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Home ownership decision in personal finance: some empirical evidence

C. Sherman Cheung[a], and Peter Miu[a,*]

[a]*DeGroote School of Business, McMaster University, Hamilton, Ontario L8S 4M4, Canada*

Abstract

Despite being one of the most important decisions a household has to make and extensively covered in personal finance textbooks, there is very little empirical guidance as to whether it pays to own a house. We examine this empirical question for households with different risk tolerance. By including home ownership into the general portfolio analysis of financial assets, we demonstrate clearly the interaction effect between financial assets and home ownership. We also offer a comprehensive analysis of 20 regional housing markets to determine whether the economic case for home ownership varies across regions. For households that decide to rent instead of owning a house, this study offers evidence on the effectiveness of hedging housing consumption risk with investments in real estate investment trusts. © 2015 Academy of Financial Services. All rights reserved.

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1. Introduction

The home ownership decision is a major decision for most households. All textbooks in personal finance cover the topic in details (e.g., see Madura, 2014). Almost all textbooks examine the home ownership decision as a "buy versus rent" decision. What is lacking in personal finance textbooks is the empirical evidence on whether a typical U.S. household should in fact own a house. This absence of empirical evidence is somewhat unusual given the emphasis on empirical evidence in modern finance. Theory is not enough unless it is

* Corresponding author. Tel.: +1-905-525-9140 ext. 23981; fax: +1-905-521-8995.
E-mail address: miupete@mcmaster.ca (P. Miu)

supported by empirical evidence. In the literature, there is not much empirical evidence that buying a house is in fact a wise decision. This lack of evidence is a cause for concern since a house is a major asset for most households and the decision is relatively expensive and inconvenient to be reversed. The question of whether a household should purchase a house takes on more urgency since the collapse of the housing market in 2008.

Our article examines empirically whether it pays to own a house by estimating the diversification benefit of home ownership in a representative investor's portfolio. Similar to holding any financial assets, home ownership may enhance the wealth of a portfolio investor in the form of capital gain, whereas at the same time help diversifying the risk of the overall investment portfolio. If home ownership offers statistically significant enhancement in the risk-return trade off, then it pays to own a house. If a house does not offer such benefit, the case for home ownership is no longer obvious. Perhaps the chapter on "buying versus renting" a house in personal finance textbooks should be approached differently. We advocate an approach where the decisions of home ownership, savings, and investment are made jointly. Therefore, this study broadens the scope of services offered by financial advisors and planners. The common practices for most financial advisors and planners tend to focus exclusively on investments, retirement planning, estate planning, and insurance needs. Residential ownership, which may represent a great part of a household's total wealth, tends to be ignored. This study equips financial advisors or planners to offer a more comprehensive guidance to their clients beyond savings and investment decisions.

The finance literature does address the home ownership decision with the emphasis on the interactions of housing choices with other financial assets. Some researchers examine the ex ante optimality of joint portfolio choices of liquid assets such as stocks, bonds, and the house. Yao and Zhang (2005), for example, derive a stylized model and provide empirical evidence for the ability of the explanatory variables in their model to predict individuals' decisions to own versus to rent a house. Whenever the investor in their model chooses to own a house, the model predicts the investor will reduce the equity proportion in their net worth, reflecting the substitution effect of the house for risky stocks. Flavin and Yamashita (2002) examine the effects of an exogenous housing ownership on the financial portfolio over a life cycle. Unfortunately, in their model, a house is not endogenously included in a household's portfolio based on its risk-return characteristics and, therefore, it cannot address the issue of whether an individual should own a house based on the risk-return characteristics of housing ownership. Hennessey (2003) investigates the home ownership choice using two case studies. His prime focus is the payoff from the ownership without explicitly taking into consideration the risk dimension. Given the importance of risk consideration in modern finance, any analysis without accounting for risk will be incomplete at best. With the exception of Goetzmann (1993) and Wu and Pandey (2012), the existing literature seems to be mostly concerned with the ex ante modeling of the housing choice and the empirical verification of the proposed models. Different from the existing literature, our article focuses on the ex-post diversification benefit of owning a house assuming very little about the model governing the behavior of our representative investor other than the standard mean-variance framework. The basic question we address in this study is whether an investor should own a house instead of renting one based on the historical risk and return characteristics of home ownership.

To capture the historical risk and return characteristics of owning a house, we first use the aggregate U.S. residential property market price index as a proxy for the return on owning a house. We also examine twenty regional residential property markets. Home ownership differs from the ownership of financial assets in one very significant way. In the case of stocks, one can obtain exposure to the whole market easily by buying an exchange-traded fund (ETF) that covers the overall United States or international markets. Common market indices such as the Standard and Poor's 500 Index are the appropriate proxy for the ownership of stocks. In the case of houses, a home owner usually owns only *one* house. An aggregate national market index for the overall U.S. housing market becomes meaningless if there are significant variations in regional housing markets. This necessitates the examination of individual regional markets. By examining individual regional markets, we can also shed light on whether the housing markets in the U.S. Sun Belt are indeed more attractive than the housing markets in the northeast United States? Further, the difference in the attractiveness of various regional housing markets is an important issue for the "buy versus rent" decision because of the fact that individuals quite often have to relocate to a different city for career or other reasons.

For individuals who choose rental instead of outright ownership, the concern for them is the consumption risk associated with rental because of future rent increases. Can these individuals replace the investments in houses with investments in real estate investment trusts (REITs)? Can they hedge their housing consumption risk by owning REITs? Is the ownership of REITs an alternative way to obtain exposure to the residential housing markets? We attempt to address this issue by verifying the attractiveness of REITs in lieu of the outright ownership of residential housing.

Goetzmann (1993) and Wu and Pandey (2012) examine the optimal allocation to a residential property using the historical risk and return characteristics of home ownership similar to part of our study. As explained later, they, however, fail to provide the statistical tests that can tell us whether a house belongs to an investor's portfolio in the first place. They implicitly assume an individual should always own a house and proceeds with estimating what fraction of his or her wealth should be allocated to the house investment. In this study, we provide the necessary statistical tests on the home ownership decision. It is well known that any in-sample portfolio performance analysis ought to result in a risk-adjusted return on the optimal portfolio no worse than that before an extra asset class is added to the portfolio. The issue is whether such improvement is too large to be explained by chance and this can only be settled by statistical tests. Goetzmann (1993) and Wu and Pandey (2012) also fail to examine alternatives to home ownership such as investments in REITs.

Some may question the appropriateness of our choice of a portfolio optimization model involving financial assets and a house. Individuals who contemplate home ownership versus rental are likely to be first-time buyers who lack the financial ability to own financial assets. Should a portfolio approach involving both financial assets and a house be appropriate when the first-time buyer may have no extra money for financial assets? First, individuals may have financial assets in their pension accounts in which they have entitlement but without accessibility for tax and other institutional reasons. The 2001 Survey of Consumer Finances (SCF) shows that about two-thirds of the U.S. households own their primary residences and the home value accounts for only 55% of a homeowner's total assets, on average. Secondly, home ownership is a long-term decision. Although first-time buyers may not have immediate ownership in financial assets, they will eventually accumulate financial assets through their 401(k). Our approach can therefore be thought of as a long-term validation of a current decision. Finally, the use of a portfolio model is a common approach adopted in the literature (e.g., Brueckner, 1997; Flavin and Yamashita, 2002; Goetzmann, 1993). By adopting an approach that is consistent with those commonly used, we ensure our results are readily comparable with those of other studies. It is our focus on the interaction effect between real estate and financial assets that enables us to gain important insights into the impact of home ownership on the investments in other financial assets. Our findings suggest that owning a house quite often results in the displacement of bond investments in the portfolio as the two assets exhibit very similar risk-return characteristics. Thus, investors and financial planners are likely to arrive at suboptimal overall investment portfolios if they focus on asset allocation involving only traditional financial assets while ignoring the substitution effect between real estate ownership and bond investments.

