Was the 2008 Crisis a "Correction" to the Housing Market?

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Abstract

In this study, using city-level housing price indices of 20 major US cities during a sample period from the first quarter of 2000 to the last quarter of 2013, we explore the local housing price movements of each city at every stage of the housing market cycle, as well as the cross-stage correlations of these movements. Our results demonstrate the existence of significant cross-sectional correlations among the run up speed during the bubble, the drop speed during the crisis, and the rebound speed after the crisis. The price change magnitude and speed of an earlier-stage are found to be influential to the housing price movements of a later stage, and the results are robust when the price is adjusted for its fundamental value, and when different types of housing price measurements (by the S&P/Case Shiller indices or the FHFA indices) are used. Our findings suggest that the recent crisis might have provided a "correction" function for the housing markets that experiences abnormal bubbles before the crisis; whereas, whether the impacts of this "correction" can sustain long is still a question.

JEL classification: R30, G01, E32

Keywords: housing cycle; fundamental value; market correction

1. Introduction

The recent US national housing market data indicates that the housing price rebound from the 2008 crisis has been in general faster and stronger than the usual expectation. However, there have been noticeable cross-area differences in the timing and strength of the rebound, indicating that the recovery follows a "zip code by zip code" pattern. This study is to analyze the characteristics of the recent housing cycle in each of the 20 major US cities. The goal is to investigate if the recent crisis was a "correction" to the "bubbles" in the US housing markets before the crisis. The 2008 crisis demonstrates that our economy is very vulnerable to the drops in the real estate values. The significant impacts of real estate markets to the economy have been studied by Chaney, Sraer and Thesmar (2012), Corradin and Popov (2012), Adelino, Schoar and Severino (2013), and so on. By exploring indicators for the local economy recovery, our study attempts to provide insights for policy makers, real estate investors, households, developers and mortgage lenders.

Our study is linked to several streams of real estate literature. First, it is associated with the studies on housing market cycles and the serial correlations in housing returns. Housing markets exhibit cycles. A market may experience a persistent growth for a certain time period, then cool down, and then rebound, resulting in a cycle. Housing cycles are often linked to the serial correlations in housing returns. Like many financial assets, residential properties are found to generate returns that follow positive serial correlations in the short run and negative serial correlations in the long run, as explored in Case and Shiller (1988, 1989), Capozza, Hendershott and Mack (2004), Gao, Lin and Na (2009), and Titman, Wang and Yang (2014), and many other studies. Our paper examines the recent housing market cycle in the US: the pre-crisis bubble period, followed by the crisis period, and then the recent rebound period. Our study is one of first few studies that are focused on the changes of local housing markets at different city-specific stages of the recent housing cycles.

This study is also associated with the thin line of literature on the cross-area price comovement during the reversals from hot markets. Kallberg, Liu and Pasquariello (2014) find that the US cross-area housing price comovement has increased since 1990s, indicating that the systematic factors have been stronger (with more market integrations) after 1990s. Li and Yang (2014) also find that cross-area housing return dispersion has dropped significantly

since 1990. In our paper, we find a similar pattern. In particular, the cross-area housing return variations are found to decrease substantially from the housing bubble period to the crisis period, and then remain low even though they start to increase due to housing market rebound.

In this study, we use two most popular home price measurements, the S&P/Case-Shiller Home Price Indices and the FHFA Home Price Indices, to explore the housing price movement at each of the 20 major US cities during their recent housing cycle, which included the bubble, crisis and rebound stages. Our study includes two major analyses. (1) Statistical analysis. Using a city-level statistical analysis, we examine each city's housing price peak (or bottom), price rise (or drop) duration, price change scope, and price rise (or drop) speed, at every stage of its recent housing cycle. We find that areas that experienced stronger run ups during the bubble stage tended to suffer more from price declines during the crisis, but rebounded also more rapidly after the crisis. (2) Regressional analysis. We first regress housing return on previous stages' housing price change extents or speeds, after controlling for usual determinants for housing returns. The results show that the bubble-stage housing price appreciation extent and speed insert significant and negative impacts on the subsequent crisis-stage housing returns, and they increase the rebound-stage housing returns. Meanwhile, the rebound-stage housing returns are negatively affected by the crisis-stage housing price appreciation extent and speed. These results remain consistent for the data of both home price indices. They also persist when we adjust housing price by its fundamental value, suggesting that these patterns are not merely driven by the fundamental value variations. Our findings indicate that the recent crisis might have provided a "housing market correction" function for most cities investigated in this study, but this correction might be partially reversed in the long-run.

As far as we know, our study is one of the first few researches that have carefully analyzed the timing and price change magnitudes and speeds of each stage (bubble, crisis and rebound) in the recent housing cycle for each major US city, and the first one that has adopted the fundamental value analysis to the recent housing cycle analysis, which is particularly suitable and necessary as compared to other housing cycles in history.

Our study also has a significant practical value. Our findings are useful for large investors to diversify the cross-area housing investment risk, for financial institutions

including mortgage companies and banks to diversify the cross-area real estate loan risk, for large developers to diversify the cross-area housing market development risk, and for relocating individuals to make wise pricing and timing decisions in house transactions.

The next section introduces the data, methodology and testing hypotheses. The third section provides details of our statistical analysis. The fourth section presents the results of our main regressional analysis, and the last section concludes.

2. Data, Methodology and Hypotheses

In this study, we investigate the following main issues: (1) are there any cross-area relations among the housing price change patterns at different stages of the recent housing cycle? (2) do the previous-stage price movement patterns affect the current housing price movement? (3) are these results driven simply by the fundamental home value changes?

A major variable in this study is the MSA-level housing price, which we measure with the MSA-level S&P/Case-Shiller Home Price Index data and the MSA-level FHFA Single-Family Housing Price Index (purchase only) data. The S&P/Case-Shiller index is so far the most influential US residential real estate price measurement that is based on the actual property transaction prices. It provides information on up to 20 major cities' general home price levels, and correspondingly our study will also cover housing markets of these 20 cities. In addition, we use the S&P/Case-Shiller 20-city composite home price index as a proxy for the national housing price level. The index from FHFA (Federal Housing Finance Agency, formerly known as the Office of Federal Housing Enterprise Oversight, or OFHEO), is largely based on the property appraisal values for single-family properties financed by Fannie Mae or Freddie Mac mortgage loans. Although this index excludes properties financed by the non-conforming loans, it is used widely in real estate research partially because of its timely reports and extensive geographic coverage. To match the MSA-coverage of S&P/Case-Shiller, we examine the same 20 MSAs using the FHFA data. Our raw data covers a long period from the 1st quarter of 1991 to the 4th quarter of 2013, but our major analyses are focused on a sample period from the 1st quarter of 2000 to the 4th quarter of 2013, which is more relevant to the recent housing cycle.

From the historical time-trend of the market average price proxied by the S&P/Case-Shiller 20-city composite price index, we find that the housing market in general experienced three distinctive stages during the sample period: the bubble stage, crisis stage, and rebound stage, forming a cycle which we call as the "recent housing market cycle". We define the start of the "bubble stage" as the quarter that most national housing price indices began to show accelerations in growth, which is also the beginning quarter of the 20-city composite price index, the 1st quarter of 2000. This stage ended at the 3rd quarter of 2006, the last quarter before the composite index declined. After this stage, the "crisis stage" started and it lasted till the 2nd quarter of 2009, the last quarter before the composite index rebounded. Subsequently, the "rebound stage" starts and lasts till the end of our sample period, the 4th quarter of 2013. These three stages are highlighted in Appendix A.

For each individual city, however, the city-level housing price movement has its own specific pace which may differ slightly or significantly from the composite index movement pace, therefore the timing of each stage of city-level housing cycle may differ city by city. Correspondingly we categorize each stage for every city, based on this city's S&P/Case-Shiller price index trend, using an approach that is similar as for the composite index. We do realize that most cities also experienced smaller sub-cycles during the rebound stage: temporary rebound, then temporary drop, and then rebound again for the second time, so we eventually divide the sample time horizon of each city into three main stages (bubble, crisis and rebound), then further divide the rebound stage into three substages (temporary rebound, temporary drop and second rebound). In Appendix B, we use New York (NY) as an example to show the city-level stage/substage categorization. We also conduct similar and independent city-level analysis using the FHFA data, which show fairly similar timing of stages/substages as the S&P/Case-Shiller data.

Our first analysis is focused on the housing price changes during different stages/substages. Due to the cross-city timing differences for the varied stages/substages of the housing market cycles, we identify the housing price peak time of each "rising" stage (that is, the bubble stage, the rebound stage, the temporary rebound substage, and the second rebound substage), and the housing price bottom time of each "declining" stage (that is, the crisis stage and the temporary drop substage) for each city. For every price-rising stage, we

estimate the "rise duration" by the number of quarters of price rise before the housing price reaches the peak time of this stage, and the "rise extent" by the price change rate during the rising time period. We then define the ratio of rise extent to rise duration as the "rise speed". Similarly, for each price-declining stage, we estimate the "drop duration" by the number of quarters of price decline before reaching the bottom time, the "drop extent" by the price change rate during the dropping time period, and use the ratio of the latter to the former as the "drop speed". From these calculations, we generate several cross-sectional variables: the duration, extent and speed of rise/drop at each of these stages. Then we analyze the cross-sectional correlations of these variables, to explore if the duration, extent and speed of one stage are in connection with those of a different stage. Both S&P/Case-Shiller data and FHFA data are examined. We test the following main hypotheses from this statistical analysis:

[Hypothesis 1] There is a positive correlation between the rise speed (extent) during the bubble stage and the drop speed (extent) during the crisis stage, that is, areas experienced stronger run ups before the crisis tended to have more significant housing price declines during the crisis.

[Hypothesis 2] The rise speed (extent) during the rebound stage is related to neither the rise speed (extent) of the bubble stage nor the drop speed (extent) during the crisis stage, that is, areas with more prominent housing price appreciation during the bubble years or more severe housing price crash during the crisis, do not necessarily rebound more quickly or slowly after the crisis.

If Hypothesis 1 is confirmed, it can serve as an evidence that the housing market crisis provides an adjustment to the bubble. If Hypothesis 2 is true, it indicates that this adjustment effect might be sufficient and long-term.

