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ABSTRACT

The Portfolio Implications of Home Ownership*

This Paper analyses the effects of residential property holdings on optimal investment portfolios. Using a mean-variance framework, we show that residential real estate offers significant diversification benefits relative to investments in stocks and bonds for US investors. Risk averse investors that hold residential real estate for investment purposes have future wealth that is less volatile. For most geographical areas in the US, investors have the best diversification benefits from residential real estate when about 30% of their investment portfolio is residential real estate. In addition to this diversification effect, we find that stocks and bonds do not provide a good hedge for positions in real estate, implying that the relative demand for either is not significantly affected by home ownership. For less risk averse agents the price return on real estate is too low in order to justify inclusion in the investment portfolio. This implies that if agents invest a significant fraction of their wealth in their house, the non-price increase, i.e., the consumption benefits, should be significant. Our estimates suggest that the order of magnitude of these non-price increases is about 10% per year.

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1. Introduction

In the average US family wealth portfolio, residential real estate is a dominant asset category. The average US homeowner, for example, holds 88% of his non-pension wealth in home equity (Englund and Quigley, 2000). Case (2000) estimates that the aggregate value of residential real estate was about $11.6 trillion at the end of 1999, which is comparable to the value of the aggregate US stock market. As reported in Kullmann (2001), according to the 1998 Survey of Consumer Finances, about 66% of households owned a home, 19% held stocks directly, and about 17% held mutual funds. Moreover, a recent study by Case, Quigly, and Shiller (2001) show that the wealth effects driving consumption expenditures are much stronger for real estate than for the stock market. This stylized facts raise at least two important questions. The first is whether it is indeed optimal to include such a substantial amount of residential real estate in an investment portfolio besides holdings in stocks and bonds. The second question is whether home ownership significantly affects the demand for stocks and bonds.

These questions have received very limited attention in the literature. Goetzmann and Ibbotson (1990) show that the returns to owner occupied housing are only weakly correlated with those to other assets, and that including residential property in a portfolio can therefore reduce its variance. Goetzmann (1993) finds that the most risk averse investors should optimally allocate approximately 50 percent of their wealth to residential real estate. Recently, Gatzlaff (2000) comes to a similar conclusion regarding the optimal allocation to housing. Gatzlaff also investigates the effects of positions in home equity on stock and bond investments, and finds increasing stock allocations and decreasing bond allocations relative to portfolios with zero weight to residential property. Englund and Quigley (2000) look at the effect the investment horizon has on the optimal allocation to housing. They find that efficient portfolios contain essentially no housing for short holding periods, while longer holding periods imply low-risk efficient portfolios containing 15 to 50 percent home equity.

Finally, Flavin & Yamashita (2002) study the properties of the household portfolio including real estate over the life cycle of an individual.

The current study sheds more light on the portfolio implications of private home-ownership and uses quarterly data for five major United States cities through 1997 to analyze the performance of real estate in portfolios relative to stocks and bonds. A major problem with real estate indices as employed here and elsewhere in the literature, is that they only represent price changes, but do not include rental income. This problem is usually handled by taking a rent as a percentage of index value. We turn this around by looking at the price returns to residential real estate, in order to investigate how high the income return should be to justify the presence of residential real estate in mean-variance efficient portfolios. This is similar to the implicit consumption benefits of owner-occupied housing in Flavin & Yamashita (2002). Our results suggest that these consumption benefits, or non price increases, are in the order of magnitude of seven percent per year when the household invests 25% of their wealth in real estate and about ten percent when the household invests 50% of their wealth in real estate. Depending on the geographical area, the non price increase must be at least between two and seven percent in order to induce households to invest in real estate.

It is well known that expected returns are very hard to estimate and lead to estimation risk in optimal portfolios.[1] Although this applies to stocks and bonds as well, it is especially severe in case of real estate because of the unobservable income return component. Also, because real estate is a much less liquid market than the market for stocks and bonds, transaction prices are not available for all properties at any given time, which implies that indices have to be estimated using regression techniques like repeated measures regression or hedonic regression. This implies that residential real estate indices such as the ones used in this paper have more estimation error than stock and bond indices.

Because estimation risk is of particular concern in case of real estate we focus on the minimum variance properties of real estate in relation to stocks and bonds. For these minimum variance portfolios we find that home equity offers significant diversification

1 See e.g., Jorion (1991) and Ter Horst, De Roon, and Werker (2001).

benefits relative to stocks and bonds: the standard deviation of the global minimum variance portfolio for stocks and bonds can be reduced by about 30% percent if real estate is added to this portfolio. These results hold both for quarterly and annual holding periods. For most geographical areas this diversification benefit is obtained if about 30% of the investment portfolio is invested in real estate. Besides that, we show that in general stocks and bonds do not provide good hedges for real estate, implying that the demand for stocks and bonds is not strongly affected by the fixed allocation to residential real estate.

