Impact of Pension Plan Liabilities on Real Estate Investment

Logical variations in real estate allocations.

Timothy M. Craft

Real estate investment has long been touted as a way to diversify a portfolio. The addition of private and public real estate increases diversification benefits because of the low correlation of real estate with other asset classes. Traditional mean-variance models predict combined allocations to private and public real estate of over 50%, but in the last ten years allocations to private real estate for defined-benefit pension plans have averaged between 4% and 5%, according to *Pensions and Investments'* annual survey of the 200 largest corporate defined-benefit pension plans. Why is there such a difference between theory and practice?

I have two purposes in this article. First, I use an asset-liability model of pension plan decision-making to predict optimal asset allocations, including to private and public real estate. The model will show how asset allocations change as the liabilities change. Second, optimal portfolios can be estimated for plans in different industries because of differences in their predicted liabilities. The same method could be used to estimate a unique portfolio optimization for an individual client based on a specific history of liabilities.

The idea of adding real estate to a portfolio is nothing new. In over the past 25 years, many studies have been made of the contribution of real estate to a mixed-asset portfolio. Foremost is the idea that real estate offers diversification benefits because of its low correlation with other asset classes. Many authors in the 1980s and 1990s concluded that real estate should constitute 20% to 30%

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or more of a diversified portfolio. All these studies use traditional mean-variance portfolio optimization.[1]

A few recent studies have looked specifically at the addition of public investments in real estate like real estate investment trusts (REITs) to an asset allocation decision. Mueller and Mueller [2003] construct mixed-asset portfolios using both private and public real estate. They find high predicted allocations to both private and public real estate, in excess of 50% depending on where one is along the efficient frontier. Feldman [2003] looks at the same question. Making corrections to the real estate return data for liquidity problems, he finds allocations to private real estate as high as 30% and allocations to public real estate as high as 15%.

A new body of literature concerning pension plan allocation emerged in the 1990s. These asset-liability or surplus return models of portfolio diversification take into account not only asset returns and variances but also changes in pension liabilities and their covariance with asset returns.[2] This research suggests that pension managers are concerned with maximizing the risk-adjusted surplus value (assets minus liabilities) of the pension. In such an optimization model, asset allocations can differ greatly from the typical mean-variance framework.

Peskin [1997] concludes that corporations can reduce costs and risks of their pension plans by following such a model. Chun, Ciochetti, and Shilling [2000] develop an asset-liability model and apply it to pension plan asset allocation decisions involving real estate. They predict allocations to real estate of between 6% and 13%, but they use only REIT returns as a measure of real estate returns. In Craft [2001] I use the same model and find allocations to private real estate as high as 16% and allocations to public real estate as high as 10%. None of these studies analyzes the effect of different funding ratios or liability streams on the optimal portfolio allocation.

ASSET-LIABILITY MODEL

In the typical mean-variance model of portfolio allocation with no short-selling and no riskless borrowing or lending, the pension manager's objective is to minimize the risk of the portfolio, subject to a given level of return and the constraints that the asset weights are all non-negative and sum to one. By varying the return between the minimum-variance portfolio return and the maximum-variance portfolio return, the manager can trace out the efficient frontier.

Asset-liability models of portfolio diversification take into account not only asset returns and variances but also changes in pension liabilities and their covariance with asset returns. Here, the pension manager is worried about the surplus value or difference between plan assets and liabilities, and thus seeks to maximize the risk-adjusted surplus return.

Under this framework, assets with returns that are highly correlated with the changes in pension liabilities are added to the portfolio to help reduce the risk of the surplus value. With assets that move with changes in the liabilities, the chances that the surplus value falls over time are diminished.

In the typical mean-variance model, the portfolio manager tries to combine assets that have low correlations with each other. Such a combination greatly reduces the risk of the portfolio. In an asset-liability model, we can think of the pension liabilities as an asset that the corporation has shorted. The manager now searches for assets that are highly correlated with the pension liabilities. Shorting one of two positively correlated assets is equivalent to combining two assets that are negatively correlated.