In summary, this study addresses a gap in the literature and is far more comprehensive than the previous studies in that we examine the suitability of home ownership for a variety of potential home owners with different degrees of risk aversion.[1] The optimal investment choice of an investor of high risk tolerance could be dramatically different from that of one who hardly wants to bear any risk given the difference in how they trade-off return versus risk. Potentially as a key component of the overall investment portfolio, home ownership may be perceived differently by the two kinds of investors in terms of its contribution to the growth of their overall wealth. For example, no matter how much diversification benefit it brings about in constraining the risk of the overall portfolio, home ownership may still be considered as a poor decision by an investor of high risk tolerance if it fails to deliver a sufficiently high return. On the other hand, a modest expected return from the appreciation of real estate price may provide sufficient incentive for a risk averse investor to decide owning the same residential property since the diversification benefit of having the real estate investment as part of his or her overall investment portfolio is highly treasured by this kind of investors. We design our empirical analysis in a way that allows us to dissect the implication of risk aversion on home ownership. We also examine the risk-return characteristics of different regional residential housing markets and how they may influence the home ownership decision. Moreover, we examine the case for investing in REITs as an alternative to outright home ownership.[2] Finally, we provide the necessary statistical test results in substantiating the arguments for or against home ownership.

By using a comprehensive approach encompassing both home ownership and financial assets, we illustrate how and to what extent the current practice of financial planning involving financial assets alone can be very problematic. Our results indicate home ownership pays for the conservative investors *not* because of the price appreciation of residential properties. Despite the potentially false impression created by the recent housing crisis, a house is attractive for its stabilizing influences in times of financial turbulences rather than its potential for price appreciation. There are regional variations in the attractiveness of home ownership with the Sun Belt lagging far behind the west coast.

2. Optimal portfolio of a representative U.S. homeowner

In this article, we consider a representative U.S. investor originally holding U.S. equities, non-North American equities, and U.S. government bonds. For this investor, we examine the effects on the risk-return tradeoff of adding real estate to the existing portfolio. Specifically, we gauge the value-adding of real estate investment by examining the extent to which it enhances the risk-adjusted expected return of the overall investment portfolio as measured by the resulting Sharpe ratio of the optimal portfolio under a mean-variance optimization framework. Therefore, it captures the diversification benefit given the fact that real estate returns are far from perfectly correlated with those of other financial assets. We compare the Sharpe ratios of two optimal portfolios: (1) the maximum Sharpe ratio of the original portfolio with the three existing financial assets as our baseline, and (2) the maximum Sharpe ratio when real estate is added to the investor's baseline portfolio. Any statistically significant improvement in the Sharpe ratio will prove that home ownership indeed offers a diversification benefit to the investor and enhances his or her risk-adjusted return.

If short selling is allowed, the maximum Sharpe ratio can be derived by first finding out the weights w of the tangency portfolio.[3]

$$w = \frac{\Sigma^{-1}(\bar{z} - R_f \cdot 1)}{B - A \cdot R_f}, \tag{1}$$

where $\bar{z}$ is the vector of the mean returns of assets
Σ is the variance-covariance matrix of asset returns
1 is the unit vector
R_f is the constant risk-free rate
$A = 1' \cdot \Sigma^{-1} \cdot 1$
$B = 1' \cdot \Sigma^{-1} \cdot \bar{z}$

The Sharpe ratio of the tangency portfolio is then equal to:

$$\Theta_p = \frac{\bar{z}_p - R_f}{\sigma_p} = \frac{\bar{z}' \cdot w - R_f}{(w' \cdot \Sigma \cdot w)^{0.5}}, \tag{2}$$

where $\bar{z}_p$ and σ_p are, respectively, the mean and *SD* of the return of the tangency portfolio. Because an individual cannot short sell a house the way a stock is sold short and most investors do not short sell individual asset classes, we consider the portfolio allocations when short selling is disallowed throughout this article. When short selling is disallowed, the weights of the tangency portfolio can be solved with the extra inequality constraint that the vector of weights is non-negative. The question of interest is whether the Sharpe ratio of the tangency portfolio when a house is added is indeed statistically significantly higher than the Sharpe ratio of that without the house. This will give us confidence that the improvement in the Sharpe ratio is not because of sampling errors. The details of the test procedure is developed by Glen and Jorion (1993) and explained in Appendix B.

One simple way to test the diversification benefits is to estimate and compare the Sharpe ratios of the tangency portfolios with and without real estate using historical average return of T-bill for R_f in Eq. (2). This ex post approach is the most common practice and is also used here. In addition to using historical T-bill returns, we also consider the resulting Sharpe ratios at different values of R_f. By varying R_f, we in effect trace out the efficient frontier by solving for different tangency portfolios.[4] This approach allows us to solve for different optimal portfolios on the frontier and evaluate the statistical significance of any difference in the respective Sharpe ratios for investors with different risk aversion parameters. By allowing for different degrees of risk aversion, we can detect if the diversification benefits are different for investors with different risk preference. Goetzmann (1993) and Wu and Pandey (2012) develop the efficient frontier of the financial assets *and* the house using historical data. What they fail to do is to examine the baseline case without the house so as to illustrate the enhancement of the risk-adjusted return as a result of investing in the residential property. By ignoring the baseline case without the house, they implicitly assume that the house has to be in the optimal portfolio and thus ruling out the possibility that home ownership may not be a value-adding proposition for (at least) some of the investors in the first place.

In this study, we proxy the return on home ownership with the price appreciation measured by the Standard and Poor's (S&P)/Case-Shiller Home Price Indices. It is obvious that the return on home ownership is more than the price appreciation of the residential property. A home is both a consumption good and an investment. The consumption component is the shelter provided by the house. By not accounting for the consumption component in our study, we clearly underestimate the return on home ownership. There are two other potential tax benefits associated with home ownership we ignore in this study. First, interest payments embedded in the mortgage are tax deductible, whereas rents in general are not. Second, the realized gain upon selling the house also receives more favorable tax treatment than capital gains from financial asset investments. Fortunately, ignoring these advantages of home ownership will only reinforce our conclusions if our test results favor home ownership based on the price appreciation alone.

3. Data

The proxies for United States and non-North American equities are the monthly total return series of the Center for Research in Security Prices' (CRSP's) value-weighted index and the MSCI Europe, Australasia and Far East (EAFE) Index, respectively. We use the total return series of the intermediate government bonds provided by the Ibbotson SBBI Yearbook to proxy for the monthly returns on U.S. government bonds. Several indices are used as proxies for the price appreciation of residential real estate. The S&P/Case-Shiller Home Price Indices are used to construct our monthly returns on home ownership as they are the most popular and comprehensive measures of U.S. residential real estate prices. We consider both the Case-Shiller 10-City composite (CS Composite 10) and the 20-City composite (CS Composite 20) indices as our proxies for the returns on the national market. The S&P/Case-Shiller index family also includes 20 regional indices for the 20 metropolitan statistical areas (MSAs). In this study, we also consider the investment in U.S. real estate investment trusts (REITs) as an alternative to home ownership. To proxy for the return on REITs, we use the popular All REITs monthly return series published by the National Association of Real Estate Investment Trusts (NAREIT).

Because the S&P/Case-Shiller indices are only available from January 1987, we consider the sample period from January 1987 to December 2011 in conducting our main empirical analysis. However, data for five of the 20 MSAs are not available until later in our sample period. Specifically, data for the Phoenix MSA are available from January 1989. Data for the Seattle MSA are available from January 1990. Data for both Atlanta and Detroit MSAs are only available from January 1991. Finally, data for the Dallas MSA are from January 2000. As a result of the late availability of the Dallas MSA data, the CS Composite 20 index, which includes the Dallas MSA, also starts from January 2000. Although we could have conducted all our analyses using only data since January 2000 for all our time series to maintain uniformity in the time coverage across all MSAs, we also want to have the longest time series possible to obtain a long-term perspective of home ownership as home ownership tends to be a long-term proposition for most individuals. Very few individuals own a house for just a year or two and then switch to renting. As a result, we perform our portfolio optimization exercise for the CS Composite 10 index and the indices of 15 MSAs together with matching financial asset returns data series covering the full sample period since January 1987. For the remaining five MSAs and the CS Composite 20 index of late data availability, we perform our analyses using shorter time series with starting dates dictated by the respective data availability dates mentioned earlier. In conducting the portfolio optimization; therefore, we consider the respective matching subsamples of the returns of other financial assets.