These results imply that investors are better off if they have about one third of their wealth invested in residential real estate, in the sense that their total wealth will be less volatile. However, although this means a lower total demand for stocks and bonds, the relative demand for stocks and bonds is not affected, since we do not find any significant hedging properties of stocks and bonds with respect to residential real estate.

The plan of this paper is as follows. The next section describes the data and provides some summary statistics. Section 3 analyzes the role of real estate in efficient portfolios and in the minimum variance portfolios. Section 4 focuses on the hedging properties of stocks, bonds, and real estate. The paper ends with some concluding remarks.

2. Data

In our study we use monthly data from January 1980 through December 1997 for United States stocks, bonds and residential real estate. The S&P 500 is used for stock returns, whereas bond returns for the entire sample period are constructed from the government bond performance indices of Salomon Brothers and JP Morgan. These data were obtained from Datastream. To obtain return series for residential real estate in specific geographic areas, house price indices were obtained from Case, Shiller, Weiss, Inc. We used the series for Los Angeles, Chicago, Boston, New York, and San Francisco. Return series for Los Angeles and Chicago are available for the entire sample period, whereas the other series are available from a later date onwards only. All series are based on housing transactions and are constructed using the weighted repeat sales method developed by Case and Shiller (1987, 1989).

In Table 1 we present summary statistics for returns on the stock and bond indices as well as the five housing indices. For both nominal and real returns, the means and standard deviations are presented as annual percentages. From the statistics in Table 1 it is clear that stocks and bonds have much higher mean returns than residential real estate, but this is partly due to the fact that we use total returns for the former two, and price returns for the latter. The associated risk - as measured by the standard deviation of returns - is also substantially higher for stocks and bonds. The exception in this respect is the residential real estate in San Francisco, where the risk is comparable to the risk of government bonds, but where again the mean return is about one third of the mean return on bonds.

Nominal stock returns appear generally to have a low correlation with both bond returns and house price changes. This would suggest that agents may obtain significant diversification benefits from investing in residential real estate besides investing in stocks and bonds. On the other hand, the low correlations between stock and bond returns and single family house price changes also suggests that stocks and bonds will not provide a proper hedge against residential real estate risks. An almost identical picture emerges from the correlations between the several classes of real estate. These correlations among the different geographical areas appear to be quite low as well. This may imply that agents will want to diversify their investments in real estate over the different parts of the country, but it also suggests that the risk associated with owning a house in, say, Chicago, can probably not be hedged with a residential real estate portfolio from Boston, or with a national real estate portfolio. Although real estate in different parts of the country seems to be comparable in terms of risk and return, judged from the correlations the risk associated with an investment in residential property is to a large extent specific to a geographic area.

These results all hold for nominal returns. The main difference between nominal and real returns are that the mean real returns are lower than the mean nominal returns, causing the mean real returns on real estate to be close to zero. The risk of the different asset classes is similar when measured in either nominal or in real terms. An important difference is apparent for the correlations: When measured in real returns, the different real estate segments are more correlated than in case of nominal returns. Whereas the correlations between nominal returns on real estate are close to zero, for real returns they are about 0.15.

Although the results in Table 1 show that the average price returns on real estate are lower than the average returns on stocks and bonds, real estate also appears to be less risky and, moreover, it has very low correlations with stocks and bonds. This suggests that there may be benefits from including real estate in an investment portfolio. In the following section we will analyze whether the mean returns on real estate are sufficiently high in order to include this asset class as part of an investment portfolio. To this end we will focus on nominal returns on stocks, bonds, and real estate.

3 The diversification benefits of real estate

3.1 Diversification benefits for risk averse agents

Our analysis starts by investigating whether adding home equity to a stock and bond portfolio improves portfolio efficiency. In this section we will provide a statistical analysis of the diversification benefits of real estate. Here we will also take into account the fact that an agent may be exposed to the risk of real estate in a certain geographic area.

