New in Town: Demographics, Immigration, and the Price of Real Estate

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Abstract

We link cross-sectional variation in both realized and expected state-level house price appreciation to cross-sectional variation in demographic changes. In particular, we extract two components of expected population growth: 1) a natural component due to predictable demographic changes related to fertility and mortality rates and 2) a non-natural component due to immigration. Our analysis shows that only the second component forecasts cross-sectional variation in state-level house price appreciation. We find that the sensitivity of both realized and expected returns to these demographic changes is stronger for states with greater population density, consistent with population growth actually causing the price appreciation rather than merely being correlated with some other phenomenon. We also document that building permits anticipate a portion of future population growth and house price appreciation. However, lagged measures of building activity do not subsume the ability of our expected immigration proxy to forecast price appreciation. Our findings are consistent with fundamentals driving an economically important portion of cross-sectional variation in state-level housing returns. However, markets appear to significantly underreact to the component of fundamentals that is arguably more difficult for market participants to anticipate.

JEL classification: G12, G14, N22

1 Introduction

During the past 15 years the US residential real estate market experienced a dramatic boom and bust. From the middle 1990s, the Case-Shiller 20-City Composite index nearly tripled in value to its peak of mid 2006, only to decline roughly 40 percent back to September 2003 levels as of January 2010. These movements obscure significant cross-sectional variation in house price appreciation as a booming state such as California had housing prices relative to a state such as Michigan rise and fall by 142% and 14% respectively over this period. This paper tries to understand what drives housing returns by explaining relative differences in state-level house price appreciation with a key fundamental variable, population growth.

In particular, we link cross-sectional variation in both realized and expected state-level house price appreciation to cross-sectional variation in demographic changes. We do so by extracting two components of expected population growth: 1) a natural component due to predictable demographic changes related to birth and death rates and 2) a non-natural component due to immigration. Presumably the natural component of realized population growth is relatively easy to forecast as the distribution of current age cohorts in combination with quite persistent mortality and fertility rates generate very accurate forecasts of future age cohort distributions. To the degree that housing consumption has a distinctive age profile, cross-sectional differences in housing demand due to the natural component of demographic changes should be well understood by markets.

However, relative population growth across states can differ dramatically due to relative differences in business opportunities that attract immigration from one state to the other. In sharp contrast to mortality and fertility rates, these opportunities can change quickly, and there can be considerable disagreement about the nature of these opportunities. We find that a significant component of relative state-level house price appreciation is strongly correlated with contemporaneous relative state-level population growth, which presumably is mostly due to unexpected immigration. Consequently, we are able to show that a significant component of realized state-level returns can be linked to fundamentals.

We then investigate the extent to which the forecastable component of immigration is incorporated into state-level house prices. We forecast cross-sectional variation in non-natural population growth using cross-sectional variation in state-level GDP growth as well as characteristics of a state's current age distribution, namely the fraction of a state's population under 65 years old. We find that predictable cross-sectional variation in expected state-level house price appreciation arises from this non-natural component, while a natural component linked to fertility and mortality rates has no forecasting power.

Consistent with intuition, the sensitivity of both realized and expected returns to these demographic changes is stronger for states with greater population density. We also document that building permits anticipate a portion of future population growth / price appreciation. However, lagged measures of building activity do not subsume the ability of our expected immigration proxy to forecast price appreciation. In conclusion, our findings are consistent with fundamentals being responsible for an important portion of cross-sectional variation in housing returns. However, markets appear to underreact to the component of fundamentals that is arguably more difficult for market participants to anticipate.

2 Related Literature

There is an extensive literature linking demographics to asset prices that includes Poterba (2001), Ang and Maddaloni (2001), Goyal (2004), Davis and Li (2003), Geanakoplos, Magill, and Quinzii (2004), Wilson, Girijasankar, and Samanthala (2006), Tamoni, Gozluklu, and Favero (2008), and Malmendier and Nagel (2009). In particular, DellaVigna and Pollet (2009) forecast both the proportion of each age group in the population as well as the demand for age-related consumption goods. They show that the resulting forecasted product demand predicts the stock returns of firms producing those goods. They argue that the inattentiveness of market participants to these predictable demographic changes is responsible for the profitable trading strategies they document.

There is also an extensive literature analyzing the dynamics of real estate prices. Liu and Mei (1992) show that REITs are forecastable by capitalization rates. Case, Goetzmann, Rouwenhorst (2004) study a factor model for international real estate returns. Case and Shiller (1990) document that prices are autocorrelated and that changes in income and population positively related to price changes at the one-year horizon. Mankiw and Weil (1988) forecast natural population growth and find contemporaneous relationship between prices and population. Their focus is on the aggregate time series only. Poterba (1991) argues that cities with high natural population growth do not exhibit higher price growth. In contrast, Saiz (2003, 2007) documents that Miami rental prices affected by unexpected immigration shock as immigration pushes up house values. On a related note, Gyourko, Mayer, and Sinai (2006) argue that the inelastic supply of land in cities can explain their faster price growth. Ottaviano and Peri (2007) find a positive contemporaneous relationship between international migration to U.S. cities, and wage and rental growth in those cities. Our findings on density is consistent with Saiz (2010), who documents higher price growth between 1970 and 2000 for cities where geographical features make construction difficult.

