.953	1.784	1.413
	(13.85)	(22.30)	(12.42)	(17.20)	(18.70)	(6.49)
log(Mortgage Rate)	-0.028	0.109	0.198	0.105	0.210	0.093
	(0.51)	(4.82)	(4.97)	(2.91)	(8.04)	(1.48)
log(Rate) Spread	0.011	0.067	0.125	-0.056	-0.050	0.048
	(0.40)	(2.76)	(3.01)	(1.18)	(1.46)	(0.57)
log(Per Capita Income)	0.307	0.658	0.702	0.794	0.761	1.130
	(5.42)	(35.92)	(20.25)	(39.23)	(38.26)	(23.36)

Table 5b -- "Bubble" Metropolitan Area House Price Regressions 1998-2007:II

Variable	El Paso	Jacksonville	Las Vegas	Miami	Phoenix	Riverside
r-Squared	0.928	0.983	0.972	0.978	0.966	0.970
Observations	42	42	42	42	42	42
Intercept	1.513	-2.740	-2.062	-3.251	-2.763	-4.310
	(3.61)	(6.48)	(3.21)	(5.26)	(4.38)	(5.23)
log(Mortgage Rate)	-0.122	-0.279	-0.551	-0.592	-0.432	-0.861
	(1.11)	(2.95)	(3.88)	(4.08)	(3.12)	(4.90)
log(Rate) Spread	-0.118	-0.081	-0.098	-0.098	-0.153	-0.197
	(5.63)	(4.31)	(3.33)	(3.31)	(5.29)	(5.69)
log(Per Capita Income)	1.124	2.372	2.428	2.765	2.565	3.570
	(14.22)	(30.09)	(20.59)	(25.39)	(21.02)	(20.86)

In Tables 5a and 5b, the pattern of increase in income capitalization is striking, but not the only surprise. Of the 6 mortgage rate parameters estimated in Table 5a, four are positive and significant – none suggest that higher rates would significantly reduce house prices. The spread variables offer some evidence of an increase in affordability via a larger spread, but this evidence is weak. In Table 5b, there is an entire reversal – all the yield curve coefficients are negative and all but one is statistically significant.

Parameter Stability and Capitalization

Given the instability of coefficients for capitalization of all three variables across cities and epochs, we examined more closely the temporal patterns of capitalization. We do this by

performing "running regressions" where we take for each quarter the trailing and leadings 10 quarters of data in order to examine the evolution of capitalization coefficients across time. The result of these regressions is a series of parameter estimates for each of the three variables. The first of these can be seen in Figures X, Y, and Z, which plot the series of parameter estimates for Indianapolis – an MSA that may exudes stability. Indeed, there is little sense that any shocks arrive to the housing market of Indianapolis over this 30+ year period. The coefficients on mortgage rates, on the long/short rate spread, and on per capita income all appear quite stable over time – in some conflict with the results from the bifurcated pre- and post- regressions reported in Tables 3b and 3c.

The next three figures plot the same estimated coefficients for the New York City MSA. There is a sharp departure in these figures from that exhibited in Indianapolis. The estimated capitalization of mortgage rates varies widely, though it follows a rough pattern of being negative during periods of house price growth and positive where price growth slows. In New York City, the spread variable appears to follow a pattern of being positive when prices are rising and hovering around zero in other times. This would be consistent with households moving down the yield curve in order to qualify for more debt during periods of rising prices. Finally, the capitalization of income appears to be consistent with the interest rates stories: as prices rise, households move down the yield curve and turn increases in income into larger mortgages and higher home prices.

These pictures suggest strongly that the standard user-cost model requires some adaptation in household behavior. Rather than a stable relationship between house prices and a single long-term interest rate, the figures for Indianapolis and New York suggest that short-run expectations influence which debt instrument is relevant and how income is capitalized into prices. In New

York, there are two distinct periods of rapidly increasing house prices and in each the temporal patterns in the capitalization of the yield curve and income variables change in a manner consistent with constrained households looking to buy more housing. In Indianapolis, there appears to be no period in which a shock to house prices could have led to changes in expectations for future house prices and there is only mild evolution of the parameters over the full 30+ year period.

This conjecture should show up in the so-called "bubble" metropolitan areas, as they move from unconstrained housing markets to artificially constrained housing markets in the frenzy to buy more housing. The last three figures plot the capitalization of income in three markets generally thought of to be housing markets in which recent prices increased for reasons beyond fundamentals. And for all three – Riverside, Miami, and Las Vegas, income capitalization is sharply higher in the years after 2001. Interestingly, Riverside experienced even higher capitalization and a subsequent collapse of capitalization around the period of the end of the Cold War. Southern California experienced a sharp rise in house prices in the late-1980s that burst when defense cuts profoundly effects the region's economic base. The negative capitalization of income reflects one shortcoming of this empirical approach. Population left the area during the early 1990s, leaving Los Angeles – in particular Riverside – more like Buffalo for a short period. Per capita income did not fall, households left, causing the fall in house prices. While there is some room to expand the empirical framework to incorporate this dynamic, there is no doubt that a single – linear and separable – relationship akin to that posited in the user-cost model does not exist. Figure X plots the full set of coefficients on per capita income by MSA for the two subsamples, pre- and post-1997. The line in the lower-right section has slope one and intercept zero – it is the line on which the coefficients pairs would be plotted if the relationship were stable. Instead, the regression line (the orange-dashed line) has slope of almost two and is highly significant. Since 1998, income has been capitalized at a much higher rate in places that were already experiencing higher capitalization.