The first column of Table 3 gives the generalized Jensen measure for each category of real estate relative to stocks and bonds. This Jensen measure is obtained as the intercept in the regression:

$$r_{estate} - \eta = \alpha_J + \beta_1(r_{stock} - \eta) + \beta_2(r_{bond} - \eta) + \varepsilon, \tag{1}$$

where η is the zero-beta rate of an efficient portfolio of stocks and bonds only. In the first panel of Table 2 we take the case of a rather risk averse investor, with risk aversion γ=80, which corresponds to a value of η close to 0.0%. The initial portfolio of this agent is located close to the GMV portfolio of stocks and bonds. As is well known by now (see, e.g., Jobson & Korkie (1989) and DeRoon, Nijman & Werker (1998)), a value of α_J that is significantly different from zero implies that significant diversification benefits are possible from investing in real estate besides an investment in stocks and bonds only. Thus, starting from the mean-variance frontier of stocks and bonds only, a value of α_J that is significantly different from zero means that the mean-variance frontier will show a significant shift outwards when real estate is also included in the investment opportunity set. It should be noted that the results in Table 2 are based on the sample period January 1989 – December 1997, for which data are available for all indices. This may cause the results to be somewhat different from the results in Table 1 for some of the house price indices.

In the first columns of Table 2, the positive values of α_J, the Jensen measure, suggest that agents that are risk averse and that initially invest in stocks and bonds only, can obtain diversification benefits by taking long positions in real estate. Moreover, the reported p-values are always below 1%, implying that the hypothesis that there are no diversification benefits, i.e., that $\alpha_J = 0$, can be rejected convincingly for each geographical area. In other words, the hypothesis that real estate is spanned by stocks and bonds can easily be rejected.

The remaining part of Table 2 answers the question whether agents want to invest in real estate in one of the geographical areas, given that they own a house in one of the areas, and therefore are exposed to real estate risk in that area. For instance, the second column of the first panel of Table 2 analyzes the diversification benefits of the five categories of real estate for an investor that has 75% of his wealth invested in stocks and bonds and that has 25% of his wealth invested in real estate in Los Angeles. A similar portfolio problem is analyzed in Flavin & Yamashita (2002). Details of how spanning tests should be performed in case of such an exogenously given exposure are given in DeRoon, Nijman & Werker (1998).

The Jensen measure for Boston is now 5.98%, suggesting that agents that already own a house in Los Angeles which comprises 25% of their wealth would still like to buy additional real estate in Boston. The associated p-value of 0.004 implies that this will result in a significant outward shift in the mean-variance frontier. This result holds more general: risk averse agents that have 25% of their wealth invested in real estate in one of the five geographical areas, can benefit from buying additional real estate in almost any of the five areas. The only exceptions are when an agent owns a house in either Los Angeles, New York or San Francisco, in which case buying additional real estate in the same area does not yield significant diversification benefits.

The remaining two panels of Table 2 show similar results when the exposure to real estate increases to 50% and 75% respectively, i.e., when the percentage of the agents wealth invested in real estate increases to 50% and 75%. The results in those two panels show that when the exposure to real estate in a given area increases, the diversification benefits offered by any of the five real estate classes decrease. When the amount invested in real estate is 75% of the agents' wealth, the only geographical are in which he wants to buy additional real estate is Chicago.

Finally, notice that even though an agent may have 75% of his wealth invested in real estate, he almost never wants to hedge this by going short in real estate in one of the other geographical areas, suggesting that the five areas may indeed be rather segmented. This result appears to be particular strong here since the analysis in Table 2 is for a very risk averse agent, i.e., one that holds a portfolio close to the GMV portfolio.

3.2 The benefits of real estate in the tangency portfolio

To analyze the results for a less risk averse agent, Table 3 presents results for a value of η for the average TBill rate over the sample period (which is 5.69% annually), which corresponds to a risk aversion of 22.[2] The first column again shows the diversification benefits from investing in real estate for an agent that initially invests in stocks and bonds and that has no exposure to real estate. Agents that are less risk averse do not wish to invest as much in real estate as the very risk averse agents in Table 2. In fact, for the investor in Table 3, portfolio benefits from investing in real estate are only obtainable if he short sells real estate, as can be seen from the negative values of the Jensen measure. Short selling real estate will result in significant diversification benefits if the real estate is located in Los Angeles, Boston or New York, but not in Chicago or San Francisco.

When the less risk averse agent has already 25% of his wealth invested in real estate in one of the five areas, the diversification benefits from shorting real estate are becoming

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2 Note that this is still a high value of risk aversion. For this specific sample period however, this is the risk aversion that corresponds to holding the tangency portfolio of stocks and bonds when the risk free rate

much stronger, as can be seen from the lower p-values in the first panel of Table 3. Except for the real estate in San Francisco, the agent would like to short any real estate when he has a 25% exposure to any of the five areas, and even for San Francisco, shorting real estate in that area gives significant diversification benefits when the agent is exposed to real estate in San Francisco.