Several recent papers are particularly relevant for our study. Plazzi, Torous, and Valkanov (2009) combine time-series and cross-section data to show that commercial real estate returns are predictable by capitalization rates. Higher capitalization rates predict high future returns, and this fact is robust to controlling for cross-sectional differences in demographic and economic factors. Results are strongest for areas of low population density. Campbell, Davis, Gallin, Martin (2009) show that a large fraction of the variance of price/rent can be explained by changing risk premia for residential real estate (both time-series and cross-section). Their analysis implies that price/rent ratios should forecast future returns. Van Nieuwerburgh and Weill (2009) provide a theoretical framework by solving a model in which workers are mobile and builders are partially constrained. Their model predicts that high productivity regions attract migration and have higher house prices. They argue that increased dispersion in productivity can explain the increase in the dispersion of house prices between 1975 and 2000.

3 Data and Sample

Our dependent variable of interest is house price appreciation. We measure this variable at the state level using transaction data collected by the Federal Housing Authority from 1975-2009. Though that data includes the District of Columbia, we exclude Washington D.C. as well as Alaska from the analysis that follows as both areas are outliers in many of the dimensions we consider. However, our findings are robust to including those two additional areas in the analysis. We convert these nominal price levels into real price levels using the NIPA GDP price deflator resulting in a real transaction-price level, $P(t, j)$, for state j at year t. These real house price index levels generate our house price appreciation variable, $\Delta P(t, t+k; j) = \frac{P(t+k;j)}{P(t,j)}$, which we measure over a period of k years. Throughout the analysis, we set $k = 4$ and study non-overlapping observations. We choose non-overlapping observations so that our standard error estimates have better small-sample properties; hopefully, a careful use of overlapping observations would give us more power. As we do rely solely on non-overlapping observations, we check to make sure that our findings are not sensitive to the particular year in which our analysis begins.

We study long-horizon returns for several reasons. For one thing, as demographics are slow-moving variables, one would expect house price sensitivity to this fundamental to be more apparent at longer horizons. Also, at shorter horizons, house prices are known to be autocorrelated. Though we include past house price appreciation as a control in all of our regressions, we want our findings of predictable house price appreciation to be robust to such serial correlation, hence our use of $k = 4$. Nevertheless, our findings are significantly stronger at short horizons of one year as well as robust to the use of $k = 3$ or $k = 5$.

We collect state-level components of US Gross Domestic Product, $GDP(t, j)$. These data, available from 1970-2009, are also deflated to create our state-level growth variable, $\Delta GDP(t-1, t; j)$. From the US Census Bureau, we retrieve state-level building permits from 1980-2009, which we denote as $H(t, j)$. Also, for 23 major US cities, we retrieve a panel of Rents ($Rent(t, k)$) and Prices ($P(t, k)$) for each city k at year t from the Bureau of Labor Statistics. We match these 23 cities to 17 states, taking simple averages where necessary, in order to generate a proxy for state-level price-to-rent ratios, $\frac{P(t,j(k))}{Rent(t,j(k))}$. As a check of the usefulness of this data, we measure the correlation of the actual state-level cross-sectionally demeaned house price appreciation series and the corresponding synthetic version for the 17 states in question. The resulting correlation is .85, which gives us comfort in the effectiveness of our matching procedure.

Our primary explanatory/forecasting variables come from state-level population data, $N_i(t, j)$, for age group i at time t for state j, available from the US Census Bureau. Specifically, we have data for the following age groups i: (0-4), (5-17), (18-24), (25-44), (45-64), and (65+). We sum over i to measure population growth as $\Delta N(t, t+k; j) = \frac{N(t+k;j)}{N(t,j)} = \frac{\sum_i N_i(t+k;j)}{\sum_i N_i(t,j)}$. We also gather birth and death rates from the Center for Disease Control. They provide the amount of births per 1000 women for selected age groups, $b(i, t)$, as well as deaths per 1000 for selected age groups: $d(i, t)$. Finally, we measure population density as the fraction of US population living in state j at time t divided by the fraction of US landmass, $L(j)$, that state j covers,

$$D(t;j) = \frac{N(t,j)/\sum_j N(t,j)}{L(j)/\sum_j L(j)}$$

4 Results

Throughout the analysis we estimate pooled regressions with the following general framework:

$$\Delta P(t,t+k;j) = a + b_X * X(t,j) + b_{\Delta P} * \Delta P(t-k,t;j) + \varepsilon(t,t+k;j) \quad (1)$$

where $X(t,j)$ is a state-level demographic variable and $k = 4$. Our standard error estimates are clustered by year to be robust to cross-correlation in the residuals. We first link house price appreciation to simple measure of contemporaneous realized population growth. Table 1 Panel A estimates equation (1) using $X(t,j) = \Delta N(t,t+k;j)$. We find a strong contemporaneous relation between house price appreciation and realized population growth as the coefficient on $\Delta P(t-k,t;j)$ is 1.1073 with a t-statistic of 8.31. The associated R^2 is 7.33%. Note that our choice of $k = 4$ appears justified by the fact that lagged house price appreciation is not significant and in fact has a negative coefficient. In the second column of Table 1 Panel A, we interact contemporaneous population growth with beginning-of-period population density. Consistent with intuition that this fundamental should be more important for states that have a high population density where land is relatively scarce, the interaction coefficient is .5624 with a t-statistic of 2.75. In fact, the R^2 jumps to nearly 20%. Columns three through five show that this finding is robust to how the interaction with population density is specified. Simply separating the data into low, medium, and high terciles produces a economically significant spread in the sensitivity of house price appreciation to population growth. These results are consistent with Saiz (2010).