Constrained and Unconstrained Metropolitan Areas

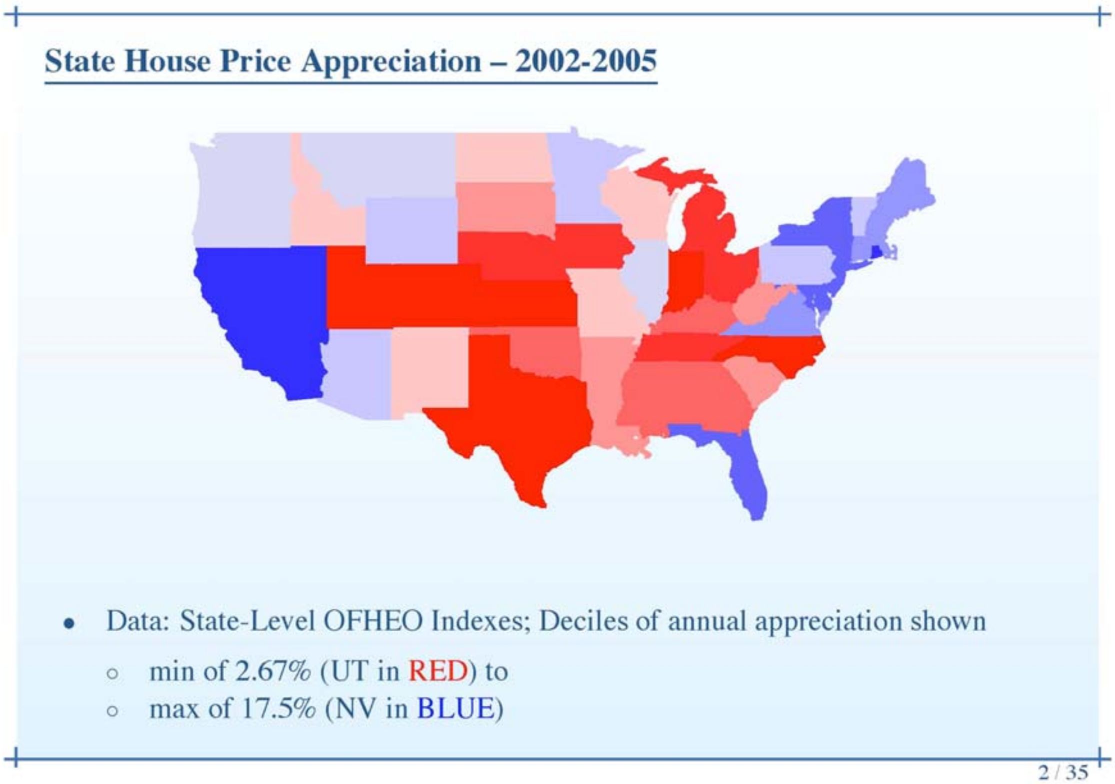
The guiding pattern that emerges from estimating the affordability constraint is that the expected relationship appears only when the housing market is constrained. There are several forms of constraints. First, regulatory environments could make supply response difficult. Alternatively, even where regulation is not a significant barrier, shocks to demand cannot be met instantaneously and a significant supply response can be delayed by a year or two as development occurs. In either case, shocks to demand will be manifest in the observed house prices. In our data, we have no information on regulation, but can informally proxy for the ready supply of available land by using MSA size (as measured by population). Furthermore, we can proxy for demand shocks by looking at population change, with a sharp increase in population making the local housing stock – at least for a short while – constrained. We do this for the latter period (a period of higher expected house prices) and for the capitalization of income and mortgage rates in Figures X-Z. In all four figures, the expected relationship is broadly supported. That is, income is capitalized at a higher rate as city size increases and as population growth is faster. Similarly, mortgage rates are more negative as cities are larger and faster growing. This are admittedly crude proxies for supply constraints, but they are suggestive that as cities move in and out of periods of constraint, the relationships between housing prices and several underwriting variables change. Though not reported, the same four graphs for the earlier period reveal only one modestly significant relationship, that between MSA size and income capitalization.

Conclusion

This research is borne of a desire to understand the behavior of house prices over the last several years. Much ink has been spilled explaining why prices were justified early as prices rose and even more has been spilled trying to explain why they weren't late in the last housing price cycle. We found the user-cost model – the standard model of housing prices – fully inadequate in helping us understand these dynamics. Though never a very good model of housing prices, the user-cost model proved particularly bad in recent years.

In light of the innovation in mortgage markets and the broadening of the pool of mortgage products, we moved to a model of affordability constraint. We did so because of some much anecdotal evidence that, in the face of rising prices and – rational or not – rising expectations of future house prices, households were moving down the yield curve to qualify for more mortgage. This results in constrained markets everywhere as supply could not keep up with rising demand. Even if markets ultimately could respond, they could not quickly enough to keep the affordability constraint from binding. Our results were far more consistent with microeconomic theory during this period. Interest rate coefficients, in particular, made more sense in the latter years than in the earlier years.

Having noted this broad agreement, there is a larger pattern of instability that may be our most important result. That is, there is little here to support a single, stable, relationship between housing prices and the basic underwriting variables. Expectations – never easy to proxy for – appear to be at work in causing shifts in estimated parameters. This work is preliminary and much more will be needed to make a coherent story about the underlying mechanics that produce such a diverse set of results. However, at this point, we are confident that the any coherent narrative will not be based on a static relationship between these and other variables.



References

Abraham, Jesse M. and Patric H. Hendershott, (1996) "Bubbles in Metropolitan Housing Markets," Journal of Housing Research, vol. 7, No. 2, 191-207

Blakely, Dixie and James Follain 1996 "In search of evidence that links rent and user cost," Regional Science and Urban Economics, 26, 406-431.

Bostic, R.W., P. S. Calem and S. M. Wachter, 2004 "Hitting the Wall: Credit as an Impediment to Homeownership"; Building Assets, Building Credit: Creating Wealth in Low-Income Communities, N. Retsinas and E. Belsky (Eds.);

Capozza, Dennis, Patric H. Hendershott and Charlotte Mack, 2004. "An Anatomy of Price Dynamics in Illiquid Markets: Analysis and Evidence from Local Housing Markets," Real Estate Economics, vol. 32(1), pages 1-32, 03.

Capozza, Dennis, Richard K. Green, Patric Hendershott, Dennis R. Capozza 1996, "Taxes, Mortgage Borrowing, and House Prices," in Henry Aaron and William Gale, eds., The Economic Effects of Fundamental Tax Reform, Brookings: Washington.

Engelhardt GV, Poterba JM 1991 House prices and demographic change: Canadian evidence. Reg Sci Urban Econ 21:539–546

Fisher, Lynn and Robert Van Order 2007 Economics of the Mortgage and Mortgage Institutions: Differences between Civil Law and Common Law Approaches, University of Michigan Ross School of Business working paper.