These effects are becoming stronger when the exposure to one of the real estate classes increases. In general, agents can benefit strongly from shorting any real estate, once they have a sizeable exposure to real estate in a particular geographic area. It is not clear from Table 3 however, whether the demand for real estate is driven by hedging demand or by speculative demand. This will be the subject of the Section 4.

The negative values of the Jensen measures observed in Table 3 indicate that investors that initially hold a portfolio of U.S. stocks and bonds only, can increase the efficiency of their portfolio by shorting real estate. The *p*-values show that for three out of the five regions the negative Jensen measures are significant, implying that for investment purposes only, investors want to take short positions in real estate. The mean price returns on real estate are generally too low to include it in a mean-variance portfolio. This seems to conflict with the fact that most agents hold a considerable part of their wealth in real estate. We therefore also interpret the results of Table 3 to calculate the implied rent or convenience yield on real estate. We find that a residential property allocation of 50 percent requires an implied average rental income must of 10.2 percent. Alternatively, agents owning a home receive a consumption benefit from this similar to the convenience yield and this convenience yield must on average also be equal to 10.2 percent in order to justify a 50 percent investment in a house. For a 25 percent investment in a house the consumption benefit non price increase must be about seven percent.

3.3 Diversification effects for the Global Minimum Variance portfolio

The results presented so far show that the mean returns of the real estate indices employed here are too low in order to justify investments in real estate. However, since the

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equals the average during the sample period.

return on real estate also consists of rental income or convenience yields, the mean price returns do not provide an appropriate expected return estimate. Since rental income and convenience yields are not directly observed, we do not have proper estimates of the actual expected return on real estate, a problem that is also mentioned by Gatzlaff (2000) e.g. In the introduction, we already stated the problems involved in estimating expected property returns. For our dataset, the effect of estimation risk may be even more prevalent, since when adding real estate to our stock and bond portfolio, the number of asset classes increases from two to seven. In addition to this, for three of the five real estate indices the number of observations is limited to a subset of the entire sample period. TerHorst, DeRoon, & Werker (2000) and Jorion (1991) show that the effect of estimation risk is an increasing function of the number of assets under consideration and a decreasing function of sample size. These authors also show that in order to account for estimation risk, it is optimal for an investor to choose a mean-variance portfolio that is closer to the global minimum variance (GMV) portfolio than the portfolio based on his actual risk aversion. This is a natural result, since the GMV portfolio is not subject to estimation risk in the mean returns. That is why the remainder of this paper focuses solely on the minimum variance properties of residential real estate in relation to stocks and bonds.

Table 4 shows the GMV portfolios for stocks and bonds plus different sets of real estate, both for nominal and real returns. For nominal returns, the GMV portfolio of stocks and bonds only has an annual standard deviation of 11.1% and consists of about 30% stocks and 70% bonds. As we add real estate from several regions, the standard deviation drops by one third to about 7.5% and investors can establish this by taking positions in real estate varying between 33% and 73%, implying that for diversification purposes real estate is an attractive investment class. The *p*-values reported in Table 4 are for a Wald test of the hypothesis that the minimum variance of portfolios with real estate is equal to the minimum variance of a portfolio of stocks and bonds only. These *p*-values, which are always smaller than 0.1 percent, confirm the diversification benefits of real estate, since the hypothesis of no diversification benefits can be rejected at any significance level. This result is even stronger when all regions are considered simultaneously: in this case the standard deviation of the

GMV drops to 5.4%, which is less than half the standard the standard deviation of the stocks and bonds portfolio. In this case the portfolio contains an investment of almost 80% in real estate. Moreover, all optimal weights are positive. Thus, for risk reduction purposes it can be optimal to invest a significant part of wealth in real estate.

Similar results hold for real returns, which are presented in the second panel of Table 4. In real terms, the standard deviation of the GMV portfolio of stocks and bonds only is 7.8%. When adding real estate this reduces to about 4.5% and even to a mere 2.5% if all regions are considered simultaneously. Again, the *p*-values show that the reduction in standard deviation is also statistically significant. Thus, in real terms the risk reduction properties of real estate appear to be even stronger. In terms of the portfolio weights themselves, the differences between nominal and real returns are only marginal. Comparing the two panels of Table 4, we only see small differences in the optimal portfolio composition, suggesting that the inflation hedging properties of the different asset classes do not differ greatly.

Although there are only small differences in optimal portfolios when comparing nominal and real returns, there are some differences in the optimal portfolios as we move across the various regions for real estate. If there is no real estate in the portfolio, the asset mix for stocks and bonds is about 30/70. When investors invest in real estate as well, this mix varies between 30/70 (Chicago) and 20/80 (San Francisco). This suggests that the investment in stocks and bonds is affected by the position in real estate. Put differently, stocks and bonds may have different hedging properties for the different real estate regions.

