Prudent Public Sector Investing and Modern Portfolio Theory: An Examination of Public Sector Defined Benefit Pension Plans

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This research examines the extent to which public pension programs allocate assets in a manner that is consistent with an optimal portfolio, as defined by Modern Portfolio Theory (MPT). The examination is pursued by way of a statistical analysis, using a portfolio optimization model and data on some of the nation's largest public DB plans. The analysis illustrates that the majority of the plans in the sample are incurring far more risk in their portfolios than is optimal given their target rates of return and that this risk level is a result of nonprudent allocation across asset classes. The findings suggest that there might be opportunities to improve the long-term performance of defined benefit plans by adjusting asset allocation targets and legal lists in a manner that is more consistent with MPT.

INTRODUCTION

Prudent diversification across different asset classes has been regarded as the single most important determinant of investment returns among public sector investment programs that place yield as their primary investment objective.[1] Theoretically, the notion of prudent diversification across assets classes has its roots in the basic principles of Modern Portfolio Theory (MPT), which proffers that diversification across asset classes lowers the risk of an investment portfolio for a given level of expected return, as long as they do not move simultaneously in the same direction at the same magnitude.

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1. GFOA, *Recommended Practices for State and Local Governments* (Chicago: Government Finance Officer Association, 2001, 148).

The goal of this paper is to examine the extent to which public sector defined benefit (DB) pension plans are allocating assets in a manner that is consistent with MPT. The examination is pursued by way of a statistical analysis, using a portfolio optimization model and data on some of the nation's largest public sector DB pension plans. The statistical analysis illustrates that the majority of the plans in the sample are incurring far more risk in their portfolios than is optimal given their target rates of return and that this risk level is a result of a failure to adhere to MPT.

The findings of the study are important for purposes of highlighting a possible remedy for addressing pressing funding challenges associated with retirement benefits at the state and local levels of government. A Pew Charitable Trusts' Center report showed that as of June 30, 2008, there was a US$452 billion shortfall in state funding for promised pension benefits across the country.[2] The study also reports that 19 states fall below the benchmark level for acceptable funding for pension obligations, which the GAO defines as 80 percent or more of existing obligations.[3] The unfunded portion for local government pension funds has been estimated to US$530 billion.[4] Neither of these estimates accounts for the investment losses that many funds incurred in 2008.

While prudent allocations across asset classes are not panacea for dealing with these funding gaps, they are an important factor. Previous research illustrates that investment allocations across asset classes explain between 80 and 90 percent of the returns of an investment portfolio[5] (Diermeier 1987).

BACKGROUND

Interest in the management of public sector pension funds has increased substantially over the past three decades. Important reasons for this are (1) the sheer growth of pension programs, (2) the large number of public pension programs that are underfunded,[6] and (3) mismanagement of public sector investments. As indicated above, this paper centers on the latter of these topics, as it relates to public sector pension fund investments.

Interest in the mismanagement of public sector pension fund investments has primarily been driven by a long series of investment debacles that plagued US public investment programs in the 1980s and 1990s, including debacles suffered by municipal-

2. Pew Center on the States, *The Trillion Dollar Gap: Underfunded State Retirement Systems and the Roads to Reform* (Washington, DC: Author, 2010).

3. U.S. Government Accountability Office (2008). State and Local Government Pension Plans: Current Structure and Funding Status, GAO 08-983T.

4. US GAO 2008.

5. M. Useem and D. Hess, "Governance and investments of public pensions," in *Pensions in the Public Sector*, eds. O. S. Mitchell, and E. C. Hustead (Philadelphia, University of Pennsylvania Press); G. P. Brinson, B. D. Singer, and G. L. Beebower, "Determinants of Portfolio Performance II: An Update," *The Financial Analysts Journal* 47, no. 3 (1991): 40–48.

6. See most recently R. Novy-Marx and J. D. Rauh, *The intergenerational transfer of public pension promises* (Manuscript, University of Chicago, 2008).

ities, community colleges, special districts and state agencies.[7] The most notable debacles in the 1980s include the losses incurred by the City of San Jose in 1984 and the losses incurred by the West Virginia Consolidated Investment fund in 1987. Both of these debacles resulted from attempts by public officials to produce extra revenue by speculating on interest movements. Both cases involved massive investments in long-term government securities using borrowed monies and were driven by hopes that interest rates would fall (which would increase bond prices). However, the continued rise in interest rates during the 1980s resulted in a more than 10 percent decline in plan assets and an overall investment loss of US$60 million for the City of San Jose.[8] The West Virginia Consolidated Investment Pool incurred US$279 million in investment losses. In 1987, when the losses for the West Virginia Consolidated Investment Pool were revealed, investment managers had invested more than US$11 billion in borrowed funds to try to cover the losses (the fund's overall assets were valued at US$2 billion). A more detailed account of how the West Virginia losses unfolded has been provided by Hayes.[9]

A second wave of debacles occurred in the 1990s. These culminated in 1994[10] in response to rapid increases in general interest rates, which were caused in part by six consecutive raises in the discount rate in 1994. These increases made explicit a systematic use of nonprudent investment practices by governments across the US.[11] The most widely publicized case was the bankruptcy declared by Orange County, California on December 6, 1994, where a loss of US$1.7 billion was sustained through risky investments in derivatives and repurchase agreements (REPOS), along with significant degrees of leveraging.[12]

The debacles that occurred in 1994 resulted in a widespread adoption by states of legislation that required governments to develop written investment policies.[13] A written investment policy includes a set of guidelines and requirements used by public agencies and others to prudently manage their investments.[14] They are typically grounded in some combination of constitutional requirements, statues, and administrative practices. Data collected by the National Association of State Treasurers[15] in 2004 indicated that (1) 14 states had some form of constitutional requirement that provide formal guidelines for the administration of public sector investment programs; (2) 35 states had adopted state

7. Thomas D. Lynch, Hannarong Shamsub and Christie Onwujuba, "A Strategy to Prevent Losses in Local Government Investment Pools," *Public Budgeting and Finance* (2002): 60–79; G. Miller, C. Larson and P. Zorn, *Investing Public Funds* 22 (Chicago, IL: Government Finance Officer Association, 1998).

