Title: Influences of Macroeconomic and Local Factors on House Price Growth Rate Volatility

A thesis submitted by
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Abstract:

The paper aims to identify the factors influencing variation in house price growth rate in Metropolitan and Micropolitan Statistical Areas in the United States. It helps to identify how town characteristics interact with macroeconomic conditions to influence volatility. Towns are defined as college, retirement and industrial towns based on demographic data and also based on housing supply elasticity ranges. Macroeconomic factors studied are both at local and national level. I have built a GARCH model to estimate volatility for each year of each CBSA. Using the predicted volatility a panel data regression model is used to study the impact of these macroeconomic variables across these towns. The results show that that national macroeconomic variables affect volatility whereas local variables are not statistically significant for all towns. Also the business cycles and housing cycles impact volatility in these towns differently.

Table of Contents

List of Tables

List of Figures

Section 1: Introduction

The housing market is a key indicator of the health of the economy. A volatile growth rate of the housing market suggests higher risk involved in housing investment. Since that will discourage investments, it may slow down the growth of the economy. Figure 1 shows the distribution of volatility of real house price growth rates from 1990 to 2015. Figure 2 breaks down this period based on business cycles to see how volatility has changed. This shows how the level of volatility varies across these cycles and how it has increased in the last two cycles. Given the fact that volatility is not consistent across these years, it is important to know the factors, which have been driving this volatility.

National factors and federal policies are likely to have a strong influence in determining changes in house prices as well as the volatility of their growth rates. Factors such as the gross domestic product, the unemployment rate, and interest rates play an important role in affecting volatility. A lower unemployment rate can lead to an increase in house price growth rate due to higher demand from employed individuals. In a period of high unemployment there can be lower demand for housing. Thus changes in these factors are likely to lead to fluctuations in house price growth rate. However, it may be possible that volatility of house price appreciation varies across regions that face the same economic conditions. Factors specific to a region or a market play an important role in influencing changes in house price growth rates. Past work on the housing market has primarily focused on house price levels or has tried to identify factors that affect volatility but not by considering macroeconomic, supply-side and demographic factors all together. It is important to know the reasons for the differences in the growth rate of house price variation.

From a policy standpoint this helps in building a perspective about how local factors influence growth of house prices and the expected house price behavior in a given Core Based Statistical Areas (CBSA) under different economic situations. This may assist in forming supply restrictive policies on land use regulations, permits et cetera. Also as mentioned before, from a housing investment standpoint variation in the appreciation of price associated with a particular region gives an idea about the riskiness involved in housing investment. Therefore it is essential to understand the possible reasons for the difference in the variation in growth rates among the CBSAs.

The goal of this paper is to identify how the interactions of macroeconomic factors with local characteristics of a CBSA determine the volatility in house price growth rates. This paper will classify CBSAs based on their specific characteristics, which can impact their demand for housing. For instance, a CBSA can be identified as a college town based on the age and current education level of its population. These towns are likely to experience a steady demand for housing due to the inflow of students moving to these places irrespective of current economic conditions. It is expected that such a place will experience less fluctuations in the growth rate of prices compared to other places. Thus, in periods of economic downturn the house prices of these regions might not experience a huge downfall. Similarly, in a period of economic boom since the demand is more consistent they may not enjoy extreme increases in price. Hence, these regions experience less fluctuation. Figure 3 shows the variation in the volatility of house price appreciation for three CBSAs. It can be seen that there is less volatility observed in the college town of Bloomington, IN relative to the CBSA Holland, MI, an industrial town.

Supply-side factors such as land-use restrictions, topography et cetera also affect the house prices of a region. Housing markets that face higher supply-side constraints are likely to experience higher volatility in house price growth rates. Due to supply-side restrictions, an improvement in economic conditions can lead to an increase in growth rates relative to other regions that do not have such prominent restrictions. In a downturn with lower demand, the inelasticity of housing supply will not lead to a significant fall in prices compared to other regions. Thus local factors have a differential impact on house price appreciation volatility. The paper also identifies the impact of supply factors for different towns on house price growth rate volatility.

This paper will use a GARCH model to identify the volatility of house price growth rates across CBSAs over time. Then using this time-varying volatility, a panel data regression model will be developed to examine how local factors along with macroeconomic conditions influence the volatility in house price growth rates for the period 1990 to 2015. This is the main model of the paper. A second model will capture the effect of macroeconomic factors and supply constraints on growth of house price volatility. The reason for having two models is due to the fact that the data on supply constraints is not available for all the metro and micro areas tracked in the paper.

Section 2: Literature Review

Past work on the housing market has either focused on house price levels or has tried to identify volatility by not considering both macroeconomic and demographic factors together. Miller and Peng (2006) identify the volatility of single-family home value growth and also studies its effect. They consider quarterly housing prices at the MSA level from the Office of Federal Housing Enterprise Oversight, per capita personal income from the BEA, population from BOC, unemployment rate, and per capita gross metropolitan product from BLS. They track 277 MSAs from the third quarter of 1990 to the second quarter of 2002. Firstly they set up a rational expectations model for the future house price growth rates. They include latent variables, which are MSA and time fixed effects in the model. To regulate variables that are both MSA and time invariant they use the lagged residual. This was possible because these variables are serially correlated hence the lagged residual will be related to the contemporaneous latent variables. In order to overcome the problem of heterogeneity of the housing market they create four MSA segments based on population as a proxy for supply constraints and use the bankruptcy rate as a proxy for homeowners' leverage. In order to account for different economic conditions, which also lead to asymmetric effect on expected house price growth rate, they include positive and negative changes in the independent variables separately in the model. The unpredictable component of the growth rate is used to estimate the volatility of home price growth rate that is the variance of the unpredictable component. The variance of this component is estimated using the GARCH model. In the final step, they use a VAR model with four lags of all the variables – house price growth rate, volatility, per capita personal income, population, unemployment rate, and per capita gross metropolitan product. This model has MSA and time fixed effects, positive and negative changes in the independent variables and the proxy lagged residuals. This VAR model helps to identify the effect of the all the macroeconomic variables on the volatility and also the effect of volatility on the macroeconomic variables. An increase in house price growth rate leads to an increase in volatility; however the impact varies across MSAs. A decline in the growth rate leads to more persistent effect on volatility in the MSAs with supply constraints and low homeowners' leverage. It is also observed that volatility is serially correlated with being most persistent and cyclic in case of MSAs with supply constraints and high homeowners' leverage. Population growth has differential impact on volatility of home value appreciation rate. The effect of an increase in volatility on house price growth rate is less immediate and become more prominent eventually. It is positively correlated to the income growth rate and has an amplifying effect on per capita personal income. An improvement in volatility does not have a considerable effect on population growth rate in areas without supply constraints whereas it significantly reduces the growth rate in areas with supply constraints. The paper shows that there is significant amount of diversity of housing markets across MSAs. Areas, which face higher supply restrictions, are more susceptible to shocks. This paper shows that the heterogeneity of the housing market and the differential impact of shocks.

Tsai and Chen (2010) analyze volatility of UK house prices, whether volatility has changed over time and different states of volatility in house prices. They examine the change in volatility using ARCH and GARCH models and account for structural break using the SWARCH model. SWARCH models work better in the presence of structural breaks in the data. They analyze all and new house prices in the UK for the period 1955Q4 to 2005Q4. Before estimating volatility they determine the autoregressive mean equation and test for the presence of ARCH using the Langrange Multiplier (LM) test. They find that the AR(1) model is most suitable for both all houses and new houses. The results of the LM test show that the series are autocorrelated. Then they estimate the volatility of the house prices using the ARCH(1), ARCH(2) and GARCH(1,1). The estimates of the coefficients are significant and the sum of the ARCH and GARCH coefficients is greater and equal to 1 which implies persistence. This persistence in the series may indicate different volatility states for the two housing markets. To examine the presence of regime-switch they use an AR(1)-SWARCH(3,1) model. The results show that there are different volatility states namely high, medium and low volatility states in housing markets for all houses. However the changes in the states are infrequent. In case of new houses there are two states –high and low states. Moreover the change in states is also more frequent in theses type of houses. They also find that the periods of different volatility states. Before 1972, the housing market was in a low volatility state.

There are structural changes in 1972 and 1977 to medium volatility and 1988 to 2002 to high volatility. The market for new houses do not experience such high volatility observed in case of all houses.

Zhou and Haurin (2010) study the volatility of house prices for individual houses. They test four hypotheses – high and low quality houses have more volatile house prices, atypical houses have more variance, houses with more land leverage have more volatile house prices, white households have less volatility than other minority households. They use American Housing Survey data for the period 1974 to 2003. The first panel has data from 1973to 1981 and 1983 and the second panel is from 1985 and is biannual. They exclude top-coded and bottom-coded observations, non-owner occupied houses, houses on lots larger than 10 acres, do not have data for all nine surveys and those with changes in structural characteristics. The independent variables used in the paper are mean home value, mean home age, home atypicality measure, and a dummy variable indicating if the house is centrally located. The control variables are the owner characteristics – dummy variables indicating white and gender, age of household head, highest school grade attained by the head and lastly length of stay in current residence. They create different segments for the data based on regions – northeast, south, west and midwest and also distinguish between urban and suburban locations. This is done to measure atypicality of the houses considered in the paper. House quality is measured using square footage of the housing.

The mean value of houses in 1985 is higher by 10% from 1974. They also observe a decline in volatility over time when the two periods are considered.

They state this can be driven by the two recessions which occurred in the first period compared to one which occurred in the much longer second period. To measure land leverage, land value is used which is available only for the first sample. Therefore to calculate land value they use a hedonic house price regression model using lot size, its square and cube. Then land leverage ratio is calculated using land value and house value. The paper shows that low-valued houses in terms of prices and square footage experience higher volatility in house prices. Additionally they find that volatility of house prices is higher for non-whites, in houses which are highly atypical and with a high level of land leverage ratio. These observations are inferred from descriptive statistics of the data.

The results of the regression for the first period show that the age of the house and the central location of a house do not impact the volatility of house prices. Houses where the head of the household is a woman, of older age, less educated and has been residing in the house for long exhibit higher volatility. Houses that have extreme values and atypical houses experience higher volatility. In the results for the second period, there is one change from the results in the first period for the control variables. Higher age of the house leads to higher volatility. The results for other independent variables are also similar. In this period they had used a different measure for atypicality which is the presence of a water body between 300 feet of the house. This variable is found to be not significant.

