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Tracking the Housing Bubble Across Metropolitan Areas—A Spatio-Temporal Comparison of House Price Indices

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Abstract

This article presents an analysis of five available house price indices that are used to track house prices at the metropolitan area level. These five indices are (1) the Federal Housing Finance Agency (FHFA) House Price Index (HPI), (2) the Standard & Poor's/Case-Shiller® Home Price Indices, (3) an adjusted version of the FHFA House Price Index, (4) the Zillow Home Value Index, and (5) the NATIONAL ASSOCIATION OF REALTORS® Median Home Price. This study first discusses the strengths and weaknesses of these indices for use in a spatio-temporal analysis. Then, it provides a comparative analysis of their change rate for 10 metropolitan statistical areas (MSAs) for two time periods: the third quarter of 2006 through the third quarter of 2007 and the first quarter of 2007 through the first quarter of 2008. In addition, this research constructs a series of spatio-temporal indicators based on time and spatial lags of the HPI for 302 MSAs for the 2000-to-2007 period. The results of this data brief could help researchers interested in spatio-temporal analyses of the latest housing bubble and of house price indices at large.

Introduction

Most of the United States has witnessed sharp changes in house prices during the past 5 years. Along with other factors, the contracting housing market has slowed the growth rate of the U.S. economy since 2007 (Federal Reserve, 2008; Joint Center for Housing Studies, 2008). Acknowledging the influence of the housing market on the economy, the federal government took several measures during the past 2 years, such as the Housing and Economic Recovery Act of 2008, the conservatorship of Fannie Mae and Freddie Mac, and additional funding for housing in the Recovery Act of 2009.¹

Before the major tightening of the housing market in 2008, experts had no agreement on the existence of a “housing bubble” in the United States. Stiglitz (1990: 13) defined an asset bubble the following way: “if the reason that the price is high today is only because investors believe that the selling price will be high tomorrow—when ‘fundamental’ factors do not seem to justify such a high price—then a bubble exists.” Some researchers concluded that the U.S. house price changes in the first half of the 2000s fit the trend (Himmelberg, Mayer, and Sinai, 2005; Smith and Smith, 2006), with no bubble and especially no burst in sight. Others (Case and Shiller, 2003; Krugman, 2005) pointed to irrational overpricing and speculative investments (Shiller, 2008).

During this debate about the housing bubble, it was unclear which house price index was the most appropriate for tracking the price changes across time and space. This data brief presents an analysis of five available house price indices that are used to track single-family house prices at the metropolitan area level. This study first discusses their strengths and weaknesses for use in a spatio-temporal analysis. Then, it provides a comparative analysis of home price change rates for 10 metropolitan statistical areas (MSAs) during two separate time periods: the third quarter of 2006 through the third quarter of 2007 and the first quarter of 2007 through the first quarter of 2008. In addition, this research constructs a series of spatio-temporal indicators based on time and spatial lags of the HPI for 302 MSAs during the 2000-to-2007 period.

House Price Indices

Five major house price indices are available at the metropolitan area level in the United States:² (1) the Federal Housing Finance Agency (FHFA) House Price Index (HPI), (2) the Standard & Poor’s/Case-Shiller® Home Price Indices (S&P/Case-Shiller®), (3) an adjusted version of the FHFA House Price Index (adjusted HPI), (4) the Zillow Home Value Index, and (5) the NATIONAL ASSOCIATION OF REALTORS® (NAR) Median Sales Price of existing homes.³

¹ For more information about the conservatorship of Fannie Mae and Freddie Mac, see Goldfarb, Cho, and Appelbaum (2008). The American Recovery and Reinvestment Act of 2009 provided an additional \$2 billion for the Neighborhood Stabilization Program (NSP) on top of the \$4 billion from the Housing and Economic Recovery Act (HUD, 2010).

² This data brief uses the Office of Management and Budget (OMB) definition of a metropolitan statistical area, with “at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties” (OMB, 2009: 8). This study focuses on the metropolitan areas because they concentrate most of the U.S. population. For more information about the demographics and role of the metropolitan areas in the United States, see Berube et al (2010).

³ The Office of Federal Housing Enterprise Oversight (OFHEO) was the original agency that created the HPI in 1996. This office was incorporated in the FHFA in 2008, based on the Housing and Economic Recovery Act of 2008.

The FHFA HPI measures the average price change in the sales or refinancing of the same single-family homes with mortgages purchased or securitized by the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac) in a particular geographical area (Calhoun, 1996). The HPI methodology is a modified version of the weighted-repeat sales methodology proposed by Case and Shiller (1989).

