Real Estate Allocation in an ALM Framework

Dirk Brounen, Melissa Porras Prado and Marno Verbeek

Abstract

This study explores real estate allocations in the investment portfolio decision from the perspective of an institutional investor, specifically a pension fund. We partition from the real estate investment decision to determine real estates role as a reserve asset, asset which moves in tandem with liabilities, or a return-generating asset. Previous studies highlight the liability influence on real estate allocations but do not offer precise guidance as to the magnitude of the effect. This paper contributes by examining the exact liability hedge qualities of real estate in light of other asset classes. Real estate assets have traditionally been regarded as safe investments with inflation hedging capabilities that offer diversification potential and high absolute returns. Nonetheless, the results show that when accounting for liability obligations direct and indirect real estate merits inclusion in a mixed-asset portfolio because of its attractive risk-reward properties and its diversification potential with stocks and bonds, but not because of its interest and inflation hedging abilities. The hedging utility of real estate is limited and it therefore appears that real estate investments exhibit return enhancement properties as opposed to interest and inflation hedging properties. To obtain greater utility a pension fund should overweight the direct property allocation towards retail and residential apartments. The latter offers high risk-adjusted returns and can thus be considered a return-generating asset class, while retail offers a hedge against liability fluctuations due to interest and inflation risk.

Keywords: Real Estate, Pension Plan Investment, Asset Liability Management.

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1. Introduction

Real estate assets have traditionally been regarded as safe investments with inflation hedging capabilities that offer diversification potential and high absolute returns. Nonetheless there is no consensus as to its role within an investment context. In the selection of portfolios based on means and variances of returns the role for real estate, as a diversifier in a portfolio, appears to be substantial. For real estate allocations the mean-variance literature predicts allocations of at least 20% to be optimal[1]. Nonetheless, institutional investors like pension funds are not solely aspiring for maximum returns at a selected level of risk in their portfolio choice. Their focus in making asset allocation decisions is on considering risk on a relative basis versus liabilities to optimize the risk adjusted surplus. When taking pension liabilities as the starting point and coordinating the management of assets and liabilities in order to maintain a surplus of assets beyond liabilities the role for real estate seems much more limited.

Chun, Ciochetti and Shilling (2000) offered the first empirical analysis of real estate allocations within an ALM framework. In their research they recognize real estate assets' correlation and diversification potential with other assets, while simultaneously adjusting for the covariance with the liability stream. The diversification potential on the liability side as a hedge against inflation turns out to be more limited and accounts for the reduced exposure to this asset class as witnessed in institutional portfolios. Even so, this earliest achievement in the asset-liability literature circumvents the imperfections associated with real estate by focusing on real estate securities (REITs) and as such limit the opportunity set of assets to solely indirect real estate.

Direct real estate has unique and appealing characteristics for asset allocation, attractive risk-return, stable income, progressive capital growth and diversification potential. Nonetheless some of its specificities, such as illiquidity and valuation biases, make it challenging to correctly integrate in an ALM framework. Asset allocation demands long term returns as input, yet the

[1] For empirical evidence on real estate allocation within mean variance optimizations please refer to: Friedman (1971), Fogler (1984), Brinson, Diermeier, Schlarbaum (1986), Firstenberg, Ross and Zisler (1987), Irwin and Landa (1987), Ennis and Burik (1991), Hoesli, Lekander and Witkiewicz (2003) and Lee and Stevenson (2005).

returns of both direct real estate are thwarted by biases in the construction of the indices. The private real estate indices are based on subjective valuations and are impaired by temporal aggregation and seasonality. Direct real estate returns are biased by appraisal smoothing and lagging

Craft (2001) was the first to incorporate direct real estate and account for valuation smoothing in the appraisal based indices for the American market, documenting a substantial allocation of 12.5% to private real estate and merely 4.7% to public real estate. Booth (2002) further upholds that liabilities impact the formation of portfolios in the allocation to direct real estate. The optimal real estate allocation for U.K. direct property investments lingers around 10%-18% depending on the maturity of the pension schemes.

These studies all underline the liability influence on real estate allocations but do not offer precise guidance as to the magnitude of the effect. This paper extents the work of Chun Ciochetti and Shilling (2000), Craft (2001) and Booth (2004) by examining the exact liability hedge qualities of real estate in light of other asset classes. We will summarize the assets impact on the pensions fund's future funding surplus and quantify the utility that investors with liabilities can derive from different asset classes. This will enable us to determine whether to classify real estate and other assets as reserve asset, asset which moves in tandem with liabilities, or return-generating asset (See Black and Jones, 1988). We widen the investment opportunity set by distinguishing between direct and indirect real estate investments and by making a distinction between sub-sectors in real estate.

Moreover, we use a liability framework, which allows for a differential in emphasis attached to liabilities, the level of risk aversion and the funding level of pension schemes. This enables us to determine how sensitive the results are to these factors, but more importantly it permits pension funds to tailor their portfolios to their particular nature and objectives. Overall, this ALM portfolio allocation model is intuitively simple and operationally straightforward and can be of great practical use for pension fund managers.

The remainder of the paper is organized as follows: we present a synthesis of the most relevant theoretical and empirical analyses on real estate allocations and liability relative investing. In the third and fourth section the data set and the methodology of the empirical tests will be presented. We proceed by quantifying real estate allocations assuming an asset-only mean variance optimization. Special consideration will be given to the impact of smoothed data on the calibration of optimal portfolios. Next, in section six, we analyze the liability hedging potential of various assets classes, results that will used in section seven to compute optimal ALM portfolios for different weights attached to liabilities, levels of risk aversion and funding levels of pension schemes. Finally, the last section summarizes our most important findings.

2. Literature Review

In the context of real estate allocations Friedman (1971) was one of the first to use the mean-variance methodology to select optimal direct real estate and mixed-asset portfolios. The inclusion of real estate assets within modern theory based portfolios resulted in a widespread belief that actual real estate allocations in investment portfolios fall short. Bajtelsmit and Worzala (1995) put forward that on average American pension funds allocate less than 4% of their assets to equity real estate. In their survey among 96 pension funds the dominate asset classes were domestic stock (42.6%) and bonds (32%) followed by international stocks (7.2%). More recently, Dar and Goetzmann (2005) surveyed leading investment managers from the U.S. and found the reported allocation among funds who invest in real estate to be relatively small 3%-5%, although a large number of funds are planning to increase their respective allocations. Nonetheless, against the classic mean-variance framework, the predicted allocations are still inconsistent with reported allocations.

The discrepancy between actual allocations and theoretical predications in this asset-only view lead Chun, Ciochetti and Shilling (2000) to re-examine pension plan investments in an asset-liability framework using U.S. REITs. The relationship between asset and liabilities seems to be at the heart of explaining the limited exposure to real estate. Within the mean-variance framework real estate plays an important role as a diversifying asset class, but when accounting for liability obligations real estate seems to offer a reduced diversification benefits as a hedge against inflation on the liability side of the balance sheet. The latter diversification potential accounts for the reduced exposure to this asset class as apparent among institutional portfolios. Pension funds allocate their assets to maximize its risk-adjusted surplus value. Chun, Ciochetti and Shilling (2000) also found cross-sectional differences in REIT allocations. For overfunded plans the optimal allocation is higher than for underfunded funds. Furthermore, the higher the rate of liability growth the larger the theoretical real estate allocation, yet in reality there is not much variation between high and low growth liabilities observable. There does appear to be a positive significant relationship between plan size and the actual portion of assets invested in real estate. Larger plans hold more real estate assets. The optimal allocation does also differ across industries.

Following this first empirical ALM study on real estate allocations Craft (2001) further examined real estate investments by distinguishing between private and public real estate allocations, while correcting for appraisal smoothing. The asset-liability framework predicts an allocation of 12.5% to private real estate and 4.7% to public real estate. And as the surplus returns increase the private real estate allocation decreases sharply while the allocation to public real estate decreases at a lower progressive pace. Moreover, overfunded pension plans are in accordance with Chun, Ciochetti, and Shilling (2000) much more likely to hold both private and public real estate than underfunded counterparts. The particular disposition and conditions of a pension fund do apparently influence the allocation decision. In accordance Booth (2002) finds considerable different optimal portfolios depending on the liability structure of the pension funds. For mature U.K. schemes (members who have already retired) direct real estate allocations prevail in all but the highest risk class around 10%. For immature pension plans (active members) index-linked U.K. government bonds and U.S. equities replace real estate allocations.

Finally, another strand of literature by Fugazza, Guidolin and Nicadono (2006) and Hoevenaars, Molenaar, Schotman and Steenkamp (2005) incorporates predictability of asset returns in the optimal portfolio choice. Fugazza, Guidolin and Nicadono (2006) explicitly distinguish the time-varying properties of real estate in light of bonds and stocks. When allowing for linear predictability patterns in indirect real estate returns the optimal allocation should obtain a weight of between 12% and 44%, depending on the risk aversion, parameter uncertainty and investment horizon. On the other hand when optimizing returns in excess of liabilities, Hoevenaars, Molenaar, Schotman and Steenkamp (2005) find that the role for indirect real estate in a liability driven investment portfolio is negligible.

All the ALM studies stress the liability influence on portfolio composition but there does not seem to be definite conclusions regarding the role for real estate. This paper extents the work of Chun Ciochetti and Shilling (2000), Craft (2001) and Booth (2004) by examining the exact liability hedge qualities of real estate in light of other asset classes. We will summarize the assets impact on the pensions fund's future funding surplus and quantify the utility that investors with liabilities can derive from different asset classes. To do so, this study applies a liability framework as developed by Sharpe and Tint (1990), which arises from a traditional mean-variance asset-only optimization but also maximizes utility while incorporating liabilities. More specifically, it involves a mean variance surplus optimization model which optimizes the expected surplus return minus a risk penalty (variance surplus return) divided by risk tolerance while taking into account the change in pension liabilities and their covariance with assets. The latter also referred to as the liability hedge credit, which summarizes the assets impact on the pensions fund's future funding surplus. The liability hedge credit is positively related to the covariance of an asset and the liability, positively related to the funding level (L_0/A_0) and inversely related to the risk tolerance (λ). This methodology allows for different optimal portfolios depending on the weight attached to liabilities, the level of risk aversion and the funding level of pension schemes. And most notably, it allows institutional investors to adjust their portfolio to their particular circumstances and objectives.