4. Hedging properties of portfolios in relation to real estate

The last issue we want to address here is whether there is a hedging demand for stocks and bonds induced by real estate. If this is the case, then the fact that agents own a house means that they will choose a different optimal portfolio of stocks and bonds than would be the case if they would rent a house.

To investigate this, let r be the vector of returns on the assets that an agent can invest in, let γ be his risk aversion parameter and let η be the associated zero-beta rate on a mean-variance efficient portfolio. The return on the residential real estate the agent is exposed to is r_E and the size of his exposure as a fraction of invested wealth is q. The optimal demand for assets as given for instance in Anderson and Danthine (1981) is

$$w = \gamma^{-1} Var[r]^{-1} \{E[r] - \eta\iota\} - qVar[r]^{-1} Cov[r, r_E] \qquad (2)$$

The first part of this optimal demand is known as the speculative demand, and equals the standard Markowitz optimal portfolio demand as analyzed in the previous section. The second term is known as the hedging demand. Only this hedging demand depends on the exogenous exposure, in this case to residential real estate. For instance, if agents have invested 50% of their wealth in their house, then q = 1.0. It then depends the (co)variances whether or not there will be a hedge demand induced by the position in real estate. If the latter term is not equal to zero, the optimal portfolio will deviate from the standard Markowitz solution, precisely because the agent wants to hedge the risk associated with owning a house.

We will first answer the question whether the demand for stocks and bonds deviates from the standard Markowitz portfolio demand when the agent owns a house. Even if the agent cannot freely invest in residential real estate in different geographical regions, his demand for stocks and bonds may be affected by the fact that he owns a house if the term $Var[r]^{-1}Cov[r,r_E]$ is not zero. Notice that this term equals the vector of slope coefficients in a regression of r_E on the returns of the available investment securities, r. To the extent that these slope coefficients are different from zero, the assets (like stocks and bonds) can serve as a hedge for real estate and the agent will use this hedge property in optimizing his portfolio. Thus, the question whether or not the hedging demand for stocks and bonds is zero can be answered by testing whether the slope coefficients in the regression are zero.

$$r_E = \alpha + \beta_1 r_{stock} + \beta_2 r_{bond} + e \qquad (3)$$

Table 5 presents the results for this regression for singe family houses in the five regions considered here. Panel A considers nominal returns, whereas Panel B considers real returns. The values in parentheses are t-values associated with the hypothesis that the slope coefficients for stocks or bonds are zero. From these t-values we see that we cannot reject the hypothesis that the hedge demand for stocks equals zero. For bonds we can reject this hypothesis only in the cases of Los Angeles and San Francisco. Thus, the demand for stocks does not seem to be affected by the fact that the agent owns a house, whereas it is only when the agent owns a house in either Los Angeles or San Francisco that his demand for bonds will differ from the speculative or Markowitz demand. Notice that for these exposures the negative value of $ß_2$ implies that there will be an additional long position in bonds, since the hedge demand for bonds equals $-q\ ß_2$.

For real returns, the results for bonds are similar to the ones for nominal returns. However, for stocks, the hedge demand is now significantly different from zero in case of Los Angeles and San Francisco, implying that for agents that own a house in those regions, the optimal portfolios contain significantly more bonds and less stocks.

Equally interesting is the question whether the demand for real estate in the five geographical areas is affected by the fact that the agent may own a house in one of the five areas. To analyze this question we add to the hedging regression the housing returns for the four areas that do not correspond to the area in which the agent owns a house. Thus we estimate the regression

$$r_{E,i} = \alpha_i + \beta_{1i} r_{stock} + \beta_{2i} r_{bond} + \Sigma_j \beta_{j+2} r_{Ej} + e_i \qquad (4)$$

The estimates of the slope coefficients and the associated t-values of this regression are reported in Table 6. As in Table 5, the hypothesis that the hedge demand for stocks is zero can never be rejected and for bonds this hypothesis can only be rejected when the agent is exposed to residential real estate in Los Angeles.