One advantage of the HPI is the control it provides for differences in the quality of the homes in its sample, given that the data come from repeated transactions on the same property (Calhoun, 1996). Further, the FHFA provides two types of HPI with large national samples: a purchase-only index (based only on sales prices) and an all-transactions index (based on sales prices and appraisal valuations for refinancing purposes) (FHFA, 2010b).

The all-transactions HPI (the HPI) has detailed temporal and spatial coverage at the metropolitan area level and it is available free of charge on the FHFA website. The FHFA estimates both the purchase-only HPI and the HPI for the United States, the 9 census divisions, the 50 states, and the District of Columbia. Only the HPI has full coverage of the 366 metropolitan areas in the United States, however, the purchase-only HPI is being calculated only for the largest 25 metropolitan areas. For 11 large metropolitan areas, the FHFA estimates the HPI for their metropolitan division components, going below the metropolitan area level.⁴ The HPI estimates at both the metropolitan area level and metropolitan division level are based on large samples, with at least 1,000 accumulated transactions (FHFA, 2010b).

The FHFA estimates quarterly the HPI at the metropolitan area level, not seasonally adjusted, and it reports it with a 2-month lag. The HPI equals 100 points for all the metropolitan areas in the first quarter of 1995. The HPI quarterly time series extends back to 1975 for most of the metropolitan areas, depending on the fulfillment of the 1,000 accumulated transactions criterion. The FHFA revises the historical estimates each quarter, based on updated information provided by Fannie Mae and Freddie Mac and the revised definitions of the metropolitan statistical areas from the Office of Management and Budget (OMB) (FHFA, 2010b). This quarterly revision allows for the comparability of the HPI estimates for a metropolitan area for all the available quarters.

Two major weaknesses of the HPI during the latest housing bubble were the low price ceiling of its underlying data and the limitation to houses backed by Fannie Mae and Freddie Mac financing. The FHFA calculates the HPI based on mortgage data from Fannie Mae and Freddie Mac, capped at relatively low ceilings during the boom years of 2004 to 2007. Although the Fannie Mae mortgage limit for a single unit home was \$417,000 in 2007, the median sale price for an existing single-family home was more than \$800,000 in the San Jose and San Francisco metropolitan areas (Fannie Mae, 2009; NAR, 2008).⁵ Consequently, the HPI did not capture the highest house prices

⁴ The FHFA calculates the all transactions HPI by metropolitan division for the following metropolitan areas: Boston-Cambridge-Quincy, MA-NH; Chicago-Naperville-Joliet, IL-IN-WI; Dallas-Fort Worth-Arlington, TX; Detroit-Warren-Livonia, MI; Los Angeles-Long Beach-Santa Ana, CA; Miami-Fort Lauderdale-Miami Beach, FL; New York-Northern New Jersey-Long Island, NY-NJ-PA; Philadelphia-Camden-Wilmington, PA-NJ-DE-MD; San Francisco-Oakland-Fremont, CA; Seattle-Tacoma-Bellevue, WA; and Washington-Arlington-Alexandria, DC-VA-MD-WV (FHFA, 2010b). For the definition of metropolitan division, see OMB (2009).

⁵ Beginning with 2008, the FHFA allows Fannie Mae and Freddie Mac to purchase or securitize mortgages up to \$729,750 for one-unit properties in high-cost areas in the contiguous United States (Fannie Mae, 2009).

during the latest housing boom and the spatial concentration of these high house prices. Further, an analysis of the differences between HPI and the S&P/Case-Schiller showed that the inclusion of houses with alternative financing diminished the HPI appreciation rates during the boom years (OFHEO, 2008a).

The HPI faces other limitations. This house index focuses only on existing single-family houses, not reflecting price changes in the sales or refinancing of other types of housing properties and new houses. Further, due to its appraisal component from refinancing transactions, the HPI tends to lag, because the appraisals are based on historical data. The quarterly revisions of the historical estimates of the HPI limit the comparison of HPI changes to the same quarterly dataset. For example, the HPI estimate for the Denver metropolitan area for the first quarter of 2008 was 201.83, as released in May 2008, while the revised HPI estimate for the first quarter of 2008 was 199.83, in May 2010 for the same metropolitan area (FHFA, 2010c; OFHEO, 2008b). A recent analysis of the revisions of the HPI estimates shows that the updates tended to moderate the longer term changes in the index from the first quarter of 2005 through the third quarter of 2009 (FHFA, 2010a).

The S&P/Case-Schiller® Home Price Index (S&P/Case-Schiller®) measures the average price change in the sales of the same single-family homes in a particular geographical area (Standard & Poor's, 2009). It employs a weighted-repeat sales methodology based on Case and Shiller (1989).