We can use data on changes in pension liabilities and funding ratios along with estimates of the correlations between liabilities and different asset classes to estimate an asset-liability model of portfolio allocation. The pension plan manager seeks to minimize the variance of the plan's surplus, subject to a given level of change (i.e., return) in the pension surplus. Therefore the optimization problem becomes:

$$\text{Minimize} \quad \sum_{i=1}^{N} w_{A,i}^2 \sigma_{A,i}^2 + w_L^2 \sigma_L^2 + \sum_{i=1}^{N} \sum_{\substack{j=1 \\ j \neq i}}^{N} w_{A,i} w_{A,j} \sigma_{ij} + \sum_{i=1}^{N} w_{A,i} w_L \sigma_{iL} \tag{1}$$

subject to

$$\sum_{i=1}^{N} w_{A,i} = 1 \tag{2}$$

$$\sum_{i=1}^{N} \left(\frac{w_{A,i}}{s} \right) R_i - \left(\frac{w_L}{s} \right) R_L = \overline{R_{SP}} \tag{3}$$

$$w_{A,i} \geq 0 \tag{4}$$

$$R_{SP} \geq 0 \tag{5}$$

where $w_{A,i}$ is the portfolio weight of each asset i, $\sigma_{A,i}$ is the standard deviation of each asset, $\sigma_{i,j}$ is the covariance

between asset i and j, and R_i is the return on each asset. To be consistent with the asset portfolio weights, w_L is defined as the ratio of liabilities to assets (the reciprocal of the funding ratio), R_L is the return or change in liabilities, σ_L is the standard deviation of pension liabilities, and σ_{iL} is the covariance between pension liabilities and asset returns.

For the surplus return, the asset and liability returns are weighted by s, the ratio of the surplus to assets. The surplus return on the portfolio, R_{SP}, is constrained to be at least zero, and no short-selling or riskless borrowing or lending is allowed.

EMPIRICAL DATA

The analysis assumes the pension manager can choose from six broad categories of asset returns: large-capitalization common stocks, small-capitalization stocks, long- and intermediate-term government bonds, private real estate, and public real estate. International investments are not examined, given my focus on real estate and the inherent problems in estimating international returns and volatility.

The stock and bond returns are from the Ibbotson Associates' *SBBI 2003 Yearbook*. Large-cap stock returns are for U.S. companies in the S&P 500. The small-cap stock returns are from an index created by Ibbotson. The bond returns are for both long-term (20-year) and intermediate (5-year) U.S. government bonds. Public real estate returns are the total return series from equity REITs as reported by the National Association of Real Estate Investment Trusts (NAREIT).

Annualized returns on private real estate are from the quarterly return index produced by the National Council of Real Estate Investment Fiduciaries (NCREIF). This index consists of returns on commercial real estate properties, primarily in metropolitan areas, generally matching the types of properties that pension plans select for investment.

Data used are annual from 1978 through 2003. This choice of time period is mainly a function of the availability of the NCREIF real estate data, which begin in 1978. Another motivation relates to the vast changes in the REIT market; REIT return data from before 1980 are probably of little current empirical value.

Exhibit 1 reports means and standard deviations of the six asset classes. Exhibit 2 shows the correlations between asset returns. Notice the relatively low correlation of both private real estate and REITs with stocks and bonds. As expected, these low correlations lead to high allocations to real estate in typical mean-variance asset allocation models.

The last thing we need to implement the asset-liability model is a measure of changes in pension liabilities. Following the methodology of Chun, Ciochetti, and Shilling [2000], we can estimate this liability series using publicly available data from Compustat, which includes data for U.S. corporations on pension assets, number of employees, and most important, the pension plan's projected benefit obligation (PBO). PBO represents the actuarial present value of all benefits earned by employees to that date plus the projected benefits attributable to future salary increases as determined by the plan's benefit formula.

By 1988, firms were required by the Financial Accounting Standards Board (FASB) Statement No. 87 to report PBO annually. I construct a panel of defined-benefit pension plans using only firms reporting PBO over the entire time period. The annual percent change in PBO is calculated for each pension plan and standardized by the number of employees. With a panel of 604 firms reporting PBO every year over 1988-2003, the mean annual rate of change in pension liabilities was 12.09% with a standard deviation of 6.88 (*Exhibit 1*).

Exhibit 2 also shows the correlations between the liabilities and the six asset classes. The two bond assets have the highest correlation with changing liabilities, followed by stocks. The correlation with both private real estate and REITs is very low, especially for private real estate. This fact will greatly affect the final results of the asset-liability model.

MODEL RESULTS

As a starting point for analysis, the results of a standard mean-variance portfolio allocation model using this data are reported in Exhibit 3. The minimum-variance portfolio consists of about 53% private real estate and under 1% REITs. As we move up the efficient frontier, the allocation to private real estate declines to zero. The allocation to REITs increases to a maximum of something over 33%, and then declines to zero.