4. Results

4.1. Descriptive statistics

The risk and return characteristics of the financial assets and the house price indices are reported in Table 1 Panel A. Among all the house price and financial asset indices, U.S. equities and REITs have the highest average returns of 0.81% and 0.82% per months, respectively. Proxied by the national house price indices of CS Composite 10 or CS Composite 20, the average monthly return on home ownership is lower than those of all financial assets. International equities represented by EAFE and REITs are the most risky asset classes based on the *SD*s of their monthly returns, whereas residential real estate represented by the CS Composite 10 and CS Composite 20 indices are the least risky. Bonds appear to be moderate in both risk and returns.

Evidence based on the CS Composite 10 and CS Composite 20 indices in Table 1 appears to indicate that a house should be considered as a consumption good to be enjoyed rather than an investment for future returns. If home ownership is an investment at all, it is the safest investment among the assets under consideration here.

As for individual MSAs, Portland stands out as the city with the best mean return at 0.40% per month, which is about one half of the mean return of U.S. equities. Detroit, on the other hand, has the worst mean return at 0.08% per month. Not one single city reports a negative mean return over the sample period. In other words, the worst scenario for owning a

Table 1 Summary statistics

Panel A: Risk-return characteristic

	N	Mean	*SD*
CS Composite-10	299	0.29%	0.91%
CS Composite-20	143	0.22%	1.12%
CRSP VW	299	0.81%	4.62%
Inter. Gov. Bond	299	0.56%	1.33%
MSCI-EAFE	299	0.54%	5.16%
All REIT	299	0.82%	5.21%
AZ-Phoenix	275	0.16%	1.35%
CA-Los Angeles[a]	299	0.34%	1.27%
CA-San Diego[a]	299	0.35%	1.21%
CA-San Francisco[a]	299	0.35%	1.41%
CO-Denver[a]	299	0.30%	0.74%
DC-Washington[a]	299	0.35%	1.02%
FL-Miami[a]	299	0.24%	1.15%
FL-Tampa	299	0.17%	1.01%
GA-Atlanta	251	0.09%	0.96%
IL-Chicago[a]	299	0.25%	1.03%
MA-Boston[a]	299	0.26%	0.92%
MI-Detroit	251	0.08%	1.20%
MN-Minneapolis	275	0.22%	1.23%
NC-Charlotte	299	0.18%	0.60%
NV-Las Vegas[a]	299	0.11%	1.39%
NY-New York[a]	299	0.26%	0.81%
OH-Cleveland	299	0.21%	0.88%
OR-Portland	299	0.40%	0.87%
TX-Dallas	143	0.09%	0.85%
WA-Seattle	263	0.31%	0.99%

Panel B: Correlation coefficient

	Case-Shiller Composite-10	Case-Shiller Composite-20	CRSP VW	Inter. Gov. Bond	MSCI-EAFE
CS Composite-20	1.00				
CRSP VW	0.04	0.09			
Inter. Gov. Bond	−0.04	−0.05	−0.08		
MSCI-EAFE	0.09	0.15	0.72	−0.09	
All REIT	0.12	0.22	0.60	−0.02	0.48
AZ-Phoenix	0.77	0.84			
CA-Los Angeles[a]	0.92	0.93			
CA-San Diego[a]	0.87	0.89			
CA-San Francisco[a]	0.86	0.87			
CO-Denver[a]	0.52	0.69			
DC-Washington[a]	0.92	0.95			
FL-Miami[a]	0.81	0.88			
FL-Tampa	0.79	0.89			
GA-Atlanta	0.65	0.72			
IL-Chicago[a]	0.74	0.85			
MA-Boston[a]	0.76	0.79			
MI-Detroit	0.66	0.75			
MN-Minneapolis	0.74	0.83			
NC-Charlott	0.54	0.62			
NV-Las Vegas[a]	0.68	0.80			
NY-New York[a]	0.86	0.89			
OH-Cleveland	0.55	0.62			
OR-Portland	0.55	0.80			
TX-Dallas	0.55	0.60			
WA-Seattle	0.66	0.80			

Note: Summary statistics of the monthly returns on the S&P/Case-Shiller indices, CRSP value-weighted (VW) index, intermediate government bonds, MSCI-EAFE index, and the All REIT index from January 1987 to December 2011. The sample periods of 5 MSAs and the CS Composite 20 index are shorter (Phoenix MSA from January 1989; Seattle from January 1990; Atlanta and Detroit from January 1991; and Dallas and the CS Composite 20 index from January 2000).

[a] CS Composite-10 components

residential property in our sample period is that the owner enjoys the shelter without much price appreciation. San Francisco has the highest risk and the lowest volatility goes to Charlotte. The *SD*s of returns of the former and latter MSAs are 1.41% and 0.60%, respectively. Los Angeles, San Diego, and San Francisco share very similar risk and return characteristics.

The individual MSA data indicate that there are sufficient variations in the performance. The experience of a home owner in one part of the country may be different from that in other parts. The implications of the variations on the home ownership decision remain to be seen. It may simply mean a somewhat lower return without reversing the conclusion that home ownership still pays when an individual is relocated from a high-return city to a low-return one.

Whether a house is a worthwhile investment depends not just on its risk-return characteristics, but also on the correlation of its returns with those of other asset classes held by the investor. We report the pair-wise correlation coefficients of the returns of the house price and financial asset indices in Table 1 Panel B. Among all pairs of different asset classes, the U.S. equities and EAFE stocks have the highest return correlation at 0.72. REITs also have relatively high correlations with U.S. equities and EAFE at 0.60 and 0.48, respectively. The CS Composite 10 and Composite 20 indices tend to have very low correlations with all other asset classes including REITs.[5] It is quite clear from the descriptive statistics that residential properties are very stable assets unaffected by movements in the prices of other financial assets in the long run. Further, residential properties (as proxied by the S&P/Case-Shiller indices) and REITs are very different assets with the latter being a high risk and high return proposition.

The correlations between individual housing markets and the CS Composite 20 index are relatively high with magnitudes at no lower than 0.60. Most of the correlations are greater than the highest correlation among financial assets, which is between U.S. equities and EAFE stocks at 0.72. The correlations between individual MSAs and the CS Composite 10 index are somewhat lower since the CS Composite 10 index does not include some of the individual MSAs under consideration.[6]

Being a safe asset does not necessarily imply that it must be included in an optimal portfolio. Likewise, a risky asset class such as equities may as well be a worthwhile investment as long as it can deliver the return that can justify the bearing of its risk. Further, portfolio choice varies from one individual to another depending on the individual's risk tolerance. To examine the potential risk-adjusted return enhancement effect brought about by home ownership, we perform the optimal portfolio analysis described in Section 2 that allows for the consideration of individual's risk tolerance.

