

The impact of housing on a homeowner's investment portfolio

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Abstract

We examine the inflation hedging and portfolio enhancing properties of residential real estate that makes up a significant part of the individual homeowner-investor's investment portfolio. Using 22 S&P/Case-Shiller city-level and composite indices, we show that residential real estate is at best a modest hedge against inflation. Adding residential real estate can potentially enhance the mean-variance efficiency of portfolios made up of financial assets such as stocks and bonds. However, to take advantage of the diversification benefits of residential real estate, homeowner-investors must rebalance their portfolios periodically, which may not always be a practically feasible option. © 2012 Academy of Financial Services. All rights reserved.

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1. Introduction

Residential real estate (single-family housing) is often a significant part of many United States investors' investment portfolio. About two-thirds of North American households own their homes (Hennessey, 2003). For many of them, it is the "single most important asset in their portfolio (Cocco, 2005)." After the recent severe housing market downturn and the ensuing tightening of credit that has severely weakened the ability¹ of many households to own residential real estate, it is imperative that we examine the investment properties of

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residential real estate, in particular, its inflation-hedging and portfolio diversification benefits. Prior studies on the investment properties of residential real estate have been sparse. While some studies such as Cocco (2005) and Hennessey (2003) have used theoretical models and case studies to examine the portfolio properties and financial impact of housing, most empirical studies on the topic have used data for commercial real estate and real estate investment trusts (REITs) (e.g., Hartzell et al., 1987; Gyourko et al., 1988), real estate mutual funds (e.g., Lin and Yung, 2007), or appraisal based private real estate data (e.g., Grauer and Hakansson, 1995; Mueller and Mueller, 2003).

The contribution of this investigation emanates from its empirical focus on residential real estate from the perspective of the individual homeowner-investors who often have a substantial part of their wealth invested in this asset class. Rather than using appraisal based data used in most prior studies of residential real estate, we use realized sales-based data. In addition, we take a comprehensive approach while studying United States residential real estate markets, drawing data from 20 metropolitan residential real estate markets along with two composite nation-wide indices. Hence, the data for this study comes from the S&P/Case-Shiller indices for 20 major metropolitan residential real estate markets in the United States along with the S&P/Case-Shiller 10-city and 20-city composite indices. The S&P/Case-Shiller indices directly reflect house price fluctuations because they are constructed using a proprietary repeat-sales methodology and so they accurately capture residential real estate returns in these markets in real-time. For most markets, the data extends back to 1987 and so allows us to examine the inflation-hedging and investment properties of residential real estate for at least 20 years.

2. Literature review

The choice of homeownership (as opposed to renting) often has a significant impact on a household's finances. Hennessey (2003) examines this financial impact with a housing choice model and using two case studies. His results point to the sub-optimality of the home purchase decision in both, the United States and Canada. So why do an overwhelming majority of North American households own their homes? Among the many psychological, regulatory, and financial factors enumerated by Hennessey (2003), is the widely held belief that home ownership is a sound financial investment. If housing is a sound financial investment, then one may postulate that it should be a good hedge for inflation and a good diversifier of financial portfolios, enhancing their reward-to-risk ratios.

There have been surprisingly few studies focusing on the effectiveness of residential real estate as a hedge for inflation. Hartzell et al. (1987) study three classes of real estate (industrial, office, and retail) and find them to be an effective hedge against both expected and unexpected inflation. Gyourko et al. (1988) investigate the inflation-hedging properties of commercial property, residential real estate and REIT stocks. They find commercial property to be most effective as an inflation hedge, followed by residential real estate while returns of REIT stocks are negatively correlated with inflation as are the returns of most other common stocks. Liu et al. (1997) discover that REIT securities are poor hedges against both

expected and unexpected inflation in countries such as the United States and the United Kingdom but in others, such as France, REIT securities are comparable with equities in their ability to hedge against inflation. Chan et al. (1990) find that unexpected inflation, changes in the risk and term structure of interest rates and changes in the discount of closed-end stock funds are major drivers of equity REIT returns. Rubens et al. (1989) examine the inflation-hedging effectiveness of commercial real estate, residential real estate, and farmland as compared with financial assets such as stocks and bonds. They use annual percentage changes in home purchase price component of Consumer Price Index (CPI) as a measure of residential real estate returns. Interestingly, they find that total residential real estate returns and its capital gains component (but not income component) are far more effective hedges against inflation than commercial real estate, farmland, stocks, and bonds. Bond and Seiler (1998) find residential real estate to be an effective hedge against both expected and unexpected inflation and they recommend the addition of residential real estate to portfolios composed of financial assets such as stocks and bonds because neither is effective as an inflation hedge, especially in times of high inflation. They also demonstrate that doing so can reduce variance of portfolio returns.

In a survey of extant literature, Seiler et al. (1999) examine whether real estate belongs to an efficient portfolio and if so, how much should be included in a mixed-asset portfolio. The articles reviewed show wide range of answers to the latter question. Ibbotson and Siegel (1984) find that between 1960 and 1982 un-levered real estate returns have a magnitude that lies between that of bonds and stocks. Moreover, they argue, real estate can be a powerful diversifier in the traditional stock-bond portfolio because real estate returns are only slightly correlated with stock and bond returns. This is attributed to the fact that stocks returns are driven by market risk and bond returns are largely determined by interest rates while real estate returns are driven by what the authors call “residual risk.” In a mixed asset portfolio, Mueller and Mueller (2003) demonstrate that both public (REITs) and private real estate investments, when combined with a portfolio of stocks and bonds, can improve the efficient frontiers substantially and suggest larger allocations of real estate than currently used in investment portfolios. Using a theoretical model, Cocco (2005) argues that inclusion of residential real estate in portfolios made up of stocks and bonds is predicted to have negative effect on the optimal weight of equity. This effect is most pronounced for young investors who are wealth-constrained as a result of mortgage payments. It is also strong for risk-averse investors for whom residential real estate price risk is a substitute for equity price risk. Goetzmann (1993) uses an earlier and much more limited four-city (Atlanta, Chicago, Dallas, and San Francisco) Case-Shiller dataset and finds that because residential real estate return generally has a negative correlation with both stock and bond returns, residential real estate should get significant weight in an efficient portfolio made up of stocks, bonds and residential real estate. He also finds this effect to be most significant for investors with high risk aversion. On a similar note, Grauer and Hakansson (1995) examine annual appraisal-based real estate data and note that the addition of residential real estate to a portfolio made of stocks and bonds can reduce variance of returns but this is only true with an active asset allocation strategy, especially for more risk-averse investors.

3. Data

Residential real estate price data comes from seasonally adjusted S&P/Case-Shiller MSA Home Price Indices, available for download from S&P's website. There are 20 city-level indices for United States metropolitan areas as well as two composite indices, one composed of 10 cities and the other 20 cities. These 22 indices contain monthly price data for select U.S. cities going back as far as 1987 using a proprietary weighted repeated sales methodology. The 10 cities covered by the 10-city composite include the metropolitan areas of Boston, Chicago, Denver, Las Vegas, Los Angeles, Miami, New York, San Diego, San Francisco, and Washington DC, while the 20-city composite includes these 10 cities as well as Atlanta, Charlotte, Cleveland, Dallas, Detroit, Minneapolis-St. Paul, Phoenix, Portland, Seattle, and Tampa. The advantage of using the Case-Shiller indices lies in the fact that they are based on realized transaction prices instead of appraised values that form the basis of other private or residential real estate indexes used in previous studies (e.g., Grauer and Hakansson, 1995; Mueller and Mueller, 2003; etc.).