Although these results are consistent with the high predicted allocations for private real estate and REITs in previous research, they are hardly consistent with actual pension plan asset allocations. Pension managers likely do not allocate funds only on mean-variance considerations. A clear example is that the minimum-variance portfolio also includes very high allocations to bonds, but few managers would choose such a portfolio—most pension plans operate at higher levels of risk. In addition, managers use their

EXHIBIT 1
Annual Returns

Assets (1978-2003)	Mean Return (%)	Standard Deviation (%)
Large-Cap Stocks	14.70	15.77
Small-Cap Stocks	18.13	19.85
Long-Term Government Bonds	10.45	12.73
Intermediate Government Bonds	9.19	7.05
Private Real Estate	9.52	6.10
Real Estate Investment Trusts	15.17	14.55
Pension Liabilities (1988-2003)	**Mean Return (%)**	**Standard Deviation (%)**
PBO Index	12.09	6.88

own judgment and past experience to place limits on the portfolio concentrations of certain asset classes.

For the first scenario using the asset-liability model, I estimate the portfolio allocations using the entire pension liabilities index. I also assume a fully funded pension with a funding ratio of 1.0. Since the funding ratio is defined as pension plan assets divided by the present value of pension plan liabilities, this implies that the w_L is also 1.0.

Exhibit 4 shows the minimum-variance portfolio has allocations to private real estate of 10.9% and to REITs of 1.12%. As the surplus risk increases, the allocation to private real estate reaches a maximum of 13% but then quickly falls to zero. REITs increase to a maximum of about 15% before falling to zero.

This result is quite different from the mean-variance model in Exhibit 3, where private real estate starts out at almost 53% and REITs increase to 33% before falling to zero. The main reason for the difference is the low correlation between changes in liabilities and both real estate returns. Given the greater correlation between liabilities and bond and stock returns, those assets are weighted more in the portfolio because they reduce the risk of the surplus return.

Also of note is the change in the allocations to stocks and bonds. The predicted allocation to long-term bonds is higher in the asset-liability model at all levels of risk, while allocations to intermediate bonds are lower. The allocations to large- and small-cap stocks are about the same as in the mean-variance model.

How sensitive are the portfolio allocations to the pension's funding ratio? As the pension plan becomes more underfunded (i.e., w_L increases), the portfolio includes less private real estate but about the same amount of REITs at all levels of risk. As the pension plan becomes more overfunded (i.e., w_L declines), more private real estate and intermediate bonds are included at lower levels of risk, and the allocation percentage declines more slowly as we go up the efficient frontier.

These results make a lot of sense compared to the original mean-variance results in Exhibit 3. As the pension plan becomes more and more overfunded, the optimization weights on the liabilities keep declining. This makes the model look more like the typical mean-variance optimization. In that model, low-risk portfolios have high allocations

EXHIBIT 2
Correlation of Asset Returns and Pension Liabilities

Assets	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs	PBO Liabilities
Large-Cap Stocks	1.00						
Small-Cap Stocks	0.59	1.00					
Long-Term Bonds	0.21	-0.08	1.00				
Intermediate Bonds	0.14	-0.07	0.94	1.00			
Private Real Estate	0.12	0.06	-0.23	-0.17	1.00		
REITs	0.32	0.68	0.14	0.13	0.04	1.00	
PBO Liabilities	0.21	0.21	0.67	0.72	-0.25	0.16	1.00

EXHIBIT 3
Optimal Asset Allocations in a Mean-Variance Framework

Portfolios			Asset Allocations (%)					
	Portfolio Standard Deviation (%)	Portfolio Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	4.12	9.77	0.00	4.03	0.00	42.65	52.91	0.41
II.	6.00	11.75	4.61	14.49	17.03	3.88	47.91	12.80
III.	8.00	12.94	9.75	21.04	16.92	0.00	33.33	18.97
IV.	10.00	13.96	14.50	26.60	14.61	0.00	19.19	25.10
V.	13.00	15.38	20.97	34.63	10.91	0.00	0.00	33.48
VI.	16.00	16.69	14.34	58.93	0.00	0.00	0.00	26.73
VII.	19.45	18.13	100.00	0.00	0.00	0.00	0.00	0.00

EXHIBIT 4
Optimal Asset Allocations in an Asset-Liability Framework—Fully Funded Pension Plan Asset Returns 1978–2003