3. Data description

Our study uses data from the United States, as for this country broad data coverage and record on both appraisal based property indices and property share indices are available. For the asset returns we use quarterly data. Data on stock returns were taken from Datastream Advance. Stock returns are based on MSCI indices, and direct real estate returns are from NCREIF series. NCREIF provides income, capital and total returns disaggregated by sector and region based on a sample of institutional-owned properties. Constituents of the NCREIF Composite Index are segregated into 4 sub-sectors: office, industrial, retail and apartments. A company is classified in a specific property sub-sector if 75 percent or more of its gross invested book assets is invested in that specific sub-sector. The return of a sector in each quarter is calculated as the sum of weighted average returns of the individual properties. Indirect real estate returns are based on Global Property Research (GPR) General National indices. The data is available since 1983 Q4. Data on fixed income returns for the U.S., the 10-year constant maturity yields, Moody's Seasoned Aaa Corporate Bond Yield and the 3-month T-bill, are from the US Federal Reserve Bank website[2]. Moody's Seasoned Aaa Corporate Bond Yield are averages of daily data. CPI index for the US are also taken from the US Federal Reserve Bank website.

In line with Campbell, Lo and MacKinlay (1997) quarterly bond returns are a loglinear function of log return and log yield:

[2] http://research.stlouisfed.org/

$$(1+r_{n,t+1}) = D_n(1+Y_{n,t}) - (D_n - \frac{1}{4})(1+Y_{n-1,t+1}) = \frac{1}{4}Y_{n-1,t+1} - (D_{n,t}(Y_{n-1,t+1} - Y_{n,t})) ,$$

where D_n is Macaulay's duration: $\frac{(1-(1+Y_{n,t})^{-n}}{1-(1+Y_{n,t})^{-1}}$ and $Y_{n,t}$ is the log annualized yield of a 10 year maturity bond at time t.

We assume a constant maturity bond as a proxy for pension liabilities. The pension fund liability will be represented by a 10-year constant maturity bond. In 2001 the Treasury temporarily suspended new issues of 30-year bonds, making the 10 year bond the longest issued Treasury for which continuous data is available. The fund is assumed to be in a stationary state, the distribution of the age cohorts and pension rights are assumed constant over time. The market value of liabilities is solely influenced by changes in interest rates and inflation. The liability return is derived as a function of log return and log yield, assuming a duration of 17 years. We calculate both the nominal $(r_{0,t+1})$ as the real liability return $(rr_{0,t+1})$.

The real rate of return is calculated as $(rr_{0,t+1}) = \frac{1+r_{0,t+1}}{1+\pi_{t+1}} - 1$, where π_{t+1} is the change in CPI index.

Direct real estate returns are based on an appraisal based index and these are biased by strong autocorrelation. In line with the Geltner (1993) approach we adjust the private real estate return series for first-order autocorrelation. The advantage of this procedure is that it avoids the assumption that returns in the private property market are uncorrelated. Geltner's model applies a reverse filter on the capital growth component of private real estate returns in order to recover the underlying unsmoothed property returns: $R_t^u = \frac{(R_t^* - (1-a)R_{t-1}^*)}{a}$, where R_t^U is the unsmoothed return at time t, R_t^* is the observable appraised-based index return at time t and a is a parameter between 0 and 1 whose value depends on the confidence factor α (α=0.5) and seasonality factor f (f= 0.15). In line with Geltner (1993) we assume that the volatility of commercial property is in the vicinity of half of that of the stock market, which results in an a of 0.40[3].

INSERT TABLE 1

[3] In our analysis we also test alternative specifications by unsmoothing real estate returns at a-factors of 0.3 and 0.5 in order to isolate the impact of this assumption on our overall results.

Table 1 displays the key statistics on the return series we employ in the subsequent analysis. The mean returns and standard deviations are computed in excess of the 3-month T-bill for the 1984-2007 sample period[4]. The performance of direct real estate at a risk adjusted basis is 0.64 versus 0.53 for stocks, 0.51 for indirect real estate, 0.49 long-term Treasury bond and 0.96 for corporate Aaa bonds. The returns on direct real estate document the lowest standard deviations and the highest autocorrelation. Following the correction approach of Geltner (1993) the autocorrelation is reduced to 0.29 and the standard deviation doubles in magnitude. Moreover the seasonality of returns is non-significant (t=-0.07, p=0.939), the fourth quarter return is no longer dominant. Table 2 tabulates the summary statistics per sub-sector.

INSERT TABLE 2

4. Methodology

To determine real estates role as a reserve asset (asset which moves in tandem with liabilities) or a return-generating asset we apply a single-period surplus optimization investment framework of Sharpe and Tint (1990) that explicitly links investment opportunities and pension-plan obligations. The objective of the pension fund is to maximize surplus utility, defined as:

$$S_{t+1} = A_{t-1} - kL_{t+1} \, , \tag{1}$$

where A_{t+1} represents the value of the fund's assets at t+1, L_{t+1} the value of the relevant liability concept and k the attached importance to it. Choosing k=1 means that full importance is attached to the liabilities, k=0 corresponds to an asset-only optimization. Denoting the return on the asset portfolio by $R_{A,\,t+1}$ and the growth rate of the liabilities by $R_{L,\,t+1,}$ the surplus can be written as:

$$S_{t+1} = A_t \left[\left(1 + R_{A,t+1}\right) - k \frac{L_t}{A_t} \left(1 + R_{t+1}\right) \right], \tag{2}$$

where L_t/A_t denotes the fund's current funding ratio.

[4] The underlying assumptions behind the mean variance optimizations are the expectations surrounding excess returns and variance of returns. We assume returns are unpredictable and partition from the traditional approach in which assets have constant expected returns that are estimated from their historical means.

Maximizing the expected utility of S_{t+1} is equivalent to maximizing that of

$$Z_{t+1} = R_{A,t+1} - k\left(\frac{L_t}{A_t}\right)R_{L,t+1} \tag{3}$$

Accordingly, Sharpe and Tint (1990) formulate the optimization problem of the pension fund as

$$\max\left[E_t(Z_{t+1}) - \frac{1}{\lambda}\operatorname{var}_t(z_{t+1})\right], \tag{4}$$

where λ denotes a fund's risk tolerance. If the portfolio weights to be chosen are denoted by ω, we have $R_A = \sum_i w_i R_{i,t+1}$, where $R_{i,t+1}$ denotes the vector of asset returns.

Note that the choice of ω only affects the first term in (4). Following Sharpe and Tint (1990) let us focus on the second term in (4), which can be written as

$$\begin{aligned} &\operatorname{var}_t\left(R_{A,t+1} - k\frac{L_t}{A_t}R_{L,t+1}\right) \\ &= \operatorname{var}_t(R_{A,t+1}) + k^2\frac{L_t^2}{A_t^2}\operatorname{var}_t(R_{L,t+1}) - 2k\frac{L_t}{A_t}\operatorname{cov}_t(R_{A,t+1}, R_{L,t+1}) \end{aligned} \tag{5}$$

The second term is irrelevant to the outcome of the maximization problem. The difference with the standard asset-only optimization problem is concentrated in the last term. It stresses that the assets' covariances with the growth rate of the laibilties are key for the optimal allocation. Sharpe and Tint (1990) define the liability hedge credit for any asset *i* as

$$LHC_i = \frac{2}{\lambda}k\frac{L_t}{A_t}\operatorname{cov}_t(R_{i,t+1}, R_{L,t+1}), \tag{6}$$

while the LHC of the entire portfolio is simply

$$LHC_a = \sum_i w_i LHC_i \ . \tag{7}$$

Other things being equal, an asset whose returns are highly correlated with liabilities provide better liability hedging and receive a greater liability hedging credit.

5. Asset-only Mean Variance Optimization

Mean-variance methodology ensures a portfolio selection that embodies the benefit of diversification between assets and identifies the efficient set of portfolios that maximize return while minimizing risk. Risk reduction is a function of low correlation coefficients between asset classes. Excess direct real estate returns appear to be only slightly correlated to stocks (ϱ=0.06) and negatively correlated to long-term treasury (ϱ=-0.07) and corporate bonds (ϱ=-0.06). Real estate stocks in contrast do not appear to be highly correlated with direct real estate investments (ϱ=0.15) but more with common stocks (ϱ=0.58). In the context of portfolio diversification direct real estate offers greater risk diversification benefits. The negative covariance of direct real estate with stocks and bonds should greatly reduce portfolio risk. Table 3 presents a correlation matrix between the returns on stocks, long-term treasury bonds, corporate bonds and direct and indirect real estate.

INSERT TABLE 3

The efficient set of portfolios that maximize return while minimizing risk are constructed under the standard mean-variance analysis. We impose short-selling constraints and portfolios must be fully invested. In the selection of portfolios based on means and variances of returns the role for direct real estate, as a risk diversifier in a portfolio, is substantial. The negative correlation of direct real estate with bonds and stocks in combination with the low standard deviation of returns results in high allocations to this asset class in the low-risk range of efficient frontier. The mean-variance model, on the basis of smoothed real estate returns, estimates allocations to direct real estate as high as 57.81%. The results are in accordance with the first strand of literature on real estate mean-variance allocations, Friedman (1971), Firstenberg, Ross and Zisler (1998), Fogler (1984), Brinson, Diermeier, Schlarbaum (1986), Irwin and Landa (1987), Ennis and Burik (1991), Hoesli, Lekander and Witkiewicz (2003) and Lee and Stevenson (2005))

The observed autocorrelation of 0.72 in the NCREIF index (direct real estate) does appear to impede optimal calibration of mean-variance efficient portfolios. The use of appraisals in the construction of the NCREIF index affects the mean and volatility of the direct real estate return distribution. When correcting for the misspecification in direct real estate returns using Geltner's approach (1993) the standard deviation of returns doubles in magnitude reducing the attractive risk adjusted return characteristic of direct real estate. The measured risk appears to be understated, overstating the direct real estate allocation by up to 15.08%. Risk diversification benefits diminish as the correlation coefficients with stocks (ϱ=0.08 vs ϱ=0.06), bonds (ϱ=-0.04 vs ϱ=-0.07, ϱ=-0.01 vs ϱ=-0.06) and indirect real estate (ϱ=0.19 vs ϱ=0.15) increases. The differences in direct real estate allocations are prevalent in the low risk portfolios, where the allocation to this particular asset class dominates. Unsmoothing direct real estate returns results in 29 bps. increase in expected returns (32 bps increase in standard deviation) for the minimum variance portfolio, while for the optimal Sharpe portfolio[5] accounting for smoothing results in an increase of expected returns of 0.80% vs 0.82% increase in standard deviation. The results of the asset-only mean variance optimization and the difference between smoothed and unsmoothed portfolios are presented in table 4, where we display two portfolios of the efficient frontier: the minimum variance portfolio and the optimal Sharpe portfolio.