The S&P/Case-Schiller® has several advantages, given its design. Similar with the HPI, the S&P/Case-Schiller® is a “constant quality” house price index, because it is based on paired sales transactions of the same property. Further, the S&P/Case-Schiller® reflects only house price changes resulting from sales, avoiding the appraisal lag affecting the HPI. Its underlying data is gathered from all publicly available information at local recording offices and accumulated in rolling 3-month periods. The S&P/Case-Schiller® is estimated based on a 3-month moving average that allows for the correcting of any delays in the collection of the paired sales transactions (Standard & Poor's, 2009).

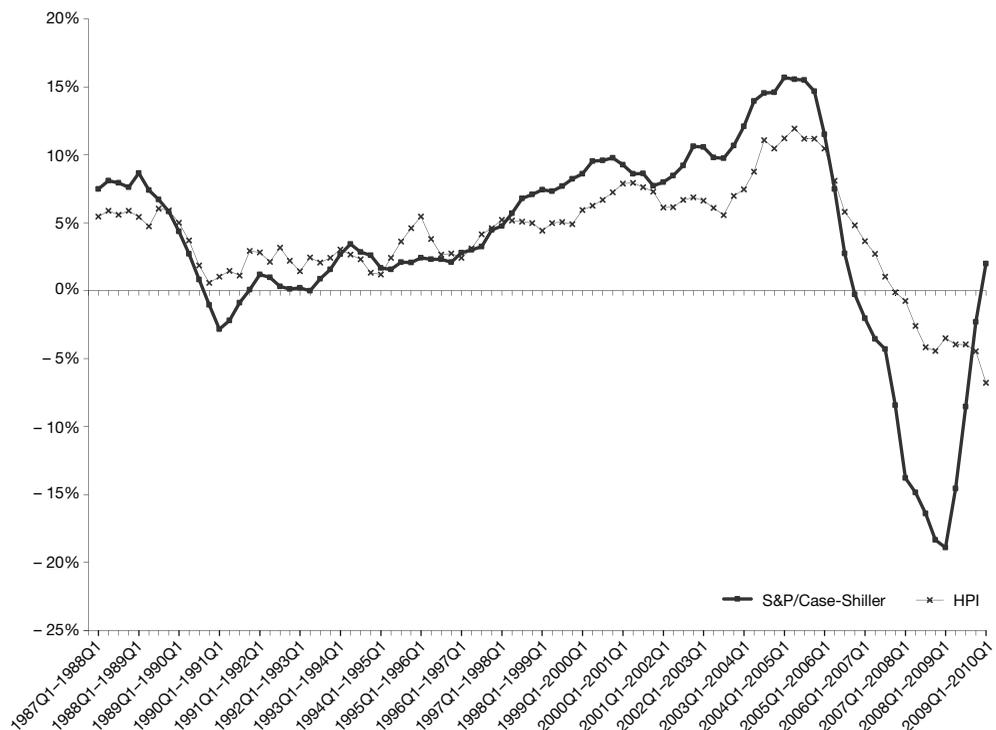
The S&P/Case-Schiller® has great temporal coverage and is available free of charge on the Standard & Poor's website (Standard & Poor's and Fiserv, Inc., 2010a). Fiserv, Inc., estimates the index monthly for 20 metropolitan areas and 2 metropolitan composite indices and quarterly reports for the United States. It releases both seasonally adjusted and not seasonally adjusted estimates of the index. The S&P/Case-Schiller® equals 100 points in January 2000 for its metropolitan area indices. The base period for the U.S. index is the first quarter of 2000. The S&P/Case-Schiller® time series extends back to January 1987 for 14 of the metropolitan areas and 1 metropolitan composite index (Standard & Poor's and Fiserv, Inc., 2010a).

The S&P/Case-Schiller® signaled the decline in house prices earlier than the HPI. As exhibit 1 illustrates, the S&P/Case-Schiller® showed an earlier and more abrupt shift in the national housing market than the HPI. This contrast between the two house indices was evident across large metropolitan areas, such as Miami and Las Vegas (see exhibits A-1 and A-2).

The S&P/Case-Schiller's® major weakness is the limited amount of geographical detail and is available for only 20 metropolitan areas. Fiserv, Inc., originally estimated the index for 10 metropolitan areas: Boston, Chicago, Denver, Las Vegas, Los Angeles, Miami, New York, San Diego, San Francisco,

Exhibit 1

Comparison of Four-Quarter Appreciation Rates of the HPI and the S&P/Case-Schiller® for the United States, First Quarter of 1987 Through First Quarter of 2010



Notes: The HPI is the Federal Housing Finance Agency (FHFA) All Transactions House Price Index and the S&P/Case-Schiller® is the S&P/Case-Schiller® Home Price Index. The indices are not seasonally adjusted.

