The Regional Sensitivity of Housing Markets to Macroeconomic Factors

Yiming Li

Econometrics, Department of Economics, University of Washington, 98195

Keywords: Housing price index (HPI), Macroeconomic factors

Abstract: During the Great Recession of 2008 triggered by the housing crisis, the Federal Reserve adopted quantitative easing to influence macroeconomic variables. The impacts of the policy on housing price indices in different U.S. States are quite distinct: some continued to plummet while others suffered only a mild drop. In view of this phenomenon, this paper studies whether there are spatial differences in the impact of macroeconomic factors on housing prices. The New England, Pacific and mountainous area in the United States are selected as representative regions. The macroeconomic variables of concern include real GDP, real disposable personal income, 1-year, 5-year, 10-year treasury rate, M2 Money Stock, unemployment rate and federal funds rate. Through the regionalized regression analysis, we can conclude that there is fairly convincing evidence suggesting the sensitivity of HPI to the macroeconomic variables does vary from place to place. Interest rates (especially the one-year treasury rate), output and price level are all quite significant for the three regions considered except for perhaps the Mountain states.

1. Introduction

It is widely recognized that property price is intimately related to macroeconomic factors. Hoyt, Coomes and Biehl (2011)[1] found that the property tax limits, when accompanied by increases in other own source revenues to state government, has a significant positive impact on the growth of housing units through empirical analysis. Jacobsen and Naug (2005)[2] used least squares regression to study the influencing factors of house price. They found that interest rate, housing construction, unemployment and household income are the important explanatory factors of house price rise, among which interest rate has the greatest impact. Otto (2007)[3] found that the variable mortgage rate has a significant impact on the growth rate of urban housing prices. Zhang, Gerlowski and Ford (2014)[4] studied the influence of both national and local forces on housing price in 20 local US real estate markets. Through reduced-form panel data fixed-effect models, their paper shows the relevance of national impacts on local markets (as embodied in national home price, for example), together with the relevance of local social-economic factors. In this paper, the focus is on the national side of the social-economic scale and several of macroeconomic factors come immediately into consideration. For instance, as shown in Ahearne, Doyle, and Martin (2005)[5], real GDP, consumption, and CPI inflation are highly correlated with real house prices. However, besides these concrete measures there are clearly other variables that real estate price depends upon, such as region's access to financial market, the general investment spirit and even the financial history. These are more Abstract factors that are hard to measure directly but doubtless influence a region's reaction to fiscal and monetary policies.

From December 2000 to December 2006, the U.S. housing price index rose from 100 to 163.88, a 63.88% increase in 6 years. From 2000 to 2006, global interest rates remained at a low level. During the same period, the subprime mortgage market in the United States developed rapidly, which led to a six-year boom in the real estate market in the United States. In 2007, the housing bubble began to break down and housing prices began to decline. In the third quarter of 2007, housing prices in the United States dropped by over 4.5 percent.

The responses of house price index to financial crisis in different regions of the United States are very different. From 2007 to 2011, house prices in New England declined slowly, while those in the Pacific and mountainous regions declined nearly plummeted. The decline in house prices has a significant impact on the consumption and economy of the United States. The U.S. government has

  DOI: 10.25236/ismeem.2019.062

adopted a series of policies, such as reducing interest rates, reducing taxes and expanding fiscal expenditure, to curb the decline in house prices. During the Great Recession of 2008, the U.S. government passed legislations that supposedly affected the macro economy in hope that these initiatives may stimulate the market and bring the economy back to health. As the fourteen federal reserve meetings took place over the period from January 2008 to June 2009, the central bank continued to employ quantitative easing to inject cash into the economy, lifting up the money supply. At the same time, quantitative easing lowered interest rate so that banks can lend with easier terms and have more liquidity.

When such measures were taken, what history witnessed was a huge difference in how different real estate markets react to them: some continued to plummet while others suffered only a mild drop. In fact, it turned out that the financial crisis brought far more devastation to some states than the others. Among those who suffered most from the housing bust are Florida, California and Oregon. The Mountain states also suffered a significant drop in real estate price but less severely than what states like California experienced. On the other hand, states in the Northeast fared better overall and in particular, the six New England states had the lowest increases in the so-called "insecurity level".