We also use a panel data to estimate a regression of quarterly housing price change rate on the 1-quarter, 2-quarter, 3-quarter and 4-quarter lagged quarterly housing price change rates, and a previous-stage' local housing price movement characteristic, where stages are defined based on each city's S&P/Case-Shiller housing price index data or its FHFA housing price index data. If j is the city index, with $j = 1 \text{ to } 20$, the regression takes the following format:

$$R_{j,y} = \varphi + \sum_{i=1}^{3} \omega_i R_{j,y-i} + \theta_k S_k + \varepsilon, \quad (1)$$

where y is the quarter index; $R_{j,y}$ is the $j-$th city's quarterly housing return at quarter y, $R_{j,y-i}$ is the $i-$quarter lagged quarterly return, with $i = 1, 2$ or 3. S_k represents the previous k–th stage's housing price movement characteristic of this city, which we estimate with either the speed or the extent of the housing price change during this previous stage. φ is a constant, ω_i and θ_k are coefficients, and ε is the error term. We include four lagged quarterly housing returns as serial correlation terms are found to be influential to housing returns in previous studies (Case and Shiller, 1988, 1989, Titman, Wang and Yang, 2014, and so on). The coefficient of a previous-stage's housing price change speed or extent, θ_k, can tell if housing returns are also affected by this earlier stage's local housing price movements. We use the OLS regression procedure to estimate the coefficients, compute the White standard errors to deal with the heteroskedasticity, and include year and quarterly dummies to control for the time fixed effects. The regression results can test the following hypotheses:

[Hypothesis 3] The crisis stage housing return is decreasing in the housing price rise speed and/or rise extent during the local bubble stage.

[Hypothesis 4] The rebound stage housing return is not affected by the housing price change speed and/or change rise extent during the bubble stage, nor affected by those during the crisis stage.

These two hypotheses are matching Hypotheses 1 and 2. If Hypothesis 3 is true, it can be another evidence that the housing market crisis works as an adjustment to the bubble. If Hypothesis 2 is true, it will be a further evidence that this adjustment effect has a long-term effect.

To better understand the correction effect, we need to know if the relations between the housing returns and the previous-stage housing price movements are driven simply by the changes in the fundamental values of housing properties, or really reflect the effects of "corrections". Therefore, we reestimate the regression in Equation (1) by adjusting all the related housing price data by the fundamental house prices. To measure these fundamental

house prices, we follow the approach in Gao et al. (2009) by estimating the following regression

$$hp_{it}^{*} = \alpha_i x_{it} + \beta m_t + d_i \quad (2)$$

where hp_{it}^{*} is the fundamental house price for market *i* at quarter *t*, x_{it} is the macro economic variables, and m_t is the mortgage cost, all in log form. In addition, the dummy variable d_i controls for location differences. Gao et al. (2009) initially include many economic variables such as median household income, employment, population, and find that the median household income is the most significant variable. They also find that including employment and population growth does not make a significant shift in the fundamental house prices. As a result, their final model uses only the median household income to reflect the general economic condition of each housing market. For the mortgage cost, they use the effective cost of a 30-year fixed rate mortgage -- the quarterly payment for borrowing $1 at a given annual rate ($rate_t$), which can be calculated as follows:

$$m_t = -\log\left\{[1-1/(1+rate_t/12)^{360}]/(rate_t/12)\right\} \quad (3)$$

Since the 2008 financial crisis, the U.S. Federal Reserve adopted Quantitative Easing (QE) policy. In order to capture the impact of the QE policy, we estimate beta separately.

Correspondingly we repeat regression in Equation (1) by using fundamental value adjusted data. The dependent variable is changed into the quarterly change rate of the price-to-fundamental ratio, and the dependent variables include the lagged change rate of the price-to-fundamental ratio, and the previous-stage change extent or speed of the price-to-fundamental ratio. Here, we use stage categorizations that are consistent with those in the earlier analyses, and test the following hypotheses:

[Hypothesis 5] The crisis stage housing price-to-fundamental ratio change rate is decreasing in the local bubble stage housing price-to-fundamental rise speed and/or extent.

[Hypothesis 6] The rebound stage housing price-to-fundamental ratio change rate is affected by neither the housing price-to-fundamental ratio change speed and/or extent of the bubble stage nor that of the crisis stage.

If the conclusions for these two hypotheses are matching those for Hypotheses 3 and 4, we can infer that "correction" effect and its permanency we detect from Hypotheses 3 and 4 are not merely driven by the fundamental housing price changes.

3. Statistical Analysis

As a starting point, based on the city-level housing price indices, we identify each city's stages and substages using the stage definition approach mentioned earlier. For each stage/substage, we analyze the city's housing price peak or bottom quarter, and calculate the duration, extent and speed of housing price rise or drop at each stage. The results are displayed in Table 1 with Panels A and B displaying the findings with S&P/CS data and FHFA data, respectively.

< Insert Table 1 about here>

3.1 By-stage analysis

3.1.1 S&P/CS data analysis

Bubble Stage

As shown in Panel A of Table 1, the bubble stage was consistently much longer than other stages in all the 20 cities. Counted from 2000 Q1, the housing price index reached the peak time around 2005 Q4 to 2007 Q4 (with an average time at 2006 Q3, according to the 20-city composite index), after experiencing 22 to 30 quarters' persistent growths (with an average rise duration of 26 quarters). The extents of price growths before reaching the price peaks were, however, quite diversified across cities. Cleveland, Dallas and Detroit experienced price growths of less than 30%, followed by Charlotte and Atlanta with about 35% growths, while Miami and Los Angeles experienced price growths of more than 170%. The 20-city average price growth was 104.33%. Correspondingly, the housing price rise speeds during this stage varied significantly across cities, ranging from 0.81% per quarter (Dallas) to 6.63% per quarter (Miami), with an average rise speed of 4.01% per quarter.

Crisis Stage

On average it took 11 quarters, i.e., about 3 years, for the housing price to drop from the bubble peak to the crisis bottom with an accumulated price drop rate of 31.90%. The bottom year was consistently 2009 in all cities except Seattle (which reached the bottom slightly later at 2010 Q1). As compared to the lengthy rise before the crisis, the price drop during the crisis was much more rapid. However, diversifications were again significant. Cities with the most rapid price slides include Las Vegas, Phoenix, Miami, San Francisco and Los Angeles, which were also the cities that experienced fast price appreciations during the bubble stage. Housing prices of these cities declined by more than 3.7% per quarter during the crisis stage. In some sense, these substantial price drops can be viewed as the "corrections" for the bubbles in the previous hot markets. Among cities that had substantial price drops, Detroit and Atlanta were two outliers. They had very slow price appreciation during the bubble time (less than 1.2% per quarter), but their prices dropped by more than 3% per quarter in the crisis. These drops were attributed to their worsening economic and employment situations.

On the other hand, cities that suffered the least at this stage (with a price drop speed of less than 2% per quarter) include Denver, Dallas and Cleveland, which happened to be the cities with the least housing price appreciations during the bubble years. These are again in support of the "correction" view of the price reversal during the crisis. Boston and New York, however, fell into a different category. They both experienced noticeable price appreciations during the bubble years but their prices did not decline too much during the crisis, demonstrating these two large cities' strong capabilities to resist the negative economic shocks.

Rebound Stage

After the housing price dropped to the bottom during the crisis, all cities have experienced rebounds. Interestingly, the two largest cities, New York and Chicago, have exhibited the slowest rebounds, with 0.08% and 0.11% per quarter of rebound speeds. These two cities behaved differently from each other before the rebound. The housing price in New York grew strongly by 4.43% per quarter during the bubble and dropped merely 1.88% per quarter during the crisis. In contrast, the price change speeds were 2.48% and -2.64% per

quarter during the two previous periods at Chicago. The results indicate that housing market rebounds seem to be more difficult at super-large cities. On the contrary, Phoenix and three cities in California, which had big jumps in bubble years while also big drops in crisis years, are among the cities that have shown the strongest rebounds. In particular, San Francesco had the highest rebound rate, 2.58% per quarter. Unlike these California cities, the two Florida cities, Miami and Tampa, did not rebound as quickly as their bubbles rises and crisis drops. However, Detroit, which was hit severely during the crisis, became one of the fastest in rebound, with a rise speed of 1.98% per quarter. Charlotte, Cleveland and Atlanta are among the cities least sensitive to the housing cycles, and they happened to be cities with slow bubble risings and slow crisis drops. Overall, the rebounds by the end of the sample periods have not dragged prices back to the bubble-peak levels yet except at Dallas and Denver. Of course, in many cities, these rebounds are expected to keep going.

The following paragraphs explore more detailed price trends during the three substages of the rebound.

Temporary Rebound As shown in Panel A of Table 1, after the housing price slid to the bottom during the crisis, each city experienced a temporary rebound except Las Vegas. On average, it took about 5 quarters for the housing price to rebound to a new small peak (at 2010 Q3) before dropping again, with an accumulated price rebound rate of 5.56% and a price appreciation speed of 1.11% per quarter. This rebound speed was much lower than the bubble rise speed (4.01% per quarter) and the crisis drop speed (2.90% per quarter). California cities performed impressively at this substage, together with Minneapolis, with growth extents of close to or above 10% and growth speeds of close to or above 2% per quarter. Dallas also had a fast temporary rebound with a 3.88% growth per quarter, but lasted only for 2 quarters. With monthly data, we can see that Las Vegas rebounded only for one month before its price declined again, suggesting that this city was still impacted by the lengthy decline trends from the previous crisis stage, and needed more time of “correction” to their “crazy” appreciations during the bubble stage.

Temporary Drop After a temporary rebound, prices moved downward again. On average it took about 6 quarters for the housing price to slump to the new bottom at 2012 Q1,

with an average drop speed of 1.55% per quarter. Then the prices moved up again, so the declines at this stage were again temporary. The average drop speed was substantially higher than the average temporary rebound speed 1.11%, and this drop sustained longer than the temporary rebound (which was 5 quarters), the 20-city composite index fell to an even lower new bottom (134.45), as compared to the previous crisis bottom (140.40). These suggest that the previous temporary rebound was overall very fragile and transient. Only 6 out of 20 cities were in the opposite (with the new bottom prices higher than the previous crisis bottom prices), including three California cities.

Second Rebound After the housing prices temporarily declined to the bottom, all the 20 cities experienced a new round of price rebounds, which were still undergoing after the end of our sample period, 2013 Q4, albeit with some tiny fluctuations in several cities. The average rebound speed was 3.33% per year, which led to an around 23.3% price increase from the bottom price level in the last substage. During this second rebound, San Francisco, Las Vegas, Detroit and Atlanta grew by more than 5% per quarter, with a scope of over 35% accumulated increase as compared to previous price bottoms. Based on the most recent data, this second rebound stage is still undergoing, indicating that the housing markets have been moving steadily out of the crisis.

3.1.2 FHFA data analysis

As shown in Panel B of Table 1, with the FHFA data, the timings of stages and substages in each city are in general similar to those identified with the S&P/CS data. As expected, the price change extents and speeds are less substantial as compared to the results in Panel A, which can be explained by the relative lower volatilities of FHFA housing price indices due to the inclusion of properties with less risky loans (only conforming-loan backed properties are included in the FHFA index constructions). Nevertheless, the cross-area differences in the by-stage analysis still exits, and are similar as those shown with the S&P/CS data.