Data on expected and realized inflation are collected from *The Wall Street Journal* (before 2001) and www.econoday.com (after 2000). Unexpected inflation is the measured difference between realized inflation and its expectation in any given month. Thirty-year Treasury yields and values of the Wilshire 5000 index are obtained from Thomson Reuters Datastream and used as to calculate monthly Treasury bond returns and equity returns, respectively.

4. Results

Table 1 contains two panels. Panel A displays summary statistics of one-year rolling buy and-hold returns using the Case-Shiller data while Panel B does the same for five-year rolling buy-and-hold returns. The median one-year returns range from just above 1% or so for Dallas to nearly 6% for Portland, Oregon. Contrary to housing's reputation as a low-risk investment, the minimum annual return is almost -36% for Phoenix while the maximum annual return is nearly 53% for Las Vegas. Not surprisingly, the 10-city and 20-city indices display more stability with median annual returns of 4% to 8%, minimum annual returns around -19%, and maximum annual returns of 17% to 20%.

Looking at a longer holding period, Panel B shows that median five-year returns range from 7% for Dallas to 43% for Portland. Despite the longer holding period, the risk of severe losses does not seem to diminish with minimum five-year returns of almost -57% for Las Vegas and around -30% for both the 10-city and 20-city indices. Correspondingly, maximum five-year returns can be as high as 145% in Miami and range from 81% to 96% for the 10-city and 20-city indices.

Table 2 shows that the monthly returns of each of the 20 city-level indices and the two composite indices display modest positive correlations. However, the 22 residential real estate returns are only very weakly correlated with the CPI (all items less shelter) and therefore, housing appears to only be a moderate inflation hedge. These residential real estate returns are also only weakly correlated with returns of Wilshire 5000 index. This observation is consistent with those presented by Lin and Yung (2007) when they observe that real estate

Table 1 Panel A: Summary statistics of one year rolling buy-and-hold returns for Case-Shiller housing indices (sample period 1987–2010)

City/index	Number observed	Mean	Median	Standard deviation	Maximum return	Minimum return
Atlanta	228	0.0233	0.0372	0.0498	0.0819	-0.1538
Boston	276	0.0358	0.0332	0.0693	0.1842	-0.1114
Charlotte	276	0.0256	0.0331	0.0349	0.0829	-0.1007
Chicago	276	0.0361	0.0421	0.0650	0.1889	-0.1841
Cleveland	276	0.0286	0.0395	0.0379	0.0879	-0.1040
Dallas*	120	0.0127	0.0148	0.0298	0.0663	-0.0543
Denver	276	0.0424	0.0406	0.0537	0.1498	-0.0556
Detroit	228	0.0128	0.0378	0.0856	0.0954	-0.2560
Las Vegas	276	0.0286	0.0337	0.1413	0.5298	-0.3309
Los Angeles	276	0.0538	0.0656	0.1340	0.3331	-0.2796
Miami	276	0.0401	0.0380	0.1212	0.3221	-0.2952
Minneapolis	252	0.0343	0.0437	0.0747	0.1452	-0.2275
New York	276	0.0362	0.0191	0.0748	0.1732	-0.1222
Phoenix	252	0.0333	0.0514	0.1420	0.4906	-0.3588
Portland	276	0.0583	0.0599	0.0708	0.2307	-0.1628
San Diego	276	0.0538	0.0599	0.1235	0.3337	-0.2667
San Francisco	276	0.0543	0.0547	0.1256	0.3114	-0.3223
Seattle	240	0.0430	0.0430	0.0727	0.1848	-0.1676
Tampa	276	0.0294	0.0216	0.1014	0.3048	-0.2326
Washington DC	276	0.0479	0.0266	0.0987	0.2694	-0.1963
CS 10-city	276	0.0425	0.0393	0.0898	0.2050	-0.1945
CS 20-city*	120	0.0383	0.0844	0.1113	0.1709	-0.1900

Table 1 Panel B: Summary statistics of five-year rolling buy-and-hold returns for Case-Shiller housing indices (sample period 1987–2010)

City/index	Number observed	Mean	Median	Standard deviation	Maximum return	Minimum return
Atlanta	180	0.1875	0.2293	0.1478	0.3408	-0.2316
Boston	228	0.2880	0.2288	0.3448	0.8748	-0.1559
Charlotte	228	0.1644	0.1670	0.0716	0.2643	-0.0643
Chicago	228	0.2414	0.2064	0.1852	0.5160	-0.2803
Cleveland	228	0.1688	0.2210	0.1309	0.3395	-0.1861
Dallas*	72	0.0696	0.0689	0.0614	0.1670	-0.0591
Denver	228	0.3140	0.3974	0.2134	0.6450	-0.0941
Detroit	180	0.1748	0.3029	0.2979	0.4665	-0.4741
Las Vegas	228	0.2946	0.2027	0.4325	1.2083	-0.5691
Los Angeles	228	0.3692	0.2911	0.5335	1.4023	-0.3572
Miami	228	0.3576	0.1383	0.4640	1.4493	-0.4625
Minneapolis	204	0.2848	0.2483	0.2794	0.6815	-0.3146
New York	228	0.3032	0.1904	0.3479	0.8959	-0.2097
Phoenix	204	0.3275	0.3275	0.3514	1.1087	-0.5349
Portland	228	0.3932	0.4265	0.1815	0.6707	-0.1587
San Diego	228	0.3799	0.2831	0.5113	1.3514	-0.3610
San Francisco	228	0.3530	0.3264	0.4081	1.0198	-0.3711
Seattle	192	0.3382	0.3625	0.1912	0.6769	-0.1555
Tampa	228	0.2730	0.1413	0.3484	1.1012	-0.4274
Washington DC	228	0.3215	0.1776	0.4077	1.2204	-0.2592
CS 10-city	228	0.3143	0.2071	0.3735	0.9562	-0.2984
CS 20-city*	72	0.3148	0.3494	0.4119	0.8102	-0.2965

* Data for S&P/Case-Shiller indices for Dallas and the 20-city composite (CS 20-city) begins in 2000.