This observation motivates the main question to investigate in this paper, that is whether the effect of macroeconomic factors on housing price vary spatially or not. Furthermore, the paper will also try to address if there is a statistically significant difference in the housing markets' sensitivity to macroeconomic factors before and after the financial crisis of 2008. Similar studies have been conducted by numerous econometricians and statisticians. For example, in Ewing, Sari and Aydin (2007)[6], the relation between housing starts and macroeconomic variables in Turkey from 1961 to 2000 is investigated. The macroeconomic variables included are price level, interest rates, output, money stock, and employment. The authors employed generalized variance decomposition to tackle the question and the result favors the claim that shocks to interest rates, output and price level have noticeable effects on changes in the Turkish housing market. In this paper, the author focuses on the U.S. housing market through the housing price index (HPI), which like housing starts, is an indicator of the housing market demand and thus reflects the market condition. But unlike the mentioned research, this paper uses multiple regressions to investigate the relationship between HPI and macroeconomic variables for a shorter period of time. The results established are generally in line with the mentioned studies.

2. Data

The three regions of concern are the New England Region (comprising of Maine, Vermont, New Hampshire, Massachusetts, Connecticut and Rhode Island), the Pacific Region (Alaska, California, Hawaii, Oregon and Washington) and the Mountain Region (Colorado, Wyoming, Nevada, New Mexico, Arizona, Montana, Idaho, and Utah). The paper uses their quarterly purchase-only indexes, namely the house price index (HPI) [7] published by the Federal Housing Finance Agency (FHFA) as an indicator of house price trends at the mentioned geographic levels.

The macroeconomic factors used in the study are:

a) Real GDP in billions of chained 2012 dollars, seasonally adjusted.

b) Real disposable personal income (RDPL) of chained 2012 dollars, seasonally adjusted.

c) CPI for all urban consumers (all items), seasonally adjusted.

d) 1-year, 5-year and 10-year treasury constant maturity rate (tr-1, tr-5 and tr-10), not seasonally adjusted.

e) M2 Money Stock (M2MS) in billions of dollars, seasonally adjusted.

f) Civilian unemployment rate (UR), seasonally adjusted.

g) Federal funds rate (Fed), not seasonally adjusted.

All the macroeconomic data [8] are published and collected from the Federal Reserve Economic Data (FRED) and are either originally or made into quarterly observation from 1991-01-01 to 2018-07-01.

Some exploratory data analysis is done to better understand the data. For example, FIGURE1 below shows a positive correlation between GDP and New England HPI with some abnormality in

the middle range of the GDP. This confirms the widely accepted view that housing price is procyclical.

The abnormality is likely to be a result of the 2008 financial crisis. In fact, if the years 2007-2009 are removed from the data, the data before and after the period each exhibits a very clear positive relationship as the figure below indicates. However, there is a discernible difference in the speed at which HPI grows with respect to the GDP, which is also likely to be a consequence of the crisis. In the following figure, the red line represents to trends before and up to 2007 and the green line represents the trend after 2009.

This observation justifies the motivation to investigate the change in the "sensitivity level" of HPI to macroeconomic factors in general before and after 2008.

On the other hand, as mentioned in the introductory section, the regions suffered in different degree in the real estate market bust. This is supported by the figure below. By studying their respective responses (their sensitivity) to macroeconomic influences, the author hopes to establish a pattern that may serve to explain this observed difference.

3. Statistical Methods

3.1 Intuition Testing

The following linear regressions with lags are run for each region to confirm intuition. The models are assumed to meet the assumptions of classical linear regression models (CLRM) except for perhaps the erogeneity assumption due to the presence of reverse causality. For instance, since the housing price is taken into account when calculating the CPI, it can be argued that it is the higher value of houses that causes a higher CPI, instead of the other way around. The same applies to interest rate in general. While it can be argued that since a higher interest rate reflects a higher borrowing cost for the banks themselves (for instance, the interest rate commercial banks bear on borrowing from the discount window), that cost is likely to be also reflected in the mortgage rate (and so in HPI), the other direction of reasoning also holds-the HPI influences investors' evaluation of the economy and thus influences the interest rate. To cope with this reverse causality problem, it is assumed that the reverse causality diminishes as the time lag increases: the current HPI is more likely to be a response to the inflation happened 2 years ago than the inflation today. Here, the author chooses a lag of four quarters in hope that it ameliorates the causality problem without compensating the size of data too much.