Evenson (2001) studies housing supply at an MSA level. She analyzes the effect on house prices due to economic shocks with the help of housing supply dynamics. House price is inversely related to supply inelasticity. She estimates price and stock of housing using employment as a proxy for demand in a conditional vector auto-regression model. Additionally she identifies the reasons for disparity in elasticities across regions. She studies 47 MSA for the period 1975-1999. House price index data is from Freddie Mac, housing inventory data is from the census and employment data is from BLS. She creates the CVAR model for house prices and stock using employment and lags of themselves and each other. A change in employment will a large and instant change in both stock and price which is why he uses contemporaneous and not lagged employment as the independent variable. Therefore supply of housing is to a factor of change in prices. In order to overcome the endogeneity problem associated with employment and house prices and stock driven by wealth effect, he uses total national employment (NE) or national employment by industry weighted by area industry share as instruments (IS). Each area is studied separately and the market clearing level of price and stock are simulated. Price and stock is again simulated after a change in employment to analyze the impact of employment shock. This gives an idea about the difference in MSAs to adjust to changes in housing demand. Except for 8 markets prices increase after an increase in demand and variation between the markets. Whereas, change is supply is positive and consistent. One-third of the markets have new equilibrium prices below the previous level which implies a shift in supply. The change in price is slow which indicates slow adjustments in the housing market.

In order to understand the contrast between the housing markets he develops faux elasticity which is defined as the percentage difference in the simulated levels of stock divided by the percentage difference in the simulated levels of price. Low faux elasticity implies the housing market has not adjusted. This faux elasticity is estimated at three, six, nine and twelve years for employment shock in the CVAR model. A negative elasticity implies a fall in equilibrium prices. Thus he interprets them as an elastic supply curve leading to the long-term price equilibrium and hence allots it a value 10. He assigns the same value to high and positive faux elasticities. He finds great variation between the years across the markets.

To determine the diversity in the results he analyzes the relationship between the adjustment dynamics due to government regulations, population density, historical growth rates and region. Data on population density is from the 1990 census, region is defined using the four divisions by the Census, historical growth rates is the employment growth rates from REIS data, and number of local governments is used as a proxy for regulation. He studies the impact of these variables on faux elasticity at one, three, six, nine, twelve years with no employment shock and also with using the employment instruments. He finds that regulation has a significant impact on the dependent variable, which is not diluted by the addition of other area characteristics. The effect wears off faster in case of the IS instruments when these variables are added. Increase in permit-issuing authorities leads to slower adjustments. Areas with higher historical growth rates adjust faster to employment shocks with the effect being very immediate. While population density has a slower rate of adjustment and so does an area in the south or west. The results show the importance of regulations in the housing market.

Case and Meyer (1996) set up a price determination model for a metropolitan area with spatially fixed distinct submarkets. They also determine town characteristics that govern cross-jurisdictional land and house prices. Lastly they analyze the movement of prices in the period 1982 to 1992 across 168 metropolitan jurisdiction characteristics. The data for house price index is obtained after making some changes to the Case and Shiller methodology. They use the arithmetic weighing method by Shiller for all houses sold more than once during the period. They created three separate indices- at an aggregate level for Massachusetts (MA), for individual jurisdictions and 168 cities and towns in eastern MA. Towns which are nearer to Boston and South Shore experience the highest growth rate in house prices and those located in the west of Boston witnessed the lowest. The data for town characteristics is from the 1980 and 1990 decennial census data, school and crime data from MA state government departments, town-level house permits from U.S. Department of Commerce and land use data from University of Massachusetts. There have been considerable changes in the variables between the two censuses. Changes in house prices are regressed on the share of residents in manufacturing sector in 1980, share of residents between age 35 and 60, the number of housing permits issued between 1982 and 1992, proximity to Boston measured through distance and square of it, 1980 level of town facilities, residential tax rate and single-family house value and its square. Due to possible endogeneity problem for the inclusion of the housing permit variable, they use IV regressions. Lagged permits and amount of vacant land are used as instruments. Towns with a higher proportion of residents working in the manufacturing experience less rise in house prices and the same is observed for towns closer to the these towns as the significance of manufacturing declined in the economy. Houses located in good school districts had less growth in house prices than other districts which can be due to the decline in enrollment across grades in public schools witnessed in that period. House prices appreciated more in towns with residents in the middle age groups, towns which are closer to Boston due to the availability of amenities and fell in those with high level of construction measured through housing permits. Towns with low house prices experienced a 10% higher increment in house prices than those towns with prices closer to the sample mean. They also capture the impact of median household income but due to the problem of endogeneity use education as an instrument variable. The results suggest that income is related to house prices and also to the share of middle-aged people in the area. Further considering the change in Asian population captures the effect of immigrant population. An increase in this variables leads to decline in house price growth. Lastly they analyzed the impact of these variables during boom and bust periods. Results show that the impact of demographics, housing permits and manufacturing variables were not different between the two types of periods. However, the impact of school quality, crime rate, 1980 median value and its square differed between the two periods. The paper highlights the heterogeneity across towns. It also suggests that changes in the independent variables leads to minor change in house price appreciation.

Lastly, the housing market was found to be slow in its reaction towards changing economic conditions.

Vandergrift et al. (2012) discuss the effect of a college on tax base and housing prices in an area where it is located. The paper analyzes whether college towns have higher house prices for different dimensions – disparity in the effect of a four-year college and community college, effect of the size of the college, effect of the college being residential. The study was done for New Jersey for the year 2000 at a municipality level. This is because data on housing related control variables are available during the census years. Dummy variables were used to identify colleges in an area. Data on mean house sale price was from The New Jersey Department of the Treasury, on college-related variables were from the State of New Jersey's Commission of Higher Education. Fall 2000 enrollment data was used to analyze the impact of that variable on housing prices. For multiple campuses of the same college dummy variables were assigned a value of one for each of these campuses and the total enrollment were split between the campuses. The effect of the college on the house prices in that area is expected to be inversely related to the size of the municipality and the distance from the college. To account for this fact the four dimensions are taken to be ratios with respect to acres of the municipality concerned. Data on open-space expenditure is from New Jersey Department of Environmental Protection. It also includes data on distances between municipalities measured using GIS and municipal centroids, municipality population, school age population, median rooms per housing unit, poverty rate, percentage of housing units that are owner-occupied, percentage of housing units that are seasonal, percentage of white population, housing vacancy rate, unemployment rate and the proportion of housing units built before 1960 from U.S. Census. High school quality is measured by the pass rate of the New Jersey High Scholl Performance Assessment test for 1999. For the municipalities having the same high schools the same test scores are used and weighted by enrollment.

They use the Lutzenhiser and Netusil's hedonic pricing model. Given the presence of a college in an area has both merits and demerits therefore the effect on price is uncertain. As mentioned earlier the impact of the college is studied at different dimensions. The college dummy is interacted with enrollment level and the percentage of students living on campus. This is to understand whether the availability of amenities is a factor of these variables. The paper includes five models to capture the impact on house prices. The first model captures the impact of the college and interaction term for enrollment; the second model adjusts the first model variables by the size of the municipality. The third model includes dummy variables for the college type- four year colleges or community colleges. The fourth model accounts for the size of the municipality with respect to this dummy variable. The fifth model has an interaction term with captures the percentage of students in a four-year college who live on campus adjusted for municipality size. The results show that house prices are higher in areas with a college but it also declines with the increasing enrollment. After considering the impact of the size of the municipality, the impact of college on house prices declines but the impact of enrollment is no longer significant. The third model shows that the impact of four-year college on increasing house prices is greater than community colleges. The effect of community college is also not significant. Enrollment is now inversely related to house prices. In the fourth model only the dummy variable to identify four-year colleges is significant. The results of the fifth model show that the extent by which a college is residential impacts the house prices. An average four-year residential college has a positive impact on house prices. In this model enrollment is significant and has a negative impact on house prices. The paper tackles the possibility that colleges are located in superior locations in two ways – including controls that capture the worth of a location, changing the dataset and analyzing the models. The largest cities are removed from the data to exclude the impact of city. The paper also account for the impact of time-varying and those which are not time-varying amenities which form the second set of estimates. The dataset for this set of estimates excludes observations after the year 1945. They carry out a third set of estimates that excludes observations for years after 1930. These exclusions reduce the number of municipalities and also are unable to capture the impact of community colleges. The results for the first estimates show that enrollment variable is no longer significant in the absence of the larger cities. This suggests that high house prices are driven by the presence of the college than the high land prices. The result s for the second and third estimates are similar to the models observed before these changes were made. With regard to control variables it is observed that open space, additional rooms and parcel size lead to higher house prices. Higher Unemployment, poverty rate and higher number of owner-occupied house lead to lower house prices. So does distance from New York. Housing in municipalities which are seasonal leads to higher prices and higher tax base leads to lower prices.

These papers refer to various factors that affect house prices and house price volatility. However none of them focuses on the interaction between macroeconomic factors and demographic factors.

Section 3: Data

The observation unit of the data is Metropolitan Statistical Areas and Micropolitan Statistical Areas (CBSA). The period tracked is from 1990 to 2015. The repeat-sales house price index is obtained at a zip code level from the Federal Housing Finance Agency (FHFA). House price index data from the FHFA is available at the CBSA level or zip code level. The reason for not getting the data at CBSA level is because some of the CBSAs get redefined during the decennial census. In order to maintain uniformity in the areas being tracked, I have used the house price index data at the zip code level. In case of a change in zip codes for a particular house, FHFA assigns all the sales of the house under the new zip code. The zip code level house price index data is aggregated at the county level using the crosswalk file from the U.S. Department of Housing and Urban Development (HUD). The file gives the residential ratio for each zip code within a county that is used as weights to aggregate the zip code level observations at the county level. Observations where the residential ratio is equal to zero are dropped since they indicate non-residential zip codes.

Macroeconomic variables are obtained from different sources. The county-level monthly unemployment rate is from the Bureau of Labor Statistics (BLS) and county level annual per capita personal income, population and the national level annual gross domestic product are from the Bureau of Economic Analysis (BEA). The 30 year national level monthly mortgage rate data is from Freddie Mac and the consumer confidence index is from the Organization for Economic Co-operation and Development (OECD). The datasets, which are not at an annual level, are aggregated at an annual level to maintain parity with the frequency of the house price index data.

The supply constraints data is Saiz' price elasticity of supply constraints at CBSA level from Saiz (2010). This data is not available for all the CBSAs tracked in this paper. It does not find a match for 532 micropolitan areas and 80 metropolitan areas. Therefore the impact of this variable is studied in a separate model.

To account for the location specific characteristics, CBSA's are defined as college towns, retirement towns and industrial towns based on age, education, employment status and type of job. The demographic data used to define these towns are from the 1990 decennial census obtained from the National Historical Geographic Information System (NHGIS) at a county level. All, house price index, macroeconomic variables and demographic variables first measured at the county level are aggregated to the CBSA level. Counties within a CBSA are identified using the Census delineation file from February 2013. The weights used to aggregate the data are the proportion of housing units in a county within a CBSA.

The towns are defined at a CBSA level after aggregating the county level data. A CBSA is defined as a college town if the percentage of individuals who are in college is higher than the mean by at least one and half standard deviation. To identify retirement towns, employment status and age variables are used. The percentage of individuals who are 65 years and above and who are not in the labor force out of the entire population in the labor force within a CBSA are identified. A CBSA is defined as a retirement town if this percentage is higher than the mean and one and half standard deviation of all the CBSAs. And lastly to define industrial towns, the percentage of individuals in industrial jobs namely in manufacturing industry for durable and non-durable goods, mining and construction industry are classified. If this percentage for a CBSA is higher by a mean and one and half standard deviation than that observed for all the CBSAs then it is defined as an industrial town. Table 1(a), (b) and (c) in Appendix I give the list of these three types of towns.