Sources: Calculated based on FHFA (2010d); Standard & Poor's and Fiserv, Inc. (2010b)

and Washington, D.C. It later added another 10 metropolitan areas: Atlanta, Charlotte, Cleveland, Dallas, Detroit, Minneapolis, Phoenix, Portland (Oregon), Seattle, and Tampa. Although most of the indices follow the OMB's definition of a metropolitan statistical area, the S&P/Case-Schiller® for the Chicago area is calculated for the Chicago-Naperville-Joliet, IL, metropolitan division and the index for New York is based on a customized metropolitan area, including select New York, New Jersey, and Connecticut counties (Standard & Poor's, 2009). Further, the S&P/Case-Schiller® U.S. index does not include house price data from 13 states, and it has incomplete data from another 29 states (Leventis, 2007; Standard & Poor's, 2009).⁶

⁶ The S&P/Case-Schiller index for the United States is a composite index of the nine census divisions, based on accumulated data from the states. Standard & Poor's does not collect data from the following states: Alabama, Alaska, Idaho, Indiana, Maine, Mississippi, Montana, North Dakota, South Carolina, South Dakota, West Virginia, Wisconsin, and Wyoming. It has incomplete coverage for the following states, at different rates: Arizona, Arkansas, California, Colorado, Delaware, Florida, Georgia, Illinois, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Missouri, Nebraska, Nevada, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Tennessee, Texas, Utah, Virginia, and Washington (Standard & Poor's, 2009).

Another potential drawback of the S&P/Case-Schiller® is its limited focus on existing single-family houses, not reflecting price changes in the sales of other types of housing properties and new houses.

The adjusted version of the FHFA House Price Index (so-called “adjusted HPI”) was created in July 2007 by the OFHEO to analyze the possible sources of divergence between the change rates of the HPI and the S&P/Case-Schiller® (Leventis, 2007). The adjustment methodology of the HPI to the S&P/Case-Schiller® was improved in 2008 (OFHEO, 2008a). The method is stepwise, resulting in an adjusted HPI that covers the same counties as the S&P/Case-Schiller® in 10 metropolitan areas, excludes appraisals, puts less weight on homes that have lengthy intervals between valuations than HPI, includes single-family homes with alternative financing, uses value weighting, excludes some of the HPI data that are not in the DataQuick data set, and uses the same data filters as the S&P/Case-Schiller® (OFHEO, 2008a).

The adjusted HPI allowed for the identification of the three main causes for the smaller change rates of the HPI in comparison with the S&P/Case-Schiller®: the appraisal component of the HPI, too much weight placed on the transactions of homes with lengthy intervals between valuations, and the omission of low and moderately priced homes with financing other than from Fannie Mae and Freddie Mac (OFHEO, 2008a).

Because the FHFA estimates the adjusted HPI only for the original 10 metropolitan areas of the S&P/Case-Schiller® and reports its four-quarter appreciation rate occasionally, the adjusted HPI is not an appropriate index to use in a spatio-temporal analysis of house price trends at the moment.⁷ This index was constructed by OFHEO (and later FHFA) to compare the HPI with the S&P/Case-Schiller®.

The Zillow Home Value Index (Zillow index) is the median Zillow estimate (Zestimate) of prices of all the houses in a given geographical area. A “Zestimate” is Zillow’s estimate of the current market value for a home (Zillow.com, 2010a). Zillow generates Zestimates for more than 70 million homes and has data for an additional 20 million homes (Zillow.com, 2010b).

The main advantage of the Zillow index is the detailed and broad geographical coverage. As of July 2010, Zillow kept track of 200 metropolitan areas (as defined by OMB) and estimated the Zillow index for 126 metropolitan areas for May 2010, based on available public data (Zillow.com, 2010c). The Zillow index is calculated also at the ZIP Code, county, metropolitan area, state, and national levels for all homes, for single-family homes, and for condominiums in a specific area. It estimates the market value of all houses in a geographical area, not only of sold houses (Zillow.com, 2010a).

A primary disadvantage of the Zillow index is that it does not stand up to academic scrutiny because Zillow estimates the market value of a house using a proprietary valuation model. Zillow uses public data on house attributes and actual sale prices to develop the model (Zillow, 2010b). Although Zillow reports month-over-month change, quarter-over-quarter change, year-over-year change, and 5- and 10-year annualized changes together with its latest estimated monthly Zillow index, it does not publicly provide the historical time series of house prices.

⁷ The OFHEO reported a time series of the adjusted HPI (March 1991–March 2007) in July 2007, but this index does not use the improved adjustment methodology, employed currently by FHFA (OFHEO, 2007b).