Except for Los Angeles, owning a house in one area does not seem to induce a hedging demand for houses in any of the other areas. This confirms the conjecture in the previous sections that the residential real estate markets in the geographical areas are segmented. The clear exception in this respect is the residential real estate market in Los Angeles, which appears to be related to all other real estate markets except New York. Owning a house in Los Angeles induces a significant hedging demand in Chicago, Boston and San Francisco, and owning a house in one of those three regions in turn induces a significant hedging demand in Los Angeles. Also, this hedging demand has the expected sign: an agent owning a house in Los Angeles would like to short houses in Chicago, Boston and San Francisco for hedging reasons, and vice versa. The results for nominal returns are almost identical to real returns, except that the t-values in case of real returns are slightly higher. Thus, even though the correlations between real estate from the different regions were higher in real terms than in nominal terms in Table 1, the results in this section indicate that inflation is not a real issue in constructing portfolios from stocks, bonds, and real estate.

6. Conclusions

In this paper, we have investigated the implications of home-ownership or real estate on investment portfolios of stocks and bonds. Our findings are clear. First, focusing on the tangency portfolio we find that the mean price returns on real estate are generally too low in order for investors to include this asset class in their portfolio. Therefore, in order for households to include real estate in their portfolio the non price increase or consumption benefit must be significant. We estimate this consumption to be about ten percent per year for households that invest 50% of their wealth in real estate. Since estimation risk of expected returns is likely to influence these results we also analyze the global minimum variance portfolios of stocks, bonds and home equity. This analysis shows that residential real estate offers significant diversification benefits: the global minimum variance portfolios contain long positions in all asset classes and adding real estate to a portfolio of stocks and bonds can reduce the standard deviation of the global minimum variance portfolio by at least

50%. This suggests that real estate should be a serious part of an investment portfolio due to the large diversification benefit that comes with it. Finally, minimizing the variance of the total investment portfolio, the portfolio of stocks and bonds is only slightly affected by the investment in real estate: the hedging properties of stocks and bonds for real estate are small, although they are somewhat stronger for real returns than for nominal returns. This suggests that the issue of home ownership is relatively unimportant when determining the composition of the stock and bond portfolio, but is very important in the entire investment portfolio.

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Table 1: Summary Statistics

	Stocks	Bonds	LA	Chi	Bos	NY	SF
	Nominal returns						
Mean	16.92	11.35	3.96	5.02	6.83	4.88	3.35
Stdev	13.99	9.46	5.74	4.32	5.71	6.39	8.36
	Real returns						
Mean	12.89	7.23	-0.17	0.89	3.45	1.60	0.11
Stdev	14.78	9.56	5.82	4.48	5.82	6.51	8.40
	Correlations (real\nominal)						
Stocks		-0.10	0.17	0.02	0.01	0.02	0.09
Bonds	-0.07		-0.18	-0.07	-0.07	0.06	-0.25
Los Angeles	0.14	-0.12		0.27	0.28	0.00	0.31
Chicago	0.02	-0.06	0.13		0.05	0.07	0.05
Boston	0.05	-0.01	0.15	0.15		0.15	0.28
New York	0.12	0.10	0.14	0.21	0.28		0.12
San Fransisco	0.17	-0.23	0.32	0.06	0.30	0.14	

This table provides annualized monthly average returns and standard deviations for stocks, bonds and residential real estate in five metropolitan areas, for the period January 1980 through December 1997. For Boston, New York and San Francisco, the residential property data are from January 1982, January 1985, and January 1989, respectively. The upper part of the correlation matrix provides correlations between nominal returns. The lower part of the matrix provides correlations between real returns.

Table 2: Spanning tests, Risk averse agent ($\gamma = 80$)

Jensen	0% exposure	real estate exposure = 25%				
	exp:	LA	Chi	Bos	NY	SF
LA	4.59	2.82	5.41	4.15	4.08	4.12
Chi	9.78	8.78	10.10	9.64	9.23	9.81
Bos	7.10	5.98	8.14	5.61	6.40	6.56
NY	6.01	5.25	6.87	5.69	4.12	5.72
SF	9.59	8.17	10.83	8.91	8.71	6.31

p-value	0% exposure	real estate exposure = 25%				
	exp:	LA	Chi	Bos	NY	SF
LA	(0.007)	(0.198)	(0.004)	(0.035)	(0.026)	(0.054)
Chi	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bos	(0.000)	(0.004)	(0.000)	(0.021)	(0.002)	(0.005)
NY	(0.004)	(0.013)	(0.002)	(0.011)	(0.104)	(0.015)
SF	(0.001)	(0.007)	(0.000)	(0.004)	(0.004)	(0.080)