- $NE\ HPI_t = \alpha_1 + \beta_{11}GDP_{t-4} + \beta_{12}RDPI_{t-4} + \beta_{13}CIA_{t-4} + \beta_{14}tr\ 1_{t-4} + \beta_{15}tr\ 5_{t-4} + \beta_{16}tr\ 10_{t-4} + \beta_{17}M\ 2MS_{t-4} + \beta_{18}UR_{t-4} + \beta_{19}Fed_{t-4} + s1_t$
- $Pac\ HPI_t = \alpha_2 + \beta_{21}GDP_{t-4} + \beta_{22}RDPI_{t-4} + \beta_{23}CIA_{t-4} + \beta_{24}tr\ 1_{t-4} + \beta_{25}tr\ 5_{t-4} + \beta_{26}tr\ 10_{t-4} + \beta_{27}M\ 2MS_{t-4} + \beta_{28}UR_{t-4} + \beta_{29}Fed_{t-4} + s2_t$
- $Mt\ HPI_t = \alpha_3 + \beta_{31}GDP_{t-4} + \beta_{32}RDPI_{t-4} + \beta_{33}CIA_{t-4} + \beta_{34}tr\ 1_{t-4} + \beta_{35}tr\ 5_{t-4} + \beta_{36}tr\ 10_{t-4} + \beta_{37}M\ 2MS_{t-4} + \beta_{38}UR_{t-4} + \beta_{39}Fed_{t-4} + s3_t$

3.2 Testing the Homogeneity of Coefficients

To answer the first question, the combined model below is estimated but from now on, the 5-year treasury rate, the M2 money supply and the real disposable personal income are no longer taken into consideration. This decision is intended to yield a more compact model that suffers less from multicollinearity. This is partly justified because

1) The 5-year treasury rate is not as crucial in providing information on the term structure as the short term and long-term interest rate.

2) The data correlation between the M2 money supply and GDP is as high as 0.94. This is theoretically based since expansionary monetary policy is likely to "expand" the economy and thus increase the GDP.

3) The data correlation between real disposable personal income and GDP is as high as 0.996: the higher the real GDP, the more disposable income people in the economy are likely to have.

Besides, from this point on, the author is contented with finding patterns in the correlation

instead of causality in the regions of concern. This is due to the consideration that in incorporating lags into the model, one blurs the boundary between causality and correlation without compensation in better insight into the relationship: it becomes almost an impossible task to estimate how much of the β's is associated with the desired ("right") causality and how much of the β's is due to reverse causality, which cannot be fully eliminated simply by incorporating lags. And thus in restricting the attention to correlation, it prevents exaggerating the scope of the model. The author adopts the special use of the word "sensitivity" from now on in a broad sense that refers specifically to correlation.

The model of concern is thus:

• HPIt = β0+βNE,GDP GDPNE,t+βMt,GDP GDPMt,t+βPac,GDP GDPPac,t+βNE,CPICPINE,t+ βMt,CP ICPIMt,t + βP ac,CP ICPIP ac,t + (other variables) + st

Where HPIt is the data formed by concatenating NE HPIt, Pac HPIt and Mt HPIt in that order. To construct the variables on the right hand side, for instance, GDPNE,t ,one forms the vector of zeros except the indexes that correspond to those of NE HPIt in HPIt for which the values are GDPt. Other variables are constructed similarly. Now for the testing, hypothesis testing of the form below is employed:

H0: βregion1, macro−factor = βregion2, macro−factor H1: βregion1, macro−factor ≠ βregion2, macro−factor

4. Results

The following figure is obtained from running the models in section 3.1.