The NATIONAL ASSOCIATION OF REALTORS® Median Home Price (NAR median home price) is the median sales price for existing homes that are at least 1 year old, based on transactions conducted through a real estate agent and those made by the owner (Bishop, 2008). The NAR calculates an index for single-family homes and one for condominiums and co-ops, reporting on a quarterly basis for metropolitan area level data and on a monthly basis for both the United States and the census region levels of data (NAR, 2010a).

The NAR median home price has broad spatial coverage at the metropolitan area level; it is estimated for 160 metropolitan areas, as defined by OMB. Given that the NAR existing house sales database extends back to 1968, the NAR median home price might have also a long time series, at least for single-family homes.

The main limitation of the NAR median home price index is the lack of control for housing quality. Further, NAR's publicly available quarterly metropolitan price report provides the estimates of the NAR median home price for the past five quarters and the past 3 years, not seasonally adjusted (NAR, 2010b). The full time series is not publicly available, but it can be acquired at a cost.

Comparison of Four-Quarter Change Rates of the House Price Indices for 10 Metropolitan Areas

This article conducts a correlation analysis of the four-quarter change rate for the five indices discussed in the previous section for two time periods: the third quarter of 2006 through the third quarter of 2007 and the first quarter of 2007 through the first quarter of 2008. The analysis was performed for 10 metropolitan areas: Boston, Chicago, Denver, Las Vegas, Los Angeles, Miami, New York, San Diego, San Francisco, and Washington, D.C. (see exhibits A-1 and A-2). The choice of the time periods and of the metropolitan areas was limited by the availability of data.

For comparability with the other house price indices, which are estimated only for single-family homes, this analysis considers the Zillow Home Value Index for single-family homes and the NATIONAL ASSOCIATION OF REALTORS® (NAR) Median Sales Price of single-family homes.

The change rate of the Zillow index correlates very highly with the change rates of the S&P/Case-Schiller®, with change rates of 95 percent for the first period and 92 percent for the second period (see exhibits A-3 and A-4). Although the adjusted HPI was constructed to align as close as possible with the S&P/Case-Schiller®, its change rate has an 87-percent correlation coefficient with the change rate in S&P/Case-Schiller® during the first period, which is lower than the Zillow index. The change rate of the Zillow index also correlates at a high level with the adjusted HPI's inflation rate (84 percent in the first period and 88 percent in the second period). The change rate of the NAR median home price has the lowest correlation with the other four indices, but its degree of association improves substantially in the second period.

Spatio-Temporal Indicators

This section develops a set of spatio-temporal indicators based on the four-quarter appreciation rates for the HPI for 302 metropolitan areas for the period from the third quarter of 1990 through the third quarter of 2007. These indicators are based on the concepts of spatial and serial autocorrelation. The analysis shows that from 1998 until 2003 and 2004, the spatio-temporal indicators intensify in value and then drop off after that period.

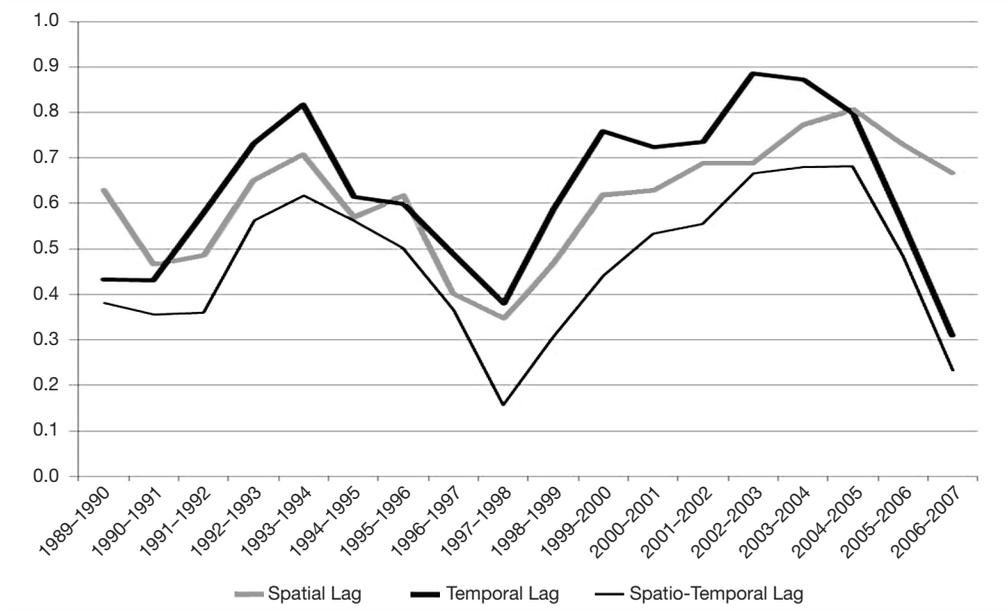
Robert Shiller and other economists have used serial autocorrelation to measure irrational exuberance in financial bubbles. Because of the spatial nature of the housing market, the results of this analysis reveal that a geographic component to the housing bubble may have existed. To capture these indicators, Global Moran’s I statistic was used. This statistic is the spatial counterpart to serial autocorrelation in a time series (Anselin, 1995). It ranges from -1 to 1, where negative values indicate a checkerboard pattern in the phenomenon being analyzed and positive values indicate just the opposite—that is, spatial clustering of similarly valued units, either high value homes adjacent to other high value homes or low value homes adjacent to other low value homes. This study also develops a spatio-temporal autocorrelation indicator to capture space and time simultaneously.