4.2. National residential market

The detailed results by using the CS Composite-10 index as our proxy for home ownership are reported in Table 2. Column 1 lists the various levels of monthly risk-free interest rate, R_f, being considered, with the last number (0.31%/month) being the ex post historical average risk-free rate based on short-term T-bills. As previously discussed, we solve for the respective optimal portfolios while disallowing short selling. The optimal allocations to

Table 2 Diversification benefits of home ownership with CS Composite-10 index as proxy

Risk-free rate	Portfolios with real estate					Portfolios without real estate				GJ *p*-value
	Portfolio weights				Sharpe ratio	Portfolio weights			Sharpe ratio	
	CRSP VW	Inter. Gov. bond	MSCI-EAFE	CS Composite-10		CRSP VW	Inter. Gov. bond	MSCI-EAFE		
0.0000	0.0579	0.4572	0.0000	0.4849	0.5806	0.1208	0.8792	0.0000	0.4752	0.000
0.0010	0.0679	0.5010	0.0000	0.4310	0.4533	0.1262	0.8738	0.0000	0.3953	0.001
0.0020	0.0882	0.5894	0.0000	0.3224	0.3343	0.1346	0.8654	0.0000	0.3156	0.032
0.0030	0.1487	0.8513	0.0000	0.0000	0.2365	0.1487	0.8513	0.0000	0.2365	—
0.0040	0.1779	0.8221	0.0000	0.0000	0.1587	0.1779	0.8221	0.0000	0.1587	—
0.0050	0.2741	0.7259	0.0000	0.0000	0.0862	0.2740	0.7260	0.0000	0.0862	—
0.0060	1.0000	0.0000	0.0000	0.0000	0.0454	1.0000	0.0000	0.0000	0.0454	—
0.0070	1.0000	0.0000	0.0000	0.0000	0.0237	1.0000	0.0000	0.0000	0.0237	—
0.0031[a]	0.1512	0.8488	0.0000	0.0000	0.2264	0.1512	0.8488	0.0000	0.2264	—

Note: Portfolio weights and Sharpe ratios of tangency portfolios with and without CS Composite-10 are reported at different levels of monthly risk-free interest rates. Optimal portfolios are obtained with short selling disallowed and based on the full sample period from February 1987 to December 2011. The *p*-values of Glen and Jorion (GJ) tests on equal Sharpe ratios are also reported.

[a] The last row corresponds to a level of risk-free interest rate of 0.31%/month that is equal to the mean return on short-term Treasuries over the sample period.

various asset classes for the case with and without residential housing are reported in Columns 2–5 and Columns 7–9, respectively. When residential housing is added, the allocation is nil when the historical average T-bills return of 0.31% is used to solve for the tangency portfolio. The optimal allocation in residential housing is also zero at higher levels of risk-free rate. Residential housing enters our investor's optimal portfolio only at lower levels of risk-free rate. Note that lower risk-free rates correspond to investors with a lower risk tolerance. This should come as no surprise as residential housing displays extremely low risk and return characteristics and, therefore, is attractive to conservative investors with low risk tolerance. The Sharpe ratios corresponding to the cases with and without residential housing are reported in Columns 6 and 10, respectively. When the residential housing enters the optimal portfolios at low levels of R_f, the improvement in the Sharpe ratio is quite meaningful. In fact, whenever it enters the optimal portfolio, the resulting Sharpe ratio is always no worse than the baseline case without the investment in residential property. This confirms the well-known fact stated earlier that whenever the estimation of the input parameters, the optimization, and the performance measure are done over the same sample period, the performance of the optimized portfolios with the extra asset class cannot be inferior by construction. Any conclusion based on this observed improvement in performance is meaningless without statistical testing. We conduct the statistical tests based on the simulation method of Glen and Jorion (1993) described earlier and in Appendix B. A p-value of 0.05 or lower will indicate that the Sharpe ratio with home ownership is statistically significantly higher than the Sharpe ratio without home ownership at the usual five-percent level, leading us to conclude that the benefit from home ownership is real rather than purely because of chance. The resulting p-values at different levels of risk-free rate are reported in the last column of Table 2. When proxied by the CS Composite 10 index, residential housing offers statistically significant diversification benefit to our representative investor at monthly R_f of 0.2% (about 2.4% annually) or lower. Given the current low interest rate environment of below 2.4%, home ownership can in fact be an optimal decision.

At zero risk-free rate, Table 2 indicates the proper allocation to a house is 48.5% of an individual's total wealth.[7] In the absence of home ownership, the optimal bond holding for this same individual is 87.9%. Home ownership reduces the optimal bond holding to 45.7%, that is, a reduction of about 42 percentage points. In effect, the investment in a house comes about almost exclusively at the expense of bond holding because of their similar risk characteristics. A financial planner, who focuses on the allocation among financial assets alone, may therefore potentially recommend an overinvestment in bonds because of the failure to capture the interaction effect between the return from home ownership and those from other financial assets. Table 2 (and subsequent tables) illustrates the importance of a more comprehensive approach in financial planning. While Goetzmann (1993) and Wu and Pandey (2012) incorporate both home ownership and financial assets in their analysis, by ignoring the baseline case of the optimal portfolio without home ownership, they cannot demonstrate the displacement effect of a house on bonds in an optimal portfolio and perform the statistical tests as we have done here.

It is important to note that home ownership is attractive not for its potential price appreciation. As pointed out in Table 1, the mean return on the CS Composite-10 index at 0.29% per month is no match for the 0.81% return from U.S. equities.

We examine the robustness of our results by repeating the previous analysis with the CS Composite 20 index as our proxy for the return of home ownership. The results are reported in Table 3. The case for home ownership is found to be weaker than that documented in Table 2. We offer several reasons for this finding. First, the CS Composite 20 index includes some weak housing markets such as Atlanta, Detroit, Phoenix, and Dallas that are not included in the CS Composite 10 index (individual housing markets will be examined later). Second, the CS Composite 20 index is available only since January 2000. With its shorter sample period (only a total of 143 monthly observations), the financial/housing crisis of 2008 exerts a stronger influence on the CS Composite 20 index than the CS Composite 10 index; thus, weakening the case for owning a residential property. Nevertheless, despite the relatively stronger negative effect of the financial/housing crisis, home ownership as represented by the CS Composite 20 index still offers statistically significant diversification benefit at a risk-free rate that is close to zero based on the *p*-value of Glen and Jorion (1993) test (see last column of Table 3). In other words, for a risk-averse investor, it still pays to own a house despite the severity of the recent financial/housing crisis and the fact that, as of the end of our sample period, most of the housing markets are still far from fully recovered from their losses. For longer-term home owners, the CS Composite 10 index, which covers a much longer time period of about 25 years, offers a more representative indication of the benefit of owning a house.

4.3. Individual metropolitan markets

As for individual cities, although there are enough similarities to draw definitive statements about home ownership, there are also interesting differences when we repeat the above optimal portfolio analysis using individual MSA indices to proxy for the return from home ownership. Among the 20 MSAs, Portland presents the best outcome for home ownership. Residential housing enters the optimal portfolio at all reasonable levels of risk-free interest rate including the historical average of 0.31%/month (see Table 4). Only at monthly R_f of 0.4% (i.e., about 4.8% annually) or above do we find residential housing becomes unattractive. These high levels of R_f correspond to individuals with relatively high-risk tolerance. The logical move for these relatively aggressive individuals is to stay out of safe assets like residential housing and invest in only stocks as indicated in Table 4. Our results suggest that, for most residents in Portland with reasonable degrees of risk aversion, home ownership definitely makes sense economically even without accounting for the consumption value of the shelter a house will provide.

To appreciate the attractiveness of real estate to residents of Portland, note that the mean return and *SD* of the U.S. equities over the same sample period (reported in Table 1) are 0.81% and 4.62%, respectively. The ratio of the mean to the *SD* corresponds to the Sharpe ratio at a zero risk-free rate. This will work out to be about 0.175% of mean return for each percentage *SD* of risk for U.S. equities. According to the results in Table 4 for Portland, the Sharpe ratio at the zero risk-free rate for an investor with home ownership is about 0.680% for each percentage point of risk. The improvement over U.S. equities investment is very dramatic. Part of the reason for the improvement is the investment in other financial assets in addition to real estate. Comparing the Sharpe ratio of 0.680 for an investor with home

Table 3 Diversification benefits of home ownership with CS Composite-20 index as proxy

Risk-free rate	Portfolios with real estate					Portfolios without real estate				GJ p-value
	Portfolio weights				Sharpe ratio	Portfolio weights			Sharpe ratio	
	CRSP VW	Inter. Gov. bond	MSCI-EAFE	CS Composite-20		CRSP VW	Inter. Gov. bond	MSCI-EAFE		
0.0000	0.0692	0.6106	0.0000	0.3202	0.4928	0.1105	0.8895	0.0000	0.4481	0.014
0.0010	0.0743	0.6772	0.0000	0.2485	0.3792	0.1050	0.8950	0.0000	0.3611	0.100
0.0020	0.0857	0.8237	0.0000	0.0905	0.2758	0.0959	0.9041	0.0000	0.2746	0.378
0.0030	0.0781	0.9219	0.0000	0.0000	0.1890	0.0781	0.9219	0.0000	0.1890	—
0.0040	0.0275	0.9725	0.0000	0.0000	0.1068	0.0275	0.9725	0.0000	0.1068	—
0.0050	0.0000	1.0000	0.0000	0.0000	0.0328	0.0000	1.0000	0.0000	0.0328	—
0.0060	—	—	—	—	—	—	—	—	—	—
0.0070	—	—	—	—	—	—	—	—	—	—
0.0018[a]	0.0828	0.7885	0.0000	0.1287	0.2919	0.0978	0.9022	0.0000	0.2890	0.307

Note: Portfolio weights and Sharpe ratios of tangency portfolios with and without CS Composite-20 are reported at different levels of monthly risk-free interest rates. Optimal portfolios are obtained with short selling disallowed and based on the sample period from February 2000 to December 2011. The p-values of Glen and Jorion (GJ) tests on equal Sharpe ratios are also reported.