8. Miller, Larson and Zorn (1998).

9. V. R. Hayes, "The Dangers of Relying on a Legal List: A Case Study of the West Virginia Consolidated Investment Fund," *Public Budgeting and Finance* 19 (1999): 49–64.

10. M. Saddler, "GFOA's New Model Investment Policy," *Government Finance Review* (2003): 41–46.

11. Lynch (2002), Miller, Larson and Zorn (1998).

12. S. Cohen and W. Eimicke, "Is Public Entrepreneurship Ethical? A Second Look at Theory and Practice," *Public Integrity* 1, no. 1 (1999): 54–74.

13. Miller, Larson and Zorn (1998).

14. Saddler (2003).

15. National Association of State Treasurers, *State Treasury Activities and Functions 2004–2005* (Lexington, KY: National Association of State Treasurers, 2004).

statues to provide such guidelines; and (3) 36 states utilized administrative practice as a means of policy adoption. In addition to this, individual governments often supplement their investment policy with internal guidelines.

Investment policies contribute towards the goal of prudent investing via the inclusion of several specific parameters that either guide or impose restrictions on investment officials. The most important parameters include legal lists of allowable securities, asset allocation requirements and prudent person statues. Legal lists provide explicit language that defines what asset classes or security types that investment officials are allowed to invest in. They contribute to prudence by preventing investment officials from investing in ill-suited instruments that can lead to substantial losses of public funds.[16] Asset allocation requirements place limits on the percentage of assets that can be invested in a particular asset class. They are often accompanied by asset allocation targets, which are target allocations set by an investment board for purposes of guiding investment officials in the process of establishing a well-diversified portfolio.

The final parameter, "prudent person statues", imposes significant professional responsibility on the investment official, by making him/her accountable for investment decisions made without good judgment and care. In brief, under the "prudent person rule," each investment choice is judged on its own merit and risky or speculative investments should be avoided.

Prudent person statues were instituted on a widespread basis towards the end of the 1990s in an effort to reform the legal lists. In practice, this often meant the substitution of legal lists with prudent person statues. The purpose of these substitutions, according to Miller et al.[16] was to ". . . recognize that new investment instruments were being designed that afforded additional investment opportunities to professionals to take advantage of market opportunities and thereby augment yields attained in public investment programs." If instituted before 1980s, the investment officials responsible for many of the investment debacles that occurred in the 1980s and 1990s could have been held accountable, based on expectations consistent with prudent person standards.[17]

However, a challenge with prudent person statues is that the standards for what to expect from an investment official in terms of their professional knowledge and expertise is not made explicit. Traditionally, the benchmark for these standards were developed in the context of cash management investments, were it is assumed that investment officials should be held accountable based on the expectation that they are reasonably well informed persons that do not have the knowledge of a professional investor or expert. According to Miller, Larson and Zorn[18] ". . . such individuals are not expected to possess great insights regarding investment economics and technical aspects of securities and markets." Given their lack of expertise, they should seek to minimize risk as a means of assuring preservation of principal. Yield is considered to be of secondary importance.

16. Miller, Larson and Zorn (1998: 44).
17. Miller, Larson and Zorn (1998: 44).
18. Miller, Larson and Zorn (1998: 45).

In the context of public pension funds, the definition of prudent person statues differs from this traditional definition. These funds are often managed by experts within a specialized unit. The expectations of performance should therefore be consistent with those of a "prudent expert".[19] The expectation of a prudent expert is not only that the investment official makes investment decisions with good judgment and care, but also that he or she utilizes their expertise for purposes of maximizing the rate of return for a given level of risk. This view of prudence is consistent with the investment objectives and strategies that tend to govern public pension investment programs, including a long-term passive investment style (i.e., portfolio decisions are not often changed with varying economic conditions) and willingness to take greater risks in the pursuit of greater returns[20] (Stalebrink & Sacco 2005).