The start date for the house price index varies across counties within a CBSA for the house price index data. In order to overcome this disparity in start year, the house price index is redefined by considering the latest start year for a county within a CBSA, as the base year. The house price index of all the counties within the CBSA is recalculated thereafter for the all the available years. If house price index is not available intermittently for a county then it is interpolated using the data available in the neighboring years. Macroeconomic variables with missing values are allotted a value of 0 to ensure maximum possible number of observations is used in building the statistical models with a dummy variable used as a flag to indicate the missing observations. Table 1 gives the definitions of the variables used in the main model and Table 2(a) gives the summary statistics of the variables at level and 2(b) gives the same of the growth rate of the variables. Table 3 (a), (b), (c) give the summary statistics of the different types of towns. The variables to note are those that are not a national level – real house price index and growth rate, real per capita personal income, population and unemployment rate. It is observed that college towns have the highest mean real house price index relative to retirement towns and industrial towns. The mean growth rate in industrial towns is negative. The real per capita income for residents in retirement towns is the highest compared to college towns and industrial towns. Given the stability of finances of the inhabitants of retirement towns possibly driven by the elderly homeowners it is expected that income will be higher. It also has the highest mean population. Population is lowest in industrial towns and it has the lowest real house price index. Industrial Towns have the highest unemployment rate this can be due to the type of job majority of the residents are engaged in. Given a lot of people working in the industrial sector are temporary and contractual workers therefore there is less job security. This and the dismal housing market scenario in these areas may be driving the low population.

Table 4 gives the number of CBSAs captured in each year for the time period considered. The total number of CBSAs are 935. It can be seen that the maximum number tracked in any given period is 914. This is because the data for the house price index originally comes from the zip code level data where around 18,000 zip codes are being reported starting from 1975. This is less than the total number of zip codes in U.S.

Section 4: Model

Predicting the influence of different factors on the volatility of the growth rate of real house prices involves estimating the volatility of the real house price appreciation. Taking a standard deviation of the real house price growth rate over the years will give only one time invariant volatility measure of the variable. Therefore, a GARCH model which helps to identify a CBSA-level and time varying volatility is a more effective approach for determining the volatility of the price series.

Let Y_{it} denote the growth rate of the real house price index for CBSA i in year t, then the following model is used to predict the error term for the GARCH model:

$$Y_{it} = \alpha_0 + \alpha_1 * \sum_{j=1}^{p} Y_{i,t-j} + u_i + v_t + \varepsilon_{it} \quad (1)$$

where u_i is a CBSA fixed effect and v_t is a vector of time fixed effects.

The error term is specified to follow a GARCH(p,q) model, therefore it can be written as:

$$\varepsilon_{it}|\Omega_{t-1} \sim N(0, h_{it})$$

$$h_{it} = \omega_0 + \sum_{j=1}^{p} \beta_j * h_{i,t-j} + \sum_{j=1}^{q} \alpha_j * \varepsilon^2{}_{i,t-j} \quad (2)$$

where h_{it} is the heteroskedastic variance. Estimating equations (1) and (2) using maximum likelihood results in the predicted variance, $\widehat{h_{it}}$.

The goal of this paper is to determine if volatility varies across different types of towns and whether macroeconomic fundamentals have different effects on volatility across these towns. Once the volatility of the house price series is predicted, a model of volatility is specified that is allowed to differ across towns. Therefore, the following panel data model of the volatility of the growth of real house prices across CBSAs for the period 1990 to 2015 is specified:

$$\widehat{h_{it}} = \beta_0 + \beta_1 * abs(\Delta Macro_{it}) + \beta_2 * abs(\Delta Macro_{it}) * Town_i + \sum\sum \gamma_t * v_t * Town_i + u_i + v_t + \eta_{it} \quad (3)$$

where $Macro_{it}$ is a vector of macroeconomic variables that are measured at the local and national levels for the ith CBSA at time t. The local variables are unemployment rate, real per capita personal income, and population; national variables are real gross domestic product, consumer confidence index, 30 year fixed rate mortgage and real national HPI. $Town_i$ denotes the vector of indicators for college towns, retirement towns and industrial or manufacturing towns. v_t is the year dummy variables, and u_i is a CBSA fixed effect. The town dummy variables are interacted with the different macroeconomic variables to capture the influence of macroeconomic variables on house price volatility depending upon town characteristics. Additionally the year dummies capture the yearly trend of national factors affecting volatility of house price growth rate. They are also interacted with the town dummies to capture the impact of national level trends and local characteristics on predicted volatility.

The impact of these variables is captured by taking their growth rates. One reason for that is this is a growth rate model. Also taking growth rate of the variables helps to make them stationary. The reason for not taking the variables at levels and at growth rate is to be able to capture the effect of the change in magnitude. Unless growth rates are considered, a change in the levels of the macroeconomic variables will not imply a similar increment for all towns. In order to overcome the problem of reverse causality relevant in case of local macroeconomic variables a one period lag of the growth rate of these variables are considered.

Note that the absolute values of the growth rates are included in equation (3). The growth rates can be split into positive and negative changes. Using the absolute value implies that the effect of these two changes is symmetric on the dependent variable. I test for the hypothesis that the estimated coefficients of the positive and negative growth rate of the variables are equal in magnitude and opposite in sign. Based on the results of this hypothesis test, absolute values of the growth rate of the macroeconomic variables are taken as independent variables.

I test the hypothesis that volatility of house prices in a CBSA depends on CBSA- level macroeconomic conditions and town characteristics. The estimates of the interaction terms capture the difference in impact of these macroeconomic variables between a town being college or retirement or industrial town relative to

Other town. In order to analyze that I test for the null hypothesis that β_2 is equal to zero. A rejection of the null hypothesis implies that the volatility of the house price growth rate driven by macroeconomic conditions differ across different types of towns.

Model 3 includes time fixed effects which helps to capture national trends. Therefore Model 3 is developed separately for local and national macroeconomic variables. This model is similar to the one with local macroeconomic variables but includes the national macroeconomic variables and excludes the time dummy variables. Additionally I also run a model using the method of Ordinary Least Square estimates (OLS) to understand the correlation between towns and volatility and macroeconomic conditions and volatility. Also a second model is estimated using the method of fixed effects (FE) estimation to capture the impact of the macroeconomic variables on predicted volatility. This model controls for CBSA and time fixed effects. These models are developed separately for both local and national macroeconomic variables.

House price growth rate volatility is expected to differ for college towns, retirement towns and industrial towns. College towns experience a constant influx of students every year and therefore have a consistent demand for housing. I expect this demand to not fluctuate a lot during varying economic conditions. Thus growth rate of house prices in these towns will presumably be more stable. Similarly, in case of retirement towns, given the consistency in demand, they will experience much less variation in house price growth rates. However, the outcome will be very different in the case of industrial towns. These towns are inhabited by industrial workers who are more vulnerable to economic conditions I expect that to be reflected in the volatility of house price growth rates in these areas. Thus local factors have a differential impact on house price volatility.

Additionally I specify a model that captures the impact of housing supply constraints on volatility. Using the distribution of price elasticity of housing supply, I create dummy variables using as cut-offs the three quartiles of the elasticity variable. So three towns are defined. The first town has elasticity less than equal to the first quartile, the second town has elasticity less than equal to the median and higher than the first quartile and the third town has elasticity less than equal to the third quartile and higher than the median. These towns are compared to the towns that have price elasticity higher than the third quartile. Similar to the previous models, Model 4 will capture the impact of areas with less supply elasticity on predicted volatility.

$$\widehat{h_{it}} = \beta_0 + \beta_1 * abs(\Delta Macro_{it}) + \beta_2 * abs(\Delta Macro_{it}) * Q_i + \sum\sum \gamma_t * v_t * Q_i + u_i + v_t + \eta_{it} \qquad (4)$$

where Q_i is the dummy variable equal to 1 in case of CBSAs that have price elasticity less than the value of the three quartiles of the variable elasticity. The rest of the variables have the same meaning as those in Model 3. Local and national macroeconomic variables are studied separately as in the pervious model. Also the correlation between the towns defined by their supply elasticity and macroeconomic variables to predicted volatility is studied using OLS method of estimation. The FE model capturing the impact of macroeconomic variables on predicted volatility is not done separately since the one developed of local and national macroeconomic variables previously already studies that.

Housing markets that are more inelastic are likely to experience higher volatility in their growth rates. Due to supply inelasticity, an improvement in economic conditions can lead to an increase in house prices hence higher growth relative to other regions that do not have such prominent restrictions. In a period of a downturn and lower demand, the inelasticity of housing supply will not lead to a significant fall in prices compared to other regions. Since there is supply constraints this will lead to fluctuations in real HPI growth rate.

Section 5: Results

Table 5 gives the results of the GARCH model. It is specified as a GARCH(2,2) model. I have tested the model at higher orders of p and q, however at the higher orders some of the lags of the ARCH term or the GARCH term were not significant. They were significant at lag 2 therefore the lag length for both these terms is 2. Figure 5 gives the response in the conditional variance to an innovation in the standardized error term. The figure shows that it is symmetric.

The mean of predicted volatility is 18.75 and the minimum and maximum is 1.32 and 2184.25, respectively. 99% percent of the observations are equal to or less than 153.35. Figure 4 gives the distribution of the mean of predicted volatility. In order to exclude outliers in predicted volatility observations, the main model will not consider observations with predicted volatility exceeding

155. The mean of the predicted volatility after excluding observations with volatility higher than 155 is 16.82.

Figure 6 plots the mean predicted volatility, the real GDP growth rate and the real house price growth rate respectively over the years. The figure shows a significant decline in the predicted volatility growth rate since 1995 and then a spike after 2005. The real GDP and HPI growth rate mimic each other with the GDP curve appearing to be a smoothened version of the HPI curve. The correlation between the real GDP growth rate and the real HPI growth rate is 33%. The correlation between volatility and these two variables is -0.04%. Thus there is a negative linear association between predicted volatility and the other two variables though the association is very weak.

Table 6 gives the summary statistics of predicted volatility by the different types of towns. The table shows that the mean predicted volatility is the lowest in the college towns compared to all other towns. The results for industrial towns and retirement towns are unexpected. Industrial towns show lower volatility compared to non-industrial towns. These towns are expected to be more sensitive to changes in economic conditions and hence change their demand for housing accordingly and thus have higher volatility. Retirement towns have the highest mean predicted volatility. Given the stable financial conditions of the homebuyers in retirement towns, I was expecting these towns to have a more stable housing market than the others. It will be interesting to see how these towns compare against each other and other towns over the years. Figure 7 helps to compare these variables across different types of towns. Towns that are non-college, nonretirement and non-industrial towns are denoted as “Others”. This figure shows that all the towns experienced a spike in predicted volatility after the Great Recession with the highest being in retirement towns. College towns and “Others” have a very similar trend for real HPI growth rate and the former also has the most stable housing market. Retirement towns experience the most amounts of fluctuations in predicted volatility. Though the towns have very similar house price index growth rates before the Great Recession, retirement towns and industrial towns experience considerable fluctuations in real house price index growth rate after that. The higher house price index growth rate in retirement towns can be due to the fact that homebuyers in these towns have much higher income than buyers in other towns.