Portfolios			Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large Cap Stocks	Small Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	6.67	0.00	2.14	26.16	27.15	32.54	10.97	1.12
II.	8.00	1.09	3.42	32.08	46.40	0.00	13.02	5.08
III.	10.00	2.34	8.00	40.52	40.28	0.00	0.00	11.20
IV.	12.00	3.27	8.71	51.36	27.18	0.00	0.00	12.76
V.	14.00	4.08	9.31	60.68	15.90	0.00	0.00	14.10
VI.	16.00	4.83	9.88	69.34	5.43	0.00	0.00	15.35
VII.	19.52	6.04	0.00	100.00	0.00	0.00	0.00	0.00

to private real estate and intermediate bonds and higher allocations to REITs in higher-risk portfolios.

Next, I apply the same analysis to individual industries by dividing the panel of pension plans into ten broad groups based on the firm's SIC code. The industry groups are: agriculture/mining, food processing, manufacturing, transportation, communication, utilities, wholesalers, retailers, finance, and services.[3]

The liability returns and correlations for each group are shown in Exhibit 5. The highest pension liability volatility is experienced by agriculture/mining and food processing firms, while the fastest-growing liabilities are in the services group. The slowest-growing sector is the retail group. Liabilities in the food processing group have the lowest correlation with liabilities in other groups, followed by transportation and communication. Liabilities in manufacturing, finance, retail, and wholesale firms have the highest correlation with each other.

Exhibit 6 reports the results of the asset-liability model for each industry group. In regard to private real estate, the communication and utilities sectors have allocations almost the same as those found in the base case in Exhibit 4. Below-average optimal allocations are found for manufacturing of between 3% and 6% and finance of between 6% and 8%. Agriculture/mining, wholesale, retail, and service pension plans would not optimally allocate any assets to private real estate. Yet transportation and food processing plans would allocate at most about 25% and 20%, respectively.

The results for REITs are more similar to the pension average. The utilities, retail, service, transportation, and manufacturing sectors have allocations to REITs that are about the same as those in Exhibit 4. The wholesale and food processing plans are below average, while the agriculture/mining sector would optimally allocate no assets to REITs. The communication and finance sectors would more heavily weight REITs.

The allocations to large- and small-cap stocks among the different industries do not differ very much from the average results. In about half the groups, the allocation to large-cap stocks is somewhat lower than the average. On the bond side, the differences between industries are greater. The service, agriculture/mining, transportation, and communication sectors will place more assets in long-term bonds than intermediate bonds. Utilities, finance, retail, and wholesale will allocate significantly more to intermediate bonds at similar levels of risk.

CONCLUSION

Typical asset portfolio models conclude that real estate should have a much higher portfolio allocation than what we actually observe. This does not mean pension managers are irrational. What they may really be doing is minimizing the variance of the surplus return of the portfolio. In this asset-liability framework, portfolio allocations are determined not only by asset returns and variances but also by correlations with changes in the liabilities of the pension plan. Assets with higher correlations to pension liabilities would receive higher weights.

Over the 1978 to 2003 time period, a mean-vari-

EXHIBIT 5

Annual Growth and Correlations in Pension Liabilities Between Different Industries

	Ag/ Mining	Food	Manufacturing	Transportation	Communication	Utilities	Wholesalers	Retail	FIRE	Service
Expected Return (%)	12.11	14.68	13.11	12.90	10.91	10.19	12.29	8.76	11.04	14.73
Standard Deviation (%)	14.32	15.29	7.83	7.58	12.09	6.76	9.01	8.61	7.10	9.90
Ag/Mining	1.00									
Food	-0.03	1.00								
Manufacturing	0.54	-0.07	1.00							
Transportation	0.50	-0.18	0.45	1.00						
Communication	0.38	-0.23	0.43	0.54	1.00					
Utilites	0.84	0.06	0.77	0.65	0.58	1.00				
Wholesalers	0.62	-0.13	0.87	0.40	0.40	0.67	1.00			
Retailers	0.76	-0.13	0.77	0.59	0.51	0.85	0.81	1.00		
FIRE	0.59	-0.19	0.87	0.57	0.64	0.87	0.63	0.79	1.00	
Service	0.29	-0.29	0.82	0.45	0.48	0.58	0.59	0.67	0.85	1.00

EXHIBIT 6

Optimal Asset Allocations in an Asset-Liability Framework by Industry Funding Ratio of 1.00