Green, Richard K. and Shilling, James D.,1997 The Impact of Initial-Year Discounts on ARM Prepayments. Real Estate Economics, Vol. 25 No. 3

Green, Richard K. and Patric H. Hendershott 1996, "Age, Demographics and Real House Prices," Regional Science and Urban Economics, 26, 465-480.

Green, Richard K., Stephen Malpezzi and Stephen K. Mayo, 2005. "Metropolitan-Specific Estimates of the Price Elasticity of Supply of Housing, and Their Sources," American Economic Review, vol. 95(2), pages 334-339, May

Green, Richard K.and Shilling James D., 1994. "Do Teaser-Rate Adjustable-Rate Mortgages Make Owner-Occupied Housing More Affordable**?**," Journal of Housing Economics, vol. 3(4), pages 263-282

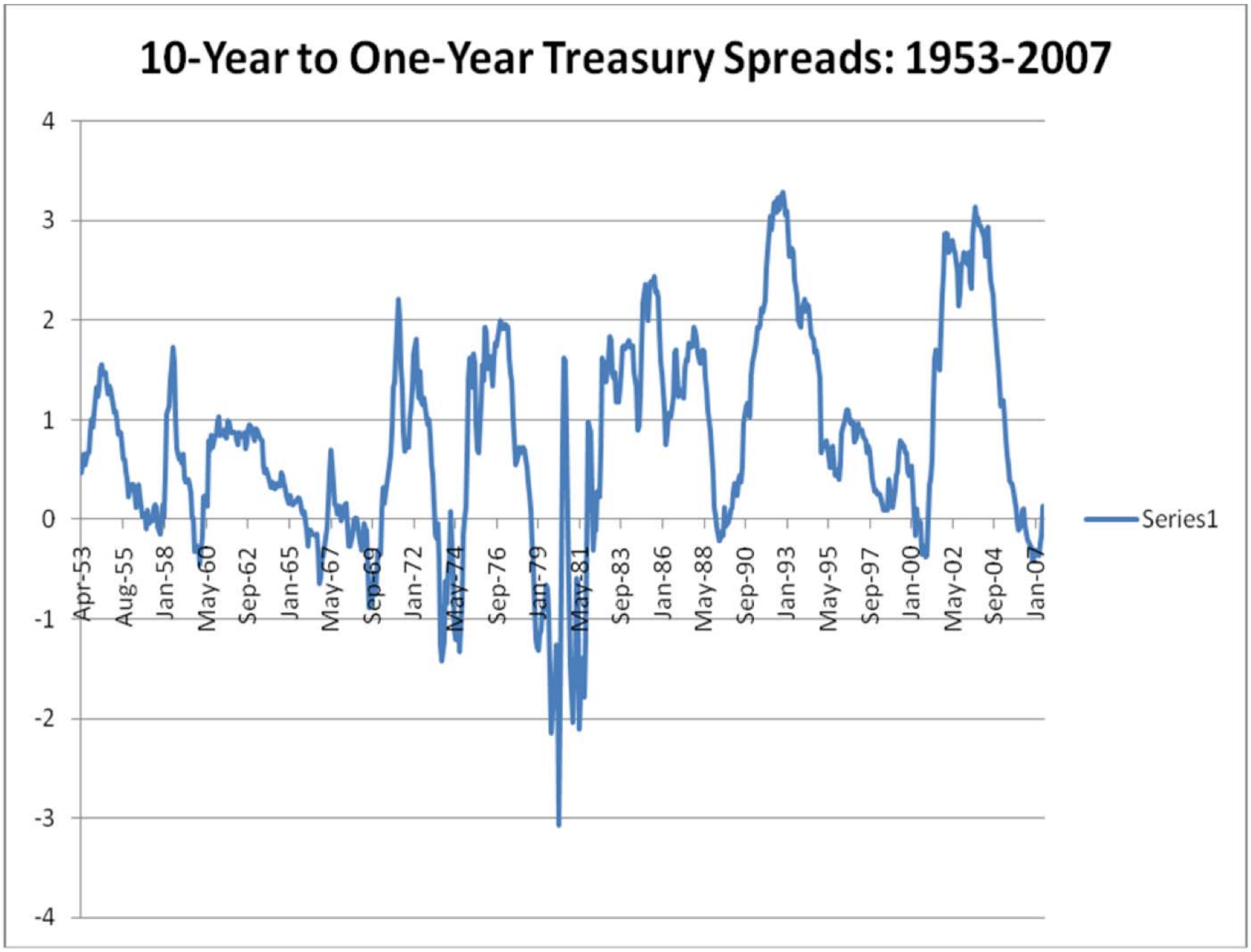
Glaeser, E., J. Gyourko, and R. Saks. 2004. "Why Have House Prices Gone Up?" Harvard University working paper.

Hwang, Min and John Quigley 2006 "Economic Fundamentals In Local Housing Markets: Evidence From U.S. Metropolitan Regions," Journal of Regional Science, 46:3, 425-453.

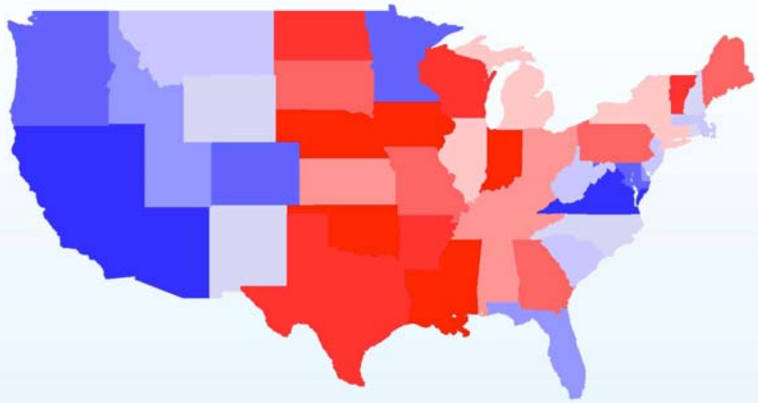
Malpezzi, Stephen, 1999. "**A** Simple Error Correction Model of House Prices," Journal of Housing Economics, vol. 8(1), pages 27-62,

Mankiw, N.G., and D. Weil. 1989. "The Baby Boom, the Baby Bust, and the Housing Market." Regional Science and Urban Economics 19, pp. 235-258.