3.2 Fundamental home price

We next estimate the fundamental home price at each quarter of our sample period for

each of the 20 cities, using the regression in Equation (2). To do so, we employ data with a longer horizon than our major sample period, from the 1st quarter of 1991 to the 4th quarter of 2013, to reduce the risk that the fundamental price estimated is biased due to the overweighting of recent financial crisis. Table 2 shows the estimates of the fundamental home price equations for both S&P/CS and FHFA home price indices.[1]

< Insert Table 2 about here>

Comparing the time-trend of the home price and that of the fundamental home price of each city, we can see some cities have similar patterns, and therefore categorize the 20 cities into the following types:

Type 1-Phoenix, Los Angeles, San Diego, San Francisco, Las Vegas These cities experienced strong price appreciation (over 100% at a speed of 4-7% per quarter) during the bubble, with substantial overvaluations (around 50%) at about one year before the bubble peak. These were followed by large price drops (over 40% at a speed of about 3-5% per quarter) during crisis, with persistent undervaluation from 2009 to 2012, especially in Las Vegas (with 20% undervaluation over three years). Then they experienced strong rebounds (with price appreciation mostly by about 30-50% at a speed of around 2% per quarter).

Type 2- DC, Miami, Tampa Like the Type 1 cities, these cities experienced strong price appreciation (over 100% at a speed of 4-7% per quarter) during the bubble, with substantial overvaluations (around 50%) at about one year before the bubble peak. Also similarly, there were large price drops (over 40% at a speed of about 3-5% per quarter) during the crisis. However, unlike the case of Type 1, the home price was very close to (or, occasionally a little bit higher than) the fundamental value from 2009 to 2011, and then became shortly undervalued at around 2012. These were followed by a medium rebound (with price appreciation by about 20-30%, at a speed of around 1% per quarter).

Type 3- Boston, Minneapolis, Portland, Seattle Unlike the first two types, these cities experienced only medium price appreciation (around 70-90% at a speed of 3% per quarter) during the bubble, with medium overvaluations (around 20-30%) at about one year before the

[1] Due to the short-history (back to 2000) of Dallas home price index from S&P/CS, we exclude this city from the S&P/CS based fundamental price analysis.

bubble peak. There were also medium price drops (around 20-35% at a speed of about 1-3% per quarter) during crisis. Overvaluation existed during most of the time between 2008 and 2011, and then turned into undervaluation. There was a medium rebound after the crisis (with price appreciation by about 10-25%, at a speed of around 0.7-1.4% per quarter).

Type 4- Chicago, New York Like Type 3 cities, these cities had medium price appreciation (around 70-100% at a speed of 2-5% per quarter) during the bubble, with medium overvaluations (around 20-30%) at about one year before the bubble peak. Then they experienced medium price drops (around 20% at a speed of about 2% per quarter) during crisis. There was overvaluation between 2009 and 2011, and then went to undervaluation. Unlike Type 3 cities, however, there was only tiny rebound after the crisis (with price appreciation by about 1.5-2%, at a speed of around 0.1% per quarter).

Type 5- Atlanta, Charlotte, Cleveland Unlike the first four types, these cities experienced only slight price appreciation (around 25-35% at a speed of 1% per quarter) during the bubble, with the price very close to or lower than the fundamental value before the bubble peak. There were also small price drops (around 10-20% at a speed of about 2-3% per quarter) during crisis. However, the overvaluation rate jumped significantly from 2008, and then price stayed overvalued till around 2011. There were slight rebounds after the crisis (with price appreciation by about 4-7%, at a speed of around 0.2-0.3% per quarter).

Type 6- Detroit This city had only a slight price appreciation (about 26% at a speed of 1% per quarter) during the bubble, with persistently moderate (less than 20%) overvaluation. Then the price dropped significantly (by over 40% with a speed of 3.21% per quarter) during crisis. However, the data between 2009 and 2012 show persistently substantial (close to 20%) undervaluation. After the crisis, there was a strong rebound (with price appreciation by over 35%, at a speed of around 2% per quarter).

Type 7- Denver This was the only city that had a quite stable price before 2012. Then there was a medium price rise. During the whole sample period, the overvaluation rate has only slightly fluctuated and been kept within (-20%, 20%).

Figure 1 uses four MSAs from different types to illustrate the varieties of the home price and fundamental value time trends across cities. The FHFA price indices exhibit

essentially similar patterns as the S&P/CS price indices. These results indicate that fundamental value changes do provide some explanations for the housing price movements, but certainly they cannot justify all the aspects of housing price patterns.

< Insert Figure 1 about here>

3.3 Cross-area diversities and the associated inter-stage correlations

Next, we analyze the cross-area price movement diversifications at different stages, and the correlations of these diversifications across-stages. The diversifications and associated cross-stage correlations can be inferred from Figure 2, which compares the patterns of price and price-to-fundamental ratio across stages, using the two sets of home indices. Clearly, the cross-area diversifications in the price change speeds and magnitudes are stronger in the bubble stage than in the crisis stage, and stronger in the crisis stage than in the rebound stage, suggesting an increasing comovements among different house markets since the recent crisis.

The detailed correlation coefficients are displayed in Table 3. We find that the cross-area diversifications in price change patterns at all stages are correlated at varied levels. For the S&P/CS data, high correlations exist between the price rise in bubble and the price drop in crisis, with a correlation coefficient magnitude of 0.629 for the price change rate (extent), and a correlation coefficient magnitude of 0.567 for the price change speed. This result confirms Hypothesis 1 that there is a positive correlation between the rise speed (and/or extent) during the bubbles stage and the drop speed (and/or extent) during the crisis stage. That is, areas experienced stronger run ups before the crisis tended to have more severe price collapse during the crisis. This high correlation provides evidence for the possible "adjustment" effect of the crisis: areas that experienced more rapid price appreciations during the bubble years received more substantial price adjustments during the crisis.

< Insert Figure 2 and Table 3 about here>

On the other hand, there are also strong correlations between the rebound patterns and the patterns during earlier stages. For the price change speeds, the correlations coefficients are 0.412 between rebound and bubble, and -0.614 between rebound and crisis. For the price change extents, the two coefficients are 0.360 and -0.712. These results are against the

predictions in Hypothesis 2 that the housing price change patterns during the rebound are unrelated to earlier-stages' housing performances. While cities experiencing stronger bubbles tended to be hit more severely (or, "adjusted" more significantly) during the crisis, in general they also rebounded more quickly and substantially after the crisis. These results indicate that the market corrections during the crisis might not be permanent, but with a tendency of reversal.

Figure 2 shows that if adjusted for the fundamental values, price change speeds and extents are ranged in narrower scopes than if without the fundamental adjustment, and correspondingly their cross-area diversifications are smaller. However, this figure and the data in Table 3 suggest that the similar inter-stage correlations in price movement patterns still stay, and these correlations are even stronger than if without the fundamental adjustment, suggesting that the conclusions from Hypothesis 1 also applies to the price movements after prices are adjusted for the fundamentals.

As displayed in Figure 2 and Table 3, the results discussed above also apply to the FHFA indices. We also examine the correlations between housing price movements of the three substages of rebound and those of the earlier two (bubble and crisis) stages. Untabluated results show that among all substages, the second rebound substage is more correlated with the first two main stages, than the two temporary stages, suggesting that the temporary stages' performances might be more random and unstable. Overall, areas experiencing stronger bubbles tended to be hit more severely, but also rebounded more quickly. Inter-stage speed correlations differ from each other, indicating that each city's housing market might be changing across different period. This is confirmed by our regression results below.

4. Regressional Analysis

In this section, we will present the results of our panel data regressions highlighted in Equation (1). We first develop these tests using the home price index data unadjusted for the fundamental values, to verify Hypothesis 3 that the crisis stage housing return is decreasing in the local bubble stage housing price rise speed and/or extent, and Hypothesis 4 that the rebound stage housing return is affected by neither the housing price change speed and/or extent of the bubble stage nor that of the crisis stage. In each regression, the dependent variable is the quarterly housing return, and the independent variables include the 1-quarter,

2-quarter, 3-quarter and 4-quarter lagged housing returns, and a previous-stage housing change factor, the change extent or the change speed of the home price. The results are displayed in Table 4.

< Insert Table 4 about here>

With the S&P/CS data, the quarterly housing return shows short-run positive serial correlations, in line with literature. For the crisis-stage returns, the 1-quarter lagged term and the 3-quarter lagged term have positive effects (with coefficients 0.731 and 0.364) at the 1% significance level. Although there is a temporary reversal with the 2-quarter lagged term negatively affecting the return (with a coefficient of -0.480), its influence magnitude is much lower than that of the positive serial correlation terms. The serial correlations are similar for the rebound-stage returns, albeit with smaller magnitudes.

After controlling for these serial-correlations, we find that consistent with the predictions in Hypothesis 3, the crisis-stage housing returns are decreasing in the bubble-stage rise speed (coefficient -0.253) and the bubble-stage rise extent (coefficient -0.011), both at a 1% significance level. In other words, housing prices declined more significantly during the crisis years in areas experiencing stronger bubbles earlier. For the rebound stage, housing returns turn out to be increasing in the bubble-stage price rise speed (coefficient 0.122 at a 5% significance level) and the bubble-stage price rise extent (coefficient 0.005 at a 5% significance level); meanwhile, the housing returns also decrease in the crisis-stage price drop speed (coefficient -0.364 at a 1% significance level) and the crisis-stage price drop extent (coefficient -0.029 at a 1% significance level). Comparably, the crisis-stage housing market performances are more influential than the bubble-stage housing market performances, which is easy to understand given that the rebound stage has a direct time-connection with the crisis stage, while more distant from the bubble stage. The significant influences from previous-stages provide evidence to reject Hypothesis 4 which predicts no relation between the housing return in rebound and previous-stages' housing price change patterns. The results suggest that markets seem to have "memories", and for those places growing fast during the bubble years, although most of them got hit severely during the crisis, their post-crisis rebound tended to be stronger. This indicates that the adjustment during the crisis might not be able to fix the pre-crisis crazy growth tendencies in the long run for at least some (if not all) cities in our sample.

The results with the FHFA data are similar as above. Since FHFA data are less volatile than the S&P/CS data, the short-run positive serial correlations among the home returns show smaller magnitudes but are more stable (as there is no temporary reversal). Nevertheless, the influences of the bubble-stage price change speed and extent on the crisis-stage housing returns are with similar magnitudes and strengths as shown by the S&P/CS data, strongly supporting Hypothesis 3. For the rebound returns, the influences from the previous-stage speeds or extents are less significant than with the S&P/CS data, but still exist with 5% to 10% significance levels. Again, Hypothesis 4 is rejected by the FHFA data.