To use the Moran’s I statistic, an adjacency matrix needed to be defined to specify how the geographic units are positioned in space. In this analysis, the first-order queen rule of adjacency was used—the rule that is most commonly applied to polygon data such as the metropolitan HPI data.

Exhibit 2 shows the Moran’s I statistic, the temporal lag, and the combined lag for percent changes in HPI for 302 metropolitan areas going back to 1988. A clear rise and then drop in all three indicators occurred throughout the housing bubble and subsequent burst, although the peak is much less than expected, given the cap on Fannie Mae and Freddie Mac loans.

Exhibit 2

Spatio-Temporal Indicators, 1990 Through 2007



We use local indicators of spatial association (LISA) to provide additional insight into the spatio-temporal dimension of the housing bubble. This map highlights five possible types of spatial association: high values surrounded by high values (high-to-high), low-to-low, high-to-low, low-to-high, and no significant association.

The LISA map shows that metropolitan areas in certain regions (the Northeast, Florida, and California) have become more similar in HPI changes over time. The maps in exhibit 3 represent regional bubbles where house prices accelerated up to a certain point before bursting. In these areas, the last map of 2006 to 2007 shows the reversal in terms of a switch to low-to-low association.

In each map, the large square indicates a high-to-high association, the large circle is a low-to-low association, the small circle is a low-to-high association, the small square is a high-to-low association, and the hollow circle is insignificant association.

Exhibit 3a

Spatial Association of the HPI Four-Quarter Appreciation Rate for Metropolitan Areas, Third Quarter of 2000 Through Third Quarter of 2001



HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index.

Source: Office of Federal Housing Enterprise Oversight (2007a)

Exhibit 3b

Spatial Association of the HPI Four-Quarter Appreciation Rate for Metropolitan Areas, Third Quarter of 2001 Through Third Quarter of 2002



HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index.
Source: Office of Federal Housing Enterprise Oversight (2007a)

Exhibit 3c

Spatial Association of the HPI Four-Quarter Appreciation Rate for Metropolitan Areas, Third Quarter of 2002 Through Third Quarter of 2003



HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index.
Source: Office of Federal Housing Enterprise Oversight (2007a)

Exhibit 3d

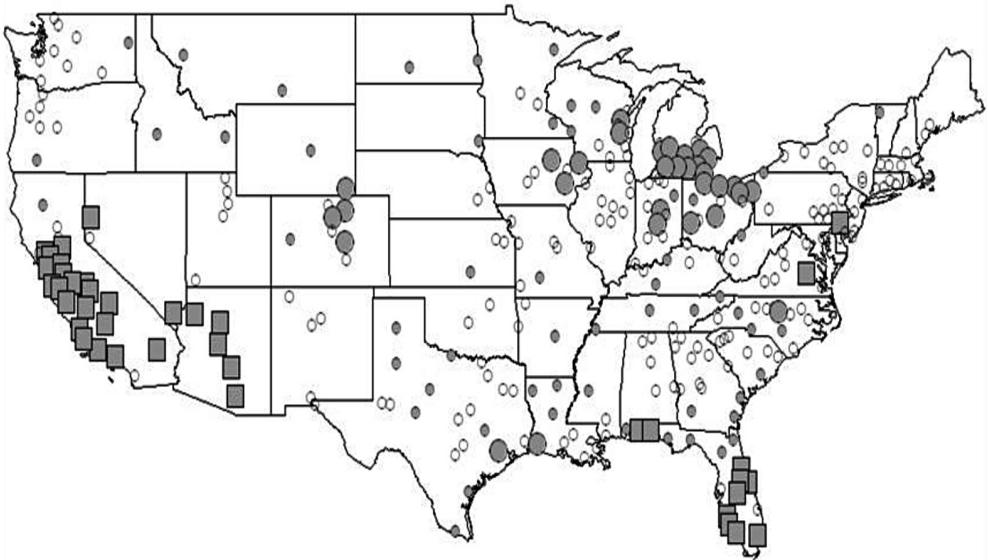
Spatial Association of the HPI Four-Quarter Appreciation Rate for Metropolitan Areas, Third Quarter of 2003 Through Third Quarter of 2004



HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index.
Source: Office of Federal Housing Enterprise Oversight (2007a)

Exhibit 3e

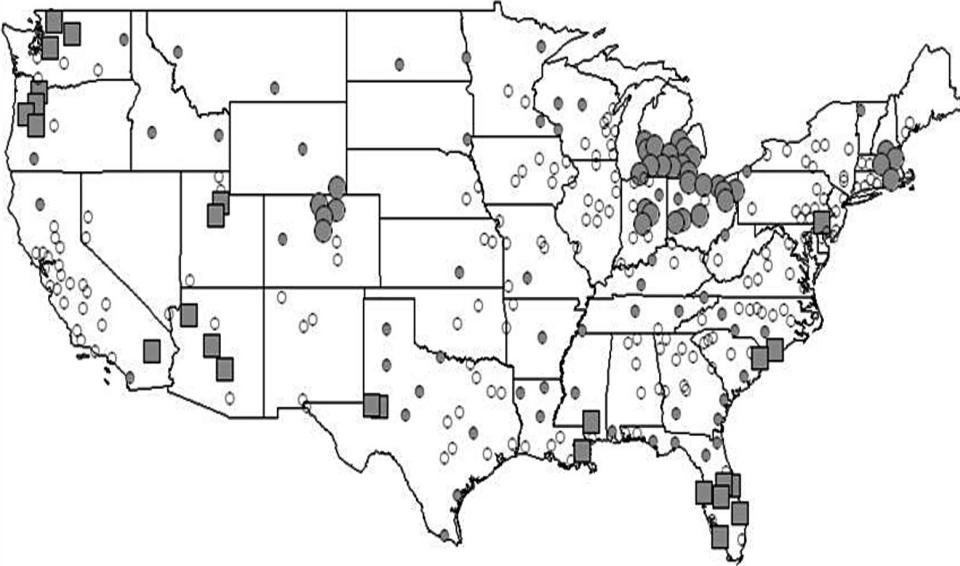
Spatial Association of the HPI Four-Quarter Appreciation Rate for Metropolitan Areas, Third Quarter of 2004 Through Third Quarter of 2005



HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index.
Source: Office of Federal Housing Enterprise Oversight (2007a)

Exhibit 3f

Spatial Association of the HPI Four-Quarter Appreciation Rate for Metropolitan Areas, Third Quarter of 2005 Through Third Quarter of 2006



HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index.
Source: Office of Federal Housing Enterprise Oversight (2007a)

Exhibit 3g

Spatial Association of the HPI Four-Quarter Appreciation Rate for Metropolitan Areas, Third Quarter of 2006 Through Third Quarter of 2007



HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index.
Source: Office of Federal Housing Enterprise Oversight (2007a)

Conclusion

This article shows that none of the analyzed house price indices is best suited for a broad spatio-temporal analysis at the metropolitan area level. An indication exists that shows the S&P/Case-Schiller® might have tracked the housing bubble and bust better than other traditional house price indices (the HPI, the NAR median home price). The S&P/Case-Schiller® has very limited metropolitan coverage, however. The four-quarter appreciation rates of the adjusted HPI and the Zillow index correlate highly with the change rate of the S&P/Case-Schiller® during the two periods analyzed in this article. Although the adjusted HPI is limited in its release, the Zillow index is based on a proprietary valuation model. Ultimately, the only house price index that has broad temporal and spatial coverage and a validated methodology is the HPI, which has not performed as well as the S&P/Case-Schiller® during the last couple of years. This analysis points towards several ways to improve the available house price indices, from the extension of the adjusted HPI to more metropolitan areas and a regular release, the estimation of the S&P/Case-Schiller® for more metropolitan areas, and the release of the Zillow valuation model.

Appendix

Exhibit A-1

Four-Quarter Appreciation Rates of 5 Single-Family House Price Indices for 10 Selected Metropolitan Areas, Third Quarter of 2006 Through Third Quarter of 2007

Metropolitan Area	HPI (%)	S&P/Case Shiller® (%)	Zillow Index for Single-Family Homes (%)	Adjusted HPI (%)	NAR Median Price for Single-Family Homes (%)
Boston	-2.51	-3.18	-4.1	-2.24	0.72
Chicago	2.16	-2.48	-3.3	-1.64	2.55
Denver	-0.32	-0.86	-0.6	-2.32	0.39
Las Vegas	-2.51	-9.05	-12.7	-12.72	-6.98
Los Angeles	-0.60	-6.99	-10.1	-7.11	1.29
Miami	-1.40	-9.96	-11.6	-8.17	-4.97
New York	0.25	-3.61	-2.6	-3.70	-0.53
San Diego	-5.07	-9.64	-10.8	-8.75	-1.89
San Francisco	-3.87	-4.58	-5.5	-5.48	8.54
Washington, D.C.	-0.38	-6.35	-5.4	-9.10	1.46

HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index. NAR = NATIONAL ASSOCIATION OF REALTORS®. S&P/Case-Schiller® = S&P/Case-Schiller® Home Price Index.