Table 1 regression result of HPI and macroeconomic factors in different regions

	NE_HPI_t	Pac_HPI_t	Mt_HPI_t
GDP_{t-4}	5.272e-02*** (4.703)	8.990e-02*** (4.356)	3.838e-02** (2.795)
$RDPI_{t-4}$	8.058e-03 (0.581)	-1.834e-02 (-0.746)	4.161e-04 (0.025)
CIA_{t-4}	-2.726e+00*** (-4.858)	-4.42e+00** (-4.433)	-1.034E+00 (-1.504)
$tr1_{t-4}$	2.952e+01** (3.252)	3.961e+01* (2.460)	2.241e+01* (2.015)
$tr5_{t-4}$	-4.020e+01** (-2.723)	-4.532e+01 (-1.731)	-6.781e+00 (-0.375)
$tr10_{t-4}$	3.855e+01** (3.027)	4.511e+01* (2.026)	9.394e+00 (0.611)
$M2MS_{t-4}$	-3.319e-04 (-0.111)	1.546e-02** (2.917)	3.653e-03 (0.998)
UR_{t-4}	6.042e+00** (2.828)	5.373e+00 (1.418)	-2.390e+00 (-0.913)
Fed_{t-4}	-1.841e+01** (-3.097)	-2.182e+01* (-2,070)	-1.536e+01* (-2.109)
Intercept	-2.136e+02*** (-5.627)	-2.198e+02** (-3.265)	-1.881e+02** (-4.045)

Several important observations can be made from the regression Tables. First, the coefficient of GDP is statistically significant (with p-value at least less than 0.01) and positive, confirming the intuition that HPI is procyclical and the pacific regions has the greatest estimated GDP coefficient. Second, the coefficient of CPI is statistically significant for two of the regions, but for all of the three, the coefficient is negative. This is counterintuitive since one would expect some measure of housing price to be involved in the calculation of CPI so if one rises, the other should also. Next, the coefficient of M2 stock is only statistically significant for the Pacific states where it is positive. And

among the treasury rates considered with different maturities, the 1-year rate seems to be most significant while the 5-year rate is least so. But it is interesting to note the 5-year rate is the only one whose coefficient is negative across all of the regions (while the other two are always positive). Furthermore, real disposable personal income is not significant for any region, which is likely to be a result of multicollinearity. The behavior of UR is somewhat perplexing since the coefficient is positive for the first two regions, meaning the HPI increases as employment decreases. Finally, the federal interest rate is negative and significant for all of the regions, which is in line with intuition since it leads to a higher cost of borrowing for the banks, which is likely to be reflected in the housing market in the form of increased mortgage rate, which reduces housing demand.

To better understand the relationship between UR and HPI, one may consult the following figures:

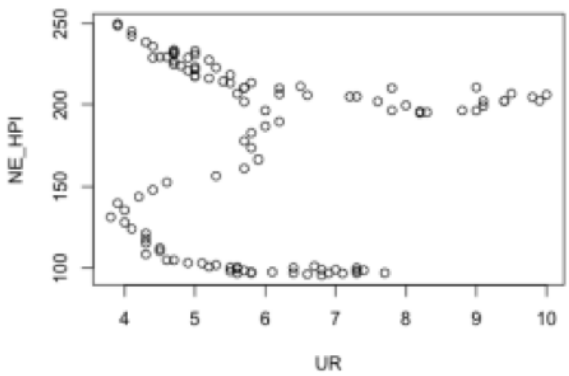

Figure 1 the correlation between HPI and UR in New England region

Source: the Federal Reserve Economic Data (FRED)

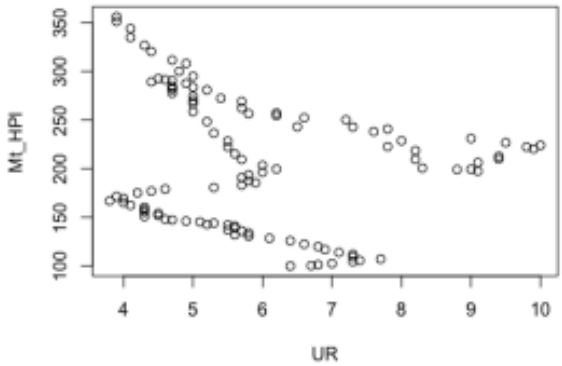

Figure 2 the correlation between HPI and UR in the pacific

Source: the Federal Reserve Economic Data (FRED)