Now we explore if these results are simply driven by the fundamental price changes, to test Hypotheses 5 and 6. To do so, we replace the price data with the price-to-fundamental ratio, to control for the influence from the fundamental changes. The fundamental prices are created following the regression in Equation (2) and the results are highlighted in Table 2. Correspondingly, for each regression in Equation (1), the dependent variable is changed into the quarterly change rate of the price-to-fundamental ratio, or, the quarterly return after the fundamental adjustment; and the independent variables include the 1-quarter, 2-quarter, 3-quarter and 4-quarter lagged quarterly change rates of the ratio, and a previous-stage housing change factor, the change extent or the change speed of the ratio. Table 5 reports the results.

With the S&P/CS data, interestingly, we find that there are persistent and strong negative serial correlations in the fundamental-adjusted quarterly return during the crisis-stage. The coefficients of the four lagged terms are -0.502, -0.435, -0.489 and -0.317, respectively, all at the 1% significance level. This suggests that the crisis-stage housing price movements had strong self-adjustment properties, which were not related to the fundamental price movements. In other words, the decline in the housing prices in the crisis, substantial as it seemed, actually received strong resistances in the downward moving, if we separated out the effects of the fundamental changes. After controlling for these serial-correlations, we find that the fundamental-adjusted returns are significantly decreasing in the bubble-stage rise speed of the adjusted prices, with the coefficient as high as -3.241 and at a 1% significance level. They also decrease in the bubble-stage rise extent, with the coefficient of -0.119 at a 1% significance level. These strongly support Hypothesis 5 and suggest that the results on Hypothesis 3 are not simply driven by the fundamental economic movements.

For the rebound-stage fundamental-adjusted returns, the positive and negative serial correlations are mixed, with the 1-quarter lagged term and the 4-quarter lagged term inserting positive effects, while the 2-quarter lagged term and the 3-quarter lagged term inserting negative effects. Compared to the persistent negative serial correlations in the crisis-stage fundamental-adjusted returns, rebounds exhibit less obvious self-adjustments, suggesting that home price rebounds have received less resistance in the upward moving. Interestingly, the bubble-stage adjusted home price change patterns (extent or speed) are almost as influential as the crisis-stage adjusted home price change patterns, with the coefficients of 0.366 (bubble-stage adjusted price change speed) as versus -0.320 (crisis-stage adjusted price change speed), and 0.014 (bubble-stage adjusted price change extent) as versus -0.032 (crisis-stage adjusted price change extent), all at the 1% significance levels. All of these provide evidence to reject Hypothesis 6 which predicts no relation between the fundamental-adjusted housing return in rebound and previous-stages' fundamental-adjusted housing price change patterns. In other words, the conclusions on Hypothesis 4 still hold when the fundamental home prices are controlled. Again, markets seem to have "memories", and may repeat the mistakes in the bubble years during the rebound years.

Finally, the results with the FHFA data are similar as above. In summary, the regressional results imply that the recent crisis did play a "correction" role in the housing markets of most cities. However, whether this correction can sustain long seems to be questionable.

5. Conclusions

This is one of first few studies that have provided detailed analysis on the bubble, crash and rebound timing, magnitude and speed in the housing markets of major US cities. We use the S&P/Case-Shiller Home Price Index data and the FHFA House Price Index data to explore whether there are cross-area relations among the housing price changes at different stages of the recent housing cycle. Our sample includes two sets of city-level price index data of 20 major US cities during a period from the first quarter of 2000 to the last quarter of 2013. For each city, we examine the price peak or bottom, rise or drop duration, price change scope

and price rise or drop speed at each stage of the local housing market cycle. We find that areas that experienced stronger run ups during the pre-crisis bubble stage tended to suffer more from price declines during the crisis, but rebounded also more rapidly after the crisis. Following the method in Gao et al. (2009), we estimate the fundamental home price at each quarter for each city. We find that the results above persist after we control for the influences from fundamental home price changes, and are generally consistent for both the S&P/Case-Shiller and the FHFA data.

We also estimate a regression of housing return on previous stages' housing price change speeds/extents using the panel data and controlling for the year and quarter fixed effects. The results show that the bubble-stage housing price appreciation magnitude and speed reduce the subsequent crisis-stage housing returns and increase the rebound-stage housing returns, while the crisis-stage housing price appreciation magnitude and speed reduce the subsequent rebound-stage housing returns. Again, the results are robust after we control for the fundamental price changes, and consistent when we use different home index data. Our findings suggest that the recent crisis might have played a "correction" role in the housing markets of most cities. However, whether this correction has long-term effects seems to be questionable.

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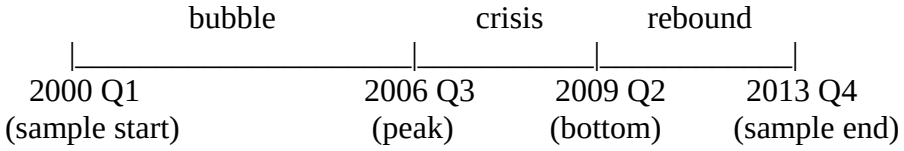
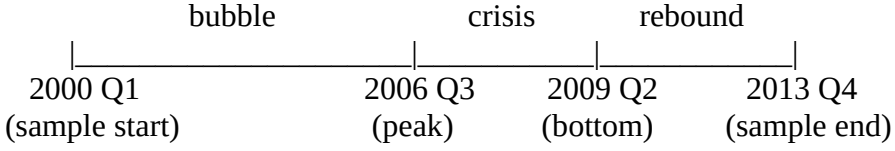
Appendix

A. Stages of national housing market
(based on the S&P/Case-Shiller 20-city home price composite index)



B. Stages of New York housing market
(based on the S&P/Case-Shiller city-level home price index)

Three main stages:



Three substages of rebound:

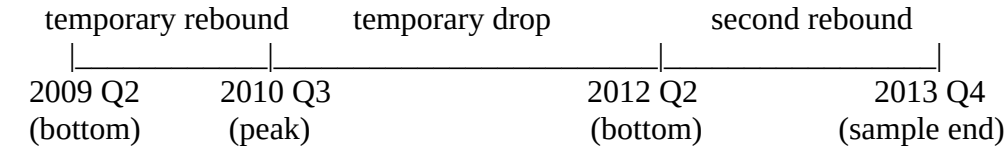


Table 1 City-level statistical analysis results by stage

Panel A Housing prices measured by CS indices

City	Bubble Stage						Crisis Stage						Rebound Stage			
	peak price	peak year	peak quarter	rise quarters (from 2000 Q1)	rise extent (from 2000 Q1)	rise speed (from 2000 Q1)	bottom price	bottom year	bottom quarter	drop quarters	drop extent	drop speed	price of 2013 Q4	rise quarters (by 2013 Q4)	rise extent (by 2013 Q4)	rise speed (by 2013 Q4)
AZ-Phoenix	226.53	2006	3	26	125.13%	4.81%	104.25	2009	2	11	-53.98%	-4.91%	144.61	18	38.71%	2.15%
CA-Los Angeles	273.86	2006	3	26	171.36%	6.59%	159.82	2009	2	11	-41.64%	-3.79%	214.76	18	34.38%	1.91%
CA-San Diego	249.56	2005	4	23	146.02%	6.35%	145.60	2009	2	14	-41.66%	-2.98%	194.03	18	33.26%	1.85%
CA-San Francisco	218.00	2006	2	25	111.47%	4.46%	120.82	2009	1	11	-44.58%	-4.05%	180.10	19	49.06%	2.58%
CO-Denver	140.06	2006	3	26	38.80%	1.49%	120.97	2009	1	10	-13.63%	-1.36%	146.48	19	21.09%	1.11%
DC-Washington	250.74	2006	2	25	148.90%	5.96%	168.66	2009	1	11	-32.74%	-2.98%	204.05	19	20.98%	1.10%
FL-Miami	280.03	2006	4	27	179.14%	6.63%	145.25	2009	2	10	-48.13%	-4.81%	175.74	18	20.99%	1.17%
FL-Tampa	237.15	2006	2	25	136.16%	5.45%	140.55	2009	2	12	-40.73%	-3.39%	154.78	18	10.12%	0.56%
GA-Atlanta	136.15	2007	3	30	35.26%	1.18%	106.34	2009	2	7	-21.89%	-3.13%	113.48	18	6.71%	0.37%
IL-Chicago	168.14	2006	4	27	67.00%	2.48%	123.70	2009	2	10	-26.43%	-2.64%	126.19	18	2.01%	0.11%
MA-Boston	182.01	2005	3	22	81.00%	3.68%	148.44	2009	1	14	-18.44%	-1.32%	168.62	19	13.59%	0.72%
MI-Detroit	126.67	2005	4	23	26.22%	1.14%	69.82	2009	2	14	-44.88%	-3.21%	94.70	18	35.63%	1.98%
MN-Minneapolis	170.94	2006	3	26	70.48%	2.71%	110.75	2009	2	11	-35.21%	-3.20%	138.77	18	25.30%	1.41%
NC-Charlotte	135.54	2007	3	30	34.93%	1.16%	119.68	2009	2	7	-11.70%	-1.67%	124.47	18	4.00%	0.22%
NV-Las Vegas	234.59	2006	3	26	133.63%	5.14%	104.44	2009	4	13	-55.48%	-4.27%	127.92	16	22.48%	1.41%
NY-New York	215.25	2006	3	26	115.25%	4.43%	170.69	2009	2	11	-20.70%	-1.88%	173.29	18	1.52%	0.08%
OH-Cleveland	123.05	2006	3	26	23.06%	0.89%	99.17	2009	1	10	-19.41%	-1.94%	105.25	19	6.13%	0.32%
OR-Portland	186.06	2007	3	30	85.17%	2.84%	147.43	2009	2	7	-20.76%	-2.97%	160.07	18	8.57%	0.48%
TX-Dallas	126.01	2007	3	30	24.41%	0.81%	112.41	2009	1	6	-10.79%	-1.80%	132.62	19	17.98%	0.95%
WA-Seattle	192.03	2007	3	30	90.30%	3.01%	144.12	2010	1	10	-24.95%	-2.49%	159.96	15	10.99%	0.73%
Composite-20	206.17	2006	3	26	104.33%	4.01%	140.40	2009	2	11	-31.90%	-2.90%	165.78	18	18.08%	1.00%