Benchmark Measure of Prudent Investing

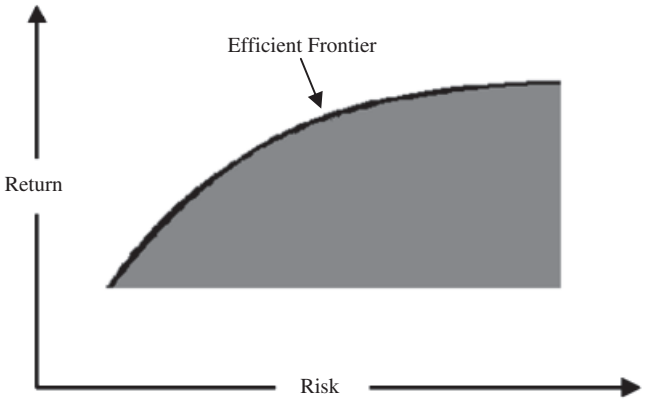
In this paper, the benchmark measure against which prudent investing is measured is that of an "optimal portfolio." The notion of an optimal portfolio is grounded in MPT and is the "efficient" portfolio that is most appropriate for an investor based on his/her expected return and risk objective. A portfolio is efficient if it has the highest expected return for a given level of risk among all "attainable" portfolios, given the set of available securities to the investor. Possible combinations of efficient portfolios can be plotted along a line, referred to as the "efficient frontier" (the black line encompassing the gray area in Figure 1). The cost associated with portfolio selection that lies below the efficient frontier comes in two forms, either (1) investment portfolios that generate inferior returns at comparable levels of risk, or (2) investment portfolios that generate excessive risk given a certain "target" rate of return.

MPT has its roots in Nobel Laureate Harry Markowitz'[21] seminal article titled "portfolio selection," which touts the benefits of diversifying a portfolio across a broad set of asset classes, including but not limited to, domestic and international stocks, derivatives, US treasury bills, bonds and notes, corporate and municipal bonds, real estate and gold. Expressed in statistical terms, Markowitz demonstrated that while an investment portfolio's expected return (based on historical data) is equal to the weighted average of its components' (i.e., the different asset classes) expected returns, the standard deviation of the portfolio is less than the weighted average of the component standard deviations. This means that the risk-return ratio of an investment portfolio will always be enhanced by broadening the set of asset classes as long as no asset classes are perfectly positively correlated (setting aside transaction costs).

Given that the correlation among different asset classes play a key role in the development of an optimal portfolio, MPT implies that an investment portfolio should not be limited to traditional investment classes (i.e., equities, bonds and cash), but also include "alternative investment classes." Alternative asset classes refer to

19. Miller, Larson and Zorn (1998: 45).
20. Useem & Hess (2001).
21. H. M. Markowitz, "Portfolio Selection," *Journal of Finance* 7, no. 1 (1952): 77–91.

FIGURE 1
Markowitz' Efficient Frontier



investments with unusual return and volatility expectations, or those for which the base economic assumptions are different from the more traditional investments, including but not limited to oil and gas, real estate, private placements of debt and equity (e.g., venture capital) and derivatives (GFOA, 2003). Owing to their unusual return patterns, alternative investments tend to have a low correlation with traditional asset classes. According to MPT's principle of diversification, alternative investments therefore hold great potential for reducing the overall risk for any given return. Hence, it is a misconception that asset classes that have been perceived as risky increase *ex ante* portfolio risk.

Having said this, it is important to note that there are a number of challenges to MPT. A number of assumptions underlying the MPT are often violated in the real world, including assumptions that investors are risk averse and always make rational decisions. Behavioral finance studies have revealed that investors consistently demonstrate behavioral biases in the investment decision process.[22] Further, the solution to the MPT-derived optimization algorithm, which revolves around the percentages of investable funds to be invested in each asset class, is extremely sensitive to the accuracy of the input data (i.e., expected returns and risk measures of the asset classes). Expected returns at best are proxies for the true returns for the asset classes. Standard deviation, a typical risk measure in the MPT model, which assumes an investor treats gains and losses indifferently, is inconsistent with the "loss aversion" (tendency to strongly prefer avoiding losses to acquiring gains) behavioral bias documented. Despite these challenges mean-variance optimization, the fundamental element of MPT, is still easily the most widely used method for pension fund asset allocation models.[23]

22. J. Nofsinger, *The Psychology of Investing*. 3rd ed (Englewood Cliffs, NJ: Prentice Hall, 2007).

23. F. J. Fabozzi, S. Focardi, and C. Jonas, "Trends in Quantitative Equity Management: Survey Results," *Quantitative Finance* 7, no. 2 (2007): 115–122.

EMPIRICAL CONTEXT

As noted above, the objective of this research is to examine the extent to which public pension programs allocate assets in a manner that is consistent with an optimal portfolio, as defined by MPT. Currently, no empirical studies have examined this issue - within the realm of public sector pension programs. However, several related studies have been conducted that examines whether select diversification restrictions interfere with the creation an optimal portfolio. These studies, conducted in a Canadian context, have centered on determining whether the so called "foreign property rule" (FPR) is overly restrictive.[24] The FPR was instituted in 1957 by the National government in Canada and limits the percentage of assets that can be invested in assets outside of Canada. One of the earlier studies was published in 1984 and draws criticism toward a 10 percent cap on investment in international equities that was present in the 1980s.[25] Based on data on risks and returns from investments in the 18 national stock markets from 1976 to 1980, this study provided evidence in support of the thesis that an elimination of international diversification would enhance portfolio returns for any given risk level.

In another study, Pink[26] produced evidence that were consistent with Michas' findings. Pink empirically tested how the 10 percent foreign investment affects the Canadian Registered Retirement Savings Plan (RRSP), using data on monthly rates of return of a sample of Canadian mutual funds drawn from the Financial Times Survey of Mutual Funds, some of which are subject to the restriction (RRSP eligible), and some that are not (RRSP ineligible). The results suggested that the RRSP ineligible funds show superior investment performance compared with RRSP eligible funds.