One concern is that our use of price appreciation is misleading concerning patterns in realized returns if variation in beginning-of-period price-to-rent ratios are correlated with our explanatory variable. This could occur in at least two ways. First, if expected housing returns are constant across states and through time, those states that provide relatively low expected price appreciation must compensate the investor with relatively low price-to-rent ratios. Second, to the extent that expected returns are not constant across states and through time. Since at least Ball (1978), financial economists have argued that scaled prices should contain information about future returns. Researchers have documented this effect in various contexts ranging from closed-end funds to international equities. In fact, some of the papers cited above document this type of phenomenon in the real estate market.

To reduce this concern, throughout the paper we also present results for a subsample of 17 states for which we are able to create a proxy for state-level price-to-rent ratios, as described in the previous section. Table 1 Panel B re-estimates the regressions in Panel A for this subsample. Though we do find a negative relation between current capitalization rates and subsequent returns, our conclusions from Panel A remain qualitatively unchanged as price-to-rent ratios are largely orthogonal to population growth.

Given the short time dimension of our sample, Panels C and D of Table 1 repeat the analysis using cross-sectionally demeaned data. Our finding that population growth is positively contemporaneously related to price appreciation continues to hold as well as the fact that the relation is stronger in densely populated states. Interestingly, price-to-rent ratios are no longer statistically significant, indicating that our finding in Panel B of a negative relation seems mainly due to an aggregate time-series effect, at least in our sample. As we observe this pattern in all the results that follow, we only present cross-sectionally demeaned findings for the rest of the paper.

In conclusion, Table 1 documents the first main finding of this paper: realized population growth plays an important role in explaining house price appreciation, particularly for dense states. The rest of the analysis examines this finding more carefully to generate novel conclusions about the role of demographics, and in particular immigration, in determining house prices.

In particular, we now turn to modeling expected natural and non-natural growth. To generate expected natural growth, we first interpolate national level birth and death rates to get rates at each age: $b(i,t)$ and $d(i,t)$. We then apply the distribution within each coarse age group for the nation as a whole to the state-level age cohorts data we have. This procedure generates an estimate of each state's population at each age: $N_i(t,j)$. For example, if in 1990, at the national level, one-year-old children made up 22% of the 0-4 year age cohort, we would assume that for California, one-year-old children were also 22% of the 0-4 year age cohort. With mortality and fertility rates at each age, along with a estimate of the distribution at each age, we are then able to forecast next period's age distribution for a state j that would be due to natural growth, $\widehat{N_i}(t, t+1; j)$. By iterating this forecast forward, we are able to generate expected state-level population levels for every age k periods out, $\widehat{N_i}(t, t+k; j)$, as well as total expected state population, $\widehat{N}(t, t+k; , j) = \sum_i \widehat{N_i}(t, t+k; j)$. Therefore, our proxy for expected natural growth is $E_t^N[\Delta N(t, t+k; j)] = \frac{\widehat{N}(t,t+k;j)-N(t,j)}{N(t,j)}$ and our proxy for realized non-natural growth is $\Delta N^{NN}(t, t+k; j) = \frac{N(t+k,j)-\widehat{N}(t,t+k;j)}{N(t,j)}$.

Figure 1 plots predicted natural population growth against realized population growth over our time period. The correlation between our predicted population growth and realized population growth is positive. Note that the explained variation appears low suggesting that additional factors besides fertility and mortality rates affects population growth. To ensure that our model for state-level fertility and mortality rates is a reasonable one, we examine forecasted and actual rates for a recent year in which state-level data is available. Figure 2 plots our predicted birth and death rates against actual state-level birth and death rates from the year 2000 in our sample. The relation between our predicted rates and the actual rates seems strong.

Consequently, Tables 2 and 3 decompose the result in Table 1 into a component due to expected natural growth ($X(t, j) = E_t^N[\Delta N(t, t+k; j)]$) and a component due to realized non-natural growth ($X(t, j) = \Delta N^{NN}(t, t+k; j)$). In Table 2, we find that the component of simple realized population growth due to expected natural growth has no predictive ability. The fact that expected natural population growth is not related to prices suggests that either builders anticipate and provide supply to offset this predictable demand and/or households anticipate this predictable demand and incorporate it into prices at an earlier time. Of course, these interpretations assume that our model of natural population growth is a good model. Alternatively, we may just have a bad model, possibly due in part to heterogeneity of fertility and mortality rates across states.

Instead, Table 3 shows that the statistically significant result of Table 1 arises entirely from the sensitivity of house price appreciation to non-natural growth. Again, this sensitivity is stronger in denser areas. We interpret this finding as being due to immigrants moving to hot economic markets with the resulting economic activity driving house prices up, as in the model of Van Nieuwerburgh and Weill (2009).

Presumably some of this non-natural population growth that we argue is due to state-level immigration is an unexpected shock that drives contemporaneous prices. We next ask whether these population shocks are truly unanticipated.