Table 2 Correlation of returns amongst various Case-Shiller housing indices, the Wilshire 5000 equity index and the 30-year U.S. Treasuries index (sample period 1987–2010)

	AT	BS	CH	CL	CT	DC	DL	DT	DV	LA	LV	MI	MN	NY	PH	PL	SD	SF	ST	TM	CS10	CS20	CPI	Equity	Bond
AT	1.00																								
BS	0.58	1.00																							
CH	0.81	0.50	1.00																						
CL	0.48	0.31	0.44	1.00																					
CT	0.60	0.24	0.47	0.25	1.00																				
DC	0.59	0.64	0.65	0.35	0.31	1.00																			
DL	0.60	0.46	0.47	0.47	0.37	0.45	1.00																		
DT	0.76	0.58	0.74	0.41	0.47	0.56	0.39	1.00																	
DV	0.58	0.55	0.41	0.50	0.29	0.34	0.57	0.53	1.00																
LA	0.58	0.57	0.58	0.30	0.37	0.84	0.38	0.54	0.29	1.00															
LV	0.55	0.39	0.58	0.34	0.40	0.69	0.28	0.57	0.31	0.74	1.00														
MI	0.66	0.53	0.69	0.38	0.39	0.84	0.41	0.61	0.38	0.80	0.75	1.00													
MN	0.80	0.60	0.75	0.45	0.39	0.66	0.56	0.75	0.53	0.60	0.56	0.67	1.00												
NY	0.65	0.76	0.66	0.29	0.35	0.78	0.39	0.61	0.42	0.71	0.57	0.75	0.65	1.00											
PH	0.72	0.48	0.69	0.40	0.51	0.77	0.46	0.67	0.47	0.72	0.68	0.88	0.68	0.68	1.00										
PL	0.66	0.16	0.56	0.40	0.52	0.42	0.49	0.55	0.28	0.41	0.57	0.61	0.48	0.33	0.68	1.00									
SD	0.56	0.64	0.55	0.34	0.30	0.82	0.36	0.55	0.40	0.91	0.72	0.73	0.62	0.67	0.63	0.33	1.00								
SF	0.65	0.63	0.58	0.41	0.37	0.76	0.47	0.59	0.52	0.79	0.59	0.71	0.67	0.62	0.72	0.42	0.84	1.00							
ST	0.68	0.30	0.57	0.36	0.52	0.50	0.45	0.56	0.34	0.57	0.59	0.62	0.49	0.52	0.67	0.62	0.50	0.55	1.00						
TM	0.65	0.52	0.67	0.35	0.40	0.78	0.44	0.58	0.42	0.74	0.69	0.89	0.65	0.74	0.85	0.62	0.65	0.67	0.63	1.00					
CS10	0.70	0.73	0.71	0.38	0.41	0.91	0.45	0.66	0.46	0.93	0.75	0.87	0.73	0.87	0.81	0.46	0.91	0.86	0.60	0.83	1.00				
CS20	0.81	0.77	0.83	0.50	0.51	0.94	0.49	0.81	0.59	0.95	0.85	0.95	0.83	0.90	0.89	0.76	0.90	0.87	0.78	0.90	1.00				
CPI	0.10	0.05	0.10	0.02	0.17	0.09	0.21	0.08	0.05	0.02	0.07	0.07	0.10	0.02	0.14	0.24	0.02	0.13	0.11	0.13	0.06	0.12	1.00		
Equity	0.14	-0.04	0.13	0.13	0.12	0.09	0.14	0.14	0.15	0.09	0.09	0.06	0.09	-0.02	0.15	0.07	0.09	0.14	0.12	0.10	0.07	0.12	0.02	1.00	
Bond	-0.02	-0.10	0.03	-0.07	-0.13	-0.05	-0.11	0.00	-0.03	-0.04	-0.04	-0.03	0.00	0.00	-0.06	-0.09	-0.02	-0.02	-0.10	0.00	-0.03	-0.01	-0.26	-0.01	1.00

City codes: AT, Atlanta; BS, Boston; CH, Chicago; CL, Cleveland; CT, Charlotte; DC, Washington, DC; DL, Dallas; DT, Detroit; DV, Denver; LA, Los Angeles; MI, Miami; MN, Minneapolis/St. Paul; NY, New York City; PH, Phoenix; PL, Portland; SD, San Diego; SF, San Francisco; ST, Seattle; TM, Tampa Bay.

Table 3 Panel A: Inflation hedging properties of residential real estate, equities, and bonds (sample period 1987–2010)

City/index	Expected inflation	Unexpected inflation	Recession	Housing bubble	Bull market	Regression R^2
Atlanta	0.242	-0.118	-0.007**	0.001	0.001	0.242
Boston	0.006	0.171	-0.009**	0.003**	-0.005**	0.194
Chicago	0.332	0.150	-0.006**	0.005**	0.001	0.195
Cleveland	0.273	-0.249	-0.001	0.000	0.002*	0.060
Charlotte	0.466**	-0.221	-0.005**	0.001	0.000	0.266
Washington DC	0.401*	-0.078	-0.008**	0.011**	0.000	0.413
Dallas*	0.385*	0.042	-0.001	0.000	0.000	0.062
Detroit	0.155	-0.068	-0.015**	0.000	0.000	0.253
Denver	0.011	0.068	-0.005**	-0.002*	0.000	0.084
Los Angeles	0.355	-0.323	-0.011**	0.013**	0.002	0.395
Las Vegas	0.688*	-0.066	-0.012**	0.013**	0.003	0.347
Miami	0.388	0.004	-0.011**	0.014**	0.001	0.438
Minneapolis	0.351	0.196	-0.009**	0.003*	-0.001	0.165
New York	-0.136	0.151	-0.008**	0.009**	-0.003**	0.422
Phoenix	0.647*	0.021	-0.014**	0.013**	0.005**	0.443
Portland	0.999**	0.044	-0.005**	0.005**	0.001	0.271
San Diego	0.247	-0.141	-0.012**	0.009**	0.000	0.277
San Francisco	0.751**	-0.225	-0.018**	0.006**	0.002	0.373
Seattle	0.299	0.381	-0.009**	0.004**	0.002	0.306
Tampa	0.490*	0.301	-0.007**	0.013**	0.001	0.417
CS 10-city	0.220	-0.064	-0.010**	0.009**	0.000	0.454
CS 20-city*	0.162	0.162	-0.010**	0.010**	-0.001	0.503
Bonds	-9.092**	-0.248	-0.007	-0.003	0.000	0.083
Equity	-0.545	-0.093	0.013	-0.001	0.052	0.174

* Data for S&P/Case-Shiller indices for Dallas and the 20-city composite (CS 20-city) begins in 2000.

* Statistically significant at $\leq 5\%$ level.

** Statistically significant at $\leq 1\%$ level.

mutual funds have low correlations with the stock market. Housing returns are also weakly (but negatively) correlated with long-term Treasury returns. Modern portfolio theory then predicts housing to be a good diversifier of portfolios made up of financial assets such as equities and bonds.

The effectiveness of residential real estate as an inflation hedge is tested through a multiple regression of the form:

$$H_{ret} = \alpha + \beta_1(\text{Expected Inflation}) + \beta_2(\text{Unexpected Inflation}) + \beta_3(\text{Recession}) \\ + \beta_4(\text{Bubble}) + \beta_5(\text{Bull Mkt}) + \varepsilon$$

Where H_{ret} is the monthly return of the Case-Shiller index for each of the 20 cities plus the two composite indices, *Expected Inflation* is the consensus estimate of monthly inflation rate, *Unexpected Inflation* is the difference between actual inflation rate and expected inflation. *Recession*, *Bubble*, and *Bull Mkt* are used as control variables in the model. *Recession* is a dummy variable that assumes a value of 1 when the National Bureau of Economic Research classifies the U.S. economy as in recession and 0 otherwise. *Bubble* is a dummy variable that controls for housing market bubble, assuming a value of 1 for all

Table 3 Panel B: Inflation hedging properties of residential real estate, equities, and bonds (sample period 1987–1995)