City	Temporary Rebound Substage						Temporary Drop Substage						Second Rebound Subtage			
	peak price	peak year	peak quarter	rise quarters (from 2000 Q1)	rise extent (from 2000 Q1)	rise speed (from 2000 Q1)	bottom price	bottom year	bottom quarter	drop quarters	drop extent	drop speed	price of 2013 Q4	rise quarters (by 2013 Q4)	rise extent (by 2013 Q4)	rise speed (by 2013 Q4)
AZ-Phoenix	110.68	2010	2	4	6.17%	1.54%	100.40	2011	3	5	-9.29%	-1.86%	144.61	9	44.03%	4.89%
CA-Los Angeles	175.73	2010	3	5	9.95%	1.99%	160.00	2012	1	6	-8.95%	-1.49%	214.76	7	34.23%	4.89%
CA-San Diego	163.81	2010	3	5	12.51%	2.50%	149.16	2012	1	6	-8.94%	-1.49%	194.03	7	30.08%	4.30%
CA-San Francisco	142.53	2010	3	6	17.97%	2.99%	125.35	2012	1	6	-12.05%	-2.01%	180.10	7	43.68%	6.24%
CO-Denver	128.31	2010	2	5	6.07%	1.21%	122.80	2012	1	7	-4.29%	-0.61%	146.48	7	19.28%	2.75%
DC-Washington	186.82	2010	3	6	10.77%	1.79%	175.87	2012	1	6	-5.86%	-0.98%	204.05	7	16.02%	2.29%
FL-Miami	148.94	2009	4	2	2.54%	1.27%	137.80	2011	4	8	-7.48%	-0.93%	175.74	8	27.53%	3.44%
FL-Tampa	142.95	2009	3	1	1.71%	1.71%	124.39	2012	1	10	-12.98%	-1.30%	154.78	7	24.43%	3.49%
GA-Atlanta	108.45	2010	3	5	1.98%	0.40%	83.75	2012	1	6	-22.78%	-3.80%	113.48	7	35.50%	5.07%
IL-Chicago	125.88	2010	3	5	1.76%	0.35%	105.33	2012	1	6	-16.33%	-2.72%	126.19	7	19.80%	2.83%
MA-Boston	157.82	2010	3	6	6.32%	1.05%	146.69	2012	1	6	-7.05%	-1.18%	168.62	7	14.95%	2.14%
MI-Detroit	71.09	2010	3	5	1.82%	0.36%	69.45	2012	1	6	-2.31%	-0.38%	94.70	7	36.36%	5.19%
MN-Minneapolis	125.64	2010	3	5	13.44%	2.69%	108.95	2011	2	3	-13.28%	-4.43%	138.77	10	27.37%	2.74%
NC-Charlotte	120.60	2009	3	1	0.77%	0.77%	109.01	2012	1	10	-9.61%	-0.96%	124.47	7	14.18%	2.03%
NV-Las Vegas	104.44	2009	4	0	0.00%	0.00%	90.00	2012	1	9	-13.83%	-1.54%	127.92	7	42.13%	6.02%
NY-New York	175.02	2010	3	5	2.54%	0.51%	157.95	2012	2	7	-9.75%	-1.39%	173.29	6	9.71%	1.62%
OH-Cleveland	106.03	2010	3	6	6.92%	1.15%	94.80	2012	1	6	-10.59%	-1.77%	105.25	7	11.02%	1.57%
OR-Portland	150.08	2009	3	1	1.80%	1.80%	129.52	2012	1	10	-13.70%	-1.37%	160.07	7	23.59%	3.37%
TX-Dallas	121.13	2009	3	2	7.76%	3.88%	113.28	2012	1	10	-6.48%	-0.65%	132.62	7	17.07%	2.44%
WA-Seattle	146.26	2010	2	1	1.48%	1.48%	130.08	2012	1	7	-11.06%	-1.58%	159.96	7	22.97%	3.28%
Composite-20	148.21	2010	3	5	5.56%	1.11%	134.45	2012	1	6	-9.28%	-1.55%	165.78	7	23.30%	3.33%

Panel B Housing prices measured by FHFA indices

City	Bubble Stage						Crisis Stage						Rebound Stage			
	peak price	peak year	peak quarter	rise quarters (from 2000 Q1)	rise extent (from 2000 Q1)	rise speed (from 2000 Q1)	bottom price	bottom year	bottom quarter	drop quarters	drop extent	drop speed	price of 2013 Q4	rise quarters (by 2013 Q4)	rise extent (by 2013 Q4)	rise speed (by 2013 Q4)
AZ-Phoenix	343.82	2006	2	25	120.91%	4.84%	192.63	2009	2	12	-43.97%	-3.66%	246.87	18	28.16%	1.56%
CA-Los Angeles	281.41	2006	3	26	184.42%	7.09%	175.88	2009	2	11	-37.50%	-3.41%	218.45	18	24.20%	1.34%
CA-San Diego	303.01	2005	3	22	145.83%	6.63%	190.52	2009	1	14	-37.12%	-2.65%	244.45	19	28.31%	1.49%
CA-San Francisco	280.09	2006	3	26	85.50%	3.29%	225.24	2009	2	11	-19.58%	-1.78%	287.97	18	27.85%	1.55%
CO-Denver	282.21	2007	2	29	35.96%	1.24%	257.52	2008	4	6	-8.75%	-1.46%	328.89	20	27.71%	1.39%
DC-Washington	288.86	2006	2	25	151.77%	6.07%	204.74	2009	1	11	-29.12%	-2.65%	262.95	19	28.43%	1.50%
FL-Miami	420.08	2007	2	29	190.77%	6.58%	226.37	2009	1	7	-46.11%	-6.59%	274.34	19	21.19%	1.12%
FL-Tampa	314.86	2006	2	25	131.82%	5.27%	192.96	2009	4	14	-38.72%	-2.77%	217.40	16	12.67%	0.79%
GA-Atlanta	201.89	2007	2	29	36.73%	1.27%	164.06	2009	1	7	-18.74%	-2.68%	179.84	19	9.62%	0.51%
IL-Chicago	240.62	2007	2	29	71.60%	2.47%	183.08	2010	1	11	-23.91%	-2.17%	184.29	15	0.66%	0.04%
MA-Boston	276.24	2005	3	22	86.12%	3.91%	229.92	2009	1	14	-16.77%	-1.20%	254.21	19	10.56%	0.56%
MI-Detroit	212.16	2005	2	21	21.13%	1.01%	121.98	2009	3	17	-42.51%	-2.50%	148.22	17	21.51%	1.27%
MN-Minneapolis	265.61	2006	2	25	65.78%	2.63%	207.60	2009	1	11	-21.84%	-1.99%	227.81	19	9.74%	0.51%
NC-Charlotte	197.47	2007	3	30	39.10%	1.30%	186.29	2008	4	5	-5.66%	-1.13%	193.71	20	3.98%	0.20%
NV-Las Vegas	270.14	2006	2	25	125.51%	5.02%	117.99	2009	4	14	-56.32%	-4.02%	148.75	16	26.07%	1.63%
NY-New York	274.94	2006	3	26	118.62%	4.56%	237.99	2009	4	13	-13.44%	-1.03%	231.67	16	-2.66%	-0.17%
OH-Cleveland	176.99	2006	2	25	21.37%	0.85%	142.78	2009	1	11	-19.33%	-1.76%	149.87	19	4.97%	0.26%
OR-Portland	345.58	2007	3	30	89.09%	2.97%	280.85	2010	1	10	-18.73%	-1.87%	308.96	15	10.01%	0.67%
TX-Dallas	175.09	2007	2	29	30.75%	1.06%	170.14	2009	1	7	-2.83%	-0.40%	198.37	19	16.59%	0.87%
WA-Seattle	304.82	2007	3	30	94.03%	3.13%	245.72	2009	3	8	-19.39%	-2.42%	261.16	17	6.28%	0.37%

City	Temporary Rebound Substage						Temporary Drop Substage						Second Rebound Subtage			
	peak price	peak year	peak quarter	rise quarters (from 2000 Q1)	rise extent (from 2000 Q1)	rise speed (from 2000 Q1)	bottom price	bottom year	bottom quarter	drop quarters	drop extent	drop speed	price of 2013 Q4	rise quarters (by 2013 Q4)	rise extent (by 2013 Q4)	rise speed (by 2013 Q4)
AZ-Phoenix	193.37	2009	3	1	0.38%	0.38%	163.18	2011	3	8	-15.61%	-1.95%	246.87	9	51.29%	5.70%
CA-Los Angeles	182.05	2010	2	4	3.51%	0.88%	167.15	2012	1	7	-8.18%	-1.17%	218.45	7	30.69%	4.38%
CA-San Diego	203.98	2010	3	6	7.06%	1.18%	189.44	2011	4	5	-7.13%	-1.43%	244.45	8	29.04%	3.63%
CA-San Francisco	239.21	2010	1	3	6.20%	2.07%	218.86	2011	2	5	-8.51%	-1.70%	287.97	10	31.58%	3.16%
CO-Denver	275.85	2010	2	6	7.12%	1.19%	261.45	2011	1	3	-5.22%	-1.74%	328.89	11	25.79%	2.34%
DC-Washington	229.76	2010	2	5	12.22%	2.44%	219.41	2011	1	3	-4.50%	-1.50%	262.95	11	19.84%	1.80%
FL-Miami	240.86	2009	3	2	6.40%	3.20%	216.19	2011	1	6	-10.24%	-1.71%	274.34	11	26.90%	2.45%
FL-Tampa	192.71	2010	3	3	-0.13%	-0.04%	171.71	2011	1	2	-10.90%	-5.45%	217.40	11	26.61%	2.42%
GA-Atlanta	172.03	2009	3	2	4.86%	2.43%	138.53	2012	1	10	-19.47%	-1.95%	179.84	7	29.82%	4.26%
IL-Chicago	187.76	2010	2	1	2.56%	2.56%	159.38	2012	1	7	-15.12%	-2.16%	184.29	7	15.63%	2.23%
MA-Boston	238.18	2010	1	4	3.59%	0.90%	225.55	2011	4	7	-5.30%	-0.76%	254.21	8	12.71%	1.59%
MI-Detroit	125.28	2009	4	1	2.71%	2.71%	113.78	2012	1	9	-9.18%	-1.02%	148.22	7	30.27%	4.32%
MN-Minneapolis	213.10	2010	3	6	2.65%	0.44%	188.61	2011	1	2	-11.49%	-5.75%	227.81	11	20.78%	1.89%
NC-Charlotte	174.92	2010	4	8	-6.10%	-0.76%	159.72	2011	1	1	-8.69%	-8.69%	193.71	11	21.28%	1.93%
NV-Las Vegas	119.39	2010	2	2	0.011865	0.00593	99.94	2012	1	7	-0.16291	-0.0233	148.75	7	48.84%	6.98%
NY-New York	239.51	2010	3	3	0.64%	0.21%	221.35	2012	1	6	-7.58%	-1.26%	231.67	7	4.66%	0.67%
OH-Cleveland	150.73	2010	3	6	5.57%	0.93%	135.99	2012	2	7	-9.78%	-1.40%	149.87	6	10.21%	1.70%
OR-Portland	287.56	2010	2	1	2.39%	2.39%	250.95	2012	1	7	-12.73%	-1.82%	308.96	7	23.12%	3.30%
TX-Dallas	174.98	2010	3	6	2.84%	0.47%	166.54	2011	4	5	-4.82%	-0.96%	198.37	8	19.11%	2.39%
WA-Seattle	248.72	2009	4	1	1.22%	1.22%	207.13	2011	4	8	-16.72%	-2.09%	261.16	8	26.09%	3.26%

This table reports results of city-level statistical analysis. Each city is identified for its three main stages during the sample period, including the bubble, crisis and rebound stages, as well as the three substages of the rebound stage - the temporary rebound, temporary drop and second rebound substages. Its housing price peak or bottom month, duration, extent and speed of housing price rise or drop at each stage are recorded. Panel A reports the results with the CS data, and Panel B reports the results with the FHFA data.