Agriculture and Mining

	Portfolios		Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	11.40	0.00	1.60	22.76	63.63	12.01	0.00	0.00
II.	12.00	1.28	2.45	37.02	60.52	0.00	0.00	0.00
III.	14.00	2.68	3.14	54.88	41.98	0.00	0.00	0.00
IV.	16.00	3.66	3.63	67.38	28.99	0.00	0.00	0.00
V.	18.00	4.52	4.05	78.25	17.70	0.00	0.00	0.00
VI.	20.00	5.31	6.24	87.31	6.45	0.00	0.00	0.00
VII.	21.89	6.02	0.00	100.00	0.00	0.00	0.00	0.00

Food Processing

	Portfolios		Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	19.58	0.00	47.07	30.22	0.00	0.00	20.67	2.05
II.	20.00	0.28	48.07	32.03	0.00	0.00	16.54	3.36
III.	22.00	1.54	50.16	43.35	0.00	0.00	0.00	6.50
IV.	24.00	2.52	27.27	72.73	0.00	0.00	0.00	0.00
V.	26.00	3.27	5.41	94.59	0.00	0.00	0.00	0.00
VI.	26.65	3.45	0.00	100.00	0.00	0.00	0.00	0.00

EXHIBIT 6 (continued)

Optimal Asset Allocations in an Asset-Liability Framework by Industry Funding Ratio of 1.00

Manufacturing

	Portfolios		Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	9.16	0.00	8.19	32.86	30.07	22.92	3.48	2.48
II.	10.00	0.61	8.44	36.20	43.57	0.67	6.71	4.41
III.	12.00	1.81	11.25	46.87	33.32	0.00	0.00	8.55
IV.	14.00	2.73	11.95	57.49	20.48	0.00	0.00	10.08
V.	16.00	3.54	12.56	66.86	9.15	0.00	0.00	11.43
VI.	18.00	4.30	11.52	77.65	0.00	0.00	0.00	10.82
VII.	20.07	5.01	0.00	100.00	0.00	0.00	0.00	0.00

Transportation

	Portfolios		Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	6.57	0.00	0.00	34.48	39.16	0.00	25.49	0.87
II.	8.00	1.22	0.00	44.95	38.58	0.00	9.85	6.62
III.	10.00	2.40	0.00	56.47	32.66	0.00	0.00	10.87
IV.	12.00	3.29	0.00	67.31	20.47	0.00	0.00	12.22
V.	14.00	4.08	0.00	76.83	9.76	0.00	0.00	13.41
VI.	16.00	4.82	0.00	86.15	0.00	0.00	0.00	13.85
VII.	19.52	5.23	0.00	100.00	0.00	0.00	0.00	0.00

Communication

	Portfolios		Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	8.76	0.00	0.00	0.00	49.53	8.35	12.71	29.41
II.	10.00	2.46	0.00	3.45	40.16	0.00	0.00	56.39
III.	12.00	3.52	0.00	16.19	25.82	0.00	0.00	57.98
IV.	14.00	4.37	0.00	26.51	14.22	0.00	0.00	59.27
V.	16.00	5.14	0.00	35.88	3.68	0.00	0.00	60.44
VI.	18.00	5.85	0.00	53.91	0.00	0.00	0.00	46.09
VII.	22.83	7.22	0.00	100.00	0.00	0.00	0.00	0.00

Utilities

	Portfolios		Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	5.24	0.00	0.00	12.68	10.59	61.02	14.03	1.68
II.	8.00	3.57	3.46	32.64	45.85	0.00	3.36	14.68
III.	10.00	4.62	5.19	43.15	34.20	0.00	0.00	17.46
IV.	12.00	5.45	5.81	52.75	22.60	0.00	0.00	18.85
V.	14.00	6.20	6.38	61.48	12.05	0.00	0.00	20.10
VI.	16.00	6.92	6.91	69.77	20.20	0.00	0.00	21.29
VII.	19.52	7.94	0.00	100.00	0.00	0.00	0.00	0.00

EXHIBIT 6 (continued)

Optimal Asset Allocations in an Asset-Liability Framework by Industry Funding Ratio of 1.00

Wholesalers

	Portfolios		Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	8.92	0.00	2.95	31.40	10.20	55.44	0.00	0.00
II.	10.00	0.90	3.85	38.53	26.80	30.83	0.00	0.00
III.	12.00	2.31	5.73	48.36	41.91	0.00	0.00	4.00
IV.	14.00	3.50	6.63	62.17	25.22	0.00	0.00	5.99
V.	16.00	4.22	7.17	70.45	15.20	0.00	0.00	7.18
VI.	18.00	5.01	7.76	79.62	0.00	0.00	0.00	8.50
VII.	20.27	5.84	0.00	100.00	0.00	0.00	0.00	0.00