Apart from the towns defined in the paper it is also interesting to analyze the predicted volatility of real house price growth rate between states in the northeast and the west coast versus the rest. The coasts are expected to have a different housing market characterized by high house prices and stricter land use regulations compared to the inland states. Figure 8 compares these two types of states[1]. Real HPI and predicted volatility in each CBSA are both weighted by the proportion of population in these CBSAs relative to the total population present in all the CBSAs. The figure shows that the coastal states experienced a much higher volatility, especially after the Great Recession, compared to inland states. Before 2005, the coastal states show an upward trend in growth rate compared to inland states which experienced more fluctuations in growth rates. However the fall in

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[1] Coastal states considered are Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, California, Oregon and Washington. Inland consists of the rest.

the real house price index in much more severe in the coastal areas after the Great Recession compared to inland states. These drive higher predicted volatility of the growth rate in these states.

The main model in the paper, Model 3, will identify the impact of macroeconomic variables and town characteristics on predicted volatility. Absolute values of the growth rate of these macro variables are taken as the independent variables in the model. A test was done to examine that the estimated coefficients of the independent variables are equal in magnitude and opposite in sign. The variables are population, real per capita income and unemployment rate. This test was done to verify if the absolute value of the growth rate of the macroeconomic variables can be used as independent variables. The results show that we fail to reject the null hypothesis that the estimated coefficients of the positive and negative growth rates of the macroeconomic variables are equal in magnitude and opposite in sign at 10% level of significance. Thus the results imply that absolute values of the growth rate can be used. This will help to capture the impact of the macroeconomic variables due to a change in their magnitude.

Given these observations let us consider the results of Model 3. Semi-standardized and standardized coefficients are used to analyze the economic significance of the variables. This is done since the dependent variable does not have a meaningful unit of measurement. The standard deviation of the dependent variable is 16.17. The results of the OLS model, fixed effects model and Model 3 for local macroeconomic variables are given in Table 7. The results of the OLS model, show that both college towns and industrial towns have predicted volatility lower than Others. Retirement towns have a higher predicted volatility than Others. The semi-standardized coefficients of College Towns and Retirement Town dummy variables show that the variables are economically significant. The results of industrial and retirement towns are not as per expectations. On average, if the town is a college town then predicted volatility is 0.28 standard deviation lower than Others. Similarly, if the town is an industrial town then predicted volatility is 0.20 standard deviation lower than Others. Whereas in case of retirement towns it is lower by 0.54 standard deviation compared to Other towns. The results of the OLS model also show that a change in the absolute value of the growth rate of the local macroeconomic variables is statistically significant.

The fixed effects model used to identify the impact of local macroeconomic variables on predicted volatility takes into consideration town level characteristics. It shows that none of the variables are statistically significant at 1% and 5% level of significance.

Model 3 is the fixed effects model which includes the interaction terms between the town dummy variables and local macroeconomic variables. The results exhibit that none of the interaction terms are statistically significant or economically significant. This shows that the local macroeconomic variables do not influence the volatility in these towns any differently than Others.

After considering the impact of local macroeconomic variables, it is essential to look at the national level macroeconomic variables and their impact on predicted volatility. The results of the test that the coefficients of the positive and negative growth rates of the national macroeconomic variables are equal in magnitude and opposite in sign show that except for the retirement towns the hypothesis is rejected for the other two towns at a 1% significance level. However if we consider these macroeconomic variables by considering them one by one it is observed that for most of these macroeconomic variables the null hypothesis cannot be rejected. Therefore the absolute values of the growth rates of the macroeconomic variables are considered to be independent variables.

Table 8, gives the results of the OLS model, fixed effects model and Model 3 for national macroeconomic variables. The OLS model captures the difference in volatility across towns and the impact of the national level macroeconomic variables on volatility. Similar to the previous OLS model, the volatility in college and industrial towns are lower than Others. Retirement town has higher volatility compared to Others. All the national level macroeconomic variables are statistically significant. A one standard deviation change in GDP growth rate leads to –0.05 standard deviation change in the predicted volatility of the real house price index growth rate on average. On average, a one standard deviation change in CCI leads to –0.05 standard deviation change in the predicted volatility of the real house price index growth rate. A one standard deviation change in the mortgage rate leads to –0.03 of standard deviation change in the predicted volatility of the real house price index growth rate. A one standard deviation increase in the absolute growth rate of national HPI leads to –0.05 of standard deviation change in the predicted volatility of the real house price index growth rate on average. The effect of real GDP, mortgage rate and national HPI are unexpected.

The results of the main model show that a one-percentage point change in GDP growth rate leads to 0.06 standard deviation higher predicted volatility in college towns compared to Others on average. A one-percentage point change in mortgage rate leads to 0.13 standard deviation higher predicted volatility in college towns compared to Others on average. A one-percentage point change in national HPI leads to -0.02 standard deviation higher predicted volatility in college towns compared to Others on average. An improvement in national HPI will imply a booming housing market. This may encourage individuals to invest. In college towns an improving HPI alone will not encourage homebuyers to invest in housing. It is mainly driven by the demand for housing made by college students. Thus any change in student population is more likely to drive demand than improvement in the housing market. The decision to move to a college town is not driven by national housing market conditions. Hence changes in this variable will not lead to higher variation in real house price growth rate in these towns. The effects of GDP and mortgage rate are unexpected. It seems to suggest that volatility is driven by business cycles and not housing cycles.

A one-percentage point change in GDP growth rate leads to -0.21 standard deviation higher predicted volatility in retirement towns compared to Others on average. A one-percentage point change in CCI leads to 0.31 standard deviation higher predicted volatility in college towns compared to Others on average. A one-percentage point change in mortgage rate leads to -0.56 standard deviation higher predicted volatility in college towns compared to Others on average. . A one-percentage point change in national HPI leads to 0.06 standard deviation higher predicted volatility in college towns compared to Others on average. However this result is expected since individuals buying houses in retirement towns are expected to not be influenced by business cycles or perceptions of business cycles. The results show that individuals who drive demand for housing in the retirement towns are driven more by the housing cycle than the business cycle. A booming housing market implies that individuals targeting a retirement home are encouraged to invest in housing. Moreover they are more likely to get an appropriate price for their current home. Thus changes in house prices will impact their purchase behavior.

A one-percentage point change in GDP growth rate leads to 0.08 standard deviation higher predicted volatility in industrial towns compared to Others on average. A one-percentage point change in national HPI growth rate leads to -0.04 squared percentage points higher predicted volatility, on average, in industrial towns compared to Others. This effect is expected since changes in macroeconomic conditions will more likely affect the housing market in these towns. Therefore this implies that individuals driving the demand for housing in these towns are more influenced by business cycles than housing cycles. This can be due to the fact that business cycles affect factors such as employment and earnings which influence the potential to buy houses. Thus a booming housing market is not a substantial reason to influence the housing purchase decisions.

Till now we have looked at the results of the impact of macroeconomic factors on house price growth rate volatility across towns defined by demographic factors. It will be interesting to also analyze the impact of macroeconomic factors across towns defined by the price elasticity of housing supply due to supply constraints. These towns are defined by their geographical or regulatory characteristics. Figure 8 shows how the housing market price volatility varies across locations. Figure 9 shows the predicted volatility of house price growth rate at different levels of price elasticity defined by the cut-offs of the three quartiles of its distribution. The figure shows that the predicted volatility of house prices is significantly higher in areas with high supply constraints compared to those with lower supply constraints. Thus as the price elasticity increases the housing market becomes less volatile. .

The summary statistics of the price elasticity are given below in Table 9 (a). Table 9 (b) gives the summary statistics of predicted volatility split by the three quartiles of its distribution. This shows that towns which have more supply constraints (i.e., those with low price elasticity) have a higher predicted volatility than those which have a highly elastic housing supply. To understand this further, the OLS model, which includes dummy variables created based on the values of the quartiles and local macroeconomic variables, is used. The results of the OLS model and Model 4 are in Table 10. The mean of the predicted volatility of the house price growth rate is 16.82. The results show that towns with the lowest supply elasticity of housing have the highest predicted volatility than those with higher supply elasticity. A town with low supply elasticity has 0.53 of standard deviation increase in predicted volatility in real house price growth rate compared to a higher price elasticity town on average. The OLS model shows that a change in the magnitude of the unemployment rate and real per capita personal income growth rate in a town lead to higher predicted volatility in that town. A one standard deviation change in per capita personal income growth rate leads to 0.23 standard deviation higher predicted volatility in the lowest elasticity towns compared to towns with the highest elasticity on average. A one standard deviation change in population growth rate leads to -0.15 standard deviation higher predicted volatility in the lowest elasticity towns compared to towns with the highest elasticity on average. On average, a one standard deviation change in unemployment rate leads to -0.18 standard deviation higher predicted volatility in the towns which have supply elasticity less than the median value compared to towns with the highest elasticity. The results of Model 4 show that local macroeconomic variables have a differential impact in towns that have low supply elasticity.

Similar to the town dummy variable model, I also examine the role of national level macroeconomic factors on predicted volatility. The result of the OLS model and the main model for macroeconomic variables are in Table 11. The results of OLS model show that towns with lowest housing supply elasticity have higher variation in real HPI growth rate compared to towns with the highest supply elasticity. It is also observed that variation is not influenced by business cycles. A one standard deviation change in the real GDP growth rate leads to a higher volatility of house price growth rate of -0.05 standard deviation points on average. Change in the GDP growth rate was expected to lead to higher variation. A one standard deviation change in the CCI growth rate leads to a higher volatility of house price growth rate of 0.04 standard deviation points on average. It was expected to lead to higher volatility in supply constraint areas. A one standard deviation change in the mortgage rate leads to a higher volatility of house price growth rate of -0.03 standard deviation points on average. Surprisingly changes in the magnitude of the mortgage rate also do not lead to higher variation. A one standard deviation change in the national HPI leads to a higher volatility of house price growth rate of -0.03 standard deviation points on average.

The results for Model 4 show that difference in variation in real house price growth rate in the towns with the lowest elasticity is affected more by housing cycles than business cycles. A one-percentage point change in the real GDP growth rate leads to a higher volatility of house price growth rate of -0.31 standard deviation on average in towns with the lowest price elasticity compared to the towns with the highest elasticity. A one-percentage point change in the real CCI growth rate leads to a lower volatility of house price growth rate of 0.42 standard deviation on average in towns with low price elasticity. A one-percentage point change in the real national HPI growth rate leads to a higher volatility of house price growth rate of 0.08 standard deviation on average in towns with low price elasticity. Finally one-percentage point change in the real mortgage rate leads to a higher volatility of house price growth rate of -0.44 standard deviation on average in towns with low price elasticity. This result is unexpected since GDP and mortgage rate changes were expected to lead to higher volatility in these towns. A one-percentage point change in the real GDP growth rate leads to a higher volatility of house price growth rate of -0.16 standard deviation on average in towns with the price elasticity less than the median but higher than the first quartile value, compared to the towns with the highest elasticity. A one-percentage point change in the real CCI growth rate leads to a lower volatility of house price growth rate of 0.24 standard deviation on average in towns with the price elasticity less than the median but higher than the first quartile value, compared to the towns with the highest elasticity. A one-percentage point change in the real mortgage rate leads to a lower volatility of house price growth rate of 0.52 standard deviation on average in towns with the price elasticity less than the median but higher than the first quartile value, compared to the towns with the highest elasticity. Business cycles have a differential impact in these towns however they do not lead to higher variation.