City/index	Expected inflation	Unexpected inflation	Recession	Housing bubble	Bull market	Regression R^2
Atlanta	-1.141*	-0.510	-0.006**	0.000	-0.001	0.220
Boston	0.029	-0.321	-0.010**	0.000	-0.002	0.330
Chicago	0.048	0.102	-0.002	0.000	0.001	0.021
Cleveland	0.183	0.151	-0.002	0.000	0.001	0.046
Charlotte	0.355	0.121	-0.005**	0.000	-0.001	0.217
Washington DC	1.624**	0.142	-0.009**	0.000	0.002	0.312
Dallas*	NA	NA	NA	NA	NA	NA
Detroit	-0.058	-0.743	-0.007*	0.000	0.000	0.120
Denver	-1.352**	0.072	-0.003	0.000	-0.004*	0.216
Los Angeles	3.896**	-0.053	-0.011**	0.000	0.007*	0.345
Las Vegas	0.577	0.194	0.000	0.000	-0.004	0.054
Miami	0.357	-0.187	-0.005**	0.000	-0.001	0.084
Minneapolis	-0.369	-0.169	-0.002	0.000	0.000	0.068
New York	-0.491	-0.168	-0.008**	0.000	-0.001	0.405
Phoenix	-0.331	0.078	-0.006**	0.000	-0.002	0.252
Portland	0.845*	0.382	0.001	0.000	-0.005**	0.180
San Diego	3.108**	0.222	-0.011**	0.000	0.004	0.267
San Francisco	2.443**	-0.489	-0.011**	0.000	0.004	0.288
Seattle	0.472	1.499	-0.009**	0.000	-0.002	0.159
Tampa	0.203	0.109	-0.002	0.000	0.001	0.036
CS 10-city	1.300**	-0.129	-0.009**	0.000	0.002	0.460
CS 20-city*	NA	NA	NA	NA	NA	NA
Bonds	-18.049	-2.372	-0.045	0.000	0.093**	0.221
Equity	-3.723	1.210	0.036	0.000	0.027*	0.167

* Data for S&P/Case-Shiller indices for Dallas and the 20-city composite (CS 20-city) begins in 2000.

* Statistically significant at $\leq 5\%$ level.

** Statistically significant at $\leq 1\%$ level.

months during which house prices in many parts of the United States rose by more than 10% a year and 0 otherwise, mainly occurring between January 2002 and April 2006. *Bull Mkt* is a dummy variable that assumes a value of 1 when U.S. equity markets are classified as being in a bull market using a methodology described by Pagan and Sussnov (2003) and 0 otherwise.

The results of the above regression are displayed in Table 3. Panel A presents the results for the entire sample period, 1987–2010. The coefficients for expected inflation of the Case-Shiller index returns are positive with one exception and several are significantly different from 0 at 5% level. However, the coefficients for unexpected inflation are mixed in sign and not significant. Insignificant coefficients also demonstrate a potential for hedging, although not as strong a potential as significant positive coefficients. Taken together, this suggests that residential real estate is at best a modest hedge against expected inflation and a weak hedge against unexpected inflation. However, when compared with long-term Treasuries or U.S. equities, especially long-term Treasuries, housing is a much stronger hedge against expected inflation. Interestingly enough, residential real estate returns were only slightly higher during the U.S. housing bubble although the differences are extremely statistically significant with few exceptions. Recessions have a uniformly negative impact on

Table 3 Panel C: Inflation hedging properties of residential real estate, equities, and bonds (sample period 1996–2000)

City/index	Expected inflation	Unexpected inflation	Recession	Housing bubble	Bull market	Regression R^2
Atlanta	-0.392	-0.182	0.000	0.000	0.000	0.031
Boston	-0.135	0.248	0.000	0.000	-0.007**	0.195
Chicago	0.662	0.278	0.000	0.000	0.000	0.031
Cleveland	0.153	0.156	0.000	0.000	-0.002	0.026
Charlotte	0.456	0.064	0.000	0.000	0.002	0.049
Washington DC	0.543	0.191	0.000	0.000	-0.007**	0.223
Dallas*	NA	NA	NA	NA	NA	NA
Detroit	-0.500	-0.113	0.000	0.000	0.000	0.039
Denver	-0.070	0.124	0.000	0.000	-0.004*	0.083
Los Angeles	-1.834**	-0.461	0.000	0.000	-0.002	0.143
Las Vegas	0.164	0.041	0.000	0.000	-0.003	0.053
Miami	0.255	0.279	0.000	0.000	-0.007**	0.303
Minneapolis	0.068	0.211	0.000	0.000	-0.004	0.059
New York	-0.558	0.085	0.000	0.000	-0.003	0.072
Phoenix	0.068	0.029	0.000	0.000	0.001	0.043
Portland	1.373*	0.232	0.000	0.000	0.001	0.113
San Diego	-0.681	-0.017	0.000	0.000	-0.004	0.048
San Francisco	0.796	0.570	0.000	0.000	-0.012**	0.157
Seattle	-1.211*	-0.233	0.000	0.000	0.001	0.110
Tampa	0.374	0.416	0.000	0.000	-0.007**	0.237
CS 10-city	-0.328	0.081	0.000	0.000	-0.005*	0.119
CS 20-city*	NA	NA	NA	NA	NA	NA
Bonds	1.359	-2.220	0.000	0.000	-0.013	0.011
Equity	-7.837	-2.187	0.000	0.000	0.053*	0.105

* Data for S&P/Case-Shiller indices for Dallas and the 20-city composite (CS 20-city) begins in 2000.

* Statistically significant at $\leq 5\%$ level.

** Statistically significant at $\leq 1\%$ level.

residential real estate returns and they are highly statistically significant. As might be expected, residential real estate returns are not appreciably different during bull and bear equity markets. The coefficients for the dummy variable *Bull Mkt* are mixed in sign and generally are not either economically or statistically different from 0.

Panels B through E of Table 3 examine the inflation hedging potential of residential real estate during various sub-periods (1987–1995, 1996–2000, 2001–2005, and 2006–2010). As evident in these tables, housing returns prove to be largely unrelated to either expected or unexpected inflation during all examined sub-periods. Hence, the inflation hedging potential of residential real estate appears to be weak across all sub-periods. Once again, we note that economic recessions have a negative impact on housing returns (Panels B and E). Generally speaking, housing market bubble does have a positive impact on housing returns as shown in Panel E covering the sub-period 2006–2010, which includes most of the months in the largest housing bubble in recent memory. Panel E also shows an association with equity bull markets and housing returns; however, such an association is not evident in other sub-periods examined. In summary, results from Panels A through E of Table 3 indicate that residential real estate returns can only be considered a modest hedge for inflation once the effect of economic recessions, housing market bubble, and equity bull markets have been accounted for.