We use a simple forecasting model of non-natural population growth where we relate current population growth to lagged GDP growth and the Share of 65+ in population. That model results in the following estimates:

$$E_t[\Delta N^{NN}(t,t+k;j)] = -0.5513+0.6066*\Delta GDP(t-1,t;j)-0.4087*\frac{N_{65+}(t;j)}{N(t;j)}; R^2 = .217$$

Table 4 then uses the fitted value from this first-stage regression as the demographic variable ($X(t,j) = E_t[\Delta N^{NN}(t,t+k;j)]$) in an estimation of equation (1). The analysis shows that cross-sectional variation in expected non-natural state-level population growth forecasts cross-sectional variation in state-level house price appreciation and (consistent with results in previous Tables) particularly so for high density states with $R^{2\prime}s$ as high as 17%.

Figures 3 and 4 examine the extent to which actual housing market activity anticipates these changes by plotting the level of building permits in event time. The events we study are 1) abnormally large (top 20%) population growth over k years and abnormally small (bottom 20%) population growth over k years and 2) abnormally large (top 20%) price growth over k years and abnormally small (bottom 20%) price growth over k years. In the plots corresponding to this analysis, the specific growth that the event refers to is the year $t+k$ value divided by the year t value. As before, we study $k = 4$. The plots graph permits normalized by population at $t-6$ as well as annual permit growth in event time. We take away several conclusions from these graphs. For one thing, permit behavior of high growth states looks largely symmetric to that of low growth states. Moreover, permit growth begins to increase (relative to average) 3 to 4 years before a positive event. However, for a positive price growth event, although permit growth increases prior to event, it starts out below average and does not reach average until year -3. Similarly, the normalized level of permits starts out below average and does not reach average until year 0. These findings are consistent with those states experiencing high price growth being states that were underdeveloped in the past. Both permits and permit growth are relatively high during periods of high price growth and high population growth (years 0-4). After year 4 permit growth for event states looks similar to non-event states suggesting that during these growth years supply catches up with demand.

Based on these findings, Table 5 includes two time-t additional controls in the forecasting regressions of Table 4. These controls are the lagged growth in permits, $\Delta H(t-k,t;j)$, and the ratio of permits to population, $\frac{H(t;j)}{N(t;j)}$. Consistent with the patterns in the event study, house prices appear to underreact to permit growth though a high ratio of permits-to-population forecasts relatively lower house price appreciation in the future. Interestingly, these two variables do not subsume the ability of our expected immigration proxy to forecast cross-sectional variation in house price appreciation. In some specifications, R^2's are as high as 33.5%.

5 Conclusion

We link cross-sectional variation in both realized and expected state-level house price appreciation to cross-sectional variation in demographic changes. In particular, we extract two components of expected population growth: 1) a natural component due to predictable demographic changes related to fertility and mortality rates and 2) a non-natural component due to immigration. Our analysis shows that only the second component forecasts cross-sectional variation in state-level house price appreciation. Our findings are consistent with fundamentals driving an economically important portion of cross-sectional variation in state-level housing returns. However, markets appear to significantly underreact to the component of fundamentals, immigration, that is arguably more difficult for market participants to anticipate.

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Table 1: **House Price Appreciation and Contemporaneous Population Growth**

This table reports pooled regressions of state-level house price appreciation ($\Delta P(t,t+k;j)$) from time t to time $t+k$ for state j on contemporaneous population growth ($\Delta N(t,t+k;j)$), an interaction with lagged population density ($D(t;j)$), and lagged state-level house price appreciation for a sample of 49 states (Panels A and C) and a sample of 17 states that have city-level rental data (Panels B and D). For the sample of states that have price and rental data for cities k, the regressions also include the lagged price-to-rent ratio ($\frac{P(t;j(k))}{Rent(t;j(k))}$). For each sample, the table reports coefficients estimated on all of the data (ALL) as well as estimated on subsamples based on splits into $D(t;j)$ terciles. In Panels C and D, both the dependent and independent variables are first cross-sectionally demeaned. Throughout the table we set $k=4$. t-statistics based on clustered (by year) standard errors are reported below point estimates.

	ALL	ALL	$D(t;j)$		
			low	medium	high
Panel A: $\Delta P(t,t+k;j)$, All 49 states					
$\Delta N(t,t+k;j)$	1.1073	0.655	0.8162	1.9359	1.9127
	8.31	3.02	3.74	2.73	2.16
$D(t;j)*\Delta N(t,t+k;j)$		.5624			
		2.75			
$\Delta P(t-k,t;j)$	-0.1191	-0.1316	-0.0563	-0.2121	-0.1707
	0.82	-0.89	0.21	1.28	1.09
R^2	0.0733	0.1923	0.0786	0.1849	0.1026
Panel B: $\Delta P(t,t+k;j)$, 17 states with rental data					
$\Delta N(t,t+k;j)$	1.037	-0.4069	2.0249	1.1787	3.7009
	2.22	0.46	3.68	1.60	2.40
$D(t;j)*\Delta N(t,t+k;j)$		1.3587			
		3.76			
$\Delta P(t-k,t;j)$	0.005	-0.0141	0.2073	-0.0344	-0.122
	0.08	0.19	3.32	0.40	1.051
$\frac{P(t;j(k))}{Rent(t;j(k))}$	-0.4246	-0.51	-0.7403	-0.6422	-0.1047
	2.82	8.98	17.79	13.4	-0.53
R^2	0.1576	0.3921	0.577	0.2848	0.2116