[a] The last row corresponds to a level of risk-free interest rate of 0.18%/month that is equal to the mean return on short-term Treasuries over the sample period.

Table 4 Diversification benefits of home ownership in Portland

Risk-free rate	Portfolios with real estate					Portfolios without real estate				GJ p-value
	Portfolio weights				Sharpe ratio	Portfolio weights			Sharpe ratio	
	CRSP VW	Inter. Gov. bond	MSCI-EAFE	CS Portland		CRSP VW	Inter. Gov. bond	MSCI-EAFE		
0.0000	0.0424	0.3795	0.0000	0.5781	0.6796	0.1208	0.8792	0.0000	0.4752	0.000
0.0010	0.0478	0.3967	0.0000	0.5555	0.5382	0.1262	0.8738	0.0000	0.3953	0.000
0.0020	0.0573	0.4274	0.0000	0.5153	0.3993	0.1346	0.8654	0.0000	0.3156	0.000
0.0030	0.0787	0.4964	0.0000	0.4250	0.2671	0.1487	0.8513	0.0000	0.2365	0.022
0.0040	0.1720	0.7972	0.0000	0.0309	0.1588	0.1779	0.8221	0.0000	0.1587	0.484
0.0050	0.2740	0.7260	0.0000	0.0000	0.0862	0.2740	0.7260	0.0000	0.0862	—
0.0060	1.0000	0.0000	0.0000	0.0000	0.0454	1.0000	0.0000	0.0000	0.0454	—
0.0070	1.0000	0.0000	0.0000	0.0000	0.0237	1.0000	0.0000	0.0000	0.0237	—
0.0031[a]	0.0835	0.5120	0.0000	0.4045	0.2511	0.1512	0.8488	0.0000	0.2264	0.030

Note: Portfolio weights and Sharpe ratios of tangency portfolios with and without CS Portland MSA index are reported at different levels of monthly risk-free interest rates. Optimal portfolios are obtained with short selling disallowed and based on the full sample period from February 1987 to December 2011. The p-values of Glen and Jorion (GJ) tests on equal Sharpe ratios are also reported.

[a] The last row corresponds to a level of risk-free interest rate of 0.31%/month that is equal to the mean return on short-term Treasuries over the sample period.

ownership with the Sharpe ratio of 0.475 for one with only financial assets and also at zero risk-free rate (see first row of Table 4), the difference of about 0.205 in Sharpe ratio can be attributed to the benefit of adding real estate to the optimal portfolio. This increase in the Sharpe ratio still exceeds the Sharp ratio of 0.175 for investing in U.S. equities alone. Home ownership in Portland clearly offers an *improvement* in the risk-adjusted payoff over that of investing in U.S. equities alone.

Similar to the value-adding proposition as demonstrated in the previous subsection by using the national CS Composite 10 index, the real estate in Portland is an attractive addition to an investor's portfolio mainly because of its ability in risk reduction rather than the potential for price appreciation. Table 1 indicates that Portland, being the best real estate market, merely offers a mean return of 0.40% per month over our sample period, which is not even half of the mean return of 0.81% per month for U.S. equities.

What is the verdict of home ownership for residents of other major metropolitans? Residential real estate in the cities of Denver, Washington DC, Los Angeles, San Diego, San Francisco, and Seattle offer slightly higher average monthly returns (ranging from 0.30% to 0.35%) than that of the CS Composite 10 index (at 0.29%), but they are also (marginally) riskier than the composite index (see the means and *SD*s of returns reported in Table 1 Panel A). Our optimal portfolio analysis using the individual MSA indices of these cities confirms that they share the same desirability in home ownership as we have previously demonstrated using the CS Composite-10 index. Residential property offers statistically significant diversification benefit at risk-free interest rate of no higher than about 0.2% per month (or about 2.4% per year). To conserve space, we only report the outcome for San Diego in Table 5 as the representative results for these six cities.[8] Home ownership is still attractive enough for most individuals except for those with high risk tolerance. Note that the optimal weight for real estate in San Diego at the zero risk-free rate representing the most conservative investor is 38.82%. In fact, the portfolio weights for real estate at all levels of risk-free rate are consistently lower than the allocations for Portland residents. Given the significantly higher housing prices for west coast cities in California, home owners in California may have to invest more than the optimal weight of 38.82% of their wealth in real estate because of the fact that fractional ownership is not very common. Comparing the asset mixes of the optimal portfolios with and without real estate in San Diego at zero risk-free rate, the addition of real estate is mainly at the expense of bond investment. The optimal weight on bonds drops from about 88% to about 55% when real estate is added. It appears that real estate serves as a close substitute for bonds because of the similarity in their (low) risk characteristics. If California residents have to overinvest in real estate because of its lumpiness, this overinvestment probably should be accommodated by a reduction in bonds. Again, our results clearly demonstrate the importance of comprehensiveness in financial planning with the investor's home ownership central to the asset allocation decision.

According to the risk-return characteristics as reported in Table 1 Panel A, residential real estate in the cities of Miami, Chicago, Boston, Charlotte, New York, and Cleveland offer slightly lower return but also lower risk than the CS Composite 10 index. Based on our optimal portfolio analysis results, these six cities are similar in terms of the degree of enhancement of risk-adjusted return home ownership can offer our representative investor. Results for Chicago are reported in Table 6 as the representative of this group. Residential

Table 5 Diversification benefits of home ownership in San Diego

Risk-free rate	Portfolios with real estate					Portfolios without real estate				GJ p-value
	Portfolio weights				Sharpe ratio	Portfolio weights			Sharpe ratio	
	CRSP VW	Inter. Gov. bond	MSCI-EAFE	CS San Diego		CRSP VW	Inter. Gov. bond	MSCI-EAFE		
0.0000	0.0666	0.5452	0.0000	0.3882	0.5604	0.1208	0.8792	0.0000	0.4752	0.000
0.0010	0.0749	0.5716	0.0000	0.3535	0.4485	0.1262	0.8738	0.0000	0.3953	0.001
0.0020	0.0896	0.6180	0.0000	0.2923	0.3401	0.1346	0.8654	0.0000	0.3156	0.022
0.0030	0.1225	0.7221	0.0000	0.1554	0.2401	0.1487	0.8513	0.0000	0.2365	0.248
0.0040	0.1779	0.8221	0.0000	0.0000	0.1587	0.1779	0.8221	0.0000	0.1587	—
0.0050	0.2741	0.7259	0.0000	0.0000	0.0862	0.2740	0.7260	0.0000	0.0862	—
0.0060	1.0000	0.0000	0.0000	0.0000	0.0454	1.0000	0.0000	0.0000	0.0454	—
0.0070	1.0000	0.0000	0.0000	0.0000	0.0237	1.0000	0.0000	0.0000	0.0237	—
0.0031[a]	0.1300	0.7455	0.0000	0.1245	0.2285	0.1512	0.8488	0.0000	0.2264	0.312

Note: Portfolio weights and Sharpe ratios of tangency portfolios with and without CS San Diego MSA index are reported at different levels of monthly risk-free interest rates. Optimal portfolios are obtained with short selling disallowed and based on the full sample period from February 1987 to December 2011. The p-values of Glen and Jorion (GJ) tests on equal Sharpe ratios are also reported

[a] The last row corresponds to a level of risk-free interest rate of 0.31%/month that is equal to the mean return on short-term Treasuries over the sample period.