Although the Canadian national government eased the restrictions from 10 percent to 20 percent in the 1990s, and up to 30 percent in 2001, researchers have continued to scrutinize the investment restrictions imposed by the Canadian national government including Milligan and Smart[27] and Burgess and Fried.[28] Milligan and Smart[29] provided new estimates of the cost of the FPR, by comparing performance of mutual funds that are constrained by the limit and those that are not. Their analysis

24. D. Burgess and J. Fried, "The Foreign Property Rule: A Cost-Benefit Analysis," *Journal of Pension Economics and Finance* 4, no. 3 (2004): 273–289; D. Burgess and J. Fried, "Canadian Retirement Savings Plans and the Foreign Property Rule," *Canadian Public Policy – Analyses de Politiques* 25, no. 3 (1999): 395–416; N. A. Michas, "Pension Funds: More Diversification," *Canadian Public Policy* 10, no. 1 (1984): 47–53.

25. Michas, 1984.

26. G. H. Pink, "Government Restriction on Foreign Investment by Pension Funds: An Empirical Examination," *Canadian Public Policy* 15, no. 3 (1989): 300–312.

27. K. Milligan and M. Smart, Restricting foreign investment: Estimating the cost of Canada's foreign property rule (Manuscript, University of Toronto, 2000).

28. Burgess and Fried (2004).

29. Milligan and Smart (2000).

indicates that the increase in the limit, from 10 percent to 20 percent, during the early 1990s, has had a significant effect on risk-adjusted returns to retirement savings in Canada. The researchers concluded that a movement in the limit from 20 percent to 30 percent would increase average annual returns by 0.31 percent, which corresponds to an increase of 9.9 percent in terminal portfolio wealth over a 20-year period.

The most recent study on the impact of the FPR was conducted by Burgess and Fried.[30] Based on an analysis of evidence collected on the effects of changes in the regulation rate from 20 percent to 30 percent over the period 2001–2002, the authors found that the FPR failed to achieve its designated objectives. These objectives included increasing the value of the Canadian dollar, reducing its volatility, decreasing the cost of capital, promoting investment in Canada, and decreasing the inequality of the plans.

A large number of similar studies have also been conducted in the context of private sector pension investment programs. Levy and Lerman[31] provided evidence that an internationally diversified portfolio of bonds would have positive impact on investment returns. The researchers conducted an empirical study based on the data on world bonds and stocks published by Ibbotson, Carr and Robinson during the period 1960–1980. According to the study, a US investor who invested in internationally diversified bond markets could have enhanced his/her portfolio performance over the period 1960–1980 by 3–5 percent a year relative to those restricting their investments to domestic bonds. The benefit from the diversification on portfolios made up of bonds and stocks for the same period were even greater.

In another study, Eun and Resnick[32] compared investment performance of US investors with that of Japanese investors, examining the gains from international diversification. From the analysis with bonds and stocks during the period 1978–1989, the study investigated the extent to which US and Japanese investors can capture the gains from international diversification under the conditions of exchange rate and parameter uncertainties. The potential benefits from international diversification would be much higher for US investors compared with Japanese investors regardless of whether a parameter uncertainty exists or not. The researchers also found that hedging exchange risk generally increase the gains from international investment for US investors, but not for Japanese investors.

While no similar studies have been conducted in the context of US public sector pension funds, several related studies have been conducted that offers insight into determinants of prudent investment choice. These include studies by Munnell and

30. Burgess and Fried (2004).

31. H. Levy and Z. Lerman, "The Benefits of International Diversification in Bonds," *Financial Analysts Journal* 44, no. 5 (1988): 56–64.

32. C. S. Eun and B. G. Resnick, "International Diversification of Investment Portfolio: U.S. and Japanese Perspectives," *Management Science* 40, no. 1 (1994): 140–161.

Sunden,[33] Mitchell and Hsin,[34] Useem and Mitchell[35] and Albrecht, Shamsub and Giannatasio.[36] The Munnell and Sunden[37] study examines the extent to which political and social considerations influence investment decisions of state and local pension funds in terms of lowering their rate of returns. The study centers on four venues through which such considerations could enter investment decision-making including economically targeted investments (ETIs), shareholder activism, divestiture (politically motivated sale of assets), and the use of pension funds to cover budgetary shortfalls. Based on a comprehensive review and a statistical analysis of data from the PENDAT (pension data) survey (administered by the Public Pension Coordinating Council (PPCC)) the study finds that the influence of these considerations on pension fund returns is limited.

Mitchell and Hsin's[38] study offers insight into the role that institutional characteristics play in the creation of an optional investment governance system, by empirically examining the impact of institutional design on the rate of return earned by pension plans. The study examined 269 different state and local government pension plans and found that the proportion of employee elected board members was negatively related to rates of returns and that external fund management added limited value to pension plan beneficiaries. They also found that plans that invested a relatively large proportion of their assets in their home states had on average lower rate of returns.

Useem and Mitchell[39] explored the relationship among public pension governance and investment strategies and financial performance. The research was based on a survey of 291 state and local retirement systems in 1992 and 1993, focusing on four major measures of investment strategies; (1) tactical investment; (2) equity investment; (3) external investment management; and (4) international investment. For governance strategies, the researchers examined investment restrictions, independent performance evaluations, and the investment board's responsibility for asset allocations and direct investment decisions. From the empirical analysis, it was found that the presence of constitutional restrictions reduced the likelihood that an investment portfolio is globally diversified. Overall, the researchers concluded that the imposition of investment constraints indirectly reduced total return.