	ALL	ALL	$D(t;j)$		
			low	medium	high
Panel C: $\Delta P(t,t+k;j)$, All 49 states, cross-sectionally demeaned					
$\Delta N(t,t+k;j)$	0.981	1.0266	0.7929	1.6335	1.7967
	5.06	5.23	2.82	2.21	3.32
$D(t;j) * \Delta N(t,t+k;j)$		0.0514			
		2.23			
$\Delta P(t-k,t;j)$	-0.0198	-0.0443	-0.0295	-0.1361	-0.0541
	0.19	0.4	0.29	1.17	0.38
R^2	0.0673	0.1816	0.0995	0.1695	0.0847
Panel D: $\Delta P(t,t+k;j)$, 17 states with rental data, cross-sectionally demeaned					
$\Delta N(t,t+k;j)$	1.2621	1.4858	2.5295	1.2455	2.9523
	2.48	3.12	2.63	2.04	2.76
$D(t;j) * \Delta N(t,t+k;j)$		.1758			
		2.57			
$\Delta P(t-k,t;j)$	-0.0423	0.0392	0.1472	-0.0233	-0.0289
	0.32	0.28	1.19	0.17	0.1
$\frac{P(t;j(k))}{Rent(t;j(k))}$	0.1367	-0.4133	-0.8519	-0.4022	0.0022
	0.38	1.3	1.25	0.44	0.01
R^2	0.0534	0.2115	0.2743	0.0762	0.1302

Table 2: **House Price Appreciation and Expected Natural Population Growth**

This table reports pooled regressions of state-level house price appreciation ($\Delta P(t, t+k; j)$) from time t to time $t+k$ for state j on expected natural population growth ($E_t^N[\Delta N(t, t+k; j)]$), an interaction with lagged population density ($D(t; j)$), and lagged state-level house price appreciation for a sample of 49 states (Panel A) and a sample of 17 states that have city-level rental data (Panel B). Both the dependent and independent variables are first cross-sectionally demeaned. For the sample of states that have price and rental data for cities k, the regressions also include the lagged price-to-rent ratio ($\frac{P(t;j(k))}{Rent(t;j(k))}$). For each sample, the table reports coefficients estimated on all of the data (ALL) as well as estimated on subsamples based on splits into $D(t; j)$ terciles. Expected natural population growth is generated by applying national birth and death rates per age cohort to the corresponding lagged state-level cohort populations as described in the text. Throughout the table we set $k = 4$. t-statistics based on clustered (by year) standard errors are reported below point estimates.

	ALL	ALL		$D(t;j)$	
			low	medium	high
Panel A: $\Delta P(t, t+k; j)$, All 49 states, cross-sectionally demeaned					
$E_t^N[\Delta N(t, t+k; j)]$	-1.5705	-0.4304	-0.9944	1.0428	-1.1158
	0.7	0.36	0.41	0.53	0.31
$D(t; j) * E_t^N[\Delta N(t, t+k; j)]$		.0475			
		0.91			
$\Delta P(t-k, t; j)$	0.0128	-0.0274	0.0398	-0.0435	-0.0446
	0.11	0.24	0.35	0.66	0.26
R^2	0.0034	0.0417	0.003	0.0036	0.0036
Panel B: $\Delta P(t, t+k; j)$, 17 states with rental data, cross-sectionally demeaned					
$E_t^N[\Delta N(t, t+k; j)]$	-2.4921	-1.0743	-3.3853	1.0324	-2.3293
	0.86	0.45	0.86	0.23	0.32
$D(t; j) * E_t^N[\Delta N(t, t+k; j)]$		0.151			
		1.90			
$\Delta P(t-k, t; j)$	0.0373	0.1327	0.1273	0.0417	0.0721
	0.3	0.88	0.86	0.34	0.22
$\frac{P(t;j(k))}{Rent(t;j(k))}$	-0.0522	-0.6521	-0.1385	-0.622	-0.1565
	0.13	1.57	0.2	0.8	0.44
R^2	0.0063	0.0921	0.0327	0.0257	0.0066

Table 3: **House Price Appreciation and Non-Natural Population Growth**

This table reports pooled regressions of state-level house price appreciation ($\Delta P(t, t+k; j)$) from time t to time $t+k$ for state j on non-natural realized population growth ($\Delta N^{NN}(t, t+k; j)$), an interaction with lagged population density (D_t), and lagged state-level house price appreciation for a sample of 49 states (Panel A) and a sample of 17 states that have city-level rental data (Panel B). Both the dependent and independent variables are first cross-sectionally demeaned. For the sample of states that have price and rental data for cities k, the regressions also include the lagged price-to-rent ratio ($\frac{P(t;j(k))}{Rent(t;j(k))}$). For each sample, the table reports coefficients estimated on all of the data (ALL) as well as estimated on subsamples based on splits into $D(t; j)$ terciles. Non-natural population growth is realized population growth minus expected natural population growth. Expected natural population growth is generated by applying national birth and death rates per age cohort to the corresponding lagged state-level cohort populations as described in the text. Throughout the table we set $k = 4$. t-statistics based on clustered (by year) standard errors are reported below point estimates.