Jensen		real estate exposure = 50%				
	exp:	LA	Chi	Bos	NY	SF
LA		0.47	5.15	2.18	2.31	1.22
Chi		6.69	8.75	8.00	7.48	7.26
Bos		3.82	8.40	2.70	4.54	3.64
NY		3.42	6.98	4.03	1.75	3.25
SF		5.56	11.15	6.44	6.46	1.29

p-value		real estate exposure = 50%				
	exp:	LA	Chi	Bos	NY	SF
LA		(0.853)	(0.025)	(0.363)	(0.294)	(0.635)
Chi		(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
Bos		(0.124)	(0.000)	(0.323)	(0.064)	(0.179)
NY		(0.149)	(0.004)	(0.110)	(0.511)	(0.221)
SF		(0.102)	(0.001)	(0.065)	(0.054)	(0.701)

Jensen		real estate exposure = 75%				
	exp:	LA	Chi	Bos	NY	SF
LA		0.39	1.74	0.30	0.71	-0.29
Chi		5.48	4.32	6.04	5.95	5.57
Bos		2.73	5.51	1.26	3.05	2.16
NY		2.09	4.30	2.35	1.15	1.87
SF		4.36	7.68	4.25	4.69	0.66

p-value		real estate exposure = 75%				
	exp:	LA	Chi	Bos	NY	SF
LA		(0.867)	(0.518)	(0.906)	(0.773)	(0.908)
Chi		(0.014)	(0.068)	(0.006)	(0.006)	(0.014)
Bos		(0.308)	(0.045)	(0.594)	(0.251)	(0.419)
NY		(0.423)	(0.118)	(0.377)	(0.616)	(0.483)
SF		(0.223)	(0.038)	(0.238)	(0.188)	(0.789)

Table 3: Spanning tests, Less risk averse agent ($\gamma = 22$)

Jensen	0% exposure	real estate exposure = 25%				
	exp:	LA	Chi	Bos	NY	SF
LA	-7.10	-8.52	-7.53	-7.88	-7.70	-8.69
Chi	-1.91	-2.56	-2.84	-2.38	-2.54	-3.00
Bos	-4.59	-5.37	-4.80	-6.41	-5.37	-6.25
NY	-5.68	-6.09	-6.07	-6.33	-7.65	-7.09
SF	-2.11	-3.17	-2.11	-3.11	-3.06	-6.50

p-value	0% exposure	real estate exposure = 25%				
	exp:	LA	Chi	Bos	NY	SF
LA	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chi	(0.121)	(0.082)	(0.085)	(0.091)	(0.076)	(0.057)
Bos	(0.015)	(0.011)	(0.016)	(0.009)	(0.010)	(0.007)
NY	(0.006)	(0.004)	(0.005)	(0.004)	(0.003)	(0.003)
SF	(0.449)	(0.291)	(0.466)	(0.311)	(0.306)	(0.072)

Jensen		real estate exposure = 50%				
	exp:	LA	Chi	Bos	NY	SF
LA		-10.17	-10.27	-10.49	-9.62	-13.83
Chi		-3.96	-6.67	-4.68	-4.46	-7.78
Bos		-6.83	-7.02	-9.98	-7.40	-11.41
NY		-7.23	-8.45	-8.65	-10.18	-11.79
SF		-5.09	-4.27	-6.24	-5.48	-13.76

p-value		real estate exposure = 50%				
	exp:	LA	Chi	Bos	NY	SF
LA		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chi		(0.042)	(0.002)	(0.014)	(0.018)	(0.000)
Bos		(0.006)	(0.002)	(0.000)	(0.003)	(0.000)
NY		(0.002)	(0.001)	(0.001)	(0.000)	(0.000)
SF		(0.134)	(0.186)	(0.073)	(0.103)	(0.000)

Jensen		real estate exposure = 75%				
	exp:	LA	Chi	Bos	NY	SF
LA		-8.16	-21.14	-14.34	-11.70	-22.05
Chi		-3.08	-18.56	-8.60	-6.47	-16.18
Bos		-5.82	-17.38	-13.38	-9.37	-19.60
NY		-6.46	-18.58	-12.29	-11.26	-19.88
SF		-4.19	-15.20	-10.39	-7.73	-21.10

p-value		real estate exposure = 75%				
	exp:	LA	Chi	Bos	NY	SF
LA		(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Chi		(0.169)	(0.000)	(0.000)	(0.003)	(0.000)
Bos		(0.030)	(0.000)	(0.000)	(0.000)	(0.000)
NY		(0.013)	(0.000)	(0.000)	(0.000)	(0.000)
SF		(0.241)	(0.000)	(0.004)	(0.030)	(0.000)