Section 6: Conclusions

This paper examined the influence of town characteristics and macroeconomic variables on the volatility of the real house price growth rate. In order to capture town characteristics, towns were classified as college, retirement, and industrial towns and also based on the elasticity of housing supply. The macroeconomic variables were also studied at two levels – CBSA and national. College and retirement towns were expected to experience fewer fluctuations in the real house price growth rate driven by changes in macroeconomic variables while industrial towns were expected to experience the opposite.

A GARCH(2,2) model was used to estimate the time varying CBSA-level volatility. The data showed that college towns have the least predicted volatility compared to all other towns. Retirement towns which have the highest predicted volatility also witnessed the highest spike in it after the Great Recession. This is also substantiated in the results of the OLS models which show that both college and industrial towns have lower volatility compared to Others and retirement towns have the highest volatility. This result is unexpected in case of industrial and retirement towns. One possible reason for the higher variation observed in retirement towns is because the individuals who purchase houses are extremely sensitive to changes in the housing market. Thus a booming housing market may lead to financial difficulties in purchasing a house. Thus they are sensitive to the housing cycle. This is also observed in the result wherein it is observed that these individuals are not sensitive to business cycle but sensitive to housing cycle. Also people who are purchase a house in the retirement towns usually move from other towns to these towns. Therefore local macroeconomic variables do not drive their decision. However they are impacted by national economic conditions. In case of industrial towns individuals purchasing a house are driven more by the current macroeconomic conditions than by changes in housing market. They are part of the labor force and also their decision to purchase a house is rarely driven by investment reasons.

The difference in the impact of local macroeconomic variables for the three different towns on variation in house price growth rate is found to be not statistically significant. This shows that local macroeconomic conditions do not affect variation. National level macroeconomic variables are found to be statistically significant in influencing a difference in variation in these towns compared to Others.

While looking into the difference in real HPI variation in towns in relation to their supply elasticity, it is observed that towns with higher supply constraints have relatively higher variation. The results show that national-level macroeconomic variables play a more important role in house price variation across these towns. However some of the macroeconomic variables do have a differential impact on the variation in real HPI observed in these towns. One interesting thing to note in the results is that the importance of the macroeconomic variables be it local or national fades away housing supply elasticity increases. Therefore individuals intending to invest in the housing market in these areas and policy makers trying to restrain the volatility in the housing market should form their decisions based on changes in these factors.

The paper highlights how macroeconomic factors interact with local factors to influence predicted volatility in real house price growth rate. It also shows how the effect or importance of macroeconomic factors is not the same for all towns. It contradicts some of the expected outcomes. Since the towns are defined based on school enrollment, age, type of job, it will be interesting to examine the relationship between the macroeconomic variables and these variables in these towns. Also this paper does not explore the interdependence between these towns. It will be interesting to know how the variation in the real

HPI in one town can influence that o another town. These topics can be explored further.

Table 1: Variable Definitions

Variables	Definition
HPI	Real House Price Index
HPI Growth rate	Growth rate of real house price index
GDP	Real gross domestic product (in Billions of Dollars – at national level)
Per Capita Personal income	Real per capita personal income (in Dollars)
Population	Population (in thousands)
Unemployment Rate	Unemployment rate
30 FRM	30 year fixed rate mortgage (at national level)
CCI	Consumer confidence index (at national level)
GDP Growth rate	Growth rate of real gross domestic product
Per Capita Personal income Growth rate	Growth rate of real per capita personal income
Population Growth rate	Growth rate of population
Unemployment Rate Growth rate	Change in unemployment rate
30 FRM Growth rate	Change in 30 year fixed rate mortgage
CCI Growth rate	Growth rate in consumer confidence index
College Town	1 if CBSA is a college town, 0 otherwise
Retirement Town	1 if CBSA is a retirement town, 0 otherwise
Industrial Town	1 if CBSA is a industrial town, 0 otherwise
Elasticity	Housing supply price elasticity
Elasticity 1st Quartile	1 if CBSA has elasticity <=1.56 (Quartile 1)
Elasticity 2nd Quartile	1 if CBSA has 1.56 < elasticity <=2.25 (Quartile 2)
Elasticity 3rd Quartile	1 if CBSA has 2.25 < elasticity <=3.47 (Quartile 3)

Table 2 (a): Summary Statistics

Variables	Mean	Standard Deviation	Minimum	Maximum
Real House Price Index (HPI)	79.21	18.47	23.42	229.54
Growth rate of real house price index	-0.06	5.44	-65.21	64.27
National Level HPI	85.67	11.39	72.91	110.03
Real gross domestic product (in Trillions of Dollars)	24.43	3.72	18.14	30.44
Real per capita personal income (in Thousands of Dollars)	14.68	3.59	2.13	69.39
Population (in Thousands)	158	394	4	8,653
Unemployment rate	6.36	2.77	0.09	31.20
30 year fixed rate mortgage	6.46	1.68	3.66	10.13
Consumer confidence index	100.01	0.80	97.87	101.36
College Town	0.07	0.26	0	1
Retirement Town	0.05	0.22	0	1
Industrial Town	0.08	0.27	0	1

Table 2 (b): Summary Statistic (Growth Rate)

Variables (Growth Rate/Change)	Mean	Standard Deviation	Minimum	Maximum
Real gross domestic product	2.38	1.06	0.26	4.01
Real per capita personal income	2.07	2.41	0.00	75.48
Population	0.96	1.28	0.00	76.34
Unemployment rate	0.62	0.65	0.00	49.08
30 year fixed rate mortgage	0.50	0.33	0.02	1.09
Consumer confidence index	0.60	0.58	0.05	2.39

Table 3(a): Summary Statistics (College Towns)

Variables	Mean	Standard Deviation	Minimum	Maximum
Real House price Index (HPI)	82.74	19.01	44.24	174.85
Real House price Index Growth Rate	0.23	4.40	-40.94	43.36
National Level HPI	85.66	11.40	72.91	110.03
Real GDP (in Trillions of Dollars)	24.41	3.73	18.14	30.44
Real Per Capita Personal Income (in Thousands)	13.52	2.96	3.62	25.41
Population (in Thousands)	91	85	4	558
Unemployment Rate	4.79	1.95	0.70	12.90
30 Year Fixed Rate Mortgage	6.47	1.69	3.66	10.13
Consumer confidence Index	100.01	0.80	97.87	101.36

Table 3(b): Summary Statistics (Retirement Towns)

Variables	Mean	Standard Deviation	Minimum	Maximum
Real House price Index (HPI)	81.50	20.16	44.19	177.57
Real House price Index Growth Rate	0.07	7.51	-41.36	45.73
National Level HPI	85.60	11.40	72.91	110.03
Real GDP (in Trillions of Dollars)	24.39	3.73	18.14	30.44
Real Per Capita Personal Income (in Thousands)	15.77	3.93	8.58	34.09
Population (in Thousands)	167	251	15	1696
Unemployment Rate	6.99	3.09	1.60	26.10
30 Year Fixed Rate Mortgage	6.48	1.69	3.66	10.13
Consumer confidence Index	100.01	0.80	97.87	101.36

Table 3(c): Summary Statistics (Industrial Towns)

Variables	Mean	Standard Deviation	Minimum	Maximum
Real House price Index (HPI)	74.43	11.09	33.89	132.14
Real House price Index Growth Rate	-0.74	4.28	-32.91	25.48
National Level HPI	85.63	11.40	72.91	110.03
Real GDP (in Trillions of Dollars)	24.43	3.71	18.14	30.44
Real Per Capita Personal Income (in Thousands)	13.45	1.80	8.69	24.34
Population (in Thousands)	56	38	13	265
Unemployment Rate	7.12	2.91	1.80	23.00
30 Year Fixed Rate Mortgage	6.46	1.67	3.66	10.13
Consumer confidence Index	100.02	0.80	97.87	101.36

Table 4: Distribution of MSAs

Year	Number of CBSA	Year	Number of CBSA
1990	790	2003	912
1991	828	2004	912
1992	869	2005	912
1993	887	2006	912
1994	888	2007	914
1995	893	2008	914
1996	896	2009	914
1997	899	2010	914
1998	908	2011	914
1999	908	2012	914
2000	908	2013	914
2001	911	2014	913
2002	912	2015	912

Table 5: Results of the GARCH Model

ARCH family regression

VARIABLES	Predicted Volatility	Predicted Volatility
First lag growth in HPI	0.32***	
	(0.02)	
Second lag growth in HPI	0.11***	
	(0.01)	
Arch term order 1		0.49***
		(0.04)
Arch term order 2		-0.45***
		(0.02)
Garch term order 1		1.27***
		(0.12)
Garch term order 2		-0.31***
		(0.09)
Constant	-1.45***	-0.05
	(0.19)	(0.06)
Observations	21,290	21,290

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Predicted Volatility Across Towns

	Mean	Std. Dev.	. Min	Max
College Town	11.92	10.26	1.84	114.57
Non- College Town	19.30	38.96	1.32	2184.25
Retirement Town	28.86	43.15	2.43	762.77
Non- Retirement Town	18.20	37.25	1.32	2184.25
Industrial Town	15.02	25.18	1.74	401.26
Non-Industrial Town	19.09	38.55	1.32	2184.25

Table 7: Results of models with local macroeconomic variables

VARIABLES (Absolute change in the variable)	OLS Model - local	FE model - local	Model 3 - local
Per Capita Personal Income	0.50*** [0.08]	0.09 [0.01]	0.06 [0.00]
	(0.08)	(0.08)	(0.09)
Population	1.58*** [0.13]	-0.56* [-0.04]	-0.62** [-0.04]
	(0.25)	(0.29)	(0.31)
Unemployment Rate	-1.12* [-0.02]	-0.43 [-0.01]	-0.41 [-0.03]
	(0.58)	(0.33)	(0.33)
Per Capita Personal Income College Town			0.14 [0.01]
			(0.19)
Population College Town			0.60 [0.04]
			(0.53)
Unemployment Rate College Town			-1.43 [-0.08]
			(2.01)
Per Capita Personal Income Retirement Town			0.69 [0.04]
			(0.54)
Population Retirement Town			1.34 [0.08]
			(1.76)
Unemployment Rate Retirement Town			-9.76 [-0.60]
			(6.21)
Per Capita Personal Income Industrial Town			-0.04 [-0.00]
			(0.19)
Population Industrial Town			0.17 [0.01]
			(1.44)
Unemployment Rate Industrial Town			1.07 [0.07]
			(2.12)
College Town	-4.60*** [-0.28]		
	(0.30)		
Retirement Town	8.74*** [0.54]		
	(0.81)		
Industrial Town	-3.17*** [-0.20]		
	(0.39)		
Constant	17.66***	17.07***	17.53***
	(0.85)	(0.68)	(0.77)
Observations	21,188	21,188	21,188
R-squared	0.05	0.03	0.07

Number of cbsa		909	909
Year FE	YES	YES	YES
CBSA FE		YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Also included in the model are time dummy variables and interaction terms between time and town dummy variables. One period lag of the growth rate of the local macroeconomic variables are considered. The semi-standardized and standardized coefficients are given in the brackets next to the estimated coefficients.