	ALL	ALL		$D(t;j)$	
			low	medium	high
Panel A: $\Delta P(t, t+k; j)$, All 49 states, cross-sectionally demeaned					
$\Delta N^{NN}(t, t+k; j)$	1.0798	0.9773	0.8643	1.9253	1.7151
	5.14	5.14	2.82	2.27	3.65
$D(t;j) * \Delta N^{NN}(t, t+k; j)$		0.0434			
		3.47			
$\Delta P(t-k, t; j)$	-0.0198	-0.0026	-0.0309	-0.1474	-0.0479
	0.19	0.02	0.3	1.23	0.33
R^2	0.0763	0.1258	0.11	0.1963	0.0829
Panel B: $\Delta P(t, t+k; j)$, 17 states with rental data, cross-sectionally demeaned					
$\Delta N^{NN}(t, t+k; j)$	1.6399	1.6272	2.9876	1.5274	3.6826
	3.01	2.92	2.86	2.37	3.34
$D(t;j) * \Delta N^{NN}(t, t+k; j)$		0.0771			
		1.71			
$\Delta P(t-k, t; j)$	-0.052	-0.0637	0.1119	-0.0289	-0.0157
	0.4	0.5	1.1	0.2	0.06
$\frac{P(t;j(k))}{Rent(t;j(k))}$	0.1634	0.2238	-0.7645	-0.3871	-0.0126
	0.47	0.76	1.35	0.42	0.05
R^2	0.0732	0.0923	0.3306	0.0864	0.1667

Table 4: **House Price Appreciation and Expected Non-Natural Population Growth**

This table reports pooled regressions of state-level house price appreciation ($\Delta P(t, t+k; j)$) from time t to time $t+k$ for state j on expected non-natural realized population growth ($E_t[\Delta N^{NN}(t, t+k; j)]$), an interaction with lagged population density ($D(t; j)$), and lagged state-level house price appreciation for a sample of 49 states (Panel A) and a sample of 17 states that have city-level rental data (Panel B). Both the dependent and independent variables are first cross-sectionally demeaned. For the sample of states that have price and rental data for cities k, the regressions also include the lagged price-to-rent ratio ($\frac{P(t;j(k))}{Rent(t;j(k))}$). For each sample, the table reports coefficients estimated on all of the data (ALL) as well as estimated on subsamples based on splits into $D(t; j)$ terciles. Expected non-natural population growth is generated by regressing non-natural population growth on lagged state-level GDP growth and the lagged share of 65+ in the population. Non-natural population growth is realized population growth minus expected natural population growth. Expected natural population growth is generated by applying national birth and death rates per age cohort to the corresponding lagged state-level cohort populations as described in the text. Throughout the table we set $k = 4$. t-statistics based on clustered (by year) standard errors are reported below point estimates.

	ALL	ALL		$D(t; j)$	
			low	medium	high
Panel A: $\Delta P(t, t+k; j)$, All 49 states, cross-sectionally demeaned					
$E_t[\Delta N^{NN}(t, t+k; j)]$	2.5329	2.5179	2.0963	2.5956	4.432
	2.73	3.12	2.61	1.92	5.14
$D(t; j) * E_t[\Delta N^{NN}(t, t+k; j)]$		0.049			
		1.72			
$\Delta P(t-k, t; j)$	-0.0828	-0.1775	-0.0746	-0.1755	-0.1612
	0.78	1.56	0.71	1.23	0.97
R^2	0.0821	0.1679	0.0977	0.1449	0.1071
Panel B: $\Delta P(t, t+k; j)$, 17 states with rental data, cross-sectionally demeaned					
$E_t[\Delta N^{NN}(t, t+k; j)]$	3.2797	3.127	4.8043	1.8883	7.6297
	4.51	4.66	2.29	1.38	5.2
$D(t; j) * E_t[\Delta N^{NN}(t, t+k; j)]$		0.1038			
		1.55			
$\Delta P(t-k, t; j)$	-0.1032	-0.14	0.0733	-0.0229	-0.2581
	0.91	1.55	0.49	0.19	0.9
$\frac{P(t;j(k))}{Rent(t;j(k))}$	0.0931	-0.2697	-0.7411	-0.48	0.036
	0.23	1.01	1.14	0.54	0.13
R^2	0.074	0.1856	0.229	0.0567	0.1742

Table 5: **House Price Appreciation, Expected Non-Natural Population Growth, and Permits**
This table reports pooled regressions of state-level house price appreciation ($\Delta P(t, t+k; j)$) from time t to time $t+k$ for state j on expected non-natural realized population growth ($E_t[\Delta N^{NN}(t, t+k; j)]$), an interaction with lagged population density ($D(t; j)$), lagged permit growth ($\Delta H(t-k, t; j)$), the lagged permit-to-population ratio ($\frac{H(t;j)}{N(t;j)}$), and lagged state-level house price appreciation for a sample of 49 states (Panel A) and a sample of 17 states that have city-level rental data (Panel B). Both the dependent and independent variables are first cross-sectionally demeaned. For the sample of states that have price and rental data for cities k, the regressions also include the lagged price-to-rent ratio ($\frac{P(t;j(k))}{Rent(t;j(k))}$). Expected non-natural population growth is generated by regressing non-natural population growth on lagged state-level GDP growth and the lagged share of 65+ in the population. Non-natural population growth is realized population growth minus expected natural population growth. Expected natural population growth is generated by applying national birth and death rates per age cohort to the corresponding lagged state-level cohort populations as described in the text. Throughout the table we set $k = 4$. t-statistics based on clustered (by year) standard errors are reported below point estimates.