Peek, J. and J. A. Wilcox, 1991 "The Baby Boom, "Pent-Up" Demand, and Future House Prices" Journal of Housing Economics, Fall, pp. 347-367.


10-Year to One-Year Treasury Spreads: 1953-2007
4
3
2
1
0
-1
-2
-3
-4
Apr-53
Aug-55
Jan-58
May-60
Sep-62
Jan-65
May-67
Sep-69
Jan-72
May-74
Sep-76
Jan-79
May-81
Sep-83
Jan-86
May-88
Sep-90
Jan-93
May-95
Sep-97
Jan-00
May-02
Sep-04
Jan-07
Series1

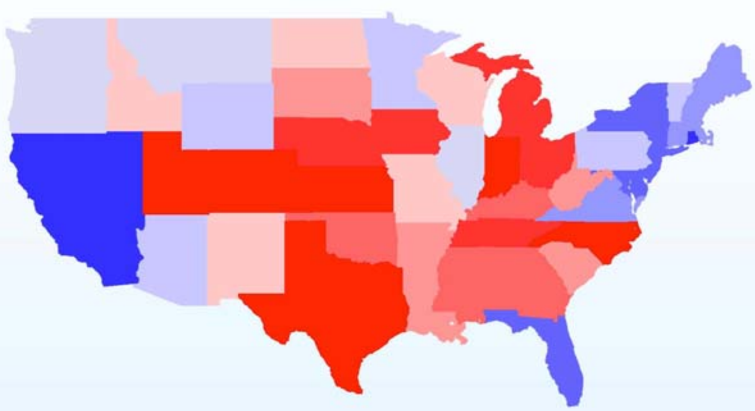
State %-age Point Increase in “Exotic” Financing – 2002-2005



- Data: Loan Performance; Deciles of total increase shown
  - min of 8.8%pts (MS in RED) to
  - max of 57.7%pts (NV in BLUE)

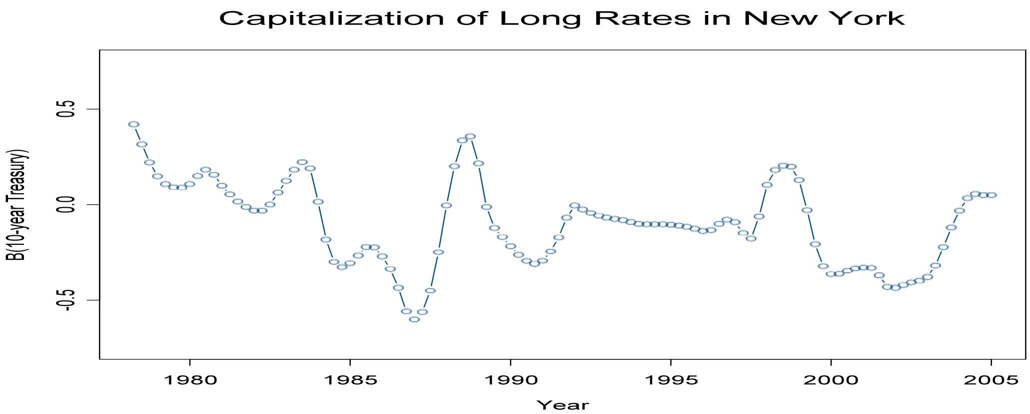
3 / 35

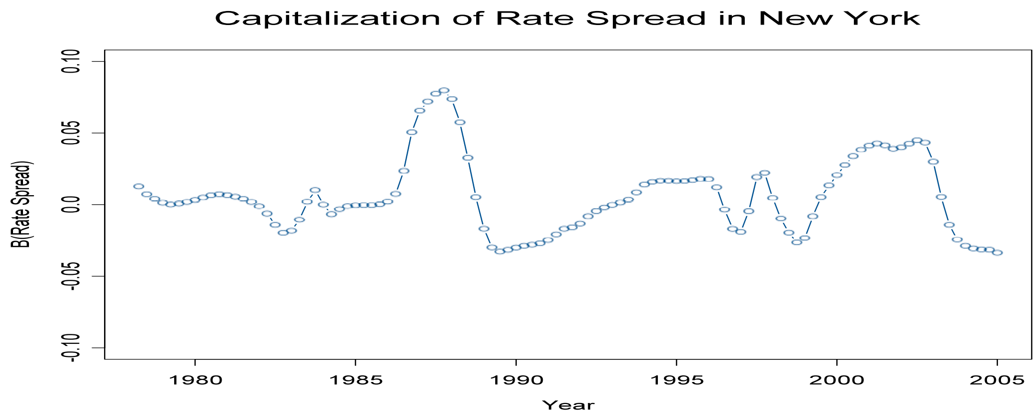
State House Price Appreciation – 2002-2005