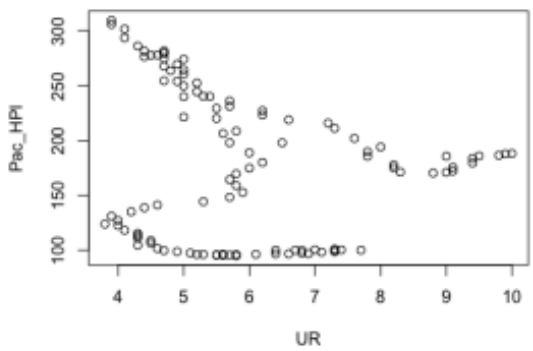

Figure 3 the correlation between HPI and UR in the mountain region

Source: the Federal Reserve Economic Data (FRED)

These figures show a rather interesting pattern: When unemployment rate is in its lower range,

there seems to be multiple trends with negative slope. However, when unemployment is high (around 7.5 % for instance), the different trends seem to converge into one clear pattern. This may be an indication of the inherent irrationality in the market in the real estate pricing. In other words, the lower trend for unemployment rate below 7.5 % may reflect the "natural" house price in a sTable economy while the higher trend reflects what happened in the overheated housing market leading to the crash and the speculation found therein. The noises in the lower range thus "confused" the regression model that tempts it to fit a positive line while in fact, if one looks carefully into the two main trends, it would be clear that both of them are negatively sloped, which is in line with the intuition. This positive estimate will persist into the following section and the reasoning above may be able to explain partly why UR is a relatively less significant variable here.

The next part corresponds to section 3.2. The following is the regression summary:

Table 2 the full sample regression after removing multicollinearity

	HPI_t
GDP_{NE}	5.800e-02*** (9.519)
GDP_{Pac}	5.471e-02*** (8.979)
GDP_{Mt}	3.430e-02*** (5.630)
CPI_{NE}	-2.602e+00*** (-5.456)
CPI_{Pac}	-2.055e+00*** (-4.308)
CPI_{Mt}	-3.163e-01 (-0.663)
$tr1_{NE}$	1.129e+01 (1.202)
$tr1_{Pac}$	2.786e+01** (2.965)
$tr1_{Mt}$	1.891e+01* (2.012)
$tr10_{NE}$	7.915e+00 (1.852)
$tr10_{Pac}$	4.950e+00 (1.158)
$tr10_{Mt}$	6.370e+00 (1.490)
Fed_{NE}	-1.142e+01 (-1.510)
Fed_{Pac}	-2.481e+01** (-3.280)
Fed_{Mt}	-1.511e+01* (-1.998)
UR_{NE}	9.462e+00*** (4.152)
UR_{Pac}	7.532e-01 (0.332)
UR_{Mt}	-3.545e+00 (-1.562)
Intercept	-2.534e+02*** (-8.163)

Before doing the hypothesis testing, there are several differences in the estimates compared to those obtained in the intuition part including:

1) All the CPI estimates are now positive

2) All the treasury rates estimates are also positive.

The unemployment rate beta estimates, as mentioned in the previous section, are still positive. The result suggests the estimates are not in general robust because of the pervasive multi-collinearity between the macro-factors.

Next, some important findings after carrying out the hypothesis testing for all variables and for each pair of the regions are (detail included in appendix):

1) There is a difference in the correlation between GDP and HPI for the New England and Mountain states.

2) There is a difference in the correlation between CPI and HPI for the New England and Mountain states and for Pacific and Mountain states.

3) There is a difference in the correlation between UR and HPI for the New England and Mountain states and for New England and Pacific states.

4) There is no significant difference in the region's response to interest rate in general.

Since in order to account for the regional difference in response to the housing market bust, one would expect a measure that separates the New England states from the Mountain and Pacific states, only unemployment rate here accounts for the difference. On the other hand, interest rate in general fails to do so as all of them seem to be homogenous across the regions. CPI is less sensitive in that aspect in the sense that it "mistakenly" put New England and Pacific into the same category. However, it would certainly be misleading in immediately claiming the importance of unemployment rate in explaining the difference. This is because the model is restricted to considering only a limited number of regions that were grouped in a very crude fashion based on regional characteristics. Such grouping might not do enough justice to the reality. For instance, in the grouping, Nevada belongs to the Mountain states whereas in reality, its behavior over the crisis resembles the Pacific states more. Also, it might be the case that important variables (for instance, those that are micro-based) are missing, which creates omitted variable bias.

Now, the following regression results correspond to section 3.3.