33. A. H. Munnell and A. Sunden, Investment Practices of State and Local Funds, in *Pensions in the Public Sector*, eds. O. S. Mitchell, and E. C. Hustead (Philadelphia, PA: University of Pennsylvania Press, 2001).

34. O. S. Mitchell and P.-L. Hsin, Public pension governance and performance, in *The Economics of Pensions: Principles, Policies and International Experience*, ed. Salvador Valdés-Prieto (Cambridge, UK: Cambridge University Press, 1997).

35. M. Useem and O. S. Mitchell, "Holders of the Purse Strings: Governance and performance of public retirement systems," *Social Science Quarterly* 81, no. 2 (2000): 489–507.

36. W. G. Albrecht, H. Shamsub, and N. A. Giannatasio, "Public Pension Fund Governance Practices and Financial Performance," *Journal of Public Budgeting, Accounting and Financial Management* 19, no. 2 (2007): 245–267.

37. Munnell and Sunden (1999).

38. Mitchell and Hsin's (1997).

39. Useem and Mitchell (2000).

Finally, Albrecht, Shamsub and Giannatasio's[40] research produced evidence that supported Useem and Mitchell's[41] argument that the existence of investment restrictions adversely affects the rates of return. In contrast to Useem and Mitchell's study, Albrecht Shamsub and Giannatasio focused on risk adjusted return, defined as abnormal return. The risk adjusted return refines the total return by measuring how much risk is involved in producing the return. It is calculated by subtracting the rate of return on an asset or portfolio from a market portfolio that carries similar risk. The advantage of using a risk adjusted return is that it allows for a more objective comparison of assets or portfolios that may vary widely in terms of their historical average rate of returns. The inclusion of abnormal returns revealed the direct and indirect effects of governance strategies while the use of total return employed in Useem and Mitchell's study only showed the indirect impact of governance on financial performance. Based on the same data of state and local government employee retirement systems for Public Pension Coordinating Council's (PPCC) 1997, 2000, and 2001 Surveys, the researchers deduced that constitutional investment restrictions reduced abnormal returns.

WORKING HYPOTHESIS

The general working hypothesis is that portfolio selection in public pension investment programs on average is inconsistent with that of an optimal portfolio, as defined by MPT. The expectation is partly grounded in the findings of previous research, which suggest that public investment officials tend to avoid risk[42] and that they perceive risk (wrongfully so) as being most effectively avoided by means of heavy portfolio allocation in traditional assets. Using this logic, it has been argued that investment officials fail to diversify prudently (i.e., according to MPT), even when investment policies provide sufficient authority for diversification to occur (Stalebrink & Sacco 2006).

The working hypothesis is also grounded in empirical research and case evidence, which suggest that investment restrictions favor allocations in traditional asset classes including fixed income securities, equities and cash. For example, the above findings by Useem and Mitchell[43] and Albrecht, Shamsub and Giannatasio[44] suggest that the imposition of investment constraints reduces global investments and that this has an adverse impact on return. A plausible explanation is that investment parameters included in written investment policies reduced rate of returns by way of interfering with the ability of investment official to create an optimal portfolio. This explanation is consistent with the findings of the above studies conducted in the Canadian context, which focused on the impact of the FPR.[45]

40. Albrecht, Shamsub and Giannatasio (2007).

41. Useem and Mitchell's (2000).

42. C. P. McCue, "The Risk-return Paradox in Local Government Investing," *Public Budgeting & Finance* 20, no. 3 (2000): 80–101.

43. Useem and Mitchell (2000).

44. Albrecht, Shamsub and Giannatasio (2007).

45. Burgess & Fried (2005), Burgess & Fried (1999), Michas (1984).

In addition, anecdotal evidence and case illustrations (for case illustrations, see[46]) suggest that legal lists and diversification requirements also might create a bias towards traditional assets that is inconsistent with the allocations of an optimal portfolio. Legal lists might prevent investments in alternative assets. Similarly, diversification requirements might require a relatively high proportion of investments in traditional asset classes, thus "crowding" out opportunities to create a portfolio that is sufficiently diversified into alternative investments. This appears to have been the case during the 1990s when investment boards expanded their target allocations in stock allocations in response to the extraordinary performance of the US stock market.

RESEARCH APPROACH

In order to determine the extent to which DB pension plans are allocating assets in a manner that matches the principles of MPT, a set of optimal portfolios were identified for different levels of target returns. Historical return data was gathered from various sources and a portfolio optimization routine was used to determine the "efficient frontier" of portfolios. The efficient frontier indicates which portfolios are the least risky given a desired target return. The return data was annual total return data. Annual data was used because it is more reflective of typical asset allocation decision timeframes for pension funds. Pension funds typically hold assets within broad classes for relatively long periods.

The sources of data with periods of availability are listed below in Table 1. The data sources used were easily available and not proprietary, such that pension funds with relatively modest budgets for consultants or data acquisition would have access to the data. Broader market data covering major asset classes was more readily available for longer periods than the alternative asset data.