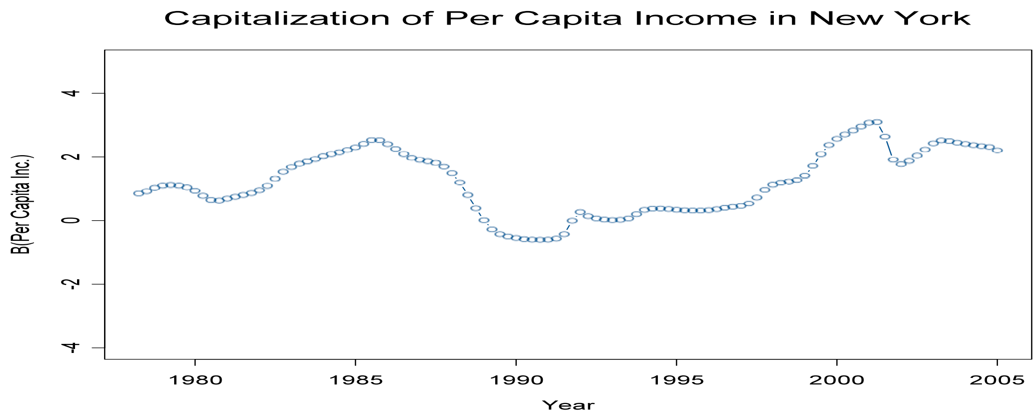


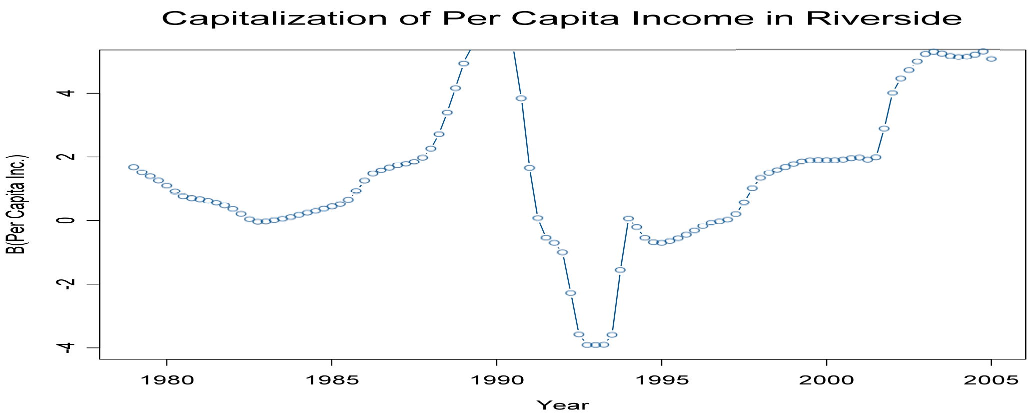
- Data: State-Level OFHEO Indexes; Deciles of annual appreciation shown
  - min of 2.67% (UT in RED) to
  - max of 17.5% (NV in BLUE)

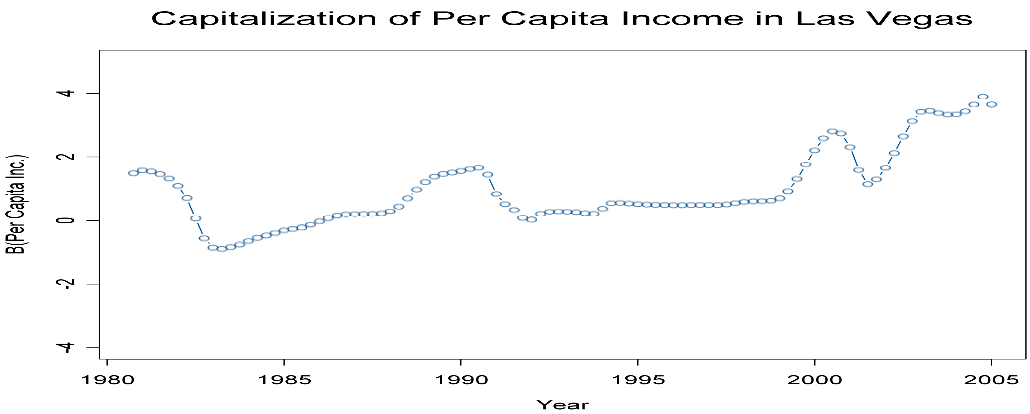
2 / 35

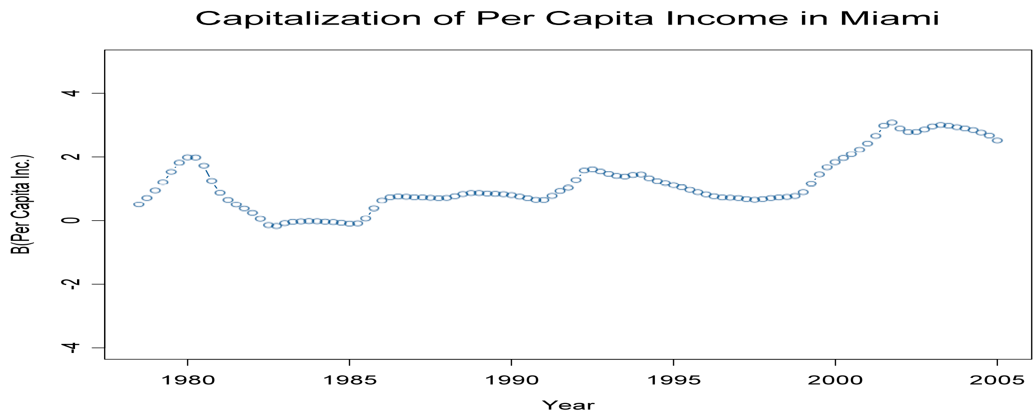

Capitalization of Long Rates in New York
B(10-year Treasury)
0.5
0.0
-0.5
1980
1985
1990
1995
2000
2005
Year

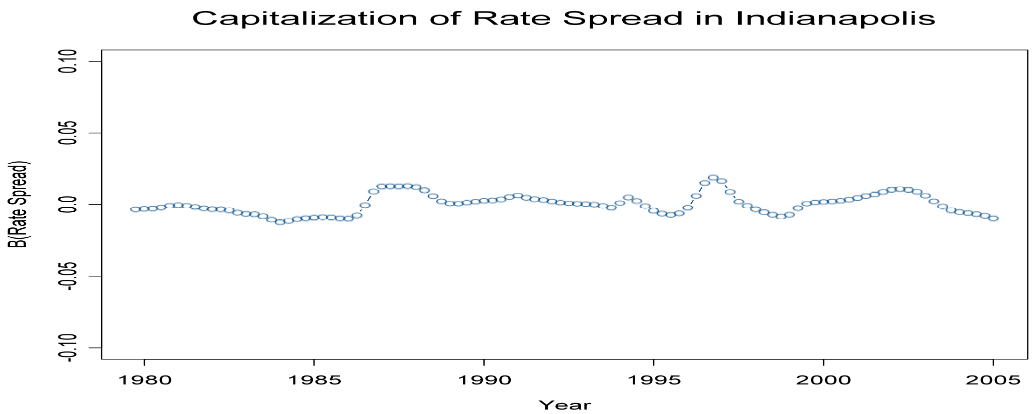

Capitalization of Rate Spread in New York
B(Rate Spread)
0.10
0.05
0.0
-0.05
-0.10
1980
1985
1990
1995
2000
2005
Year