Table 8: Results of models with national macroeconomic variables

VARIABLES (Absolute change in the variable)	OLS Model - national	FE model - national	Model 3 - national
GDP	-0.82*** [-0.05] (0.14)	-0.83*** [-0.05] (0.15)	-0.83*** [-0.05] (0.17)
CCI	1.46*** [0.05] (0.28)	1.54*** [0.06] (0.21)	1.40*** [0.05] (0.23)
Mortgage Rate	-1.50*** [-0.03] (0.43)	-1.24*** [-0.03] (0.42)	-1.05** [-0.02] (0.46)
National HPI	-0.22*** [-0.04] (0.06)	-0.27*** [-0.05] (0.05)	-0.23*** [-0.04] (0.05)
GDP College Town			0.92*** [0.06] (0.32)
CCI College Town			-0.53[-0.03] (0.60)
Mortgage Rate College Town			2.16**[0.13] (0.94)
National HPI College Town			-0.38**[-0.02] (0.15)
GDP Retirement Town			-3.52*** [-0.21] (0.87)
CCI Retirement Town			5.12*** [0.31] (1.56)
Mortgage Rate Retirement Town			-9.12*** [-0.56] (2.37)
National HPI Retirement Town			0.96***[0.06] (0.27)
GDP Industrial Town			1.25*** [0.08] (0.31)
CCI Industrial Town			-0.83 [-0.05] (0.69)
Mortgage Rate _Industrial Town			1.84 [0.11] (1.52)
National HPI Industrial Town			-0.63*** [-0.04] (0.19)
College Town	-4.59*** [-0.28] (0.30)		
Retirement Town	8.72*** [0.54]		

	(0.82)		
Industrial Town	-3.16*** [-0.20]		
	(0.39)		
Constant	16.65***	19.03***	18.93***
	(0.63)	(0.55)	(0.54)
Observations	21,188	21,188	21,188
R-squared	0.03	0.01	0.03
Number of cbsa		909	909
CBSA FE		YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Also included in the models are local macroeconomic variables. The semi-standardized and standardized coefficients are given in the brackets next to the estimated coefficients

Table 9 (a): Summary Statistics of Price Elasticity

Variable	Obs.	Mean	Std. Dev.	Min	Max
Volatility	6,292	2.90	1.80	0.75	11.37

Table 9 (b): Summary Statistics of Volatility by Price Elasticity

	Mean	Std. Dev.	Min	Max
Elasticity 1st Quartile	28.69	40.31	2.09	377.71
Elasticity 2nd Quartile	20.9	42.13	1.55	554.48
Elasticity 3rd Quartile	11.29	24.89	1.36	702.48
Elasticity Above 3rd Quartile	7.85	5.89	1.32	67.09

Table 10: Results of the models with price elasticity of housing supply and local macro variables

VARIABLES (Absolute change in the variable)	OLS Model- local	Model 4 - local
Per Capita Personal Income	0.36*** [0.05]	0.115 [0.02]
	(0.08)	(0.081)
Population	0.59** [0.05]	-0.520*** [-0.04]
	(0.23)	(0.191)
Unemployment Rate	0.67*** [0.05]	-0.345** [-0.03]
	(0.16)	(0.174)
Per Capita Personal Income 1st Quartile		1.527** [0.23]
		(0.655)
Population 1st Quartile		-1.924** [-0.15]
		(0.939)
Unemployment Rate 1st Quartile		0.817 [0.06]
		(1.295)
Per Capita Personal Income 2nd Quartile		-0.077 [-0.01]
		(0.566)
Population 2nd Quartile		-0.269 [-0.02]
		(1.180)
Unemployment Rate 2nd Quartile		-2.515*** [-0.18]
		(0.821)
Per Capita Personal Income 3rd Quartile		0.214 [0.03]
		(0.289)
Population 3rd Quartile		0.183 [0.01]
		(0.374)
Unemployment Rate 3rd Quartile		-1.568 [-0.11]
		(0.989)
Elasticity 1st Quartile	8.53*** [0.53]	
	(0.74)	
Elasticity 2nd Quartile	0.30 [0.04]	
	(0.60)	
Elasticity 3rd Quartile	-5.99*** [-0.89]	
	(0.33)	
Constant	11.79***	16.765***
	(0.95)	(0.499)
Observations	21,968	21,968
R-squared	0.04	0.089

Number of cbsa1	909
cbsa Year FE	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Also included in the model are time dummy variables and interaction terms between time and town dummy variables. One period lags of the growth rates of the local macroeconomic variables are considered. The semi-standardized and standardized coefficients are given in the brackets next to the estimated coefficient

Table 11: Results of the models with price elasticity of housing supply and national macro variables

VARIABLES (Absolute change in the variable)	OLS Model - National	Model 4
GDP	-0.754*** [-0.05]	-0.388** [-0.03]
	(0.137)	(0.159)
CCI	1.208*** [0.04]	0.936*** [0.03]
	(0.283)	(0.232)
Mortgage Rate	-1.594*** [-0.03]	-0.237 [-0.00]
	(0.433)	(0.431)
National HPI	-0.177*** [-0.03]	-0.368*** [-0.06]
	(0.058)	(0.051)
GDP 1st Quartile		-5.084*** [-0.31]
		(0.730)
Mortgage Rate 1st Quartile		-7.164*** [-0.44]
		(2.219)
CCI 1st Quartile		6.870*** [0.42]
		(1.302)
National HPI 1st Quartile		1.310*** [0.08]
		(0.259)
GDP 2nd Quartile		-2.625*** [-0.16]
		(0.756)
Mortgage Rate 2nd Quartile		-8.422*** [-0.52]
		(2.198)
CCI 2nd Quartile		3.837*** [0.24]
		(1.213)
National HPI 2nd Quartile		0.313 [0.02]
		(0.205)
GDP 3rd Quartile		0.160 [0.01]
		(0.374)
Mortgage Rate 3rd Quartile		0.063 [0.00]
		(1.273)
CCI 3rd Quartile		0.605 [0.04]
		(0.783)
National HPI 3rd Quartile		-0.081 [-0.01]
		(0.091)
Elasticity 1st Quartile	9.095*** [0.56]	
	(0.783)	
Elasticity 2nd Quartile	0.483 [0.03]	

	(0.634)	
Elasticity 3rd Quartile	-5.875*** [-0.36]	
	(0.338)	
Constant	15.467***	19.111***
	(0.645)	(0.591)
Observations	21,188	21,188
R-squared	0.035	0.035
Number of cbsa1		909
cbsa FE		YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Also included in the models are local macroeconomic variables. The semi-standardized and standardized coefficients are given in the brackets next to the estimated coefficients