INSERT TABLE 4

Table 5 reports portfolio compositions for five points on the efficient frontier proportional to the risk from the Minimum Variance (MVP) portfolios, beginning with the minimum variance portfolio (MVP) and optimal Sharpe portfolio and ending up high risk range of the efficient frontier. Mean variance efficient portfolios tend to contain a high level of direct real estate and a high portion of indirect real estate at higher risk levels. At the higher risk tolerance levels indirect property investments substitute the direct counterpart. The absence of indirect real estate in the low risk portfolios can be explained by the high standard deviation of the asset class and the high correlation with stocks, while direct real estate appears to offer superior risk-adjusted returns next to risk diversification properties. The efficient real estate allocations range between 16.76% and 31.3%. The results are in line with those of Ziering and Mclntosh (1997), Ziobrowski and Ziobrowski (1997), Kallberg, Lui and Greig (1996), and Mueller and Mueller (2003), who account for the added smoothing risk but still find an optimal real estate allocation of 20%-30%. On the basis of a mean-variance asset only optimization direct real estate warrants inclusion in a mixed-asset portfolio because of its attractive risk-reward properties and its low correlation with stocks and bonds.

INSERT TABLE 5

Within the direct real estate asset category the selection of sub-sectors could further influence the risk diversification, as found by Firstenberg, Ross and Zisler (1988). The correlation among property types and with the other asset classes differs substantially. Office and Industrial (ϱ=0.78) and Apartment (ϱ=0.53) are found to be highly correlated. Retail

[5] The Optimal Sharpe portfolio represents the tangency portfolio that optimizes the mean excess return divided by the standard deviation of returns.

materializes as a distinct sub-sector in itself as it correlates the least with the remaining sub-sectors. Risk diversification benefits with stocks can be mainly derived from the direct retail (ϱ=-0.12) and apartment sub-sectors (ϱ=-0.01), while industrial (ϱ=-0.08) and apartment (ϱ=-0.018) tend to display a negative correlation with bonds. Real estate stocks appear to be highly exposed to the office (ϱ=0.24) and industrial (ϱ=0.19) sub-sectors and the least to retail properties (ϱ=0.01).

INSERT TABLE 7

At a risk adjusted basis[6] the performance of the industrial (0.77), apartment (0.89) and retail (0.65) properties were most promising, while office property rendered the worst risk adjusted performance (0.22). Under these conditions apartment and retail properties offer great diversification benefits, as well as return generating characteristics. Consequently, the minimum variance efficient portfolio attributes a substantial allocation to Apartments (25.11%) and Industrial (12.50%) at the expense of Office (0.00%) and Retail (3.94%) to a lesser extent. At the high range of the efficient frontier Apartment (30.20%) and Retail (7.30%) dominate the industrial sub-sector (3.34%). Furthermore, diversifying the composition of the direct real estate portfolio among property types can increase the portfolio's expected return for a given level of risk. The minimum variance portfolio (MVP) has an expected return of 4.69% against 4.38% (σ=2.94% vs. σ=3.38%) when not distinguishing between property types. Similarly for the Sharpe portfolio, the expected return is 4.85% against 4.53% (σ= 2.99%, σ=3.38%). Table 8 displays the minimum variance portfolio (MVP) and optimal Sharpe portfolio for the unsmoothed direct real estate returns across sub-sectors[7].

INSERT TABLE 8

6. Liability Hedge Potential

An asset-liability model (ALM) is a model of the assets and liabilities that facilitates decision-making with respect to asset allocation and the properties of the liabilities. An important distinguishing feature is the interdependence between asset and liabilities. The liability hedge

[6] Risk adjusted performance is calculate as annualized return in excess of t-bill divided by the annualized standard deviation of returns.

[7] Total allocations differ from the aggregate NCREIF allocation due to the return adjustment in the number of properties per property type. Constituents of the NCREIF Composite Index are segregated into 4 sub-sectors: office, industrial, retail and apartments. A company is classified in a specific property sub-sector if 75 percent or more of its gross invested book assets is invested in that specific sub-sector. The return of a sector in each quarter is calculated as the sum of weighted average returns of the individual properties.

credit (LHC) quantifies the utility that investors with liabilities can derive from different asset classes and determines the exact liability hedge qualities of real estate in light of other asset classes.

For a single asset the LHC follows directly from the correlations of the asset return with the liability returns, current assets to liability ratio and the risk aversion.

$$LHC_i = \frac{2}{\lambda} k \frac{L_t}{A_t} \text{cov}_t \left(R_{i,t+1}, R_{L,t+1} \right) \qquad (6)$$

The liability hedge credit is positively related to the covariance of an asset and the liability and to the current assets to current liabilities (L_0/A_0), while inversely related to the risk aversion (λ). The correlation between liabilities and both direct (ϱ=-0.043) and indirect (ϱ=-0.037) real estate is negative, see also table 8. Direct and indirect real estate appear therefore to offer reduced hedging benefits against inflation and interest rates. The LHC for direct real estate is slightly negative ranging from -0.0094% in the full surplus optimization scenario for fully funded funds with a typical risk aversion (λ=10) to -0.0142% for underfunded funds (L/A=1.5) under similar constraints. Including direct real estate results in a slight penalty. The low standard deviation and risk-reward characteristics of direct real estate render it more attractive for overfunded and more risk averse funds. As the funding status improves so does the hedging utility to be derived from the asset class. The difference between hedging nominal or real liabilities does not seem to be of economic significance, direct real estate responds most to interest rate risk as opposed to inflation risk, but again no positive liability benefit can be attributed to this asset class.

For indirect real estate the covariability with liabilities is somewhat worse, due to the higher standard deviation of the asset class. Attaching less importance to maximizing surplus but more to absolute returns does improve the return to be derived from indirect real estate. Moreover, the higher the risk aversion of the institutional investor the lower the liability penalty for the real estate asset class.

Direct real estate and indirect real estate do provide more utility than stocks, the correlation of stocks with liabilities is negative (ϱ=-0.166) and double the magnitude of direct real estate. However the hedging utility is limited and it therefore appears that direct and indirect real estate investments provide return enhancement properties next to risk diversification as opposed to interest and inflation diversification. Solely fixed income instruments offer a liability benefit ($LHC_{Treasury}$=0.28, $LHC_{CoporateAaa}$=0.15) for the portfolio of a pension fund, as the correlation between these asset and liabilities is high (ϱ=0.99 and ϱ=0.90)[8]. Including these asset classes in a pension portfolio can enhance returns up to 28 and 15 bps for fully funded funds with a typical risk aversion (λ=10). A clear distinction arises between return generating like stocks and real estate and liability hedging asset classes like bonds, as the latter provide the most utility when the funding status is unfavorable, while return generating assets provide an improved utility when pension funds are overfunded.

INSERT FIGURE 1

A difference in hedging capacity may persist in the different type of direct property investments. Gyourko and Linneman (1988) found considerable heterogeneity in the inflation hedging potential of a wide array of property types. According to Hudson-Wilson, Fabozzi and Gordon (2006) the triple net basis leases of industrial, office and retail properties offer inflation protection, as the rental contracts defer real estate taxes, property insurance, and operating expenses to the tenant. Particularly, retail properties should exhibit inflation hedging properties, as retail properties are leased on the triple net basis plus administrative expenses surcharge. Nonetheless, this is theoretically only possible in the absence of oversupply.

When distinguishing between office, retail, industrial and apartment properties, the only positive hedge against liabilities is in effect retail. Retail property appears to be a reserve asset, asset which moves in tandem with liabilities, (ϱ=0.02). The hedging utility remains positive under varying funding levels, weights of importance of liabilities and risk aversion. Interestingly, the actual positive hedge of the retail sub-sector is derived from capital gains, not the rent component as anticipated by Hudson-Wilson, Fabozzi and Gordon (2006). Apparently, retail rental contracts are not effective in hedging inflation and interest rate movements. Office, industrial and apartment properties overall seem to be poor interests and inflation hedgers. For these property types the income return and capital gains do not display liability hedging properties. The rental contracts (income return) do in fact perform better as a hedge against inflation and interest rates but remain negatively related nonetheless. The performance of apartment properties are favorable at a risk adjusted basis (Annualized excess return =4.81%, σ =2.91%), but in terms of hedging liabilities its performance is particularly

8 Note that liabilities were derived from constant maturity bond, as such the hedging potential might be biased upwards.

adverse, mainly attributable to the capital gains component of returns. A higher funding level does reduce the hedging bonus of retail and the hedging penalty of the of return generating sub-sectors, as does attaching less importance to maximizing surplus but more to absolute return.

INSERT FIGURE 2 & 3

In accordance with Hudson-Wilson, Fabozzi and Gordon (2006), rental contracts are only effective under tight market conditions. Under bull market conditions the LHC's are positive for all sub-sectors, but under bearish conditions solely retail withstands to hedge inflation and interest rate risk. When there is an oversupply, which is likely under a bear market cycle tenants will renegotiate their leases and eradicate any inflation hedging potential stemming from the triple net lease conditions. Market fundamentals are the deterministic factor behind rent inflation. Retail appears to be the least cyclical property type, whereas the office sub-sector demonstrates high cyclicality, during bearish conditions this property type performs particularly bad, while during market upturns its performance is favorable. See figure 4 for an exhibition of the LHC's per property type under bull and bear market cycles.