Table 3 Panel D: Inflation hedging properties of residential real estate, equities, and bonds (sample period 2001–2005)

City/index	Expected inflation	Unexpected inflation	Recession	Housing bubble	Bull market	Regression R^2
Atlanta	0.071	-0.355	0.000	-0.001	0.001	0.064
Boston	-0.164	0.725	-0.001	0.002	-0.006**	0.262
Chicago	-0.076	0.203	0.003	0.001	0.001	0.069
Cleveland	0.024	-0.251	0.001	0.002	0.000	0.051
Charlotte	0.081	-0.363	-0.003	-0.001	0.001	0.076
Washington DC	0.299	0.125	-0.003	0.000	0.002	0.207
Dallas*	-0.109	0.259	-0.004	-0.005*	0.000	0.138
Detroit	-0.175	-0.293	0.000	0.000	-0.001	0.054
Denver	0.462*	-0.199	-0.002	-0.005*	0.000	0.201
Los Angeles	0.200	0.400	-0.002	0.005	0.003	0.361
Las Vegas	0.402	-0.045	0.003	0.000	0.013**	0.202
Miami	0.619	0.220	0.001	0.000	0.006*	0.334
Minneapolis	-0.336	0.424	0.000	-0.002	-0.001	0.245
New York	-0.144	0.486	0.002	0.005**	-0.002	0.151
Phoenix	1.441*	-0.480	0.000	-0.003	0.014**	0.311
Portland	0.728*	-0.868	0.001	-0.001	0.007**	0.344
San Diego	-0.178	0.425	-0.002	0.005	-0.001	0.077
San Francisco	0.430	0.438	-0.016**	0.002	-0.002	0.479
Seattle	0.302	-0.336	0.002	0.000	0.007**	0.398
Tampa	0.332	0.532	0.002	0.002	0.007**	0.258
CS 10-city	0.137	0.366	-0.002	0.003	0.001	0.360
CS 20-city	0.184	0.199	-0.002	0.002	0.001	0.395
Bonds	-9.229	2.845	0.012	0.052	-0.031	0.082
Equity	-2.726	-1.515	0.004	-0.019	0.046**	0.180

* Data for S&P/Case-Shiller indices for Dallas and the 20-city composite (CS 20-city) begins in 2000.

* Statistically significant at $\leq 5\%$ level.

** Statistically significant at $\leq 1\%$ level.

We next analyze diversification opportunities offered by residential real estate by studying the impact of its addition to a financial portfolio comprised of stocks and bonds. We examine the weight given to real estate in mean-variance optimized portfolios with three assets: Residential real estate from one of the 22 Case-Shiller indices, U.S. equities (as proxied by Wilshire 5000 index) and bonds (as proxied by 30-year U.S. Treasuries). To achieve mean variance optimization, for each portfolio, a simulation of 1,000 trials is conducted during which portfolio returns and standard deviations are computed after a random draw of portfolio weights for the three asset classes. We measure portfolio efficiency with the Sharpe ratio and seek to optimize the portfolio by finding the one that maximizes the Sharpe ratio. Hence, the simulation seeks to optimize asset weights in the portfolio to maximize the Sharpe ratio:

$$\text{Max} \left[\frac{\mu_p - RFR}{\sigma_p} \right] \Big|_{\forall p} \left\{ \begin{array}{l} \sum_i W_{pi} = 1 \\ w_{pi} \geq 0 \end{array} \right.$$

Where μ_p is the mean portfolio return over the sample period, RFR is the average risk-free rate over the sample period and σ_p is the standard deviation of portfolio returns over the

Table 3 Panel E: Inflation hedging properties of residential real estate, equities, and bonds (sample period 2006–2010)

City/index	Expected inflation	Unexpected inflation	Recession	Housing bubble	Bull market	Regression R^2
Atlanta	0.207	0.615	-0.002	0.005	0.009*	0.386
Boston	0.246	1.244*	0.001	-0.002	0.006*	0.290
Chicago	0.095	0.769	-0.004	0.010*	0.007	0.325
Cleveland	0.187	-0.623	0.012**	0.002	0.016**	0.201
Charlotte	0.786**	-1.281*	-0.005*	0.004	0.000	0.458
Washington DC	0.003	0.658	0.001	0.004	0.018**	0.569
Dallas	0.462*	0.152	0.007*	0.000	0.010**	0.281
Detroit	-0.105	1.782	-0.007	0.004	0.010	0.364
Denver	0.049	0.374	0.007**	0.002	0.011**	0.305
Los Angeles	-0.539	0.702	-0.002	0.009*	0.022**	0.670
Las Vegas	0.073	-0.197	-0.020**	0.013**	0.006	0.757
Miami	-0.297	0.772	-0.006	0.018**	0.019**	0.698
Minneapolis	0.291	1.386	-0.005	0.007	0.011	0.317
New York	0.158	0.369	-0.006*	0.007**	0.001	0.394
Phoenix	0.078	0.632	-0.012**	0.013**	0.018**	0.715
Portland	0.411	0.605	-0.009**	0.014**	0.002	0.566
San Diego	-0.616	1.417	0.001	0.004	0.023**	0.586
San Francisco	-0.132	1.952	0.003	0.001	0.033**	0.670
Seattle	0.437	-0.174	-0.010**	0.011**	0.003	0.569
Tampa	0.217	0.764	-0.003	0.018**	0.011**	0.600
CS 10-city	-0.129	0.726	-0.002	0.007**	0.014**	0.683
CS 20-city	-0.045	0.704	-0.003	0.007**	0.013**	0.681
Bonds	-12.350**	6.172	-0.054	-0.030	-0.051	0.316
Equity	2.089	0.808	0.039	-0.005	0.093**	0.337

* Statistically significant at $\leq 5\%$ level.

** Statistically significant at $\leq 1\%$ level.

sample period. The optimization of asset weights (w_{pi}) in each portfolio (p) is conducted subject to the constraints that the portfolio is fully invested (all asset weights sum up to 1) and that each asset weight is greater than or equal to 0 (long-only portfolios). As mentioned earlier, 1,000 trials are conducted for each portfolio over the entire sample period and each sub-period to select the optimal portfolio weights. To assess the risk of the portfolio, we observe the optimal portfolio's standard deviation as well as its probability of loss. The probability of loss is simply the relative frequency with which a negative return was observed in the 1,000 trials.

The results for the entire sample period (1987–2010) as well as four sub-periods (1987–1995, 1996–2000, 2001–2005, and 2006–2010) are shown in Table 4. For the complete sample period (Panel A), the optimal portfolio for residents of most of the Case-Shiller index cities is heavily weighted towards equities, closely followed by bonds. Residential real estate typically carries a small weight in the optimal portfolio with notable exceptions in the case of Washington DC, Los Angeles, Portland, San Diego, and San Francisco. Interestingly, there are several distinct weight patterns for the sub-periods under investigation. In the first sub-period from 1987 to 1995 (Panel B), weight of equities is generally between 80% and 90% for all Case-Shiller index cities, with the exception of Portland. However, the second sub-period from 1996 to 2000 (Panel C) sees joint dominance of residential real estate and

Table 4 Panel A: Complete sample period (1987–2010), optimal portfolio characteristics