Figure1: Frequency of Volatility in HPI

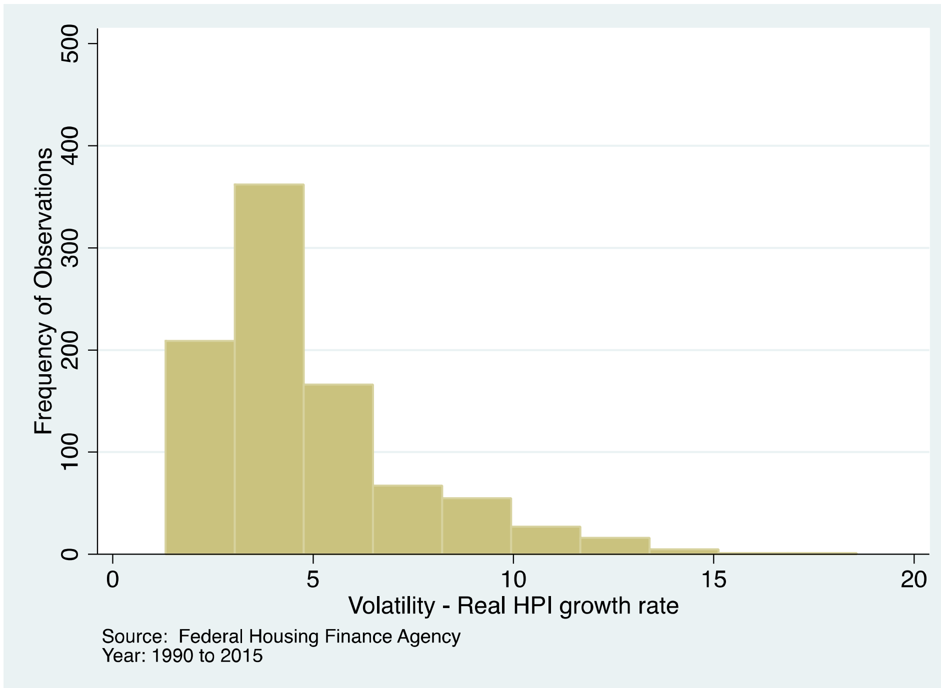


Figure 2: Volatility of HPI Growth Rate from 1990 to 2015 across Business Cycles

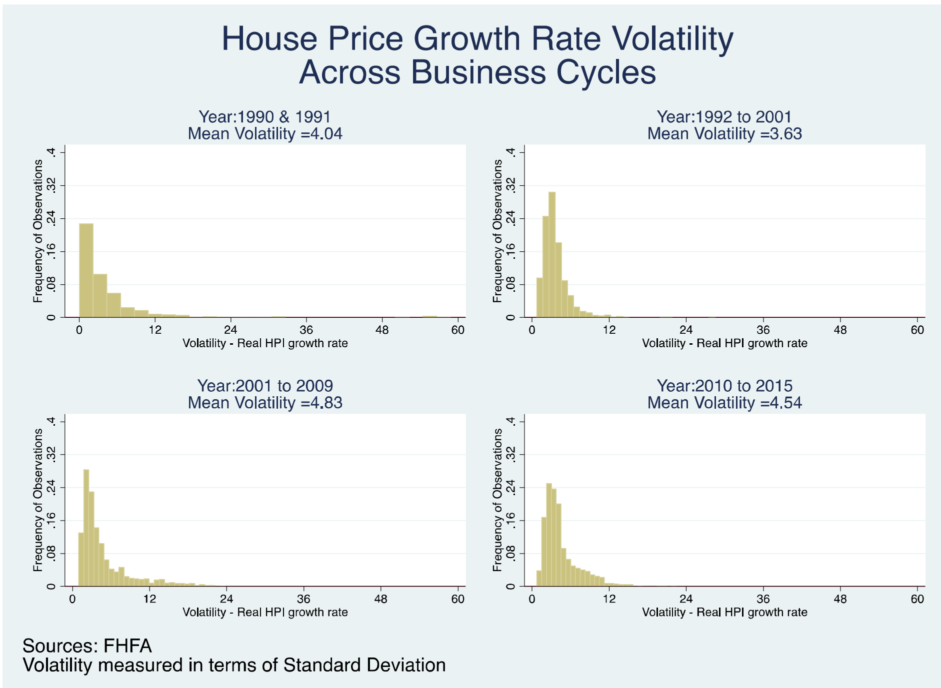


Figure 3: Difference in House Price Variation Across MSAs

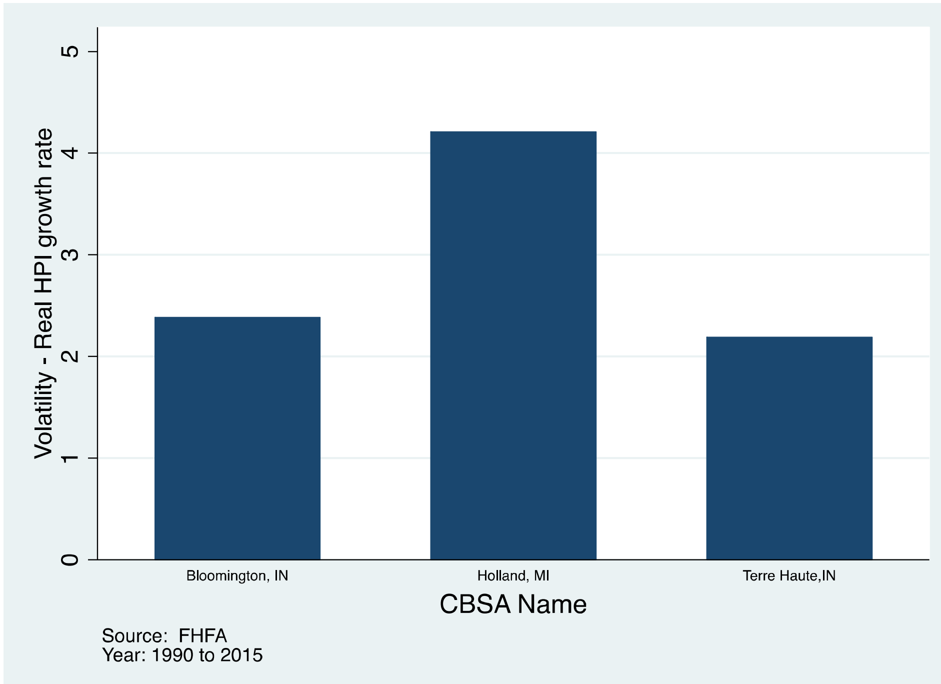


Figure 4 : Distribution of predicted volatility

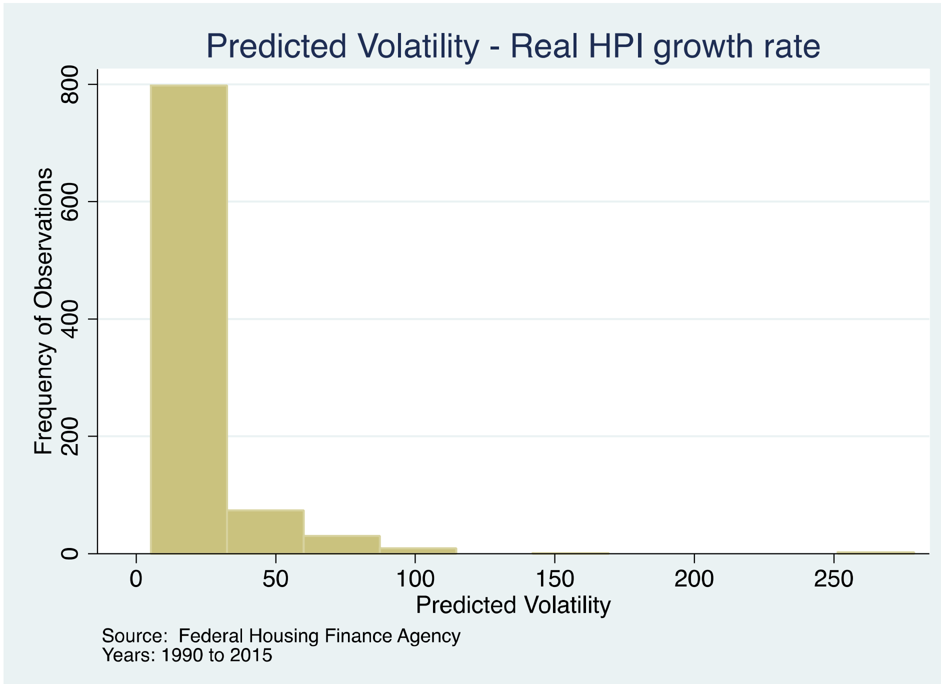


Figure 5: New Impact Curve – Response of Conditional Variance

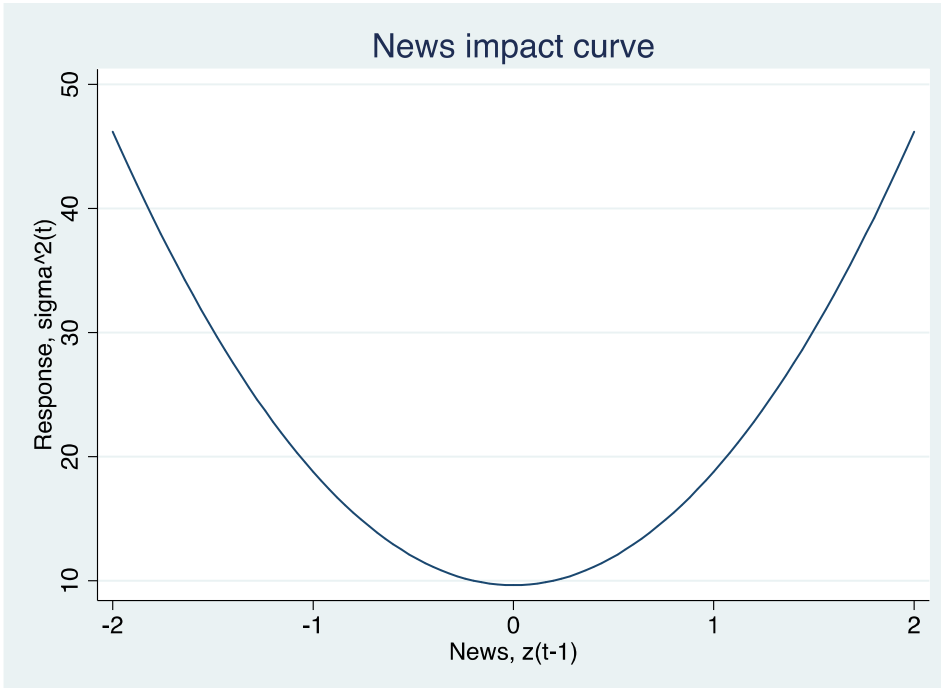


Figure 6: Predicted Volatility, Real HPI & GDP Growth Rate at MSA Level: 1990-2015

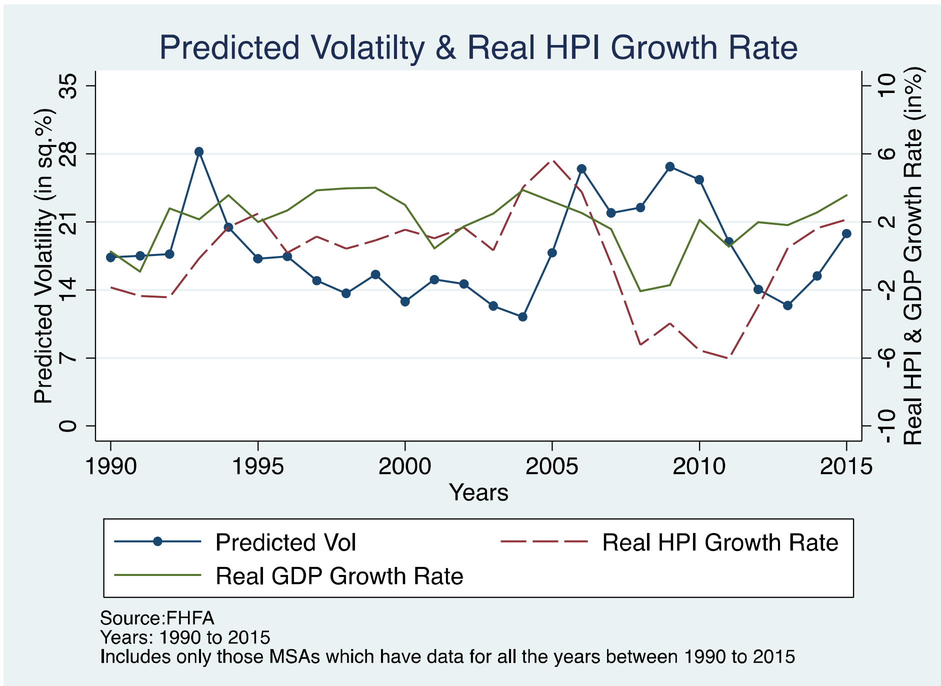


Figure 7: Predicted Volatility & Real HPI Across Towns

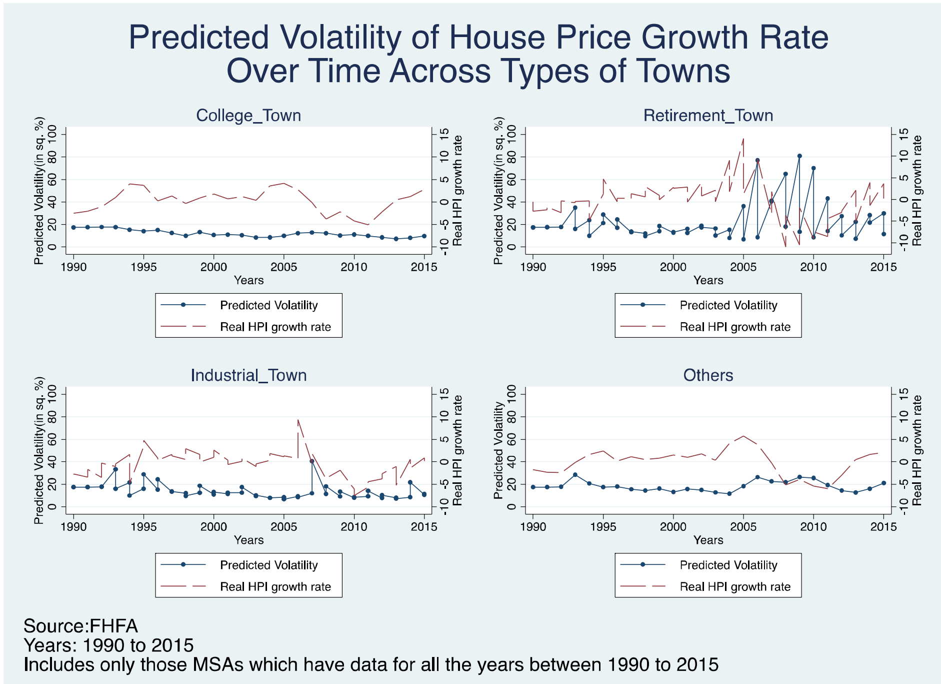


Figure 8: Predicted Volatility & Real HPI Growth Rate in Coastal vs. Inland States