INSERT FIGURE 4

7. ALM Portfolio Optimization

Within the mean-variance (asset-only) framework real estate plays an important role as a diversifying asset class, mean-variance efficient portfolios tend to contain a high level of direct real estate and a high portion of indirect real estate at higher risk levels. When accounting for liability obligations real estate offers a reduced hedging benefits against inflation and interest rates. The correlation between liabilities and both direct (ϱ=-0.043) and indirect (ϱ=-0.037) real estate is negative and consequently so is the liability hedging return to be derived from these asset classes. Nonetheless, the correlation and hedging properties of both property categories is greater than that of stocks (ϱ=-0.167), resulting in a higher weight for property in an ALM framework.

INSERT TABLE 9

At low risk levels the total real estate allocation in an ALM framework seems in line with the asset-only scenario. To obtain a similar standard deviation as the minimum variance portfolio in the asset-only scenario a fully invested pension fund would need to allocate 30.97% to direct real estate when considering liabilities versus the 31.3% when focusing on asset returns solely. The annualized cost of ignoring liabilities is 0.15%, as the total return is slightly higher when considering the co-movement of assets with liabilities.

The equivalent maximum Sharpe ratio portfolio still contains considerable direct real estate exposure, 25.03% versus 26.33%. Again this is mainly attributable to the higher LHC of direct real estate vis-à-vis indirect real estate and stocks. Furthermore, as funding ratios improve or the importance attached to liabilities deteriorate, or as institutional investors prefer higher levels of risk aversion, direct real estate obtains a position in the higher risk portfolios. Direct real estate materialize in an asset-liability portfolio as a relatively safe asset class of particular utility to fully funded or risk-averse pension funds. At higher risk levels, real estate exposure in terms of direct real estate erodes as real estate stocks dominate direct real estate. For underfunded pension funds high return-generating asset classes, such as indirect real estate and stocks, offer more utility in an optimal portfolio. The optimal portfolio allocations for real estate range from 12% to 30%, which result in an expected return utility between 4.4% and 6%, depending on the level of risk aversion and funding ratio of the pension fund. For medium risk portfolios the indirect real estate allocation when considering liabilities support the findings of Chun, Ciochetti and Shilling (2000), who find a lower optimal allocation of 10% to U.S. REITs. The optimal allocations as found by Craft (2001) of 12.5% to private real estate and 4.7% to public real estate corresponds with an expected return of 5.3% and a standard deviation of 4.5%.

When differentiating between direct property types more efficient portfolios arise, a pension fund can attain a higher expected return for a given risk level. To obtain surplus utility a pension fund should overweight the direct property allocation towards retail and residential apartments. The latter offers high risk-adjusted returns and can thus be considered a return-generating asset class, while retail offers a hedge against liability fluctuations due to interest and inflation risk. Especially against the asset-only mean variance efficient allocations differences are apparent. The hedging properties of the retail sub-sector, as well as its low correlation with other sub-sectors and asset classes merit higher allocations under an ALM framework. The minimum variance efficient portfolio in the asset-only scenario attributes a substantial allocation to Apartments (25.11%) and Industrial (12.50%) at the expense of office (0.00%) and Retail (3.94%) to a lesser extent. At the high range of the efficient frontier Apartment (30.20%) and Retail (7.30%) dominate the industrial sub-sector (3.34%). The equivalent minimum variance portfolio when accounting for liabilities in contrast contains solely Retail (10.37%) and Apartment (28.20%). At higher risk levels the optimal Sharpe ratio allocates slightly more to Retail (10.54%) at the expense of Apartment properties (28.03%).

INSERT TABLE 13 & 14

When accounting for liability obligation direct real estate warrants inclusion in a mixed-asset portfolio because of its attractive risk-reward properties and its diversification potential with stocks and bonds, but not because of its interest and inflation hedging abilities. An institutional investor can nevertheless obtain a more efficient portfolio by distinguishing between direct property types. To maximize the hedging potential of certain sub-sectors a pension fund should overweight the direct property allocation towards retail. Indirect real estate is a substitute at higher risk levels.

8. Conclusion

Real estate assets have traditionally been regarded as safe investments with inflation hedging capabilities that offer diversification potential and high absolute returns. Nonetheless, the results show that when accounting for liability obligations direct real estate warrants inclusion in a mixed-asset portfolio because of its attractive risk-reward properties and its diversification potential with stocks and bonds, but not because of its interest and inflation hedging abilities. The hedging utility of real estate is limited and it therefore appears that direct and indirect real estate investments provide return enhancement properties as opposed to interest and inflation properties. Even so, direct real estate and indirect real estate do provide more utility than stocks. The optimal portfolio allocations for real estate range from 12% to 30%, which result in an expected return utility between 4.4% and 6%, depending on the level of risk aversion and funding ratio of the pension fund. As funding ratios and the importance attached to liabilities deteriorate, and at higher levels of risk aversion, direct real estate obtains a position in the higher risk portfolios. Direct real estate is especially dominant in the low-risk range portfolios and disappears at higher risk levels in favor of real estate stocks. To obtain surplus utility a pension fund should overweight the direct property allocation towards retail and residential apartments. The latter offers high risk-adjusted returns and can thus be considered a return-generating asset class, while retail offers a hedge against liability fluctuations due to interest and inflation risk. However, the favorable liability hedging properties can solely be attributed to the capital gains income component.

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Table 1. Real Estate and Financial Asset Returns USA

Mean returns and standard deviations are annualized quarterly total returns related to the sample period of 1984-2006. The mean returns and standard deviations are computed in excess of the 3-month T-bill. Stock returns are based on MSCI indices, and direct real estate returns are from NAREIT series for the U.S. and IPD for the European market. Indirect real estate returns are based on GPR indices. The 10-year constant maturity yields, Moody's Seasoned Aaa Corporate Bond Yield and the 3-month T-bill are from the US Federal Reserve Bank website.

Annualized Return Panel A: USA	*Return*	*Excess Return*	*σ*	*Autocorrelation*
Stock (MSCI)	11.94%	7.17%	13.41%	0.02
Real Estate Stock (GPR)	13.10%	8.32%	16.24%	0.05
Direct Real Estate (NCREIF)	8.48%	3.70%	3.45%	0.72
Unsmoothed Direct Real Estate (NCREIF*)	8.58%	3.80%	5.96%	0.29
10-Year Treasury Constant Maturity Rate	8.55%	3.77%	7.72%	0.02
Moody's Seasoned Aaa Corporate Bond Yield	9.08%	4.30%	4.49%	0.03

Subperiod (1984-1994)	*Excess Return*	*Σ*
Stock (MSCI)	7.39%	13.47%
Real Estate Stock (GPR)	5.62%	18.88%
Direct Real Estate (NCREIF)	-0.96%	3.07%
Unsmoothed Direct Real Estate (NCREIF*)	-1.21%	6.97%
10-Year Treasury Constant Maturity Rate	4.42%	8.54%
Moody's Seasoned Aaa Corporate Bond Yield	4.67%	5.05%

Subperiod (1995-2007)	*Excess Return*	*Σ*
Stock (MSCI)	6.97%	13.50%
Real Estate Stock (GPR)	10.75%	13.55%
Direct Real Estate (NCREIF)	7.88%	2.21%
Unsmoothed Direct Real Estate (NCREIF*)	8.30%	3.68%
10-Year Treasury Constant Maturity Rate	3.19%	6.98%
Moody's Seasoned Aaa Corporate Bond Yield	3.97%	3.98%

Descriptives: Bonds	*YTM*	*Return*	*Excess return*
10-Year Treasury Constant Maturity Rate	6.75%	8.55%	3.77%
Moody's Seasoned Aaa Corporate Bond Yield	7.88%	9.08%	4.30%

Table 2. Direct Real Estate Returns per sub-sector USA

Mean returns and standard deviations are annualized quarterly total returns related to the sample period of 1984-2006. The mean returns and standard deviations are computed in excess of the 3-month T-bill. Direct real estate returns are from NAREIT series for the U.S. The unsmoothed Real Estate returns were adjusted for first-order autocorrelation using Geltner's model (1993). Constituents of the NCREIF Composite Index are segregated into 4 sub-sectors: office, industrial, retail and apartments. A company is classified in a specific property sub-sector if 75 percent or more of its gross invested book assets is invested in that specific sub-sector. The return of a sector in each quarter is calculated as the sum of weighted average returns of the individual properties.

Annualized Return Direct Real Estate: USA	*Return*	*Excess Return*	*σ*	*Autocorrelation*
Unsmoothed Direct Real Estate (NCREIF*)	8.58%	3.80%	5.96%	0.29
Office	6.52%	1.57%	4.67%	0.65
Retail	9.79%	4.97%	3.83%	0.55
Industrial	8.94%	4.09%	3.30%	0.76
Apartment	9.64%	4.81%	2.91%	0.61

Unsmoothed Geltner approach (a=0.4)	*Return*	*Excess Return*	*σ*	*Autocorrelation*
Office	6.72%	1.94%	8.95%	0.07
Retail	9.76%	4.98%	7.68%	-0.14
Industrial	9.00%	4.23%	5.51%	0.41
Apartment	9.76%	4.99%	5.57%	0.04

Table 3. Correlation Matrix USA

In the second panel the mean returns and correlations are computed in excess of the 3-month T-bill. NCREIF* stands for unsmoothed direct real estate returns, adjusted for first-order-autocorrelation using Geltner's model (1993).

Correlation returns	*MSCI*	*GPR*	*NCREIF*	*NCREIF**	*10Y Treasury Bond*	*Corporate Aaa Bond*
MSCI	1.00					
GPR	0.58	1.00				
NCREIF	0.07	0.10	1.00			
NCREIF*	0.08	0.16	0.82	1.00		
10Y Treasury Bond	-0.14	-0.02	-0.03	-0.02	1.00	
Corporate Aaa Bond	-0.11	0.00	-0.05	-0.02	0.92	1.00

Correlation Excess returns	*MSCI*	*GPR*	*NCREIF*	*NCREIF**	*10Y Treasury Bond*	*Corporate Aaa Bond*
MSCI	1.00					
GPR	0.58	1.00				
NCREIF	0.06	0.15	1.00			
NCREIF*	0.08	0.19	0.83	1.00		
10Y Treasury Bond	-0.18	-0.02	-0.07	-0.04	1.00	
Corporate Aaa Bond	-0.14	0.03	-0.06	-0.01	0.91	1.00

Table 4. Mean-Variance Allocations USA

Portfolios were derived using historical excess return and risk characteristics (1984-2006). The upper part of the table reports allocations using smoothed Real Estate returns and the bottom half includes unsmoothed returns. The unsmoothed Real Estate returns were adjusted for first-order autocorrelation using Geltner's model (1993), where the a-factor equaled 0.4. The fixed income assets consist of a 10-year constant maturity yields and Moody's Seasoned Aaa Corporate Bond Yield. The Optimal Sharpe portfolio represents the tangency portfolio that optimizes the mean excess return divided by the standard deviation of returns.