Table 6 Diversification benefits of home ownership in Chicago

Risk-free rate	Portfolios with real estate					Portfolios without real estate				GJ p-value
	Portfolio weights				Sharpe ratio	Portfolio weights			Sharpe ratio	
	CRSP VW	Inter. Gov. bond	MSCI-EAFE	CS Chicago		CRSP VW	Inter. Gov. bond	MSCI-EAFE		
0.0000	0.0742	0.5704	0.0000	0.3554	0.5192	0.1208	0.8792	0.0000	0.4752	0.001
0.0010	0.0897	0.6420	0.0000	0.2683	0.4121	0.1262	0.8738	0.0000	0.3953	0.029
0.0020	0.1223	0.7928	0.0000	0.0849	0.3165	0.1346	0.8654	0.0000	0.3156	0.351
0.0030	0.1487	0.8513	0.0000	0.0000	0.2365	0.1487	0.8513	0.0000	0.2365	—
0.0040	0.1779	0.8221	0.0000	0.0000	0.1587	0.1779	0.8221	0.0000	0.1587	—
0.0050	0.2740	0.7260	0.0000	0.0000	0.0862	0.2740	0.7260	0.0000	0.0862	—
0.0060	1.0000	0.0000	0.0000	0.0000	0.0454	1.0000	0.0000	0.0000	0.0454	—
0.0070	1.0000	0.0000	0.0000	0.0000	0.0237	1.0000	0.0000	0.0000	0.0237	—
0.0031[a]	0.1512	0.8488	0.0000	0.0000	0.2264	0.1512	0.8488	0.0000	0.2264	—

Note: Portfolio weights and Sharpe ratios of tangency portfolios with and without CS Chicago MSA index are reported at different levels of monthly risk-free interest rates. Optimal portfolios are obtained with short selling disallowed and based on the full sample period from February 1987 to December 2011. The p-values of Glen and Jorion (GJ) tests on equal Sharpe ratios are also reported.

[a] The last row corresponds to a level of risk-free interest rate of 0.31%/month that is equal to the mean return on short-term Treasuries over the sample period.

housing offers statistically significant diversification benefit only at R_f of 0.1% per month or lower. The case for home ownership in these cities is weaker than that of the previous group of cities (i.e., Denver, Washington DC, Los Angeles, San Diego, San Francisco, and Seattle) as reported in Table 5. It is also weaker than the outcome when we use the CS Composite 10 index as our proxy (see Table 2). At zero risk-free rate an investor still has meaningful optimal exposure to real estate at 35.54%.

Phoenix, Minneapolis, Las Vegas, Dallas, and Tampa are somewhat less attractive comparing with the other markets we have examined so far. Table 7 reports the results for Dallas as the representative of this group. Home ownership in this group of cities offers statistically significant diversification benefit only at risk-free interest rate that is close to zero. In other words, home ownership is only attractive to the somewhat more risk-averse individuals. At zero risk-free rate, optimal bond holdings with and without real estate are 59.96% and 88.95%, respectively. In other words, the addition of 33.36% in real estate displaces 28.99% in bonds. Consistent with earlier results, bond and real estate are almost perfect substitutes. As a result, financial planners should not focus on investment decisions involving financial assets alone without accounting for home ownership. However, the results for Dallas have to be interpreted with caution as there are only 143 monthly observations as opposed to 299 observations for most other cities and the CS Composite 10 index. Because the CS Dallas MSA data are only available since January 2000, the 2008 financial/housing crisis has a relatively greater impact on Dallas than other cities and thus potentially resulting in a bias against the case for home ownership.

In which of the metropolitans should a potential home buyer really think twice before signing on the dotted line? Based on our optimal portfolio analysis results, Atlanta and Detroit are the only two cities where residential property offers no significant diversification benefit regardless of the investor's risk preference. It is actually not a surprising result if we take a closer look at the statistics reported in Table 1 Panel A. Among our sample of 20 cities, Atlanta and Detroit offer the lowest average monthly return of 0.09% and 0.08%, respectively; whereas both cities display *SD*s higher than that of the CS Composite 10 index. Based on this risk-return characteristics alone, we are quite sure that these two cities have very little to offer. Only the portfolio results of Atlanta are reported here (see Table 8).

With the exception of Atlanta and Detroit, home ownership in all cities can significantly enhance the risk-adjusted return of our representative investor when the risk-free interest rate is close to zero. Because we have ignored the consumption benefit of home ownership in our analysis, it is fair to say that home ownership pays in 18 of the 20 markets. It is harder to make a definite statement about owning a house in Atlanta and Detroit, because the consumption value may or may not be able to compensate for the lack-luster portfolio results documented above. In general, our results indicate that residential housing is an attractive investment despite the recent great recession. The conclusion would have been stronger if the consumption component provided by the residential property has been accounted for. An interesting find was that certain cities in the Sun Belt regions such as Atlanta and to a lesser extent Phoenix, Dallas, Tampa, and Las Vegas appear to be less attractive. Housing properties in the west coast cities such as Los Angeles, San Diego, San Francisco, Seattle, and Portland offer better risk and return tradeoff in addition to the pleasant weather.

Table 7 Diversification benefits of home ownership in Dallas

Risk-free rate	Portfolios with real estate					Portfolios without real estate				GJ *p*-value
	Portfolio weights				Sharpe ratio	Portfolio weights			Sharpe ratio	
	CRSP VW	Inter. Gov. bond	MSCI-EAFE	CS Dallas		CRSP VW	Inter. Gov. bond	MSCI-EAFE		
0.0000	0.0668	0.5996	0.0000	0.3336	0.4798	0.1105	0.8895	0.0000	0.4481	0.037
0.0010	0.0883	0.7782	0.0000	0.1335	0.3634	0.1050	0.8950	0.0000	0.3611	0.349
0.0020	0.0959	0.9041	0.0000	0.0000	0.2746	0.0959	0.9041	0.0000	0.2746	—
0.0030	0.0781	0.9219	0.0000	0.0000	0.1890	0.0781	0.9219	0.0000	0.1890	—
0.0040	0.0275	0.9725	0.0000	0.0000	0.1068	0.0275	0.9725	0.0000	0.1068	—
0.0050	0.0000	1.0000	0.0000	0.0000	0.0328	0.0000	1.0000	0.0000	0.0328	—
0.0060	—	—	—	—	—	—	—	—	—	—
0.0070	—	—	—	—	—	—	—	—	—	—
0.0018[a]	0.0978	0.9022	0.0000	0.0000	0.2890	0.0978	0.9022	0.0000	0.2890	—

Note: Portfolio weights and Sharpe ratios of tangency portfolios with and without CS Dallas MSA index are reported at different levels of monthly risk-free interest rates. Optimal portfolios are obtained with short selling disallowed and based on the sample period from February 2000 to December 2011. The *p*-values of Glen and Jorion (GJ) tests on equal Sharpe ratios are also reported.

[a] The last row corresponds to a level of risk-free interest rate of 0.18%/month that is equal to the mean return on short-term Treasuries over the sample period.