Panel A: $\Delta P(t, t+k; j)$, All 49 states, cross-sectionally demeaned

$E_t[\Delta N^{NN}(t, t+k; j)]$	2.3367	2.4798	1.5205	2.9543	1.91
	4.77	4.59	3.19	3.99	2.59
$D(t; j) * E_t[\Delta N^{NN}(t, t+k; j)]$		0.0392	0.0426	0.0364	0.0255
		1.69	2.34	1.63	1.00
$\Delta P(t-k, t; j)$	-0.0649	-0.1807	-0.3371	-0.164	
	0.4	1.46	2.97	1.26	
$\Delta H(t-k, t; j)$			0.1594		0.1359
			5.97		5.45
$\frac{H(t;j)}{N(t;j)}$				-5.1479	-10.32
				3.04	3.56
R^2	0.0604	0.155	0.2808	0.1662	0.2432

Panel B: $\Delta P(t, t+k; j)$, 17 states with rental data, cross-sectionally demeaned

$E_t[\Delta N^{NN}(t, t+k; j)]$	2.6242	2.5366	1.5721	3.9859	3.064
	4.85	4.36	2.69	12.4	5.1
$D(t; j) * E_t[\Delta N^{NN}(t, t+k; j)]$		0.0744	0.0729	0.062	0.0576
		5.58	4.97	5.31	5.42
$\Delta P(t-k, t; j)$	0.0391	0.0306	-0.1649	0.0998	
	0.3	0.32	1.05	0.87	
$\frac{P(t;j(k))}{Rent(t;j(k))}$	-0.0719	-0.4686	-0.03	-0.5462	-0.4768
	0.19	1.55	1.08	1.83	2.6
$\Delta H(t-k, t; j)$			0.1575		0.1591
			2.25		4.10
$\frac{H(t;j)}{N(t;j)}$				-18.2054	-21.89
				1.83	2.60
R^2	0.073	0.17	0.2564	0.2334	0.335

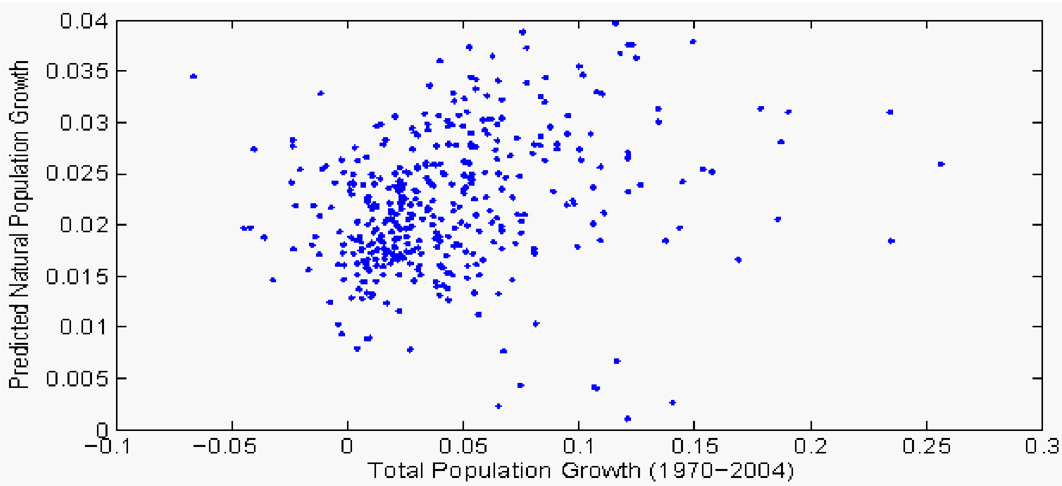

Figure 1: We plot our proxy for expected natural population growth, $E_t^N[\Delta N(t,t+k;j)] = \frac{\widehat{N}(t,t+k;j)-N(t,j)}{N(t,j)}$, against realized population growth, $\frac{N(t,t+k;j)-N(t,j)}{N(t,j)}$, for 49 states over the 1970-2004 time period. We use national mortality and fertility rates, the national distribution of age within age cohorts, and time t values of state-level population for each of these age cohorts to forecast next period's population for a state j that would be due to natural growth, $\widehat{N_i}(t,t+1;j)$. Interating these forecasts forward generates our expectation of expected natural population growth. We set $k = 4$.