Mean-Variance Allocations (Asset Only)

Portfolios			Weight			
	E(r)	σ	MSCI	GPR	NCREIF	Fixed Income
Minimum Variance	4.09%	2.58%	4.67%	0.00%	57.81%	37.52%
Sharpe Optimal	4.21%	2.61%	7.66%	0.00%	52.06%	40.27%
Unsmoothed Real Estate Returns						
Minimum Variance	4.38%	3.38%	8.18%	0.00%	31.30%	60.51%
Sharpe Optimal	4.53%	3.43%	12.42%	0.00%	26.33%	61.25%

Table 5. Mean-Variance Efficient Portfolios (Asset-only) USA

Portfolios were derived using historical excess return and risk characteristics. Direct Real Estate Returns (NAREIT) were adjusted for first-order autocorrelation using Geltner's model (1993). The fixed income assets consist of a 10-year constant maturity yields and Moody's Seasoned Aaa Corporate Bond Yield. Portfolio compositions are reported for five points on the efficient frontier proportional to the risk from the Minimum Variance (MVP) portfolios. The Optimal Sharpe portfolio represents the tangency portfolio that optimizes the mean excess return divided by the standard deviation of returns.

Unsmoothed Real Estate Returns	**MVP**	**Sharpe Optimal**	**10%**	**30%**	**50%**	**70%**	**90%**
E(r)	4.38%	4.53%	4.78%	5.14%	5.42%	5.67%	5.89%
σ	3.38%	3.43%	3.71%	4.39%	5.06%	5.74%	6.41%
Portfolio Weights							
MSCI	8.18%	12.42%	14.62%	17.74%	20.23%	22.34%	24.16%
GPR	0.00%	0.00%	3.81%	9.37%	13.66%	17.99%	22.26%
NCREIF	31.30%	26.33%	19.88%	10.52%	3.10%	0.00%	0.00%
Fixed Income	60.51%	61.25%	61.70%	62.38%	63.00%	59.67%	53.58%
Total Real Estate Exposure	31.30%	26.33%	23.68%	19.89%	16.76%	17.99%	22.26%

Table 6. Mean-Variance Efficient Portfolios (Asset-only) USA under different unsmoothing scenarios
Direct Real Estate Returns (NAREIT) were adjusted for first-order autocorrelation using Geltner's model (1993) under alternative specifications by unsmoothing real estate returns at a-factors of 0.5 and 0.3. The fixed income assets consist of a 10-year constant maturity yields and Moody's Seasoned Aaa Corporate Bond Yield. Portfolio compositions are reported proportional to the risk from the Minimum Variance (MVP) portfolios. The Optimal Sharpe portfolio represents the tangency portfolio that optimizes the mean excess return divided by the standard deviation of returns.

Mean-Variance Allocations (Asset Only)

a	Portfolios	E(r)	σ	Weight MSCI	GPR	NCREIF*	Fixed Income	Total Real Estate	Difference with a=0.4
	Unsmoothed Real Estate Returns								
0.4	Minimum Variance	4.38%	3.38%	8.18%	0.00%	31.30%	60.51%	31.30%	
	Sharpe Optimal	4.53%	3.43%	12.42%	0.00%	26.33%	61.25%	26.33%	
0.5	Minimum Variance	4.29%	3.15%	6.96%	0.00%	39.92%	53.12%	39.92%	8.61%
	Sharpe Optimal	4.43%	3.20%	10.90%	0.00%	34.29%	54.82%	34.29%	7.96%
0.3	Minimum Variance	4.21%	3.63%	9.75%	0.00%	20.69%	69.56%	20.69%	-10.62%
	Sharpe Optimal	4.40%	3.72%	14.14%	0.83%	20.30%	64.74%	21.12%	-5.21%

a		E(r)	σ	MSCI	GPR	NCREIF	Fixed Income	Total Real Estate	Difference with a=0.4
0.4	10%	4.78%	3.71%	14.62%	3.81%	19.88%	61.70%	23.68%	
	30%	5.14%	4.39%	17.74%	9.37%	10.52%	62.38%	19.89%	
	50%	5.42%	5.06%	20.23%	13.66%	3.10%	63.00%	16.76%	
	70%	5.67%	5.74%	22.34%	17.99%	0.00%	59.67%	17.99%	
	90%	5.89%	6.41%	24.16%	22.26%	0.00%	53.58%	22.26%	
0.5	10%	4.82%	3.71%	14.82%	5.33%	22.33%	57.52%	27.66%	2.45%
	30%	5.15%	4.39%	17.70%	10.03%	12.57%	59.71%	22.60%	2.05%
	50%	5.42%	5.06%	20.21%	13.93%	4.49%	61.37%	18.42%	1.38%
	70%	5.67%	5.74%	22.33%	18.00%	0.00%	59.68%	18.00%	0.00%
	90%	5.89%	6.41%	24.14%	22.27%	0.00%	53.59%	22.27%	0.00%
0.3	10%	4.67%	3.71%	13.96%	0.91%	16.51%	68.62%	17.42%	-3.37%
	30%	5.12%	4.39%	17.81%	8.45%	7.54%	66.20%	15.98%	-2.98%
	50%	5.42%	5.06%	20.28%	13.39%	1.75%	64.58%	15.14%	-1.35%
	70%	5.67%	5.74%	22.27%	18.04%	0.00%	59.69%	18.04%	0.00%
	90%	5.89%	6.41%	24.13%	22.28%	0.00%	53.59%	22.28%	0.00%

Table 7. Correlation Matrix direct property types

Correlations are computed in excess of the 3-month T-bill over 1984-2006 period. The sub-sector returns were derived from the NCREIF returns. Constituents of the NCREIF Composite Index are segregated into 4 sub-sectors: office, industrial, retail and apartments. A company is classified in a specific property sub-sector if 75 percent or more of its gross invested book assets is invested in that specific sub-sector. The return of a sector in each quarter is calculated as the sum of weighted average returns of the individual properties. Returns were adjusted for first-order-autocorrelation using Geltner's model (1993).

	Office	*Retail*	*Industrial*	*Apartment*	*MSCI*	*GPR*	*10Y-bond*
Office	1.00						
Retail	0.41	1.00					
Industrial	0.78	0.47	1.00				
Apartment	0.53	0.36	0.58	1.00			
MSCI	0.19	-0.12	0.13	-0.01	1.00		
GPR	0.24	0.01	0.19	0.08	0.58	1.00	
10Y-bond	-0.02	0.00	-0.08	-0.18	-0.18	-0.02	1.00
Corporate Aaa bond	0.00	0.05	-0.08	-0.15	-0.14	0.03	0.91

Table 8. Mean-Variance Allocations per sub-sector

Portfolios were derived using historical excess return and risk characteristics (1984-2006). The sub-sector returns were derived from the NCREIF returns. Constituents of the NCREIF Composite Index are segregated into 4 sub-sectors: office, industrial, retail and apartments. A company is classified in a specific property sub-sector if 75 percent or more of its gross invested book assets is invested in that specific sub-sector. The return of a sector in each quarter is calculated as the sum of weighted average returns of the individual properties. The direct real estate returns were adjusted for first-order autocorrelation using Geltner's model (1993). The fixed income assets consist of a 10-year constant maturity yields and Moody's Seasoned Aaa Corporate Bond Yield. The Optimal Sharpe portfolio represents the tangency portfolio that optimizes the mean excess return divided by the standard deviation of returns

Portfolios	Minimum Variance Weights	Optimal Sharpe Weights
Office	0.00%	0.00%
Retail	3.94%	7.30%
Industrial	12.50%	3.34%
Apartment	25.11%	30.20%
MSCI	7.05%	10.20%
GPR	0.00%	0.00%
Fixed Income	51.41%	48.95%
Total Direct	41.55%	40.84%
E(r)	4.69%	4.85%
σ	2.94%	2.99%

Table 9. Correlation of asset returns with real pension liabilities (1984-2006).

We assume a constant maturity bond as a proxy for pension liabilities. The pension fund liability will be represented by a 10-year constant maturity bond. The fund is assumed to be in a stationary state, the distribution of the age cohorts and pension rights are assumed constant over time. The market value of liabilities is solely influenced by changes in interest rates and inflation. The liability return is derived as a function of log return and log yield, assuming a duration of 17 years. The real rate of return is adjusted for the change in CPI index. The correlations are computed in excess of the 3-month T-bill. NCREIF* stands for unsmoothed direct real estate returns, adjusted for first-order-autocorrelation using Geltner's model (1993).

	MSCI	*GPR*	*NCREIF**	*10Y-bond*	*Corporate Aaa*
MSCI	1.00				
GPR	0.58	1.00			
NCREIF*	0.08	0.19	1.00		
10Y-bond	-0.18	-0.02	-0.04	1.00	
Corporate Aaa	-0.14	0.03	-0.02	0.91	1.00
Liability (real)	-0.16	-0.04	-0.04	0.99	0.91

Table 10. Correlation of property types with real pension liabilities (1984-2006).
We assume a constant maturity bond as a proxy for pension liabilities. The pension fund liability will be represented by a 10-year constant maturity bond. The fund is assumed to be in a stationary state, the distribution of the age cohorts and pension rights are assumed constant over time. The market value of liabilities is solely influenced by changes in interest rates and inflation. The liability return is derived as a function of log return and log yield, assuming a duration of 17 years. The real rate of return is adjusted for the change in CPI index. The correlations are computed in excess of the 3-month T-bill. NCREIF* stands for unsmoothed direct real estate returns, adjusted for first-order-autocorrelation using Geltner's model (1993). Constituents of the NCREIF Composite Index are segregated into 4 sub-sectors: office, industrial, retail and apartments. A company is classified in a specific property sub-sector if 75 percent or more of its gross invested book assets is invested in that specific sub-sector. The return of a sector in each quarter is calculated as the sum of weighted average returns of the individual properties.