City/index	Optimal portfolio weights			Portfolio characteristics			
	Housing index	Stocks	Bonds	Mean return	Standard deviation	Sharpe ratio	Probability of loss
Atlanta (1991–2010)	0.80%	81.30%	17.90%	0.56%	3.75%	0.060	44.09%
Boston	0.03%	96.79%	3.18%	0.54%	4.52%	0.045	45.07%
Chicago	0.61%	98.85%	0.54%	0.54%	4.62%	0.045	45.32%
Cleveland	0.28%	91.16%	7.76%	0.53%	4.32%	0.045	45.15%
Charlotte	0.64%	95.72%	3.34%	0.53%	4.47%	0.045	45.25%
Washington DC	75.51%	23.82%	0.67%	0.41%	1.31%	0.056	38.00%
Dallas (2000–2010)	1.52%	2.22%	96.26%	0.25%	5.15%	0.008	48.08%
Denver	2.81%	95.22%	1.97%	0.53%	4.45%	0.045	45.22%
Detroit (1991–2010)	0.00%	85.66%	14.34%	0.57%	3.89%	0.060	44.21%
Los Angeles	63.22%	35.50%	1.28%	0.43%	1.87%	0.051	40.89%
Miami	2.81%	95.16%	2.03%	0.53%	4.45%	0.045	45.24%
Minneapolis (1989–2005)	1.98%	94.50%	3.52%	0.63%	4.36%	0.068	44.28%
New York	1.13%	96.97%	1.90%	0.54%	4.53%	0.045	45.27%
Phoenix (1989–2010)	0.50%	77.62%	21.88%	0.55%	3.77%	0.057	44.21%
Portland	89.61%	5.23%	5.16%	0.42%	0.78%	0.112	29.18%
Seattle (1990–2010)	31.71%	54.26%	14.04%	0.48%	2.64%	0.056	42.76%
San Diego	74.89%	24.59%	0.52%	0.41%	1.48%	0.055	38.93%
San Francisco	70.85%	28.97%	0.18%	0.42%	1.71%	0.051	40.25%
Tampa	0.05%	96.50%	3.44%	0.54%	4.51%	0.045	45.26%
Las Vegas	0.09%	91.30%	8.61%	0.52%	4.29%	0.044	45.14%
CS 10-City	87.72%	8.03%	4.25%	0.33%	0.86%	0.149	34.81%
CS 20-City (2000–2010)	9.01%	1.25%	89.74%	0.24%	4.81%	0.008	47.97%
Stocks and bonds only		99.78%	0.22%	0.54%	4.66%	0.045	45.35%
Average monthly risk-free rate (1987–2010)			0.21%				
Average monthly risk-free rate (2000–2010)			0.33%				

Notes: Portfolios comprising the indicated Case-Shiller housing index, the Wilshire 5000 index (stocks), and the 30-year Treasuries index (bonds). Optimal portfolio is one that maximizes the Sharpe ratio in a simulation of 1,000 trials where portfolio weights for each trial are selected at random.

equities with a less than 10% weight for bonds in every city. During this period, there is a clear substitution effect between housing and equities. The optimal portfolio is dominated by residential real estate between 2001 and 2005 (Panel D) in each of the cities, leaving no more than a 20% weight for equities and bonds combined. In the final sub-period from 2006 to 2010 (Panel E), the optimal portfolio swings sharply towards bonds leaving residential real estate and equities with a combined weight of 20% or less.

While the inclusion of residential real estate does not meaningfully change either the Sharpe ratio or the loss probability of the optimal portfolio for the overall sample period, this is not always true in the four sub-periods. During the second and third sub-periods, a large number of city-level optimal portfolios including housing have much higher Sharpe ratios and much lower loss probabilities when compared with the equity-and-bond only optimal portfolios. This is also true for the composite Case-Shiller indices. These results are sensible because a quick inspection of weights of residential real estate for the overall period and for the first and fourth sub-periods reveals they are almost exclusively less than 5% with very few exceptions. With such low weights, it is unreasonable to expect the optimal portfolio

Table 4 Panel B: Sub-period 1 (1987–1995)

City/index	Optimal portfolio weights			Portfolio characteristics			
	Housing index	Stock	Bond	Mean return	Standard deviation	Sharpe ratio	Probability of loss
Atlanta (1991–1995)	0.04%	89.87%	10.09%	1.06%	2.88%	0.208	35.65%
Boston	0.88%	89.57%	9.55%	0.70%	4.05%	0.060	43.12%
Chicago	9.53%	88.71%	1.76%	0.70%	3.83%	0.064	42.77%
Cleveland	3.89%	94.63%	1.48%	0.72%	4.07%	0.065	42.95%
Charlotte	1.72%	94.79%	3.50%	0.72%	4.12%	0.063	43.05%
Washington DC	4.04%	94.32%	1.65%	0.72%	4.06%	0.064	42.99%
Dallas*	NA	NA	NA	NA	NA	NA	NA
Denver	7.52%	90.98%	1.50%	0.70%	3.92%	0.063	42.87%
Detroit (1991–1995)	1.63%	98.29%	0.08%	1.05%	2.77%	0.212	35.29%
Los Angeles	1.49%	84.31%	14.20%	0.68%	3.98%	0.057	43.17%
Miami	6.85%	86.42%	6.73%	0.68%	3.83%	0.058	42.93%
Minneapolis (1989–1995)	1.29%	88.61%	10.10%	0.88%	3.38%	0.125	29.71%
New York	0.79%	95.99%	3.22%	0.72%	4.16%	0.064	43.09%
Phoenix (1989–1995)	1.97%	88.46%	9.57%	0.87%	3.35%	0.124	29.71%
Portland	96.90%	2.73%	0.38%	0.65%	0.54%	0.357	11.16%
Seattle (1990–1995)	5.20%	85.54%	9.26%	0.89%	3.18%	0.135	29.99%
San Diego	1.90%	96.55%	1.55%	0.73%	4.15%	0.064	43.06%
San Francisco	4.99%	91.97%	3.04%	0.71%	3.99%	0.063	42.95%
Tampa	0.58%	88.43%	10.99%	0.70%	4.04%	0.059	43.14%
Las Vegas	1.96%	97.87%	0.16%	0.70%	4.19%	0.065	43.07%
CS 10-city	1.17%	88.14%	10.69%	0.70%	4.02%	0.059	43.11%
CS 20-city*	NA	NA	NA	NA	NA	NA	NA
Stocks and bonds only		99.43%	0.57%	0.74%	4.26%	0.066	43.12%
Average monthly risk-free rate			0.46%				

Notes: Portfolios comprising the indicated Case-Shiller housing index, the Wilshire 5000 index (stocks), and the 30-year Treasuries index (bonds). Optimal portfolio is one that maximizes the Sharpe ratio in a simulation of 1,000 trials where portfolio weights for each trial are selected at random.

* Data for S&P/Case-Shiller indices for Dallas and the 20-city composite (CS 20-city) begins in 2000.

including real estate to behave very differently from ones without. On the other hand, for optimal portfolios with significant weights in residential real estate, witnessed during sub-periods 2 and 3, we do find significant increases in Sharpe ratios and decreases in loss probabilities.