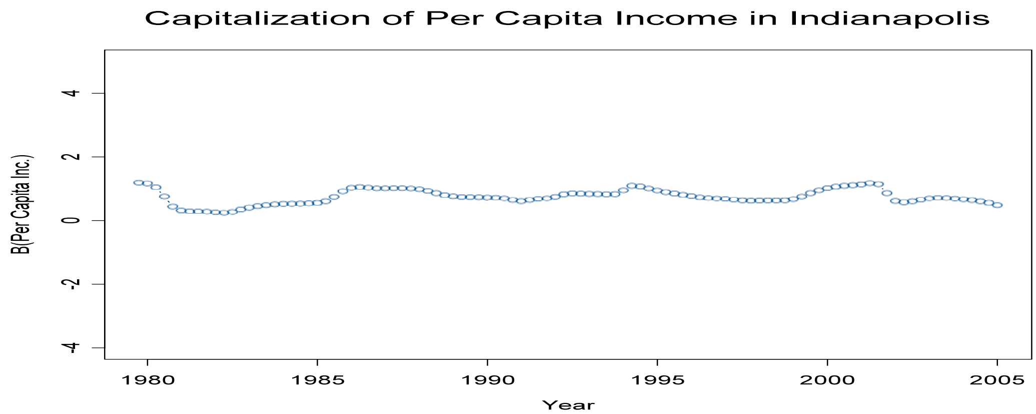

Capitalization of Per Capita Income in New York
B(Per Capita Inc.)
4
2
0
-2
-4
1980
1985
1990
1995
2000
2005
Year

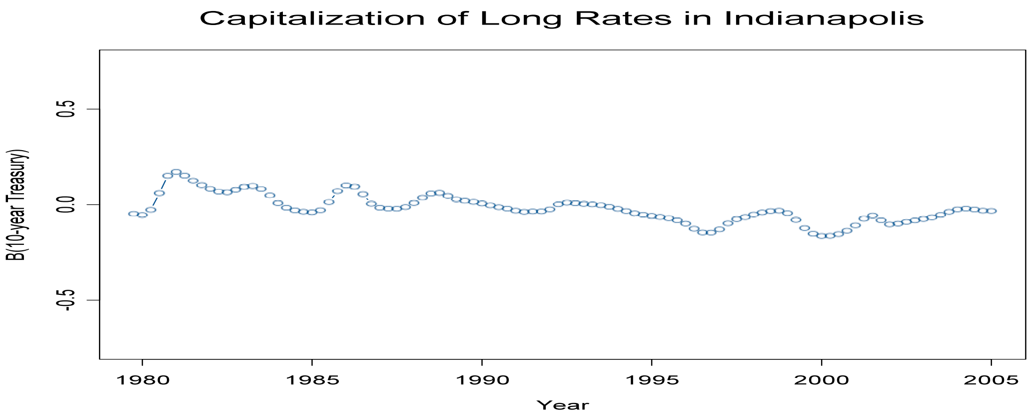

Capitalization of Per Capita Income in Riverside
B(Per Capita Inc.)
-4
-2
0
2
4
1980
1985
1990
1995
2000
2005
Year


Capitalization of Per Capita Income in Las Vegas
B(Per Capita Inc.)
4
2
0
-2
-4
1980
1985
1990
1995
2000
2005
Year

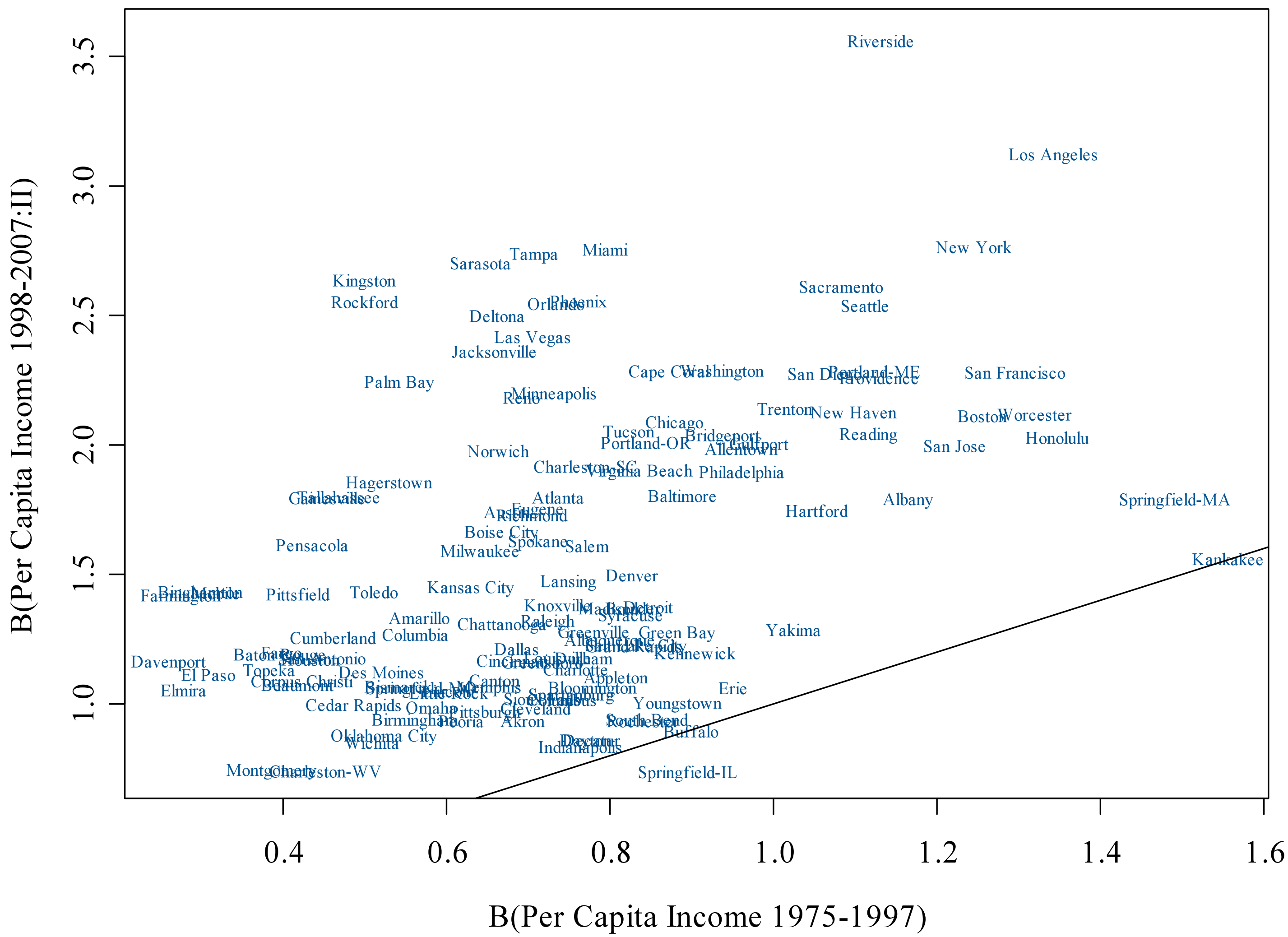

Capitalization of Per Capita Income in Miami
B(Per Capita Inc.)
4
2
0
-2
-4
1980
1985
1990
1995
2000
2005
Year