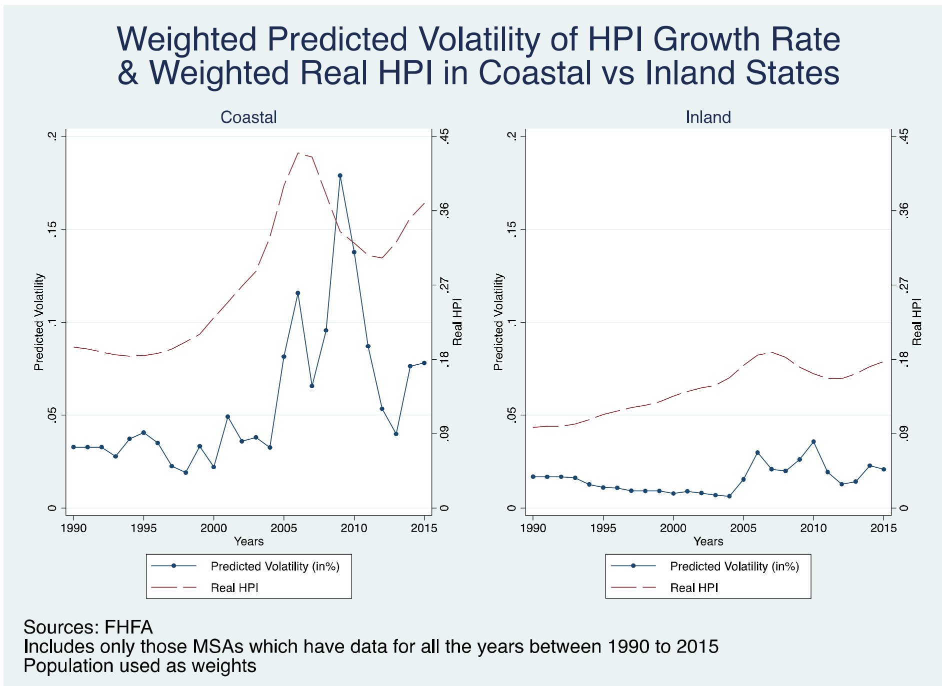
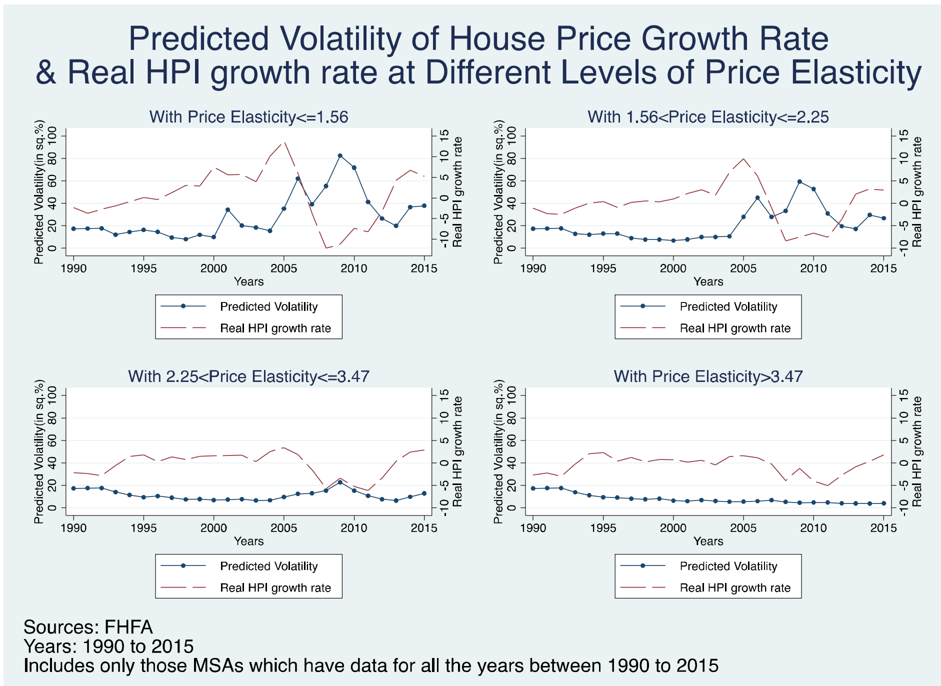


Figure 9: Predicted Volatility & Price Elasticity of Housing Supply



Appendix I

Table 1(a): List of College Towns

CBSA Code	CBSA Title
11180	Ames, IA
11460	Ann Arbor, MI
11660	Arkadelphia, AR
11900	Athens, OH
12020	Athens-Clarke County, GA
12220	Auburn-Opelika, AL
13660	Big Rapids, MI
13980	Blacksburg-Christiansburg-Radford, VA
14010	Bloomington, IL
14020	Bloomington, IN
14380	Boone, NC
14500	Boulder, CO
14580	Bozeman, MT
15100	Brookings, SD
16060	Carbondale-Marion, IL
16580	Champaign-Urbana, IL
16660	Charleston-Mattoon, IL
16820	Charlottesville, VA
17780	College Station-Bryan, TX
17860	Columbia, MO
18700	Corvallis, OR
19000	Cullowhee, NC
21260	Ellensburg, WA
22380	Flagstaff, AZ
22660	Fort Collins, CO
23540	Gainesville, FL
24220	Grand Forks, ND-MN
24780	Greenville, NC
26340	Houghton, MI
26660	Huntsville, TX
26980	Iowa City, IA
27060	Ithaca, NY
28260	Kearney, NE
28860	Kirksville, MO
29200	Lafayette-West Lafayette, IN
29620	Lansing-East Lansing, MI
29660	Laramie, WY
29940	Lawrence, KS
30860	Logan, UT-ID
31380	Macomb, IL

31540	Madison, WI
31740	Manhattan, KS
31860	Mankato-North Mankato, MN
32340	Maryville, MO
32860	Menomonie, WI
34060	Morgantown, WV
34140	Moscow, ID
34380	Mount Pleasant, MI
34620	Muncie, IN
34660	Murray, KY
34860	Nacogdoches, TX
37060	Oxford, MS
38780	Portales, NM
39340	Provo-Orem, UT
39420	Pullman, WA
39940	Rexburg, ID
40080	Richmond-Berea, KY
40820	Ruston, LA
44260	Starkville, MS
44300	State College, PA
44340	Statesboro, GA
44500	Stephenville, TX
44660	Stillwater, OK
45220	Tallahassee, FL
46820	Vermillion, SD
47660	Warrensburg, MO
49100	Winona, MN

Table 1(b): List of Retirement Towns

CBSA Code	CBSA Title
10660	Albert Lea, MN
11220	Amsterdam, NY
12380	Austin, MN
12700	Barnstable Town, MA
14700	Branson, MO
14820	Brevard, NC
15060	Brookings, OR
15900	Canton, IL
15980	Cape Coral-Fort Myers, FL
17340	Clearlake, CA
19660	Deltona-Daytona Beach-Ormond Beach, FL
19700	Deming, NM
20660	Easton, MD

23240	Fredericksburg, TX
24420	Grants Pass, OR
26140	Homosassa Springs, FL
26300	Hot Springs, AR
27020	Iron Mountain, MI-WI
27780	Johnstown, PA
28500	Kerrville, TX
29420	Lake Havasu City-Kingman, AZ
29460	Lakeland-Winter Haven, FL
33100	Miami-Fort Lauderdale-West Palm Beach, FL
34260	Mountain Home, AR
34940	Naples-Immokalee-Marco Island, FL
35260	New Castle, PA
35440	Newport, OR
35580	New Ulm, MN
35840	North Port-Sarasota-Bradenton, FL
36100	Ocala, FL
36140	Ocean City, NJ
36860	Ottawa-Peru, IL
37740	Payson, AZ
38240	Pinehurst-Southern Pines, NC
38820	Port Angeles, WA
38940	Port St. Lucie, FL
39060	Pottsville, PA
39140	Prescott, AZ
39460	Punta Gorda, FL
42540	Scranton--Wilkes-Barre--Hazleton, PA
42680	Sebastian-Vero Beach, FL
42700	Sebring, FL
44020	Spirit Lake, IA
45300	Tampa-St. Petersburg-Clearwater, FL
45540	The Villages, FL
46020	Truckee-Grass Valley, CA
49380	Worthington, MN

Table 1(c): List of Industrial Towns

CBSA Code	CBSA Title
10620	Albemarle, NC
11380	Andrews, TX
11420	Angola, IN
11940	Athens, TN
12140	Auburn, IN
12680	Bardstown, KY

13500	Bennettsville, SC
14420	Borger, TX
14820	Brevard, NC
15340	Bucyrus, OH
15500	Burlington, NC
15660	Calhoun, GA
15780	Camden, AR
15820	Campbellsville, KY
16340	Cedartown, GA
17420	Cleveland, TN
18220	Connersville, IN
18420	Corinth, MS
18460	Cornelia, GA
18740	Coshocton, OH
18820	Crawfordsville, IN
19140	Dalton, GA
19260	Danville, VA
19420	Dayton, TN
19540	Decatur, IN
19580	Defiance, OH
20540	Dyersburg, TN
21140	Elkhart-Goshen, IN
22580	Forest City, NC
23380	Fremont, OH
23500	Gaffney, SC
24620	Greeneville, TN
24940	Greenwood, SC
25860	Hickory-Lenoir-Morganton, NC
25880	Hillsdale, MI
26090	Holland, MI
26540	Huntington, IN
27540	Jasper, IN
28340	Kendallville, IN
29300	LaGrange, GA
29900	Laurinburg, NC
29980	Lawrenceburg, TN
30280	Lewisburg, TN
31300	Lumberton, NC
31820	Manitowoc, WI
32000	Marion, NC
32300	Martinsville, VA
33220	Midland, MI
34100	Morristown, TN
34340	Mount Airy, NC

35140	Newberry, SC
35940	Norwalk, OH
37220	Pahrump, NV
38500	Plymouth, IN
39060	Pottsville, PA
40460	Rockingham, NC
41820	Sanford, NC
42460	Scottsboro, AL
42860	Seneca, SC
43100	Sheboygan, WI
43140	Shelby, NC
43180	Shelbyville, TN
43380	Sidney, OH
43900	Spartanburg, SC
44780	Sturgis, MI
44900	Summerville, GA
45180	Talladega-Sylacauga, AL
45580	Thomaston, GA
45740	Toccoa, GA
46460	Union City, TN-KY
46500	Urbana, OH
46740	Valley, AL
46780	Van Wert, OH
47340	Wabash, IN
47700	Warsaw, IN

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