	Office	*Retail*	*Industrial*	*Apartment*
Office	1.00			
Retail	0.41	1.00		
Industrial	0.78	0.47	1.00	
Apartment	0.53	0.36	0.58	1.00
Liability (real)	-0.03	0.02	-0.09	-0.22

Table 11. Liability Hedge Credit (LHC) per asset class

The liability hedge credit (LHC) quantifies the utility that investors with liabilities can derive from different asset classes. LHC is positively related to the covariance of an asset and the liability and to the current assets to current liabilities (L_0/A_0), while inversely related to the risk aversion (λ). LHC further depends on the weight of importance attached to it (k), full consideration of liabilities (k=1) yields similar results as surplus optimization, while no consideration (k=0) provides the same results as an asset-only methodology. Liability Hedge Credit for Nominal Liabilities are adjusted for interest rate risk and Real Liabilities are adjusted for inflation and interest rate risk. The real rate of return is calculated as $(rr_{0,t+1}) = \frac{1+r_{0,t+1}}{1+\pi_{t+1}} - 1$, where π_{t+1} is the change in CPI index.

Nominal Liability Hedge Credit

LHC: λ=10, k=1

L/A	*1.5*	*1*	*0.75*	*0.5*
MSCI	-0.1207%	-0.0805%	-0.0604%	-0.0402%
GPR	-0.0217%	-0.0145%	-0.0109%	-0.0072%
NCREIF*	-0.0122%	-0.0081%	-0.0061%	-0.0041%
10Y-bond	0.4164%	0.2776%	0.2082%	0.1388%
Corporate Aaa	0.2216%	0.1478%	0.1108%	0.0739%

Real Liability Hedge Credit

LHC:λ=10, k=1

L/A	*1.5*	*1*	*0.75*	*0.5*
MSCI	-0.1232%	-0.0821%	-0.0616%	-0.0411%
GPR	-0.0332%	-0.0221%	-0.0166%	-0.0111%
NCREIF*	-0.0142%	-0.0094%	-0.0071%	-0.0047%
10Y-bond	0.4228%	0.2818%	0.2114%	0.1409%
Corporate Aaa	0.2250%	0.1500%	0.1125%	0.0750%

$$LHC_i = \frac{2}{\lambda} k \frac{L_t}{A_t} \text{cov}_t\left(R_{i,t+1}, R_{L,t+1}\right)$$

Table 12. Liability Hedge Credit (LHC) per property type

The liability hedge credit (LHC) quantifies the utility that investors with liabilities can derive from different direct property types. LHC is positively related to the covariance of an asset and the liability and to the current assets to current liabilities (L_0/A_0), while inversely related to the risk aversion (λ). LHC further depends on the weight of importance attached to it (k), full consideration of liabilities (k=1) yields similar results as surplus optimization, while no consideration (k=0) provides the same results as an asset-only methodology. Liability Hedge Credit for Nominal Liabilities are adjusted for interest rate risk and Real Liabilities are adjusted for inflation and interest rate risk. The real rate of return is calculated as $(rr_{0,t+1}) = \dfrac{1+r_{0,t+1}}{1+\pi_{t+1}} - 1$, where π_{t+1} is the change in CPI index.

Constituents of the NCREIF Composite Index are segregated into 4 sub-sectors: office, industrial, retail and apartments. A company is classified in a specific property sub-sector if 75 percent or more of its gross invested book assets is invested in that specific sub-sector. The return of a sector in each quarter is calculated as the sum of weighted average returns of the individual properties.

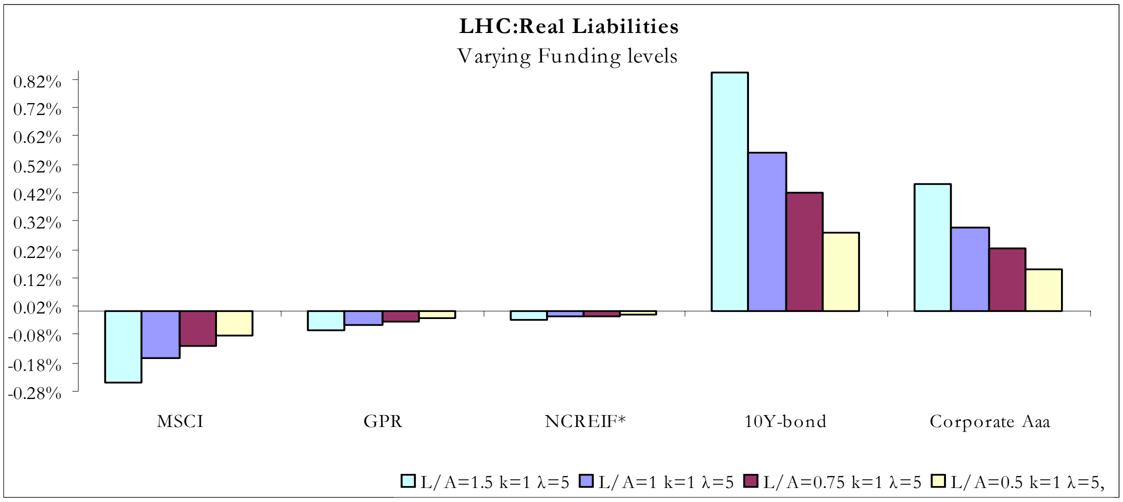
Nominal Liability hedge Credit				
LHC:λ=10, k=1				
L/A	*1.5*	*1*	*0.75*	*0.5*
Office	-0.0109%	-0.0073%	-0.0055%	-0.0036%
Retail	0.0072%	0.0048%	0.0036%	0.0024%
Industrial	-0.0240%	-0.0160%	-0.0120%	-0.0080%
Apartment	-0.0655%	-0.0437%	-0.0327%	-0.0218%

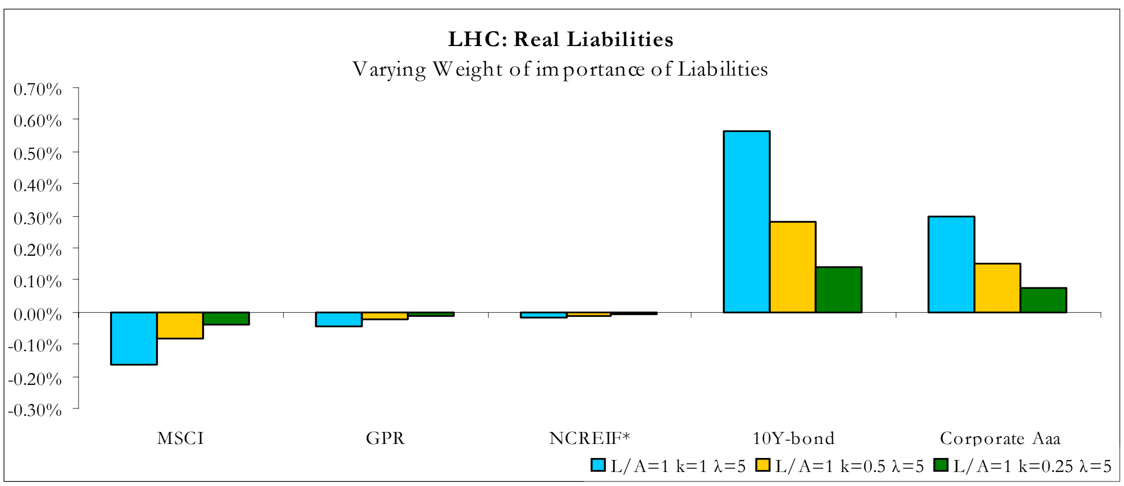
Real Liability Hedge Credit				
LHC: λ=10, k=1				
L/A	*1.5*	*1*	*0.75*	*0.5*
Office	-0.0154%	-0.0102%	-0.0077%	-0.0051%
Retail	0.0085%	0.0057%	0.0043%	0.0028%
Industrial	-0.0263%	-0.0175%	-0.0131%	-0.0088%
Apartment	-0.0667%	-0.0445%	-0.0334%	-0.0222%

$$LHC_i = \frac{2}{\lambda} k \frac{L_t}{A_t} \operatorname{cov}_t \left(R_{i,t+1}, R_{L,t+1}\right)$$

Figure 1 liability hedge credit (LHC) per asset class

The liability hedge credit (LHC) quantifies the utility that investors with liabilities can derive from different asset classes. LHC is positively related to the covariance of an asset and the liability and to the current assets to current liabilities (L_0/A_0), while inversely related to the risk aversion (λ). LHC further depends on the weight of importance attached to it (k), full consideration of liabilities (k=1) yields similar results as surplus optimization, while no consideration (k=0) provides the same results as an asset-only methodology. The following graphs depict LHC's for varying funding levels, weight of importance and risk aversion. Liability Hedge Credit for Real Liabilities are adjusted for inflation and interest rate risk.