Retailers

	Portfolios		Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	6.07	0.00	1.31	16.02	0.33	82.34	0.00	0.00
II.	8.00	4.79	5.43	31.95	50.82	1.50	0.97	9.33
III.	10.00	6.00	6.66	45.17	36.40	0.00	0.00	11.77
IV.	12.00	6.87	7.31	55.23	24.23	0.00	0.00	13.23
V.	14.00	7.64	7.89	64.20	13.39	0.00	0.00	14.52
VI.	16.00	8.37	8.44	72.64	3.18	0.00	0.00	15.73
VII.	19.52	9.37	0.00	100.00	0.00	0.00	0.00	0.00

Finance, Insurance, and Real Estate

	Portfolios		Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	5.54	0.00	0.59	13.08	14.13	56.12	8.74	7.33
II.	8.00	2.29	4.69	25.49	46.48	0.00	6.72	16.62
III.	10.00	3.43	7.43	35.49	36.49	0.00	0.00	20.59
IV.	12.00	4.13	8.08	45.53	24.36	0.00	0.00	22.03
V.	14.00	4.94	8.66	54.48	13.54	0.00	0.00	23.32
VI.	16.00	5.79	9.21	62.19	3.35	0.00	0.00	24.53
VII.	19.52	7.09	0.00	100.00	0.00	0.00	0.00	0.00

Service

	Portfolios		Asset Allocations (%)					
	Surplus Standard Deviation (%)	Surplus Return (%)	Large-Cap Stocks	Small-Cap Stocks	Long-Term Bonds	Intermediate Bonds	Private Real Estate	REITs
I.	12.04	0.00	8.32	44.81	36.57	0.00	0.00	10.31
II.	14.00	1.00	9.07	56.40	22.55	0.00	0.00	11.98
III.	16.00	1.86	9.72	66.38	10.49	0.00	0.00	13.41
IV.	18.00	2.65	9.70	76.27	0.00	0.00	0.00	14.02
V.	20.00	3.37	0.00	98.89	0.00	0.00	0.00	1.11
VI.	20.10	3.40	0.00	100.00	0.00	0.00	0.00	0.00

ance model would predict private real estate allocations of as much as 53% and REIT allocations of 33%. In an asset-liability framework, though, a fully funded pension plan would allocate at most only about 13% for private real estate and 15% for REITs, depending on the level of risk. These lower estimated allocations result from the low correlations between both private and public real estate and pension liabilities. Underfunded plans hold less private real estate but about the same amount of public real estate. Overfunded pension plans are much more likely to hold both private and public real estate.

As the data are divided into industry subgroups, pension plan liabilities have a greater impact on allocations to private real estate. Smaller allocations are optimal for pension plans in manufacturing, finance, service, retail, and wholesale industries. Higher allocations are recommended for food processing and transportation firms. Investments in REITs do not vary as much among the different industries.

Of course this is not the only reason real estate might have a low allocation in the portfolio. Other issues include the high transaction costs and management fees for private real estate compared to other assets. Illiquidity of both private real estate and REITs could also be an issue.

My main conclusion is that an asset-liability model predicts much lower allocations to both private real estate and REITs than the standard mean-variance model, and these allocations change depending on the pension plan's liabilities. Different industries will therefore have different optimal portfolio allocations.

This same analysis could be extended to the individual firm level. Given a history of liability changes over time, the asset-liability model could provide a unique efficient frontier set of asset allocations specifically for that firm.

ENDNOTES

[1]For a selection of literature on real estate investments see: Fogler [1984]; Hartzell, Hekman, and Miles [1986]; Webb and Rubens [1987]; Firstenberg, Ross, and Zisler [1988]; Ziering and McIntosh [1997]; and Ziobrowski and Ziobrowski [1997].

[2]The research on liability models begins with Leibowitz [1987], Sharpe [1990], and Leibowitz, Kogelman, and Bader [1994].

[3]Industry groups are divided by the SIC codes: agriculture/mining 0-1499; food processing 2000-2099; manufacturing 2100-3999; transportation 4100-4699; communication 4800-4899; utilities 4900-4999; wholesalers 5000-5199; retailers 5200-5999; finance, insurance, and real estate 6000-6799; and service 7000-8999.

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