Table 8 Diversification benefits of home ownership in Atlanta

Risk-free rate	Portfolios with real estate					Portfolios without real estate				GJ p-value
	Portfolio weights				Sharpe ratio	Portfolio weights			Sharpe ratio	
	CRSP VW	Inter. Gov. bond	MSCI-EAFE	CS Atlanta		CRSP VW	Inter. Gov. bond	MSCI-EAFE		
0.0000	0.1077	0.7097	0.0000	0.1827	0.4894	0.1369	0.8631	0.0000	0.4821	0.108
0.0010	0.1430	0.8570	0.0000	0.0000	0.3998	0.1430	0.8570	0.0000	0.3998	—
0.0020	0.1522	0.8478	0.0000	0.0000	0.3179	0.1522	0.8478	0.0000	0.3179	—
0.0030	0.1680	0.8320	0.0000	0.0000	0.2368	0.1680	0.8320	0.0000	0.2368	—
0.0040	0.2018	0.7982	0.0000	0.0000	0.1574	0.2018	0.7982	0.0000	0.1574	—
0.0050	0.3227	0.6773	0.0000	0.0000	0.0851	0.3227	0.6773	0.0000	0.0851	—
0.0060	1.0000	0.0000	0.0000	0.0000	0.0487	1.0000	0.0000	0.0000	0.0487	—
0.0070	1.0000	0.0000	0.0000	0.0000	0.0265	1.0000	0.0000	0.0000	0.0265	—
0.0026[a]	0.1612	0.8388	0.0000	0.0000	0.2657	0.1612	0.8388	0.0000	0.2657	—

Note: Portfolio weights and Sharpe ratios of tangency portfolios with and without CS Atlanta MSA index are reported at different levels of monthly risk-free interest rates. Optimal portfolios are obtained with short selling disallowed and based on the sample period from February 1991 to December 2011. The p-values of Glen and Jorion (GJ) tests on equal Sharpe ratios are also reported.

[a] The last row corresponds to a level of risk-free interest rate of 0.26%/month that is equal to the mean return on short-term Treasuries over the sample period.

4.4. Real estate investment trusts

Finally, we conduct an optimal portfolio analysis for individuals who intend to use REITs as a substitute for owning a residential property. The results (reported in Table 9) indicate that REITs offer no statistically significant diversification benefit at all levels of R_f.[9] The risk and return characteristics of REITs as reported in Table 1 more or less speak for the futility of REITs in our representative investor's portfolio. The summary statistics in Table 1 clearly indicate that REITs have a somewhat higher risk (based on the *SD* of return) than the U.S. equity as proxied by the CRSP value-weighted index; whereas they have essentially the same average return. Further, REITs have the second highest correlation with the U.S. equities among the return series. This renders REITs a rather unattractive investment except for the most aggressive investor (i.e., as represented by the cases of high levels of risk-free interest rate reported in Table 9). This finding is compatible with that of Liu and Mei (1992) who find that the returns on REITs resemble those of small cap stocks. The improvement in the Sharpe ratio in these cases of higher levels of R_f is, nevertheless, still statistically insignificant. Direct investment in a house pays in the long-run. Investment in an indirect securitized asset class like REITs is no substitute. This information should be useful to renters who may want to hedge the future housing consumption needs with REITs.

Tables 7, 8, and 9 clearly provide examples of the situation where the inclusion of an extra asset always results in the Sharpe ratio no worse than the baseline case without the extra asset. Without the backing of any statistical tests, such a finding does not necessarily imply an investor will be benefited by including the extra asset in constructing his or her optimal portfolio. The results of our statistical tests suggest that part of the observed enhancement in the in-sample performance when residential property is added may in fact be the result of a pure random effect. The statistical tests performed in this study are crucial to ascertain the contribution of real estate investment to the investor's/homeowner's optimal portfolio.

5. Conclusion

Without any good solid empirical evidence on the payoff of home ownership, it is hard to make sound decision regarding one of the biggest decisions a typical household has to make. To compound the matter, financial advisors tend to ignore the home ownership question and focus on the savings and investment decisions involving financial assets. By providing the empirical evidence for the economic benefit of home ownership in a portfolio context involving financial assets and home ownership, we provide a complete analysis beyond what normally offered by financial advisors. Our evidence indicates that the financing of home ownership quite often comes about at the expense of bond investments because bonds and real estate share very similar risk and return characteristics. Any financial planner who ignores a client's home ownership will likely recommend an overinvestment in bonds. While the economics of home ownership for conservative individuals is compelling based on our empirical findings, the "buy versus rent" decision also depends on the subjective lifestyle choice as pointed out in some personal finance texts.

Table 9 Diversification benefits of investing in All REIT

Risk-free rate	Portfolios with real estate					Portfolios without real estate				GJ p-value
	Portfolio weights				Sharpe ratio	Portfolio weights			Sharpe ratio	
	CRSP VW	Inter. Gov. bond	MSCI-EAFE	All REIT		CRSP VW	Inter. Gov. bond	MSCI-EAFE		
0.0000	0.0993	0.8703	0.0000	0.0304	0.4777	0.1208	0.8792	0.0000	0.4752	0.222
0.0010	0.1029	0.8642	0.0000	0.0330	0.3977	0.1262	0.8738	0.0000	0.3953	0.245
0.0020	0.1085	0.8548	0.0000	0.0367	0.3180	0.1346	0.8654	0.0000	0.3156	0.265
0.0030	0.1180	0.8389	0.0000	0.0431	0.2389	0.1487	0.8513	0.0000	0.2365	0.284
0.0040	0.1374	0.8062	0.0000	0.0564	0.1613	0.1779	0.8221	0.0000	0.1587	0.302
0.0050	0.2007	0.7000	0.0000	0.0994	0.0894	0.2740	0.7260	0.0000	0.0862	0.307
0.0060	0.6128	0.0000	0.0000	0.3872	0.0488	1.0000	0.0000	0.0000	0.0454	0.299
0.0070	0.5812	0.0000	0.0000	0.4188	0.0259	1.0000	0.0000	0.0000	0.0237	0.304
0.0031[a]	0.1196	0.8361	0.0000	0.0443	0.2288	0.1512	0.8488	0.0000	0.2264	0.288

Note: Portfolio weights and Sharpe ratios of tangency portfolios with and without All REIT are reported at different levels of monthly risk-free interest rates. Optimal portfolios are obtained with short selling disallowed and based on the full sample period from February 1987 to December 2011. The p-values of Glen and Jorion (GJ) tests on equal Sharpe ratios are also reported.

[a] The last row corresponds to a level of risk-free interest rate of 0.31%/month that is equal to the mean return on short-term Treasuries over the sample period.

By varying the degree of risk aversion, we show that home ownership is attractive to conservative investors because of the extremely low risk in investing in residential property as a result of its relatively stable rate of price appreciation. Although the market value of residential real estate may have been affected by the volatility in the financial markets during the recent housing crisis, it is in general insensitive to the movements in the financial markets over our 25-year sample period. The correlations of the returns on residential real estate with those of financial assets are in fact very low. These near-zero correlations suggest an individual should own a house because of its stabilizing influences in times of financial turbulences rather than its potential for price appreciation. The price appreciation of the best residential market, Portland, is merely one half that of the U.S. equities. The 2008 housing crisis should not displace our perception of the long-run stability of residential property price. REITs simply lack the conservative characteristics of a regular house to be qualified as viable substitutes.

Another major contribution of this article is the comprehensive examination of the 20 regional residential property markets. The Sun Belt housing markets are no more attractive than the northeastern part of the United States. The west coast in general and Portland in particular tend to stand out as the more attractive markets.

Notes

1 The degree of risk aversion of an individual is likely to be associated with a number of factors including gender, age, wealth and income levels, and other personal characteristics related to his or her inherent risk preference.

2 An investor can easily obtain exposure to the REIT sector by buying an ETF that replicates a REIT index or by buying an actively managed mutual fund that specializes in REITs. For empirical evidence on the performance of actively managed mutual funds that specialize in the REIT sector, see Kaushik and Pennathur (2012).

3 See, for example, Ingersoll (1987, Ch. 4), for the derivation. Appendix A to this article also provides a detailed exposition of our portfolio framework.

4 Elton, Gruber, Brown, and Goetzmann (2006, Ch. 6) suggest the variation of the risk-free rate as a way to trace out the frontier.

5 Perhaps not surprisingly, the CS Composite 10 and Composite 20 indices are almost perfectly positively correlated with each other.