Table 2 Fundamental Home Price

Panel A Estimates for CS Home Price Indices

Parameter		Estimate	Stderr	Pr>|t|
beta -	after QE	-0.241	0.042	<0.0001
beta -	before QE	-0.299	0.043	<0.0001
alpha -	Atlanta-Sandy Springs-Marietta, GA	1.344	0.096	<0.0001
alpha -	Boston-Cambridge-Quincy, MA-NH	2.217	0.081	<0.0001
alpha -	Charlotte-Gastonia-Rock Hill, NC-SC	1.396	0.098	<0.0001
alpha -	Chicago-Joliet-Naperville, IL-IN-WI	1.525	0.086	<0.0001
alpha -	Cleveland-Elyria-Mentor, OH	1.337	0.112	<0.0001
alpha -	Denver-Aurora-Broomfield, CO	2.258	0.093	<0.0001
alpha -	Detroit-Warren-Livonia, MI	1.393	0.103	<0.0001
alpha -	Las Vegas-Paradise, NV	1.785	0.102	<0.0001
alpha -	Los Angeles-Long Beach-Santa Ana, CA	2.73	0.096	<0.0001
alpha -	Miami-Fort Lauderdale-Pompano Beach, FL	2.518	0.101	<0.0001
alpha -	Minneapolis-St. Paul-Bloomington, MN-WI	1.514	0.075	<0.0001
alpha -	New York-Northern New Jersey-Long Island, NY-NJ	2.201	0.081	<0.0001
alpha -	Phoenix-Mesa-Glendale, AZ	1.873	0.086	<0.0001
alpha -	Portland-Vancouver-Hillsboro, OR-WA	2.084	0.087	<0.0001
alpha -	San Diego-Carlsbad-San Marcos, CA	2.154	0.076	<0.0001
alpha -	San Francisco-Oakland-Fremont, CA	2.01	0.076	<0.0001
alpha -	Seattle-Tacoma-Bellevue, WA	1.711	0.071	<0.0001
alpha -	Tampa-St. Petersburg-Clearwater, FL	1.821	0.086	<0.0001
alpha -	Washington-Arlington-Alexandria, DC-VA-MD-WV	1.743	0.066	<0.0001

Panel B Estimates for FHFA Home Price Indices

Parameter		Estimate	Stderr	Pr>|t|
beta -	after QE	-0.3	0.041	<0.0001
beta -	before QE	-0.348	0.042	<0.0001
alpha -	Atlanta-Sandy Springs-Marietta, GA	1.367	0.095	<0.0001
alpha -	Boston-Cambridge-Quincy, MA-NH	2.147	0.081	<0.0001
alpha -	Charlotte-Gastonia-Rock Hill, NC-SC	1.46	0.098	<0.0001
alpha -	Chicago-Joliet-Naperville, IL-IN-WI	1.488	0.086	<0.0001
alpha -	Cleveland-Elyria-Mentor, OH	1.115	0.111	<0.0001
alpha -	Dallas-Fort Worth-Arlington, TX	1.337	0.084	<0.0001
alpha -	Denver-Aurora-Broomfield, CO	2.21	0.092	<0.0001
alpha -	Detroit-Warren-Livonia, MI	1.218	0.103	<0.0001
alpha -	Las Vegas-Paradise, NV	1.455	0.102	<0.0001
alpha -	Los Angeles-Long Beach-Santa Ana, CA	2.581	0.095	<0.0001
alpha -	Miami-Fort Lauderdale-Pompano Beach, FL	2.772	0.101	<0.0001
alpha -	Minneapolis-St. Paul-Bloomington, MN-WI	1.558	0.075	<0.0001
alpha -	New York-Northern New Jersey-Long Island, NY-NJ	2.167	0.081	<0.0001
alpha -	Phoenix-Mesa-Glendale, AZ	1.912	0.085	<0.0001
alpha -	Portland-Vancouver-Hillsboro, OR-WA	2.111	0.086	<0.0001
alpha -	San Diego-Carlsbad-San Marcos, CA	2.097	0.076	<0.0001
alpha -	San Francisco-Oakland-Fremont, CA	2.159	0.076	<0.0001
alpha -	Seattle-Tacoma-Bellevue, WA	1.718	0.07	<0.0001
alpha -	Tampa-St. Petersburg-Clearwater, FL	1.938	0.085	<0.0001
alpha -	Washington-Arlington-Alexandria, DC-VA-MD-WV	1.808	0.066	<0.0001

Note: since the 2008 financial crisis, the US Federal Reserve adopted Quantitative Easing (QE). In order to capture the impact of the QE policy, we estimate beta separately. The data used for this regression covers a period from the 1st quarter of 1991 to the 4th quarter of 2013.

Table 3 Coefficients of correlations among cross-sectional price change variables of varied stages

Panel A Housing prices measured by CS indices

		Price						Price-to-fundamental ratio					
		Bubble: rise rate	Bubble: rise speed	Crisis: drop rate	Crisis: drop speed	Rebou: rise rate	Rebou: rise speed	Bubble: rise rate	Bubble: rise speed	Crisis: drop rate	Crisis: drop speed	Rebou: rise rate	Rebou: rise speed
Price	Bubble: rise rate	1.000											
	Bubble: rise speed	0.990	1.000										
	Crisis: drop rate	**-0.629**	-0.635	1.000									
	Crisis: drop speed	-0.608	**-0.567**	0.901	1.000								
	Rebound: rise rate	**0.360**	0.400	**-0.712**	-0.589	1.000							
	Rebound: rise speed	0.375	**0.412**	-0.742	**-0.614**	0.997	1.000						
Price-to-fundamental ratio	Bubble: rise rate	**0.832**	0.829	-0.695	-0.707	0.337	0.345	1.000					
	Bubble: rise speed	0.850	**0.863**	-0.715	-0.681	0.385	0.393	0.992	1.000				
	Crisis: drop rate	-0.545	-0.586	**0.762**	0.659	-0.696	-0.702	**-0.739**	-0.767	1.000			
	Crisis: drop speed	-0.458	-0.462	0.619	**0.691**	-0.573	-0.568	-0.708	**-0.694**	0.912	1.000		
	Rebound: rise rate	0.183	0.229	-0.600	-0.517	**0.794**	0.800	**0.292**	0.327	**-0.791**	-0.727	1.000	
	Rebound: rise speed	0.197	0.242	-0.620	-0.534	0.783	**0.793**	0.319	**0.353**	-0.807	**-0.739**	0.998	1.000

Panel B Housing prices measured by FHFA indices

		Price						Price-to-fundamental ratio					
		Bubble: rise rate	Bubble: rise speed	Crisis: drop rate	Crisis: drop speed	Rebou: rise rate	Rebou: rise speed	Bubble: rise rate	Bubble: rise speed	Crisis: drop rate	Crisis: drop speed	Rebou: rise rate	Rebou: rise speed
Price	Bubble: rise rate	1.000											
	Bubble: rise speed	0.983	1.000										
	Crisis: drop rate	**-0.609**	-0.629	1.000									
	Crisis: drop speed	-0.667	**-0.606**	0.818	1.000								
	Rebound: rise rate	**0.369**	0.418	**-0.506**	-0.412	1.000							
	Rebound: rise speed	0.380	**0.428**	-0.571	**-0.438**	0.992	1.000						
Price-to-fundamental ratio	Bubble: rise rate	**0.954**	0.936	-0.737	-0.745	0.358	0.391	1.000					
	Bubble: rise speed	0.942	**0.957**	-0.758	-0.687	0.412	0.444	0.984	1.000				
	Crisis: drop rate	-0.625	-0.663	**0.849**	0.715	-0.640	-0.667	**-0.741**	-0.776	1.000			
	Crisis: drop speed	-0.572	-0.556	0.652	**0.745**	-0.567	-0.561	-0.662	**-0.641**	0.896	1.000		
	Rebound: rise rate	0.246	0.294	-0.486	-0.466	**0.811**	0.790	**0.268**	0.319	**-0.609**	-0.531	1.000	
	Rebound: rise speed	0.242	0.292	-0.510	-0.473	0.808	**0.794**	0.276	**0.329**	-0.618	**-0.520**	0.997	1.000

This table reports the coefficients of the correlations among main statistical analysis variables (displayed in Table 1) of different stages.

Table 4 Effects of price change patterns of previous stages without the fundamental adjustment

Panel A Regression of quarterly CS return

	Crisis-stage				Rebound-stage							
Variable	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val
Intercept	-0.006	0.388	-0.005	0.500	-0.005	0.234	-0.011	0.017 **	-0.005	0.235	-0.010	0.027 **
Quarterly CS return (-1)	0.731	<.0001 ***	0.724	<.0001 ***	0.377	<.0001 ***	0.366	<.0001 ***	0.379	<.0001 ***	0.365	<.0001 ***
Quarterly CS return (-2)	-0.480	<.0001 ***	-0.476	<.0001 ***	-0.178	0.001 ***	-0.176	0.001 ***	-0.177	0.001 ***	-0.172	0.001 ***
Quarterly CS return (-3)	0.364	0.001 ***	0.358	0.001 ***	0.002	0.977	0.000	0.994	0.003	0.962	0.000	0.997
Quarterly CS return (-4)	0.151	0.145	0.165	0.114	0.150	0.003 ***	0.157	0.002 ***	0.151	0.003 ***	0.163	0.001 ***
Bubble-stage price change speed	-0.253	0.000 ***			0.122	0.013 **						
Crisis-stage price change speed							-0.364	<.0001 ***				
Bubble-stage price change extent			-0.011	0.000 ***					0.005	0.020 **		
Crisis-stage price change extent											-0.029	<.0001 ***
Quarter dummies	Yes		Yes		Yes		Yes		Yes		Yes	
Year dummies	Yes		Yes		Yes		Yes		Yes		Yes	
Number of observations	204		204		342		342		342		342	
Adjusted R^2	0.762		0.764		0.705		0.711		0.705		0.714	