ANALYSIS

The analysis proceeded in two steps. First, expected returns and volatility measures were generated (Table 2). The expected returns were calculated as the arithmetic averages of the historical annual returns and the volatility measures were the standard deviations of the annual returns. Some interesting patterns in Table 2 are worth pointing out. While mean equity return is high, the volatility of the returns is also high. Domestic and international bonds have both lower returns and lower volatility, with international bonds having slightly higher volatility than domestic bonds. Real estate has a high return relative to the volatility, and as an asset class it has low correlation with stocks and negative correlation with bonds. Alternative assets have a roughly equal mean return and volatility and also have low or negative correlations with the other asset classes. The inclusion of cash as operationalized by Treasury bills may cause interest because they are often viewed as risk free assets

46. Useem and Hess (2001).

providing a small return with certainty and therefore having no correlation with other asset classes. This may be true in a single period, however in a multiperiod world the correlation is no longer zero as the Treasury bill return varies over time.

The dataset was next analyzed using a standard portfolio optimization model.[47] This analysis produced the efficient frontier of minimum variance portfolios for expected rates of return ranging from 6 percent to 10 percent, a typical range of pension plan expected returns from an actuary standpoint.

For the purposes of this research the most important output from the portfolio optimization routine is the asset allocations that correspond to the minimum variance portfolios at each level of expected return. These allocations are shown in Table 3. There are again some very interesting observations and trends within the results. The first obvious observation is the relatively minor role that stocks play in the optimal portfolios. Stock allocation is at most 5.24 percent of an optimal portfolio, and this occurs at an expected return of 9.5 percent. This minor role is being driven by the relatively high volatility per unit of return that is noted in Table 2. Another intriguing result is the high proportion of real estate in the portfolios, increasing from a minimum of 18.49 percent of the optimal portfolio at an expected rate of return of 6 percent to comprising nearly two-thirds of the optimal portfolio with an expected return of 9.5 percent. This result is driven in part both by the relatively high volatility to expected return ratio of this asset class and its low positive or even negative correlations with other asset classes. In terms of minimizing portfolio variance while meeting a certain return target, real estate seems to have offered a good alternative to stocks during the historical period to 2007. Alternative asset classes also play an important part of the optimal portfolios, especially when expected return is low. This is in large part due to the low correlations between alternative assets and other asset classes. Not surprisingly, bond investments are a large part of the optimal portfolio at low levels of expected returns but their usefulness in meeting return expectations diminishes as expected returns increases.

Comparison of Optimal Portfolios to Observed Portfolios

The final step in the research was to compare the optimal portfolios generated by the optimization program to portfolios observed in DB pension funds. The data on pension funds was taken from the Public Fund Survey, an online compendium of 101 large public DB pension systems.[48] After excluding some data points, there were 94 pension plans with data available for analysis. The plans included in the Public Funds Survey are some

47. For more on the implementation of portfolio optimization models, see Cornuejols Gerard and Tütüncü Reha, *Optimization Methods in Finance* (Cambridge, UK: Cambridge University Press, 2007) or many other textbooks in finance and applied mathematics. The program used for optimization was the What's Best® add-in for Excel® (LINDO Systems Inc., 2008).

48. National Association of State Retirement Administrators/National Council on Teacher Retirement (NASRA/NCTR) (2007). Public fund survey. Available from: *http://www.publicfundsurvey.org/publicfundsurvey/index.htm* (Accessed May 2008).

TABLE 1
Data Used for Asset Allocation Model

Variable Name	Definition	Source	Years
Stocks	Mixed Portfolio of 50% Large Stocks/ 50% Small Stocks	Ibbotson; *Stocks, Bonds and Bills* 2006	1926–2006
Domestic bonds	Mixed Portfolio of 33% Long-Term Government Bonds/33% Long-Term Corporate Bonds/33% Intermediate-Term Government Bonds	Ibbotson; *Stocks, Bonds and Bills* 2006	1926–2006
International bonds	Global Financial Data World ex-USA Government Bonds	Global Financial Data Inc.	1924–2006
Real estate	NCREIF Property Index—Market-value weighted index of investment properties	National Council of Real Estate Investment Fiduciaries (NCREIF)	1978–2006
Alternative assets	Mixed Portfolio of 50% Hedge Funds/ 50% Commodities	Hedge Funds: Hedge Fund Research Inc. *Fund of Funds Database*; Commodities: Jefferies & Co. Inc. *Reuters/ Jefferies—CRB Index*	Hedge Funds: 1990–2006; Commodities: 1982–2006
Cash	Treasury Bills	Ibbotson; *Stocks, Bonds and Bills* 2006	1926–2006

Note: See section "Robustness Checks" below for alternative asset class and portfolio definitions.

TABLE 2
Summary Statistics for the Asset Allocation Dataset

	Stocks	Domestic Bonds	International Bonds	Real Estate	Alternative Assets	Cash
Measure						
Expected return (mean)	14.85%	5.80%	5.77%	10.30%	7.38%	3.77%
Volatility (SD)	24.89%	7.51%	11.65%	6.26%	7.34%	3.08%
Years of data	81	81	81	29	17	81
Correlation matrix						
Stocks	1.00	0.05	0.22	0.05	0.13	− 0.08
Domestic bonds	0.05	1.00	0.42	− 0.28	− 0.04	0.29
International bonds	0.22	0.42	1.00	− 0.37	− 0.04	0.22
Real estate	0.05	− 0.28	− 0.37	1.00	− 0.06	0.33
Alternative assets	0.13	− 0.04	− 0.04	− 0.06	1.00	− 0.10
Cash	− 0.08	0.29	0.22	0.33	− 0.10	1.00