We examine the above issue further in Table 5 where we examine three-year overlapping rolling windows of optimal portfolios including the 10-city Case-Shiller index along with the equity and Treasury indices. Because we are using monthly returns, we choose to use three-year rolling windows to have sufficient sample size. Once again, we observe the temporal variation in optimal portfolio weights. Of note is the period from 1996 to 2006, when the housing index makes up 84% or higher of the optimal portfolio. While the mean return of the optimal portfolio was lower than in preceding periods when equities dominated, portfolio standard deviation and probability of loss are substantially reduced resulting in more efficient portfolios with higher Sharpe ratios. Once again, we note that the housing index appeared to have substituted the dominance of equities in the optimal mix during the years 1996–2006. We also note that the recent weakness in both the housing and equities

Table 4 Panel C: Sub-period 2 (1996–2000)

City/index	Optimal portfolio weights			Portfolio characteristics			
	Housing index	Stocks	Bonds	Mean return	Standard deviation	Sharpe ratio	Probability of loss
Atlanta	86.46%	13.05%	0.49%	0.56%	0.69%	0.198	20.83%
Boston	93.38%	3.90%	2.72%	0.84%	0.41%	1.030	1.49%
Chicago	37.04%	62.91%	0.04%	0.89%	3.01%	0.155	38.40%
Cleveland	5.32%	92.71%	1.93%	1.10%	4.45%	0.153	40.18%
Charlotte	6.73%	89.85%	3.42%	1.07%	4.32%	0.151	40.18%
Washington DC	2.36%	96.36%	1.29%	1.13%	4.61%	0.154	40.28%
Dallas*	NA	NA	NA	NA	NA	NA	NA
Denver	90.31%	6.00%	3.69%	0.79%	0.47%	0.774	4.89%
Detroit	91.93%	7.10%	0.97%	0.66%	0.37%	0.620	4.47%
Los Angeles	93.18%	5.42%	1.40%	0.69%	0.50%	0.542	8.78%
Miami	4.69%	91.01%	4.30%	1.09%	4.38%	0.152	40.20%
Minneapolis	89.89%	8.07%	2.04%	0.67%	0.55%	0.459	11.38%
New York	97.08%	0.73%	2.18%	0.58%	0.39%	0.409	6.87%
Phoenix	90.29%	5.91%	3.80%	0.52%	0.40%	0.256	9.40%
Portland	4.13%	94.09%	1.78%	1.11%	4.51%	0.154	40.25%
Seattle	96.43%	0.07%	3.50%	0.62%	0.42%	0.478	6.95%
San Diego	93.69%	2.35%	3.96%	0.80%	0.60%	0.631	9.07%
San Francisco	92.87%	0.97%	6.15%	1.06%	0.87%	0.727	11.49%
Tampa	15.92%	83.87%	0.22%	1.04%	4.00%	0.154	39.76%
Las Vegas	15.52%	82.94%	1.54%	1.01%	3.97%	0.149	39.96%
CS 10-city	88.78%	10.86%	0.36%	0.71%	0.56%	0.509	10.67%
CS 20-city*	NA	NA	NA	NA	NA	NA	NA
Stocks and bonds only		99.70%	0.30%	1.16%	4.77%	0.155	40.38%
Average monthly risk-free rate			0.42%				

Notes: Portfolios comprising the indicated Case-Shiller housing index, the Wilshire 5000 index (stocks), and the 30-year Treasuries index (bonds). Optimal portfolio is one that maximizes the Sharpe ratio in a simulation of 1,000 trials where portfolio weights for each trial are selected at random.

* Data for S&P/Case-Shiller indices for Dallas and the 20-city composite (CS 20-city) begins in 2000.

markets during the years 2008–2010 has resulted in bonds dominating the optimal portfolio. However, once again, these optimal portfolios have become more risky, with higher standard deviation and probability of loss, as well as less efficient, with lower Sharpe ratios. Hence, we observe that the optimal allocation of residential real estate in the investor's portfolio is time varying and this fact therefore calls for a dynamic asset allocation strategy with periodic rebalancing.

In summary, our analysis indicates that residential real-estate displays a high level of volatility and provides only a moderate hedge against expected and unexpected inflation after accounting for the impact of economic recessions, housing market bubbles, and bull equity markets. In the portfolio context, adding housing to the mix of a traditional stock and bond portfolio can enhance portfolio performance, as indicated by higher Sharpe ratios and lower loss probability. However, the optimal weight of residential real estate in the portfolio is time varying and often not high enough to warrant tying up a large proportion of the individual homeowner-investor's wealth. The best allocation of residential real estate in an investment portfolio can only arise from a dynamic strategy with periodic rebalancing.

Table 4 Panel D: Sub-period 3 (2001–2005)

City/index	Optimal portfolio weights			Portfolio characteristics			
	Housing index	Stocks	Bonds	Mean return	Standard deviation	Sharpe ratio	Probability of loss
Atlanta	89.31%	7.79%	2.90%	0.32%	0.36%	0.394	18.92%
Boston	90.50%	6.91%	2.59%	0.67%	0.44%	1.110	6.75%
Chicago	85.37%	6.36%	8.26%	0.62%	0.58%	0.770	14.34%
Cleveland	94.67%	1.97%	3.37%	0.27%	0.34%	0.288	21.23%
Charlotte	93.09%	3.43%	3.48%	0.27%	0.39%	0.251	24.05%
Washington DC	94.84%	4.54%	0.62%	1.26%	0.49%	2.205	0.65%
Dallas (2000–2005)	96.29%	0.24%	3.47%	0.30%	0.45%	0.267	25.53%
Denver	93.19%	1.04%	5.77%	0.31%	0.47%	0.297	25.10%
Detroit	91.74%	7.79%	0.47%	0.26%	0.46%	0.194	28.12%
Los Angeles	95.94%	0.66%	3.40%	1.41%	0.62%	2.009	1.14%
Miami	95.25%	4.42%	0.33%	1.41%	0.56%	2.208	0.29%
Minneapolis	91.00%	8.09%	0.91%	0.64%	0.41%	1.130	5.77%
New York	94.70%	4.60%	0.70%	1.01%	0.29%	2.866	0.73%
Phoenix	95.42%	2.78%	1.80%	1.17%	1.13%	0.882	15.12%
Portland	89.09%	7.24%	3.66%	0.70%	0.61%	0.847	13.03%
Seattle	82.98%	8.67%	8.35%	0.63%	0.72%	0.633	19.06%
San Diego	84.81%	8.68%	6.51%	1.10%	0.78%	1.194	7.72%
San Francisco	95.80%	0.73%	3.47%	0.83%	0.91%	0.715	18.29%
Tampa	93.02%	4.42%	2.56%	1.13%	0.71%	1.349	5.33%
Las Vegas	93.44%	3.12%	3.45%	1.23%	1.21%	0.867	15.77%
CS 10-city	94.12%	4.35%	1.53%	0.95%	0.44%	1.722	1.37%
CS 20-city (2000–2005)	98.60%	0.70%	0.69%	0.97%	0.29%	2.710	0.10%
Stocks and bonds only		0.16%	99.84%	0.43%	6.87%	0.037	47.51%
Average monthly risk-free rate			0.18%				

Notes: Portfolios comprising the indicated Case-Shiller housing index, the Wilshire 5000 index (stocks), and the 30-year Treasuries index (bonds). Optimal portfolio is one that maximizes the Sharpe ratio in a simulation of 1,000 trials where portfolio weights for each trial are selected at random.