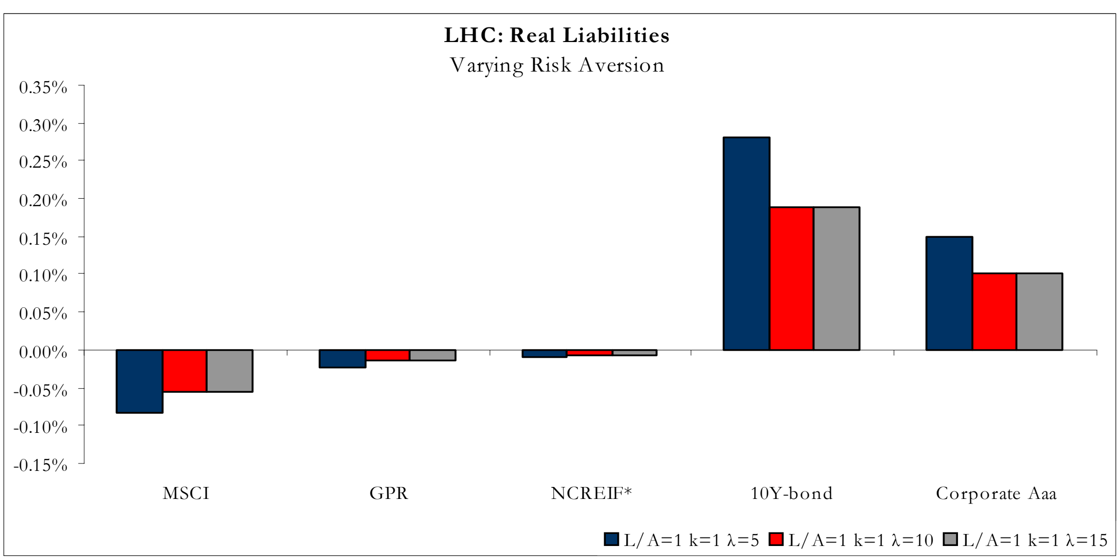
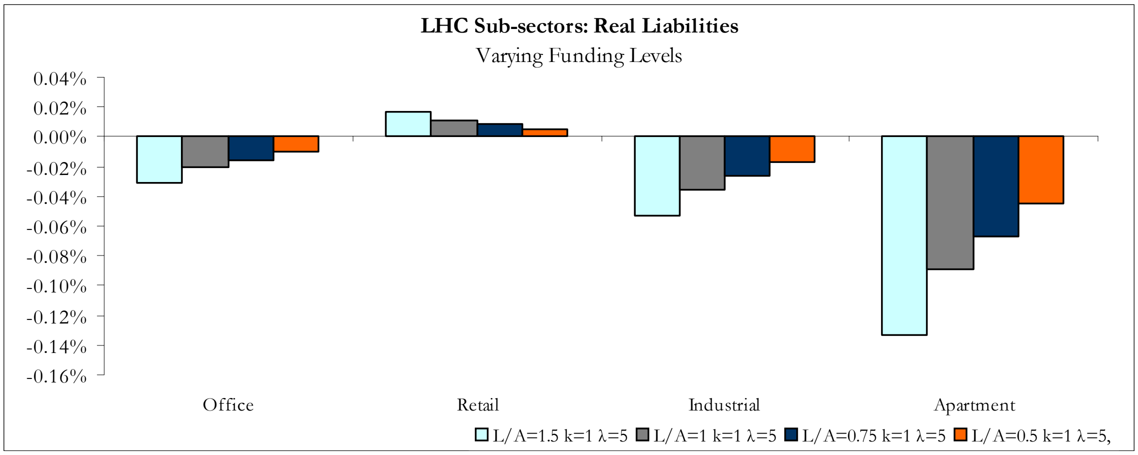
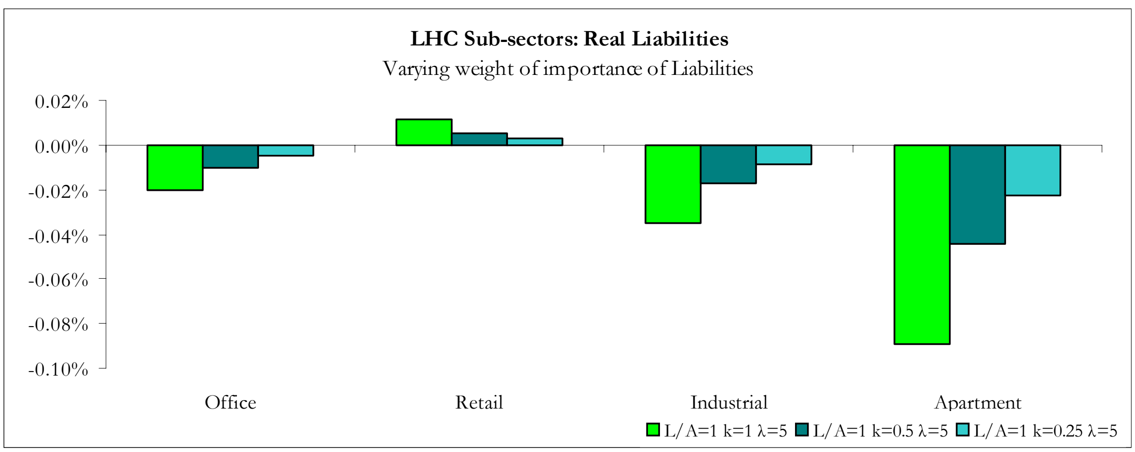


Figure 2 Liability Hedge Credit (LHC) per property type

The liability hedge credit (LHC) quantifies the utility that investors with liabilities can derive from different direct property types. LHC is positively related to the covariance of an asset and the liability and to the current assets to current liabilities (L_0/A_0), while inversely related to the risk aversion (λ). LHC further depends on the weight of importance attached to it (k), full consideration of liabilities (k=1) yields similar results as surplus optimization, while no consideration (k=0) provides the same results as an asset-only methodology. The following graphs depict LHC's for varying funding levels, weight of importance and risk aversion. Liability Hedge Credit for Real Liabilities are adjusted for inflation and interest rate risk. Constituents of the NCREIF Composite Index are segregated into 4 sub-sectors: office, industrial, retail and apartments. A company is classified in a specific property sub-sector if 75 percent or more of its gross invested book assets is invested in that specific sub-sector. The return of a sector in each quarter is calculated as the sum of weighted average returns of the individual properties.





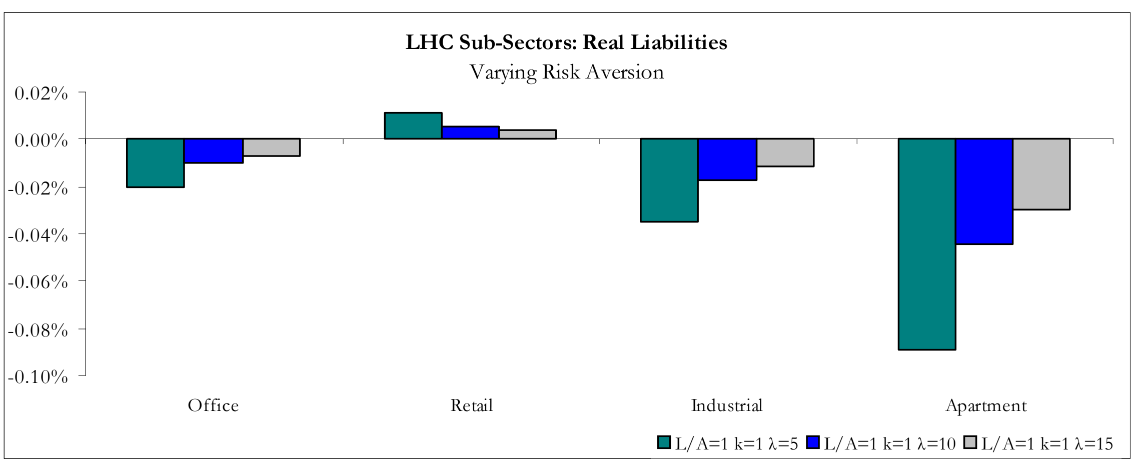
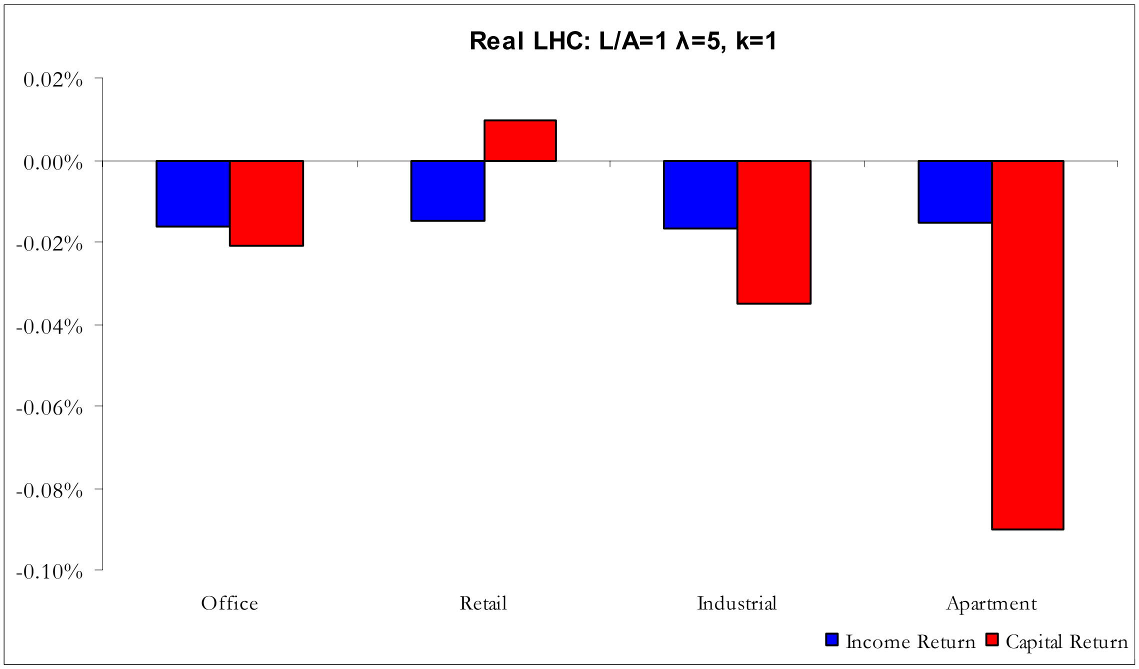