TABLE 3
Asset Allocation for Efficient Portfolios

	Optimal Allocations							
Asset/target return	**6.00%**	**6.25%**	**6.50%**	**6.75%**	**7.00%**	**7.25%**	**7.50%**	**7.75%**
Stocks	1.01%	1.02%	1.03%	1.05%	1.06%	1.08%	1.09%	1.10%
Domestic bonds	9.29%	10.26%	11.23%	12.20%	13.17%	14.13%	15.10%	16.07%
International bonds	3.02%	3.68%	4.33%	4.99%	5.65%	6.31%	6.96%	7.62%
Real estate	18.49%	21.45%	24.42%	27.39%	30.36%	33.33%	36.29%	39.26%
Alternative assets	16.32%	16.74%	17.16%	17.59%	18.01%	18.44%	18.86%	19.28%
Cash	51.88%	46.85%	41.82%	36.79%	31.75%	26.72%	21.69%	16.66%
Asset/target return		**8.00%**	**8.25%**	**8.50%**	**8.75%**	**9.00%**	**9.25%**	**9.50%**
Stocks		1.12%	1.13%	1.15%	1.91%	3.02%	4.13%	5.24%
Domestic bonds		17.04%	18.01%	18.98%	17.34%	14.53%	11.72%	8.91%
International bonds		8.28%	8.94%	9.59%	9.35%	8.69%	8.03%	7.38%
Real estate		42.23%	45.20%	48.17%	51.72%	55.53%	59.35%	63.17%
Alternative assets		19.71%	20.13%	20.55%	19.68%	18.22%	16.76%	15.31%
Cash		11.63%	6.60%	1.57%	0.00%	0.00%	0.00%	0.00%

of the largest in the nation, the average system market value of assets in 2007 for our sample was US$12.4 billion. The data used for the analysis was the ''target return'' of the fund used in its actuarial valuation and data on the plans' asset allocation.

Comparisons were done using the ratio of the expected volatility of the funds' returns compared with the expected volatility of the optimal asset allocation at the target rate of return for the fund (we measure volatility using standard deviation). The results of the analysis are shown below in Table 4. Panel 1 lists the summary asset allocation and target return data for the plans, and Panel 2 shows the results of the relative volatility ratios. The summary statistics on asset allocation indicate that despite a relatively low average target rate of return (approximately 8 percent), the funds in the survey have a disproportionately large asset allocation in equity investments compared with the optimal portfolio (over 55 percent). Their allocation to real estate and alternative assets is far below those in the optimal portfolio.

The volatility analysis results follow logically from the large allocation to equities. The average volatility ratio is 4.55, indicating that the funds on average have a standard deviation that is more than four times greater than the optimal portfolio. The fund that is operating closest to optimality given their stated target rate of return is still incurring over twice the amount of risk as the optimal portfolio. The fund that is operating farthest from optimality is taking over 6.3 times the amount of risk that the optimal portfolio would take for an equal expected return. Only three plans in our sample are taking less than three times as much risk as necessary, while 78 plans are taking more than four times the risk of the optimal portfolio and 25 plans are taking more than 5 times the risk. The implications of these results are that the plans in our sample are taking on far more risk than the optimal portfolio would incur given their target returns. This excessive risk taking is driven by an unexplainable reliance on equity investments.

Figure 2 shows the results graphically. The efficient frontier indicated by the portfolio optimization model is shown at the left of the figure. The plans are shown in the same expected return-volatility space. The graph clearly confirms the results from Table 4 indicating that the plans in the database are taking on risk that is far greater than optimal given their target return.

Robustness Checks

To determine the robustness of the results, the optimization models were also re-estimated using various different sets of inputs. For the first re-estimation, the geometric means of each asset class were used along with the corresponding volatility measures calculated from the geometric mean. Geometric mean is typically used to measure the realized compound rate of return over multiple periods while arithmetic mean is a better measure of average performance over single periods. The greater the dispersion of the return distribution, the bigger the difference between the two means. With historical annual returns being volatile, geometric means better reflect how assets grew over time.

For the second re-estimation, the original arithmetic mean returns for all asset classes were used except for Real Estate. Property appraisals are used in the NCREIF index calculation. Appraisal-based property values exhibit significant inertia due to appraisals typically are conducted infrequently. Returns calculated based on percentage changes in

TABLE 4
Results of Fund Portfolio Analysis, 2007

Panel 1: Characteristics of funds in sample

	Stocks	Domestic Bonds	International Bonds	Real Estate	Alternative Assets	Cash	Target Rate
Mean	55.73%	27.21%	0.84%	6.10%	7.68%	1.55%	7.96%
Minimum	0.00%	14.00%	0.00%	0.00%	0.00%	0.00%	6.00%
Maximum	72.80%	94.70%	13.40%	18.70%	30.60%	8.20%	8.50%