5. Conclusion

Given that a significant portion of an individual homeowner-investor's wealth is often tied up in residential real estate (housing), we examine its investment performance in this study. In contrast to most previous studies in this arena, we use realized prices based (as opposed to appraisal based) housing price returns based on the S&P/Case-Shiller MSA home price indices. In addition, by using 20 different citywide (MSA) indices as well as two composite indexes, we attempt to provide a more comprehensive overview of U.S. housing markets. The analysis presented in this article shows that residential real estate has the potential of providing a modest hedge for inflation during most time periods. In this regard, our observations are consistent with previous studies (e.g., Bond and Seiler, 1998; Rubens et al., 1989). In addition, consistent with prior studies (e.g., Goetzmann, 1993; Graur et al., 1996; Mueller and Mueller, 2003; Cocco, 2005), we find that individual investors will benefit from enhanced portfolio efficiency by adding residential real estate to their portfolio. Although a high weight in housing was optimal during the years 1996–2006, this is not always the case. For about half of the time span covered in this study the optimal allocation of housing was

Table 4 Panel E: Sub-period 4 (2006–2010)

City/index	Optimal portfolio weights			Portfolio characteristics			
	Housing index	Stocks	Bonds	Mean return	Standard deviation	Sharpe ratio	Probability of loss
Atlanta	1.00%	16.31%	82.69%	0.09%	6.38%	-0.013	49.42%
Boston	0.02%	6.30%	93.68%	0.10%	7.33%	-0.011	49.45%
Chicago	1.14%	15.81%	83.05%	0.09%	6.42%	-0.014	49.43%
Cleveland	0.35%	3.98%	95.67%	0.10%	7.51%	-0.011	49.47%
Charlotte	0.23%	5.90%	93.87%	0.10%	7.35%	-0.011	49.46%
Washington DC	0.13%	17.45%	82.42%	0.10%	6.36%	-0.013	49.39%
Dallas	1.33%	2.43%	96.24%	0.10%	7.57%	-0.011	49.48%
Denver	1.84%	4.16%	94.00%	0.10%	7.38%	-0.011	49.48%
Detroit	1.81%	0.67%	97.52%	0.08%	7.70%	-0.013	49.48%
Los Angeles	2.12%	13.01%	84.87%	0.08%	6.57%	-0.015	49.41%
Miami	0.77%	10.55%	88.68%	0.09%	6.89%	-0.013	49.47%
Minneapolis	2.89%	1.81%	95.31%	0.08%	7.51%	-0.013	49.47%
New York	2.76%	3.40%	93.83%	0.09%	7.37%	-0.012	49.43%
Phoenix	0.66%	6.34%	92.99%	0.09%	7.27%	-0.012	49.50%
Portland	0.46%	1.29%	98.25%	0.10%	7.75%	-0.010	49.49%
Seattle	0.17%	18.60%	81.23%	0.10%	6.26%	-0.013	49.38%
San Diego	1.26%	0.13%	98.61%	0.09%	7.79%	-0.011	49.53%
San Francisco	0.91%	3.26%	95.84%	0.09%	7.53%	-0.011	49.51%
Tampa	0.46%	8.20%	91.34%	0.10%	7.13%	-0.012	49.47%
Las Vegas	0.16%	19.85%	80.00%	0.10%	6.16%	-0.014	49.38%
CS 10-city	0.69%	6.65%	92.66%	0.10%	7.24%	-0.011	49.47%
CS 20-city	0.43%	3.30%	96.27%	0.10%	7.57%	-0.011	49.48%
Stocks and bonds only		0.10%	99.90%	0.10%	7.89%	-0.010	49.48%
Average monthly risk-free rate			0.18%				

Notes: Portfolios comprising the indicated Case-Shiller housing index, the Wilshire 5000 index (stocks), and the 30-year Treasuries index (bonds). Optimal portfolio is one that maximizes the Sharpe ratio in a simulation of 1,000 trials where portfolio weights for each trial are selected at random.

significantly below (less than 7%) the typical weight in a home-owner investor's portfolio. Hence, for about half the sample period examined, our results concur with the conclusion drawn by Hennessey (2003) that housing is a suboptimal investment, especially at the levels of proportional wealth allocated to it by many homeowner investors. From a purely investment perspective, individual homeowner-investors may be over-invested in housing. Because the optimal allocation of housing in an investor's portfolio is time varying, we believe that a dynamic allocation strategy will be more beneficial for the individual investor's portfolio, an observation in agreement with earlier studies (such as Grauer et al., 1995). As a practical matter, the lumpiness and illiquidity of real estate may restrict many homeowners from such dynamic rebalancing of their portfolios. In addition, proper rebalancing on an ex ante basis will require superior market timing ability, a skill that has been found lacking even in professional real estate fund managers as shown by Lin and Yung (2007). Our analysis is also limited by its omission of considerations such as the highly levered nature of home ownership as well as its federal tax advantages. Finally, an important consideration for many homeowners may just be that residential real estate is best regarded as part consumption and part investment, rather than purely an investment choice.

Table 5 Temporal Portfolio Characteristics

Three-year rolling window	Optimal portfolio weights				Portfolio characteristics		
	CS10A	Stocks	Bonds	Mean return	Standard deviation	Sharpe ratio	Probability of loss
1987–1989	97.10%	2.25%	0.65%	0.74%	0.30%	0.558	1.92%
1988–1990	1.19%	98.68%	0.13%	0.69%	3.96%	0.018	43.10%
1989–1991	0.42%	65.63%	33.95%	1.12%	4.72%	0.115	40.58%
1990–1992	1.37%	98.41%	0.23%	0.62%	4.17%	0.040	44.11%
1991–1993	0.87%	76.11%	22.42%	1.20%	3.00%	0.289	34.51%
1992–1994	3.59%	91.70%	4.70%	0.28%	2.26%	−0.008	35.10%
1993–1995	1.43%	95.09%	3.48%	0.95%	2.37%	0.252	34.40%
1994–1996	5.44%	93.30%	1.26%	1.13%	2.59%	0.279	33.12%
1995–1997	0.18%	97.57%	2.26%	1.98%	3.04%	0.509	25.75%
1996–1998	91.32%	8.36%	0.32%	0.55%	0.46%	0.300	11.26%
1997–1999	90.95%	6.52%	2.54%	0.73%	0.38%	0.872	2.29%
1998–2000	97.44%	2.30%	0.26%	0.89%	0.22%	2.085	0.10%
1999–2001	87.20%	9.03%	3.78%	0.75%	0.53%	0.681	7.65%
2000–2002	92.09%	6.02%	1.89%	0.85%	0.41%	1.359	2.27%
2001–2003	94.00%	2.53%	3.47%	0.92%	0.42%	1.782	1.25%
2002–2004	94.85%	1.97%	3.18%	1.17%	0.38%	2.789	0.45%
2003–2005	95.99%	2.51%	1.50%	1.21%	0.32%	3.335	0.10%
2004–2006	84.73%	13.90%	1.37%	0.86%	0.62%	0.969	8.22%
2005–2007	0.41%	85.64%	13.95%	0.54%	1.88%	0.108	38.60%
2006–2008	1.90%	0.94%	97.16%	1.42%	7.01%	0.162	41.96%
2007–2009	6.78%	5.07%	88.15%	0.03%	7.75%	−0.017	49.83%
2008–2010	0.78%	7.52%	91.70%	4.61%	8.42%	0.001	49.74%

Notes: Properties of rolling and overlapping three-year optimal portfolios. Portfolios comprise the 10-city Case-Shiller housing index (CS10A), the Wilshire 5000 index (stocks), and the 30-year Treasuries index (bonds). Optimal portfolio is one that maximizes the Sharpe ratio in a simulation of 1,000 trials where portfolio weights for each trial are selected at random.

Notes

- 1 Despite the recent tightening of credit, the desire to own a home remains high amongst U.S. households and is only moderately diminished after the recent housing market downturn, according to a recent Fannie Mae report (Berland and Wyman, 2010).

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