Capitalization of Rate Spread in Indianapolis
B(Rate Spread)
0.10
0.05
0.0
-0.05
-0.10
1980
1985
1990
1995
2000
2005
Year

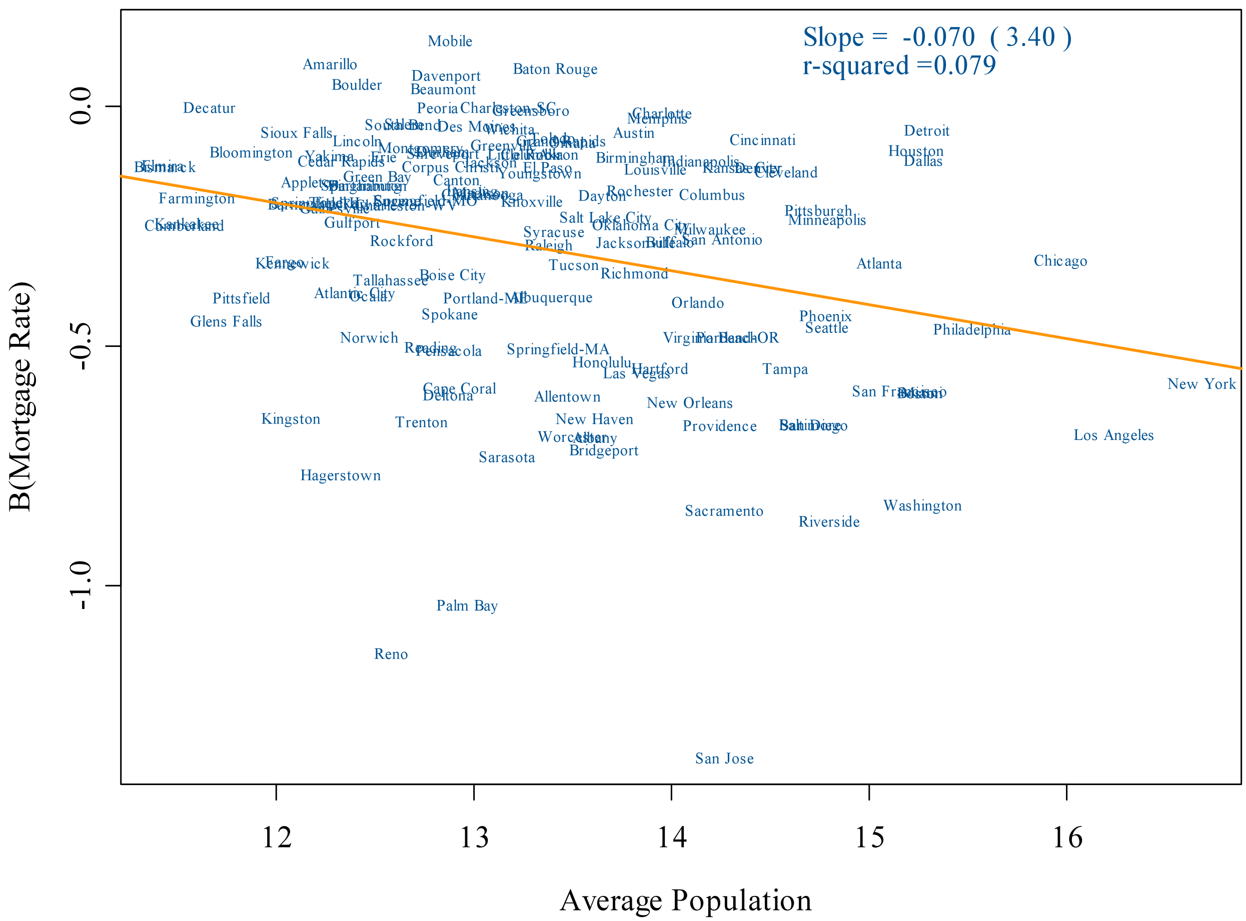

Capitalization of Per Capita Income in Indianapolis
B(Per Capita Inc.)
4
2
0
-2
-4
1980
1985
1990
1995
2000
2005
Year


Capitalization of Long Rates in Indianapolis
B(10-year Treasury)
0.5
0.0
-0.5
1980
1985
1990
1995
2000
2005
Year