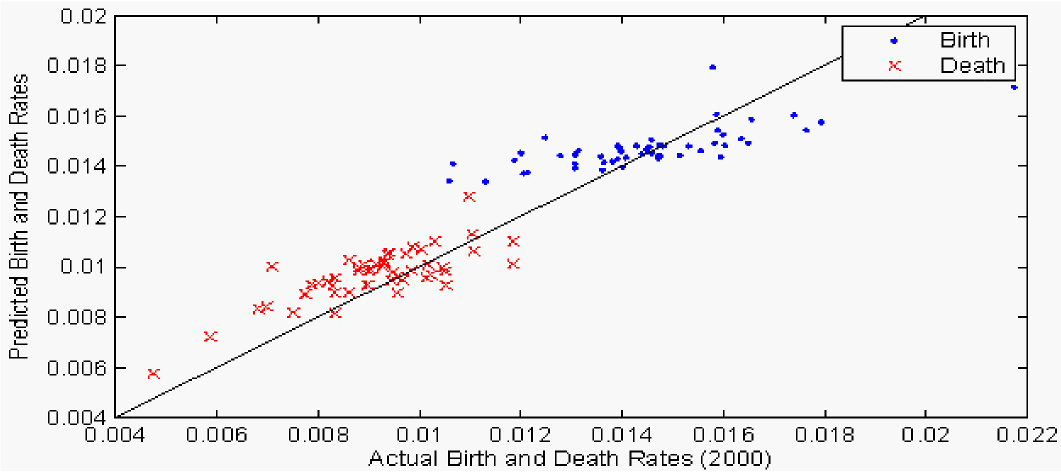

Figure 2: This figure plots our predicted state-level birth and death rates for a recent year in which actual state-level data is available. To generate our predicted state-level birth and death rates, we first interpolate national level birth and death rates (available at particular ages) to get rates at each age: $b(i,t)$ and $d(i,t)$. We then apply the distribution within each coarse age group for the nation as a whole to the state-level age cohorts data we have. This procedure generates an estimate of each state's population at each age: $N_i(t,j)$. With the predicted mortality and fertility rates at each age, along with a estimate of the distribution at each age, we are then able to forecast the composite fertility rates and composite mortaility rates for the state each year.

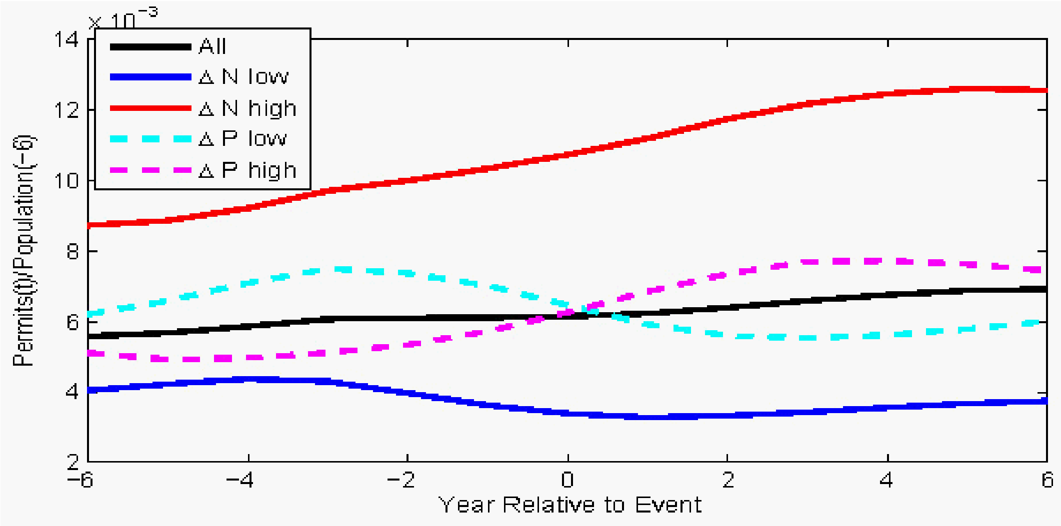

Figure 3: This figure examines the extent to which housing market activity anticipates changes in population growth as well as house price appreciation. Specifically, we study 1) abnormally large (top 20%) population growth over k years and abnormally small (bottom 20%) population growth over k years and 2) abnormally large (top 20%) price growth over k years and abnormally small (bottom 20%) price growth over k years, where the specific growth that the event refers to is the year $t + k$ value divided by the year t value. The figure plots permits normalized by population at $t - 6$ in event time. We set $k = 4$.

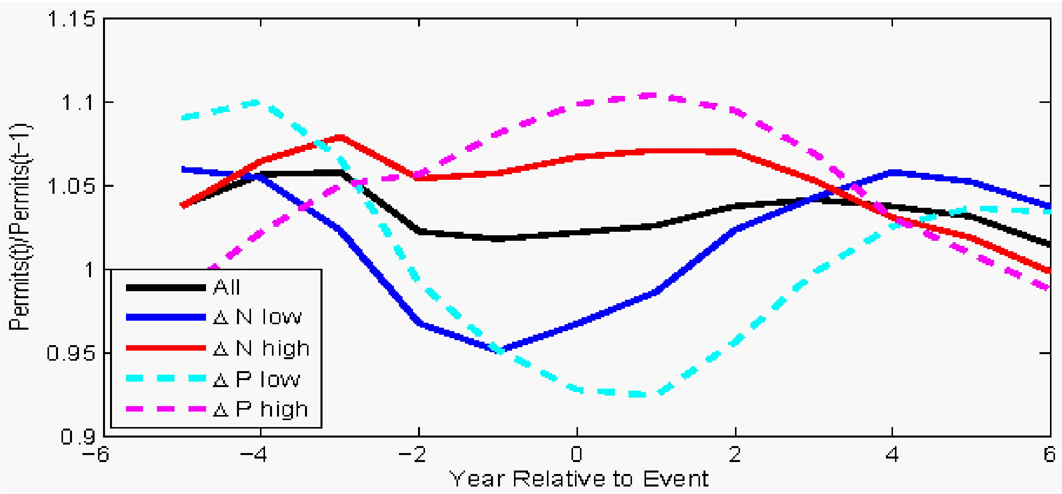

Figure 4: This figure examines the extent to which housing market activity anticipates changes in population growth as well as house price appreciation. Specifically, we study 1) abnormally large (top 20%) population growth over k years and abnormally small (bottom 20%) population growth over k years and 2) abnormally large (top 20%) price growth over k years and abnormally small (bottom 20%) price growth over k years, where the specific growth that the event refers to is the year $t+k$ value divided by the year t value. The figure plots annual permit growth in event time. We set $k = 4$.