6 Pair-wise correlations between individual MSAs are computed but not produced here to conserve space. The statistics are available on request.

7 The allocation to home ownership would have been higher if the consumption value of the house has been explicitly accounted for as part of the return.

8 Results for all individual cities are available upon request.

9 Stevenson (2000) also tests for the statistical significance of diversification benefits of adding REITs to an equity portfolio without bonds and finds the Sharpe ratio of the combined portfolio to be not significantly greater than that of the pure equity portfolio.

Appendix A: Sharpe ratio and optimal portfolio weight

Sharpe ratio Θ is a commonly used measure of risk-adjusted return. It can be defined as the amount of expected return ($\bar{z}$) over the risk-free interest rate (R_f) per unit of return *SD* (σ). That is,

$$\Theta = \frac{\bar{z} - R_f}{\sigma}$$

The higher the Sharpe ratio the more (excess) return can be generated by an asset with the same amount of risk. For a portfolio of assets, optimizing the Sharpe ratio will lead us to invest only at portfolios that lie on the *efficient frontier* in a plot of expected returns against *SD*s of all possible portfolio compositions as defined by the proportions of the total investment amount (i.e., *weights*) on individual assets making up the portfolios (see Figure A1).

In Figure A1, $\bar{z}_p$ and σ_p are, respectively, the expected return and the *SD* of return of the portfolio. Given a risk-free interest rate of R_f, the portfolio that delivers the highest Sharpe ratio is referred to as the *tangency portfolio*, which can be represented by the tangency point at the efficient frontier of a straight line having an intercept of R_f (see Figure A1).

To solve for the weights w of the tangency portfolio, we can consider the portfolio optimization problem of an investor having the opportunity to invest \$1 in a portfolio making up of n risky assets and a risk-free asset delivering a return of R_f. Let $\bar{z}$ denotes the $n \times 1$ vector of the expected returns of risky assets and Σ the $n \times n$ variance-covariance matrix of risky asset returns. Let δ denotes the $n \times 1$ vector of the amounts of money invested in each of the risky assets. The assumption of fully investing \$1 ensures that the amount of money invested in the risk-free asset equals to $\$1 - \delta' \times 1$, where 1 is the $n \times 1$ unit vector. Suppose

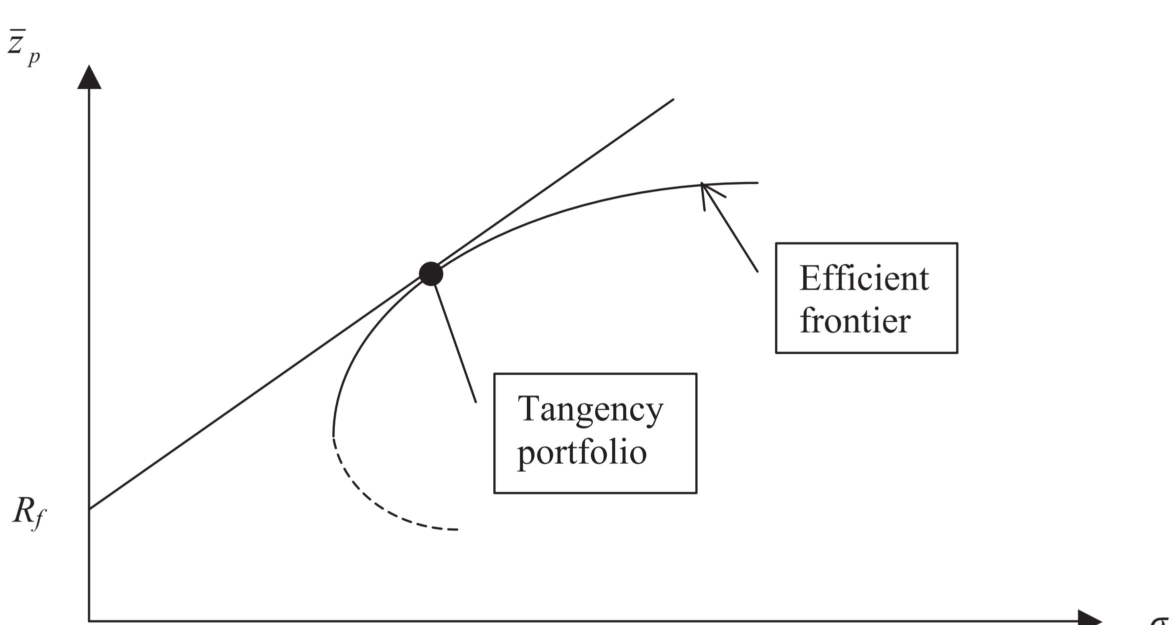

Fig. A1.

the investor targets an expected return of R_p to be generated from his portfolio. The optimal portfolio that he or she should hold is, therefore, the portfolio that can deliver an expected return of R_p, whereas at the same time being the least risky (i.e., with the smallest *SD* or variance). The investor should invest in a portfolio with composition δ such that the variance of portfolio return ($\delta' \times \Sigma \times \delta$) can be minimized, whereas at the same time conforming to the constraint that the target expected return of R_p can be achieved. That is,

$$\min_{\delta}(\delta' \times \Sigma \times \delta)$$

subject to

$$\delta' \times \bar{z} + R_f \times (\$1 - \delta' \times 1) = R_p$$

The first order condition of the above optimization problem gives us the optimal value for δ:

$$\delta = \lambda \times \Sigma^{-1} \times (\bar{z} - R_f \times 1)$$

where λ is a certain constant. The weights *w* of the risky assets within the optimal risky portfolio (i.e., the tangency portfolio) is, therefore, the normalized value of δ. That is,

$$w = \frac{\delta}{1' \times \delta} = \frac{\lambda \times \Sigma^{-1} \times (\bar{z} - R_f \times 1)}{\lambda \times 1' \times \Sigma^{-1} \times (\bar{z} - R_f \times 1)} = \frac{\Sigma^{-1} \times (\bar{z} - R_f \times 1)}{1' \times \Sigma^{-1} \times \bar{z} - R_f \times 1' \times \Sigma^{-1} \times 1}$$

This gives us Eq. (1).

The Sharpe ratio of the tangency portfolio is its expected excess return over the risk-free interest rate divided by its *SD* of return. That is:

$$\Theta_p = \frac{\bar{z}_p - R_f}{\sigma_p} = \frac{\bar{z}' \cdot w - R_f}{(w' \cdot \Sigma \cdot w)^{0.5}},$$

which is our Eq. (2).

Appendix B

Let us define *T* as the number of monthly observations. Also, let Θ_1 be the Sharpe ratio of the tangency portfolio before the addition of the residential property and Θ_2 be the Sharpe ratio after the addition. The null hypothesis to be tested is $H_0 : \Theta_1 = \Theta_2$. When short selling is allowed, the test statistic presented in Gibbons, Ross, and Shanken (1989) and Jobson and Korkie (1989) is:

$$F = (T - 4) \times \frac{\Theta_2^2 - \Theta_1^2}{1 + \Theta_1^2}, \tag{3}$$

where *F* follows a *F*-distribution with 1 and *T*-4 degrees of freedom.

In this study, we consider the case where short selling is disallowed. Under this condition, the *F* statistic of Eq. (3) will not be following the *F*-distribution and needs to be simulated before hypothesis tests can be conducted. We conduct the simulations by following the method proposed by Glen and Jorion (1993). We first estimate the means, variances, and the covariances using historical return data. The expected return of the additional asset class (i.e., real estate in this study) is then modified so that the original tangency portfolio is still mean-variance efficient after this additional asset class is included. This in effect ensures the null hypothesis is satisfied in the subsequent simulation exercise. With these modified parameters, T random samples of joint returns are drawn from a multivariate normal distribution. Based on these simulated returns, a new set of means and variance-covariance matrix are estimated. Sharpe ratios of the tangency portfolios with and without the additional asset class can then be estimated. Finally, the value of the test statistic of Eq. (3) is computed and recorded. The empirical distribution of the statistic is generated under the null hypothesis by repeating this process 1,000 times.

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