Panel B Regression of quarterly FHFA return

	Crisis-stage				Rebound-stage							
Variable	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val
Intercept	-0.010	0.240	-0.008	0.334	0.003	0.576	0.001	0.799	0.003	0.576	0.001	0.919
Quarterly FHFA return (-1)	0.013	0.904	0.010	0.925	-0.044	0.453	-0.048	0.412	-0.043	0.465	-0.051	0.384
Quarterly FHFA return (-2)	0.421	<.0001 ***	0.422	<.0001 ***	0.012	0.833	0.013	0.815	0.013	0.818	0.012	0.826
Quarterly FHFA return (-3)	0.192	0.022 **	0.199	0.016 **	0.102	0.053 *	0.110	0.038 **	0.103	0.051 *	0.114	0.028 **
Quarterly FHFA return (-4)	0.000	0.998	0.010	0.923	0.174	0.001 ***	0.184	0.000 ***	0.174	0.001 ***	0.188	0.000 ***
Bubble-stage price change speed	-0.258	0.002 ***			0.110	0.060 *						
Crisis-stage price change speed							-0.224	0.038 **				
Bubble-stage price change extent			-0.010	0.003 ***					0.004	0.096 *		
Crisis-stage price change extent											-0.024	0.010 **
Quarter dummies	Yes		Yes		Yes		Yes		Yes		Yes	
Year dummies	Yes		Yes		Yes		Yes		Yes		Yes	
Number of observations	214		214		358		358		358		358	
Adjusted R^2	0.532		0.534		0.556		0.559		0.556		0.562	

This table reports the results of our main regression highlighted in Equation (2), with price unadjusted for the fundamental value. In Panels A and B, the dependent variables are the quarterly CS return and the quarterly FHFA return, respectively, during 2000 Q1~2013Q4. In each panel, the independent variables include the 1-quarter, 2-quarter, 3-quarter and 4-quarter lagged terms of the dependent variable, and a previous-stage local price change speed or extent reported in Table 1. Regressions reported in Panel A exclude the data of Dallas, while regressions in Panel B include the data of Dallas. Quarter dummies and year dummies are also included to control for the fixed effects. Results are estimated from OLS regressions with panel data, and White standard errors are used to control for the heteroskedasticity. ***, ** and * indicate significance at the 1% level, 5% level and 10% level, respectively.

Table 5 Effects of price change patterns of previous stages with the fundamental adjustment

Panel A Regression of quarterly change rate of CS price-to-fundamental-ratio

	Crisis-stage				Rebound-stage							
Variable	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val
Intercept	-0.069	<.0001 ***	-0.070	<.0001 ***	-0.013	0.003 ***	-0.006	0.136	-0.012	0.004 ***	-0.006	0.135
Quarterly ratio change rate (-1)	-0.502	<.0001 ***	-0.490	<.0001 ***	0.268	<.0001 ***	0.352	<.0001 ***	0.269	<.0001 ***	0.344	<.0001 ***
Quarterly ratio change rate (-2)	-0.435	<.0001 ***	-0.418	<.0001 ***	-0.157	0.005 ***	-0.190	0.000 ***	-0.156	0.005 ***	-0.193	0.000 ***
Quarterly ratio change rate (-3)	-0.489	<.0001 ***	-0.477	<.0001 ***	-0.101	0.047 **	0.001	0.988	-0.100	0.049 **	-0.004	0.950
Quarterly ratio change rate (-4)	-0.317	<.0001 ***	-0.313	<.0001 ***	0.103	0.035 **	0.137	0.006 ***	0.104	0.034 **	0.136	0.006 ***
Bubble-stage ratio change speed	-3.241	<.0001 ***			0.366	0.003 ***						
Crisis-stage ratio change speed							-0.320	0.001 ***				
Bubble-stage price change extent			-0.119	<.0001 ***					0.014	0.004 ***		
Crisis-stage price change extent											-0.032	<.0001 ***
Quarter dummies	Yes		Yes		Yes		Yes		Yes		Yes	
Year dummies	Yes		Yes		Yes		Yes		Yes		Yes	
Number of observations	204		204		342		342		342		342	
Adjusted R^2	0.645		0.633		0.686		0.711		0.686		0.715	

Panel B Regression of quarterly change rate of FHFA price-to-fundamental-ratio

	Crisis-stage				Rebound-stage							
Variable	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val
Intercept	-0.022	0.027 **	-0.023	0.023 **	-0.002	0.715	0.007	0.179	-0.002	0.769	0.005	0.317
Quarterly ratio change rate (-1)	-0.364	<.0001 ***	-0.343	<.0001 ***	-0.068	0.223	-0.093	0.099 *	-0.065	0.241	-0.100	0.070 *
Quarterly ratio change rate (-2)	-0.364	<.0001 ***	-0.345	<.0001 ***	-0.027	0.618	-0.003	0.955	-0.026	0.639	-0.007	0.907
Quarterly ratio change rate (-3)	-0.399	<.0001 ***	-0.381	<.0001 ***	-0.025	0.671	0.088	0.093 *	-0.024	0.685	0.091	0.076 *
Quarterly ratio change rate (-4)	-0.392	<.0001 ***	-0.380	<.0001 ***	0.041	0.299	0.164	0.001 ***	0.041	0.302	0.170	0.001 ***
Bubble-stage ratio change speed	-3.324	<.0001 ***			0.403	0.007 ***						
Crisis-stage ratio change speed							-0.178	0.012 **				
Bubble-stage price change extent			-0.123	<.0001 ***					0.014	0.017 **		
Crisis-stage price change extent											-0.026	0.001 ***
Quarter dummies	Yes		Yes		Yes		Yes		Yes		Yes	
Year dummies	Yes		Yes		Yes		Yes		Yes		Yes	
Number of observations	214		214		358		358		358		358	
Adjusted R^2	0.586		0.571		0.539		0.555		0.537		0.561	

This table reports the results of our main regression highlighted in Equation (2), with price adjusted for the fundamental value. In Panels A and B, the dependent variables are the quarterly change rate of CS price-to-fundamental ratio and that of FHFA price-to-fundamental ratio, respectively, during 2000 Q1~2013Q4. In each panel, the independent variables include the 1-quarter, 2-quarter, 3-quarter and 4-quarter lagged terms of the dependent variable, and a previous-stage local price-to-fundamental change speed or extent reported in Table 1. Regressions reported in Panel A exclude the data of Dallas, while regressions in Panel B include the data of Dallas. Quarter dummies and year dummies are also included to control for the fixed effects. Results are estimated from OLS regressions with panel data, and White standard errors are used to control for the heteroskedasticity. ***, ** and * indicate significance at the 1% level, 5% level and 10% level, respectively.