Figure 3 Liability Hedge Credit (LHC) per income component

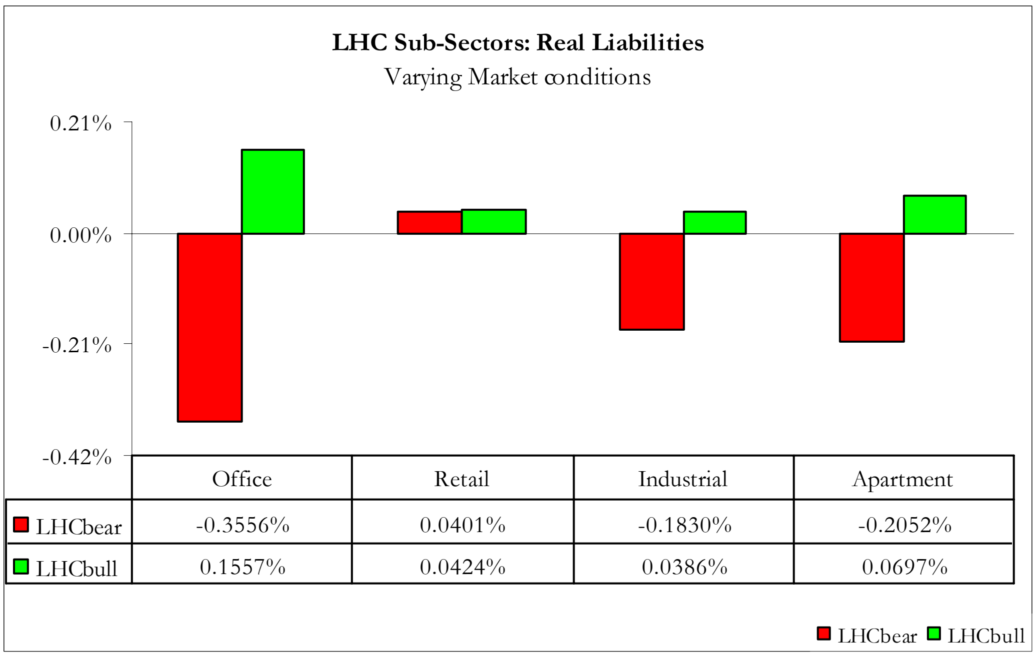
Derivation of the liability hedge credit (LHC) to the income components of direct property types. For the LHC calculation we assume $L_0/A_0 = 1$, $\lambda=5$, $k=1$. Both the income as the capital returns are based on NCREIF returns and were computed in excess of the 3-month T-bill. The direct real estate returns were adjusted for first-order autocorrelation using Geltner's model (1993). Constituents of the NCREIF Composite Index are segregated into 4 sub-sectors: office, industrial, retail and apartments. A company is classified in a specific property sub-sector if 75 percent or more of its gross invested book assets is invested in that specific sub-sector. The return of a sector in each quarter is calculated as the sum of weighted average returns of the individual properties.



$$LHC_i = \frac{2}{\lambda} k \frac{L_t}{A_t} \operatorname{cov}_t\left(R_{i,t+1}, R_{L,t+1}\right)$$

Figure 4 Liability Hedge Credit (LHC) under varying market conditions

Derivation of the liability hedge credit (LHC) to market circumstances of direct property types. For the LHC calculation we assume $L_0/A_0 = 1$, $\lambda=5$, $k=1$. Both the income as the capital returns are based on NCREIF returns and were computed in excess of the 3-month T-bill. The direct real estate returns were adjusted for first-order autocorrelation using Geltner's model (1993). Constituents of the NCREIF Composite Index are segregated into 4 sub-sectors: office, industrial, retail and apartments. A company is classified in a specific property sub-sector if 75 percent or more of its gross invested book assets is invested in that specific sub-sector. The return of a sector in each quarter is calculated as the sum of weighted average returns of the individual properties. The LHC bull is calculated over the recognized bull cycle of 1997-1999 and the bear is calculated over the recognized bear cycle of 1989-1991.



	Office	Retail	Industrial	Apartment
LHCbear	-0.3556%	0.0401%	-0.1830%	-0.2052%
LHCbull	0.1557%	0.0424%	0.0386%	0.0697%

$$LHC_i = \frac{2}{\lambda} k \frac{L_t}{A_t} \operatorname{cov}_t\left(R_{i,t+1}, R_{L,t+1}\right)$$

Table 13. Asset-only versus ALM allocations

Portfolios were derived using historical excess return and risk characteristics (1984-2006). Mean returns and standard deviations are annualized quarterly total returns related to the sample period of 1984-2006. The mean returns and standard deviations are computed in excess of the 3-month T-bill. Stock returns are based on MSCI indices, and direct real estate returns are from NAREIT series for the U.S. Indirect real estate returns are based on GPR indices. The fixed income assets consist of a 10-year constant maturity yields and Moody's Seasoned Aaa Corporate Bond Yield. The direct real estate returns were adjusted for first-order autocorrelation using Geltner's model (1993) (a=0.4). Portfolio compositions are reported proportional to the risk from the Minimum Variance (MVP) portfolios. The Optimal Sharpe portfolio represents the tangency portfolio that optimizes the mean excess return divided by the standard deviation of returns. Minimum Variance and Maximum Sharpe Ratio weights are determined by maximizing the objective function given the standard deviation of the asset-only portfolios.

			Portfolio Weight				
Portfolios	Er	σ	Stocks (MSCI)	Indirect Real Estate (GPR)	Direct Real Estate (NCREIF*)	Fixed Income	Total Real Estate
Mean-Variance Allocations (Asset Only)							
Minimum Variance	4.38%	3.38%	8.18%	0.00%	31.30%	60.51%	31.30%
Optimal Sharpe	4.53%	3.43%	12.42%	0.00%	26.33%	61.25%	26.33%
10%	4.78%	3.71%	14.62%	3.81%	19.88%	61.70%	23.68%
30%	5.14%	4.39%	17.74%	9.37%	10.52%	62.38%	19.89%
50%	5.42%	5.06%	20.23%	13.66%	3.10%	63.00%	16.76%
70%	5.67%	5.74%	22.34%	17.99%	0.00%	59.67%	17.99%
90%	5.89%	6.41%	24.16%	22.26%	0.00%	53.58%	22.26%
ALM Allocations (Real Liabilities)							
L/A=1.5 k=1 λ=5							
Minimum Variance	4.61%	3.38%	8.34%	0.00%	31.02%	60.64%	31.02%
Optimal Sharpe	4.75%	3.43%	11.84%	0.03%	24.49%	63.64%	24.52%
10%	5.00%	3.71%	13.35%	3.91%	16.06%	66.68%	19.96%
30%	5.35%	4.39%	15.52%	9.53%	3.78%	71.17%	13.31%
50%	5.61%	5.06%	16.91%	15.42%	0.00%	67.68%	15.42%
70%	5.81%	5.74%	17.82%	21.00%	0.00%	61.18%	21.00%
90%	5.98%	6.41%	18.60%	25.96%	0.00%	55.44%	25.96%
L/A=1 k=1 λ=5							
Minimum Variance	4.53%	3.38%	8.31%	0.00%	30.97%	60.71%	30.97%
Optimal Sharpe	4.67%	3.43%	12.05%	0.03%	25.03%	62.89%	25.06%
10%	4.91%	3.71%	13.81%	3.91%	17.21%	65.08%	21.11%
30%	5.26%	4.39%	16.30%	9.52%	5.72%	68.46%	15.23%
50%	5.53%	5.06%	18.10%	14.66%	0.00%	67.24%	14.66%
70%	5.74%	5.74%	19.42%	19.98%	0.00%	60.60%	19.98%
90%	5.92%	6.41%	20.58%	24.70%	0.00%	54.72%	24.70%
L/A=0.5 k=0.5 λ=5							
Minimum Variance	4.41%	3.38%	8.36%	0.00%	31.08%	60.56%	31.08%
Optimal Sharpe	4.54%	3.43%	12.35%	0.00%	25.97%	61.68%	25.97%
10%	4.79%	3.71%	14.45%	3.86%	19.35%	62.34%	23.21%
30%	5.14%	4.39%	17.38%	9.44%	9.20%	63.98%	18.63%
50%	5.40%	5.06%	19.77%	13.78%	1.57%	64.88%	15.35%
70%	5.64%	5.74%	21.74%	18.42%	0.00%	59.85%	18.42%
90%	5.84%	6.41%	23.32%	22.85%	0.00%	53.83%	22.85%
L/A=0.5 k=0.5 λ=10							
Minimum Variance	4.40%	3.38%	8.36%	0.00%	31.09%	60.55%	31.09%
Optimal Sharpe	4.54%	3.43%	12.39%	0.00%	26.14%	61.47%	26.14%
10%	4.78%	3.71%	14.53%	3.81%	19.42%	62.24%	23.23%
30%	5.14%	4.39%	17.60%	9.39%	9.96%	63.05%	19.35%
50%	5.41%	5.06%	20.04%	13.71%	2.42%	63.83%	16.12%
70%	5.65%	5.74%	22.15%	18.13%	0.00%	59.72%	18.13%
90%	5.86%	6.41%	23.76%	22.54%	0.00%	53.69%	22.54%

Table 14. ALM Allocations per sub-sector

Portfolios were derived using historical excess return and risk characteristics (1984-2006). The sub-sector returns were derived from the NCREIF returns. The direct real estate returns were adjusted for first-order autocorrelation using Geltner's model (1993). Stock returns are based on MSCI indices, and indirect real estate returns are based on GPR indices. The fixed income assets consist of a 10-year constant maturity yields and Moody's Seasoned Aaa Corporate Bond Yield. The Optimal Sharpe portfolio represents the tangency portfolio that optimizes the mean excess return divided by the standard deviation of returns. Minimum Variance and Maximum Sharpe Ratio weights are determined by maximizing the objective function given the standard deviation of the asset-only portfolios.

Portfolios	Minimum Variance Weights	Maximum Sharpe Ratio Weights
Office	0.00%	0.00%
Retail	10.37%	10.54%
Industrial	0.00%	0.00%
Apartment	28.20%	28.03%
MSCI	12.50%	12.63%
GPR	5.51%	6.12%
Fixed Income	43.43%	42.68%
Total Direct	38.57%	38.57%
E(r)	5.15%	5.17%
σ	3.38%	3.43%

Figure 5. Real Estate Allocations

Total Real Estate Allocation for varying surplus utility levels. Direct real estate returns are from NAREIT series and indirect real estate returns are based on GPR indices. The direct real estate returns were adjusted for first-order autocorrelation using Geltner's model (1993). Direct real estate is especially dominant in the low-risk range portfolios and disappears at higher risk levels in favor of real estate stocks.