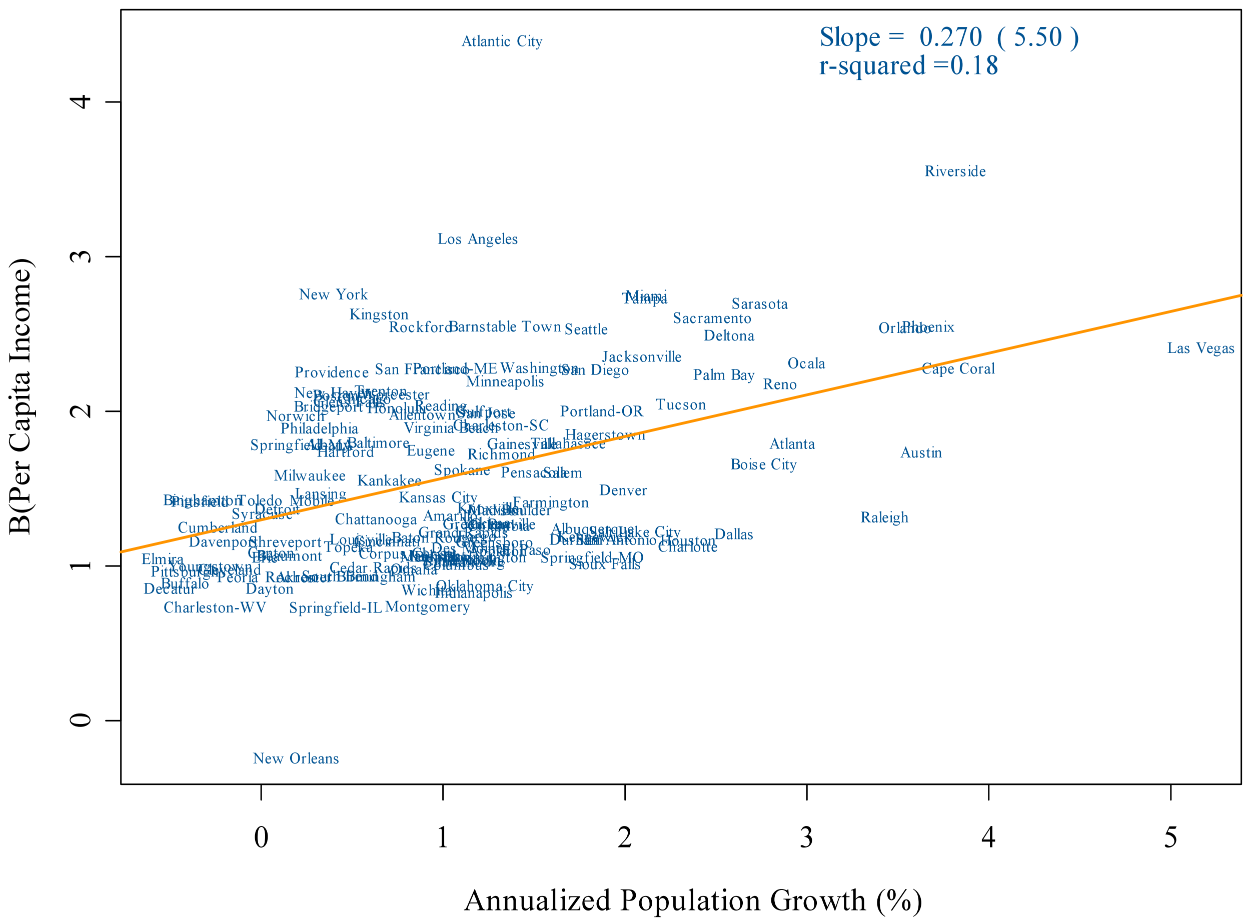
Evolution of Income Capitalization



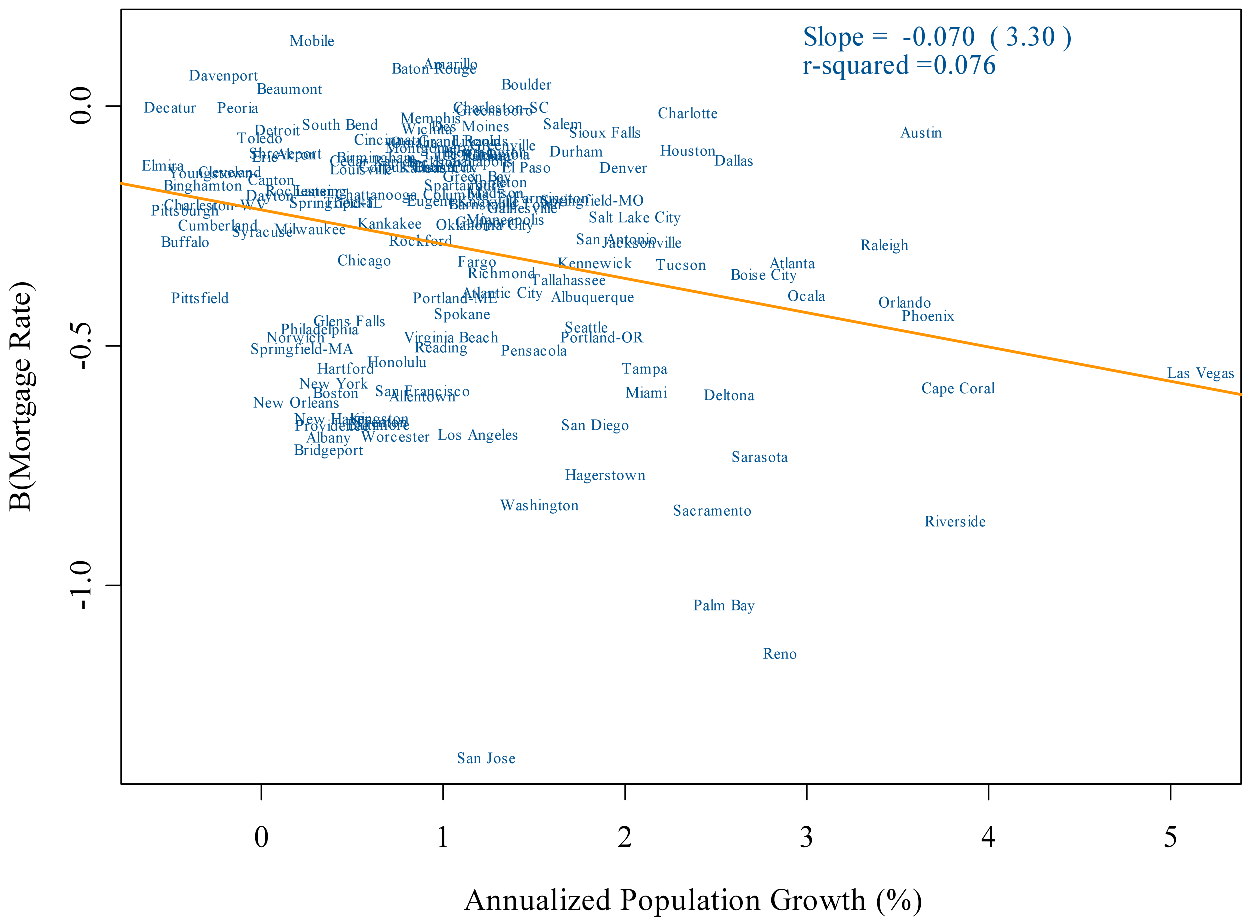
Late Years 1998-2007:II



Late Years 1998-2007:II



Late Years 1998-2007:II



Late Years 1998-2007:II