Figure 1 Examples of Different Housing Price and Fundamental Patterns

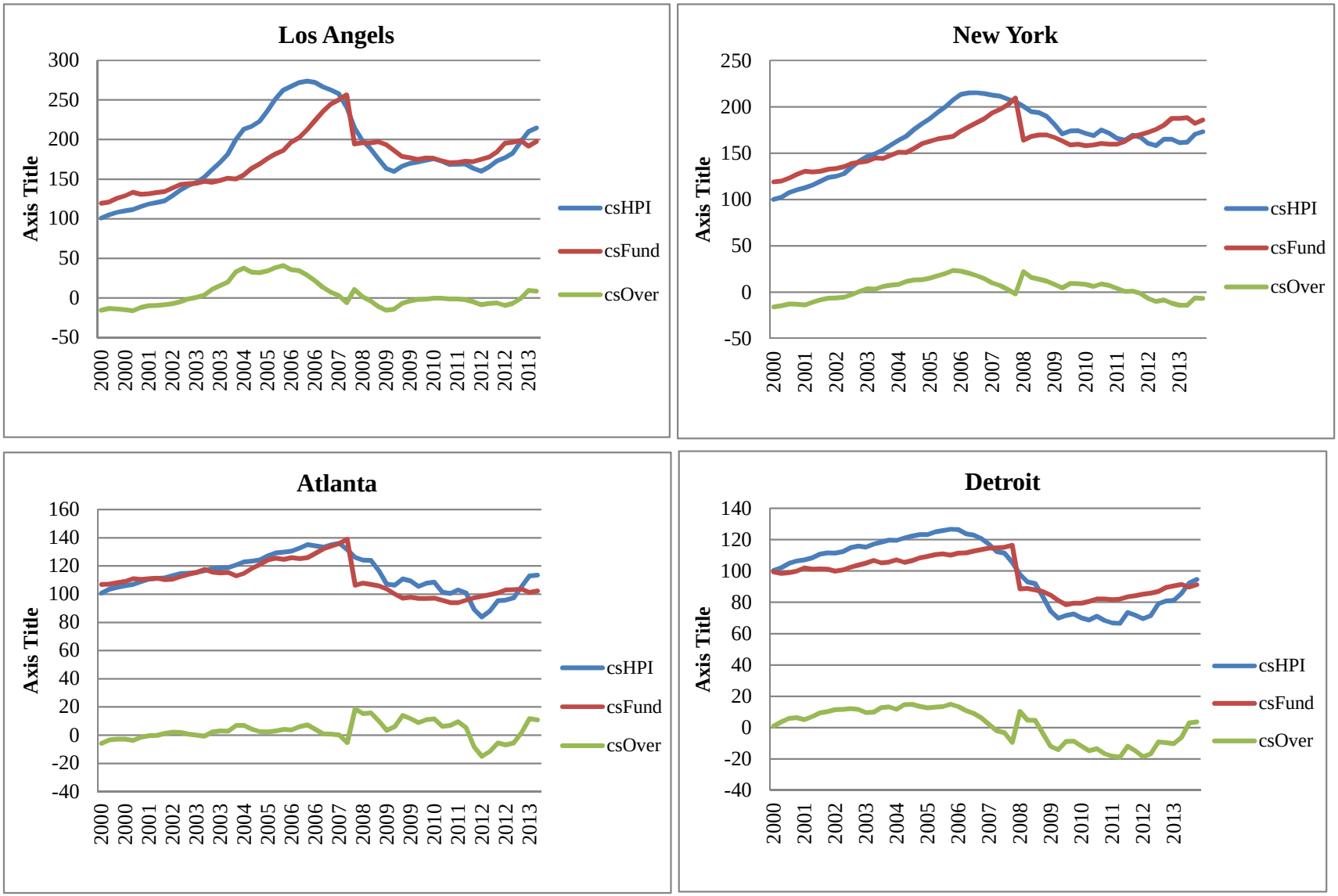
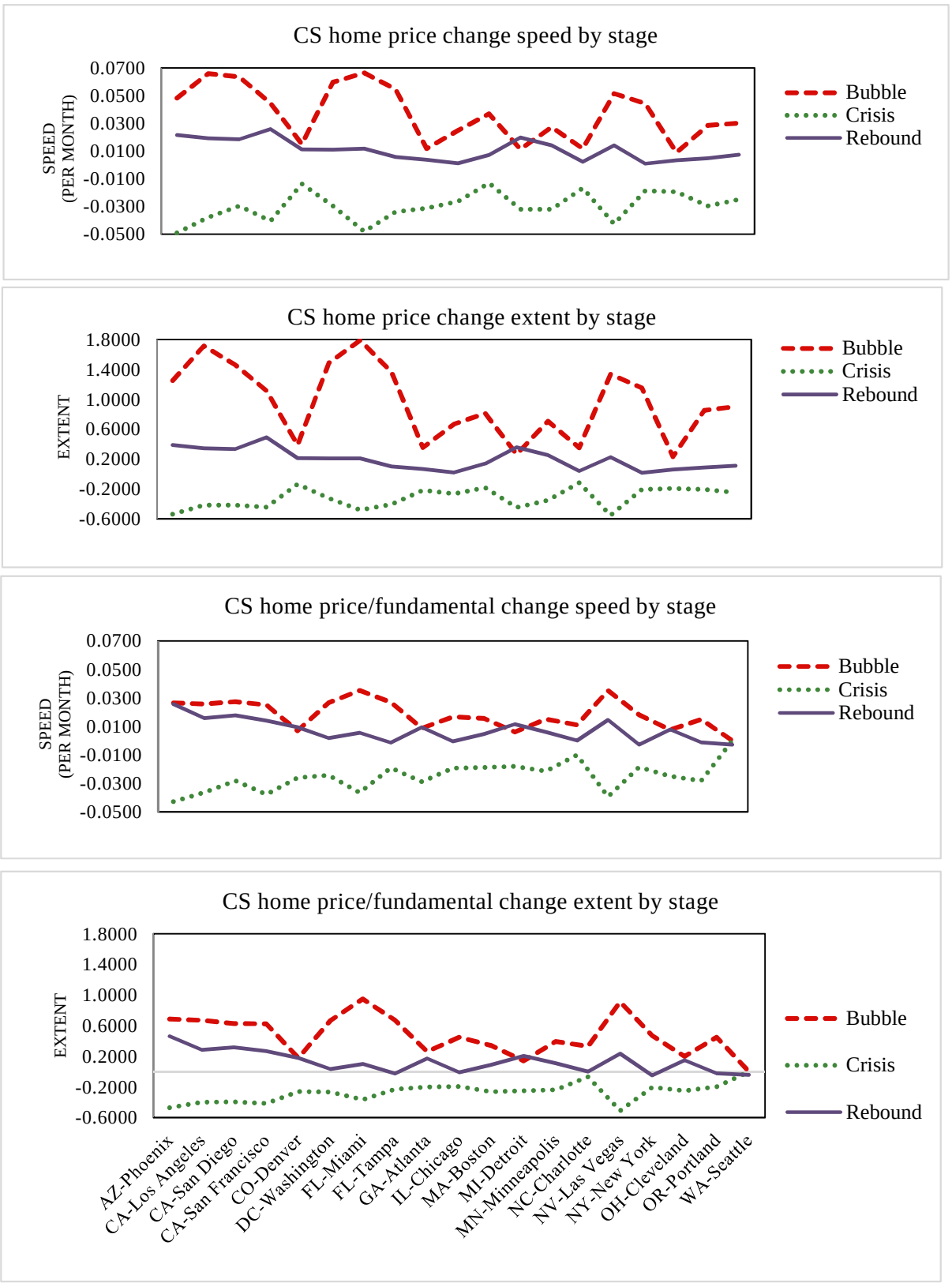
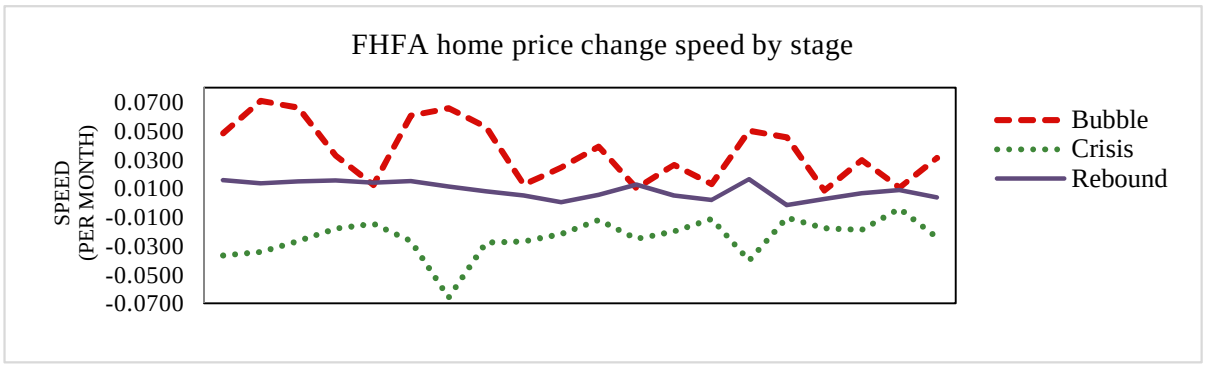
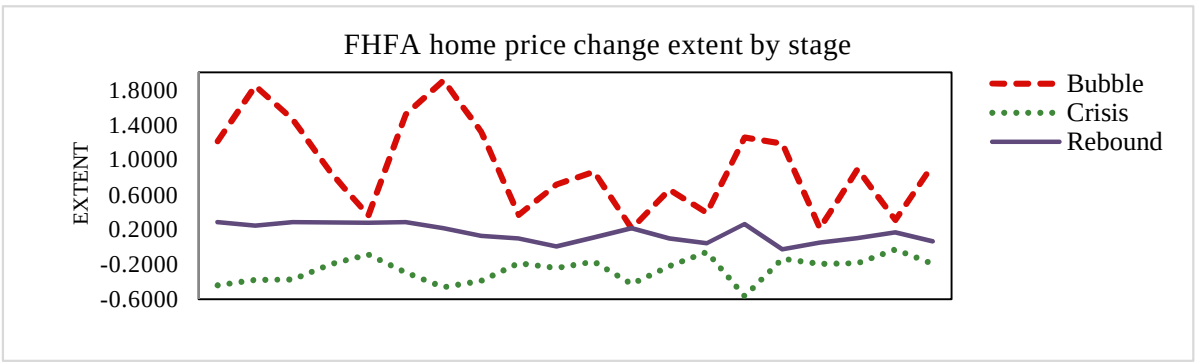
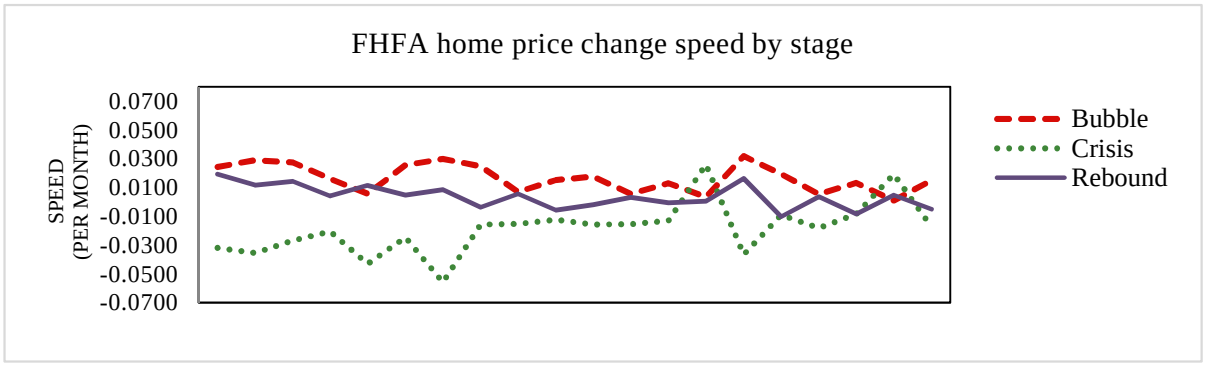


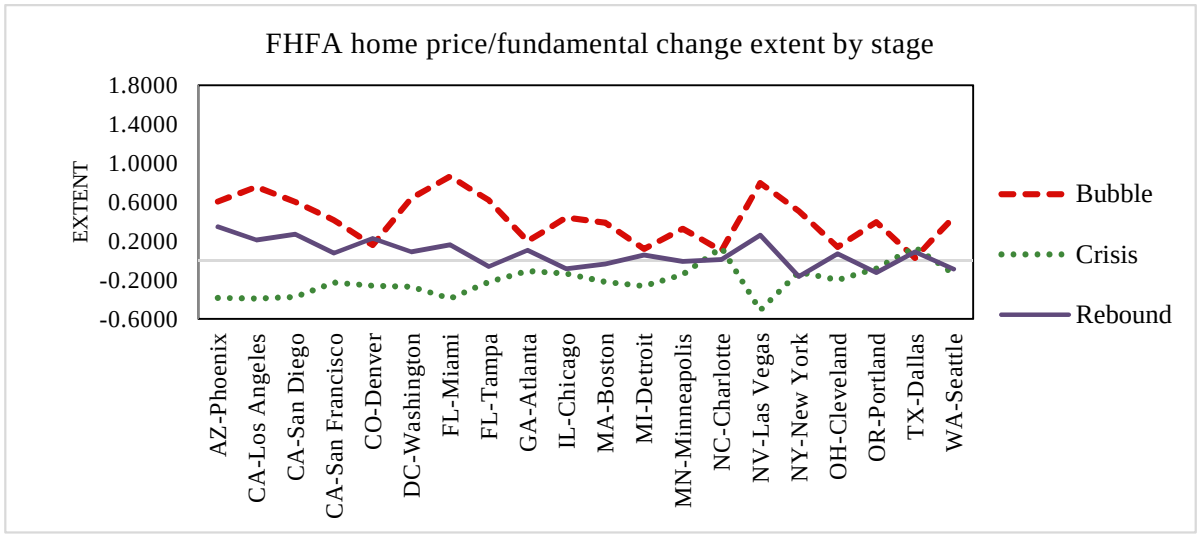
Figure 2 Cross-City Variations in Housing Price Change by Stage




FHFA home price change speed by stage
SPEED (PER MONTH)
0.0700
0.0500
0.0300
0.0100
-0.0100
-0.0300
-0.0500
-0.0700
Bubble
Crisis
Rebound


FHFA home price change extent by stage
EXTENT
1.8000
1.4000
1.0000
0.6000
0.2000
-0.2000
-0.6000
Bubble
Crisis
Rebound


FHFA home price change speed by stage
SPEED (PER MONTH)
0.0700
0.0500
0.0300
0.0100
-0.0100
-0.0300
-0.0500
-0.0700
Bubble
Crisis
Rebound


FHFA home price/fundamental change extent by stage
EXTENT
1.8000
1.4000
1.0000
0.6000
0.2000
-0.2000
-0.6000
AZ-Phoenix
CA-Los Angeles
CA-San Diego
CA-San Francisco
CO-Denver
DC-Washington
FL-Miami
FL-Tampa
GA-Atlanta
IL-Chicago
MA-Boston
MI-Detroit
MN-Minneapolis
NC-Charlotte
NV-Las Vegas
NY-New York
OH-Cleveland
OR-Portland
TX-Dallas
WA-Seattle
Bubble
Crisis
Rebound