Table 4: Global Minimum Variance Portfolios

	Nominal returns						
Stocks	0.31	0.08	0.08	0.10	0.11	0.11	0.04
Bonds	0.69	0.28	0.19	0.31	0.37	0.55	0.19
Los Angeles		0.63					0.11
Chicgo			0.73				0.39
Boston				0.59			0.12
New York					0.52		0.10
San Fransisco						0.33	0.05
Mean	13.1%	7.2%	7.2%	9.5%	8.6%	8.9%	4.3%
Stdev	11.1%	7.5%	6.1%	7.3%	7.8%	7.7%	5.3%
P		< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%
	Real returns						
Stocks	0.31	0.07	0.07	0.09	0.10	0.10	0.02
Bonds	0.69	0.28	0.19	0.31	0.38	0.56	0.19
Los Angeles		0.65					0.12
Chicago			0.74				0.44
Boston				0.60			0.09
New York					0.52		0.09
San Fransisco						0.34	0.06
Mean	9.0%	2.9%	2.9%	6.1%	5.3%	5.5%	0.9%
Stdev	7.8%	4.6%	3.8%	4.5%	5.0%	4.3%	2.5%
P		<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

The table provides the Global Minimum Variance (GMV) portfolios for stocks and bonds only and for stocks and bonds plus one or more categories of real estate. The bottom lines of each panel show the mean and standard deviation of the GMV portfolio returns and the *p*-value associated with a Wald test that the standard deviation of the portfolio equals the standard deviation of the GMV portfolio of stocks and bonds only as reported in the first column. The first panel shows the portfolios based on nominal returns, the second panel based on real returns.

Table 5: Hedge Regressions

	Nominal returns		Real returns	
	Stocks	Bonds	Stocks	Bonds
LA	0.04	-0.08	0.05	-0.07
	(1.32)	(2.03)	(1.93)	(1.61)
Chi	0.00	-0.05	0.01	-0.03
	(0.14)	(1.44)	(0.30)	(0.80)
Bos	0.00	-0.03	0.02	-0.01
	(0.09)	(0.57)	(0.61)	(0.17)
NY	0.05	0.07	0.06	0.09
	(1.46)	(1.06)	(1.56)	(1.36)
SF	0.05	0.32	0.10	-0.29
	(0.77)	(2.63)	(1.63)	(2.36)

The table shows the slope coefficients of a regression of real estate in a certain geographical area on stocks and bonds. The values in parentheses are *t*-statistics. The first two columns show regression results based on nominal returns, the last two columns show regression results based on real returns.

Table 6: Hedge Regressions

	Nominal returns						
	Stocks	Bonds	LA	Chi	Bos	NY	SF
Los Angeles	0.06	-0.06	--	0.35	0.20	-0.06	0.13
	(1.60)	-(0.86)	--	(2.80)	(2.30)	-(0.76)	(2.24)
Chicago	-0.01	-0.02	0.21	--	-0.02	0.05	-0.02
	-(0.33)	-(0.43)	(2.80)	--	-(0.37)	(0.87)	-(0.45)
Boston	-0.02	0.01	0.26	-0.05	--	0.11	0.13
	-(0.53)	(0.09)	(2.30)	-(0.37)	--	(1.32)	(1.95)
New York	0.01	0.09	-0.10	0.15	0.15	--	0.09
	(0.23)	(0.93)	-(0.76)	(0.87)	(1.32)	--	(1.19)
San Fransisco	0.03	-0.27	0.37	-0.10	0.28	0.15	--
	(0.38)	-(2.26)	(2.24)	-(0.45)	(1.95)	(1.19)	--

	Real returns						
	Stocks	Bonds	LA	Chi	Bos	NY	SF
Los Angeles	0.06	-0.06	--	0.34	0.21	-0.05	0.12
	(1.55)	-(0.81)	--	(2.64)	(2.48)	-(0.66)	(2.13)
Chicago	-0.01	-0.02	0.19	--	0.00	0.06	-0.02
	-(0.21)	-(0.44)	(2.64)	--	(0.03)	(1.02)	-(0.52)
Boston	0.00	0.05	0.28	0.01	--	0.14	0.14
	(0.00)	(0.58)	(2.48)	(0.03)	--	(1.65)	(2.10)
New York	0.01	0.12	-0.09	0.18	0.19	--	0.10
	(0.26)	(1.24)	-(0.66)	(1.02)	(1.65)	--	(1.25)
San Fransisco	0.06	-0.26	0.35	-0.12	0.30	0.16	--
	(1.00)	-(2.25)	(2.13)	-(0.52)	(2.10)	(1.25)	--

The table shows the slope coefficients of a regression of real estate in a certain geographical area on stocks and bonds and on the four other real estate classes. The values in parentheses are *t*-statistics. The first panel shows regression results based on nominal returns, the last panel shows regression results based on real returns.