Notes: The appreciation rates of the House Price Indices are not adjusted for inflation. In this example, the HPI and the adjusted HPI use the S&P/Case-Schiller® index's metropolitan area definitions. The HPI is unrevised. The four-quarter appreciation rate for the S&P/Case-Schiller® index is calculated based on the change of the index between September 2006 and September 2007.

Sources: Humphries (2008); Joint Center for Housing Studies (2008); Office of Federal Housing Enterprise Oversight (2008a); Standard & Poor's and Fiserv, Inc. (2010a)

Exhibit A-2

Four-Quarter Appreciation Rates of 5 Single-Family House Price Indices for 10 Selected Metropolitan Areas, First Quarter of 2007 Through First Quarter of 2008

Metropolitan Area	HPI (%)	S&P/Case Shiller® (%)	Zillow Index for Single-Family Homes (%)	Adjusted HPI (%)	NAR Median Price for Single-Family Homes (%)
Boston	-1.61	-5.92	-8.8	-7.75	-7.82
Chicago	0.23	-10.00	-7.1	-11.02	-6.62
Denver	0.90	-5.04	-5.1	-9.89	-6.64
Las Vegas	-12.06	-25.92	-25.6	-21.05	-20.15
Los Angeles	-9.01	-21.72	-16.3	-19.89	-21.30
Miami	-7.95	-24.56	-18.6	-21.24	-17.23
New York	-1.30	-7.45	-1.9	-6.52	-3.95
San Diego	-10.02	-20.51	-16.3	-19.10	-22.88
San Francisco	-8.27	-20.23	-13.8	-20.23	-6.10
Washington, D.C.	-4.85	-14.25	-10.6	-16.06	-13.09

HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index. NAR = NATIONAL ASSOCIATION OF REALTORS®. S&P/Case-Shiller® = S&P/Case-Schiller® Home Price Index.

Notes: The appreciation rates of the House Price Indices are not adjusted for inflation. In this example, the HPI and the adjusted HPI use the S&P/Case-Shiller® index's metropolitan area definitions. The HPI is unrevised. The four-quarter appreciation rate for the S&P/Case-Shiller® index is calculated based on the change of the index between March 2007 and March 2008.

Sources: Office of Federal Housing Enterprise Oversight (2008c); Standard & Poor's and Fiserv, Inc. (2010a); Zillow.com (2008); NAR (2008)

Exhibit A-3

The Correlation Coefficients Between the Four-Quarter Appreciation Rates of 5 Single-Family House Price Indices for 10 Selected Metropolitan Areas, Third Quarter of 2006 Through Third Quarter of 2007

	HPI (%)	S&P/Case Shiller® (%)	Zillow Index for Single-Family Homes (%)	Adjusted HPI (%)	NAR Median Price for Single-Family Homes (%)
HPI	100				
S&P/Case Shiller®	50.8	100.0			
Zillow index for single-family homes	49.2	95.4	100.0		
Adjusted HPI	45.0	87.8	84.8	100.0	
NAR median price for single-family homes	4.9	57.1	56.9	54.2	100.0

HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index. NAR = NATIONAL ASSOCIATION OF REALTORS®. S&P/Case-Shiller® = S&P/Case-Schiller® Home Price Index.

Source: Calculated by authors

Exhibit A-4

The Correlation Coefficients Between the Four-Quarter Appreciation Rates of 5 Single-Family House Price Indices for 10 Selected Metropolitan Areas, First Quarter of 2007 Through First Quarter of 2008

	HPI (%)	S&P/Case Shiller® (%)	Zillow Index for Single-Family Homes (%)	Adjusted HPI (%)	NAR Median Price for Single-Family Homes (%)
HPI	100.0				
S&P/Case Shiller®	94.8	100.0			
Zillow index for single-family homes	91.7	92.3	100.0		
Adjusted HPI	90.8	96.3	88.6	100.0	
NAR median price for single-family homes	81.2	77.9	81.3	75.3	100.0

HPI = The Federal Housing Finance Agency (FHFA) All Transactions House Price Index. NAR = NATIONAL ASSOCIATION OF REALTORS®. S&P/Case-Shiller® = S&P/Case-Schiller® Home Price Index.

Source: Calculated by authors

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