Table 3 test for structural differences in the coefficients around 2008

	NE_HPI_t	Pac_HPI_t	Mt_HPI_t
	Pr(>|t|)		
GDP_t	2.212e-13 ***	0.112253	5.44e-10 ***
CPI_t	0.05949	0.002059 **	0.115
$Tr1_t$	0.00428 **	0.000804 ***	1.03e-05 ***
$Tr10_t$	0.01680 *	0.000600 ***	3.91e-06 ***
UR_t	<2e-16 ***	5.34e-12 ***	<2e-16 ***
Fed_t	0.87141	0.526384	0.885
dum_{aft}	2.34e-16 ***	2.89e-07 ***	9.35e-09 ***
$dum_{aft*}GDP_t$	0.00334 **	0.000219 ***	0.666
$dum_{aft}*CPI_t$	0.81671	3.03e-06 ***	0.364
$dum_{aft}*tr1_t$	0.37033	0.084839	0.209
$dum_{aft}*tr10_t$	0.00749 **	0.000196 ***	1.96e-06 ***
$dum_{aft}*UR_t$	<2e-16 ***	2.68e-14 ***	<2e-16 ***
$dum_{aft}*Fed_t$	0.00924 **	0.000343 ***	0.238
Intercept	<2e-16 ***	<2e-16 ***	<2e-16 ***

To interpret the result, a time inconsistency in a variable before and after 2008 can be said to exist if the corresponding term $dum_{aft} * variable$ is statistically different from zero. With this one may infer the New England states experienced structural change in 4 variables, Mountain states in nearly 6, and Pacific states in 2. All of the region considered have experienced structural change in the sensitivity to the unemployment rate with their p-values less than 0.1 %. This in a sense confirms

the hypothesis that the relationship between unemployment and HPI is irrational before and up to the financial crisis and was adjusted to the normal relationship gradually afterward.

5. Conclusion

The results from the section 3.1 are generally in line with the findings in Ewing, Sari and Aydin (2007)[6] mentioned in the introduction. Interest rates (especially the one-year treasury rate), output and price level are all quite significant for the three regions considered except for perhaps the Mountain states. There is fairly convincing evidence suggesting the sensitivity of HPI to the macroeconomic variables does vary from place to place. However, the approach in this research is unable to establish a consistent pattern that reflects in some interpretable sense the nature of the housing markets in the regions.

However, the sensitivity to unemployment rate does separate out the less affected regions from the more affected in the Great Recession, as far as this paper concerns. Though this may be a result of chance and thus weak in robustness (for instance, when one considers more regions with more delicate differences), it can also imply that the sensitivity to unemployment rate can be a measure of "irrationality" that truthfully reflects the reality. This is supported by the fact that, almost with certainty, all of the regional HPI experienced change in the "unemployment sensitivity" after 2008, suggesting there was something inherently abnormal about its behavior. One curiosity raised by the study is the sign of CPI, which seems to be negative in the model of section 3.1 where the coefficients are forced to be constant throughout the entire period. However, when the coefficients are allowed to change after 2008, the anomaly is eliminated.

References

[1] W. H. Hoyt, P. A. Coomes, and A. M. Biehl, "Tax Limits and Housing Markets: Some Evidence at the State Level," Real Estate Econ., 2011.

[2] D. H. Jacobsen and B. E. Naug, "What drives house prices?," Econ. Bull. (Norges Bank), 2005.

[3] G. Otto, "The growth of house prices in Australian capital cities: What do economic fundamentals explain?," Aust. Econ. Rev., 2007.

[4] T. Zhang, D. A. Gerlowski, and D. Ford, "Housing Price Variability: National and Local Impacts." 20-Oct-2014.

[5] A. G. Ahearne, J. Ammer, B. M. Doyle, L. S. Kole, and R. F. Martin, "Monetary Policy and House Prices: A Cross-Country Study," Work. Pap. Cent. Bank Chile, 2005.

[6] R. Sari, B. T. Ewing, and B. Aydin, "Macroeconomic Variables and the Housing Market in Turkey," Emerg. Mark. Financ. Trade, 2007.

[7] House Price Index. 2019. URL:https://www.fhfa.gov/DataTools/Downloads/pages/house- price-index.aspx.

[8] Macroeconomic Data. 2019. URL: https://fred.stlouisfed.org/