Panel 2: Summary measures of volatility ratios

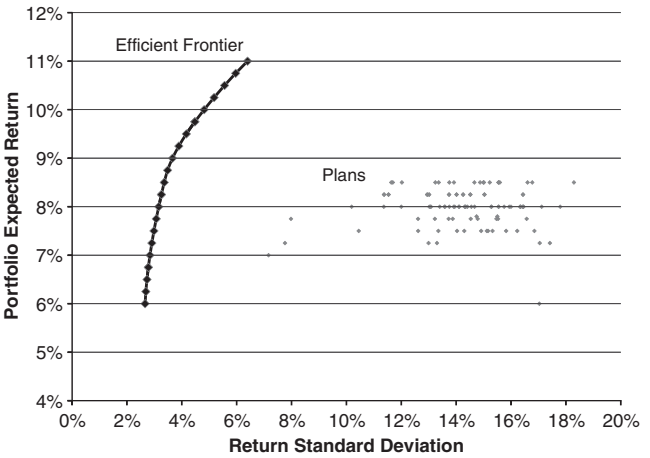
	Annual Data
Mean	21.188
SD	6.077
Minimum	6.351
Maximum	40.904

the index value thus has a tendency to underestimate volatility.[49] Real estate returns were adjusted in this model using a two-step process.[50] First, returns on the NCREIF NPI were compared with the Moody's/REAL real estate index for 2001–2007. The Moody's/

49. J. K. Yau, T. Schneeweis, T. R. Robinson and L. R. Weiss, Alternative Investments Portfolio Management, in *Managing Investment Portfolios: A Dynamic Process*, 3rd eds. J. L. Maginn, D. L. Tuttle, D. W. McLeavey, J. E. Pinto, (Hoboken, NJ: CFA Institute, 2007).

50. Z. Lin and K. D. Vandell, "Illiquidity and Pricing Biases in the Real Estate Market," *Real Estate Economics* 35, no. 3 (2007): 291–330; R. Brown, "Diversity in Asset Allocation," *Pensions* 13 (2007): 79–81; CalPERS. (n.d.). California Public Employees Retirement System (CalPERS). Retrieved December 9, 2008 from *http://www.calpers.ca.gov/*; CalPERS. (2007). *CalPERS Total fund statement of investment policy*. Retrieved December 9, 2008 from *http://www.calpers.ca.gov/eip-cs/investments/policies/invo-policy-statement/total-fund-statement.pdf*; CalPERS. (2008). *CalPERS Statement of investment policy for asset allocation strategy*. Retrieved December 9, 2008 from *http://www.calpers.ca.gov/eip-docs/investments/policies/asset-allocation/asset-alloc-strgy.pdf*; G. de Menil, "Why Should the Portfolios of Mandatory, Private Pension Funds be Captive? (The Foreign Investment Question)," *Journal of Banking and Finance* 29 (2004): 123–141; C. E. Goebel and P. M. Kivarkis, "The Evolution of Pension Investment and Risk Management in the United States," *Benefits Quarterly* 23, no. 4 (2007): 35–44; M. W. Griffin, "A Global Perspective on Pension Fund Asset Allocation," *Financial Analysts Journal* 54, no. 2 (1998): 60–68; M. J. Kreindler, "The Rush to Alternatives: Are You Ready?," *Benefits Law Journal* 18, no. 3 (2005): 54–62; A. J. Maggs, "State Pension Funds are Hedging Their Bets," *Benefits Law Journal* 19, no. 3 (2006): 70–79; H. M. Markowitz (1955). *Portfolio Selection*. Retrieved from ProQuest database. (AAT T-02902); O. S. Mitchell, P.-L. Hsin, (1994). Public pension governance and performance. Nat'l Bureau of Econ. Research Working Paper No. 4632; J. B. Pennington and B. H. Kleiner, "New Developments in Diversification and Portfolio Strategies," Management Research News *19, no. 10*

FIGURE 2
Efficient Frontier and Observed Pension Plans, 2007



REAL index is a ''repeat sales'' index on commercial real estate. Since the index uses repeat sales of properties to develop the price index, the returns on it should not be susceptible to illiquidity and marketing biases noted in the previous literature. The expected return on the Moody's/REAL was found to be 76 percent of the return of the NCREIF NPI and the volatility of the Moody's/REAL was 80 percent of the NPI. Next, those ratios were applied to the 1978–2007 returns on the NPI to create an adjusted return series. A potential weakness with this methodology exists if the relative return ratios changed between the 1978–2000 and 2001–2007 periods. Still, it is an empirical way to adjust for the biases noted in the NPI series. For the third re-estimation, both the geometric mean returns and the adjusted real estate returns were employed.

Next, to assess whether our construction of the hypothetical optimal portfolio using fixed percentages had created returns that funds could not emulate, we estimated a model where the optimal allocations were determined by a broad asset class (such as stocks, domestic bonds, international bonds). The results of this analysis also were nearly identical to our base results.

Finally, we restricted the asset choices to the three asset classes most commonly present in the sample funds, stocks, domestic bonds, and cash. This should rule out any measurement problems in alternative asset classes as well as address the issue that investments in certain asset classes may be restricted by statue or ordinance. The results of

(footnote Continued)
(1996): 27–34; J. Tobin, ''Liquidity Preference as Behavior Towards Risk,'' The Review of Economic Studies 25 (1958): 65–86.

this analysis did indicate a higher proportion of stocks in the optimal portfolio. However, the new optimal allocation to stocks was still about one-half of that indicated in the sample (at the 8 percent target return level the optimal model with three assets indicates an optimal allocation of 27.8 percent to stocks versus an observed allocation of 57.4 percent for the 35 plans in the sample with the same target return). Based on the exhaustive battery of robustness checks, we feel confident that our results fairly represent a hypothetical optimum to which existing plan asset allocations can be measured. The observed portfolios of large pension funds are much more heavily invested in equities than our optimal portfolios would indicate. And as a result, the risk assumed by these plans of yearly fluctuations in portfolio value is much greater than necessary.

SUMMARY AND CONCLUSION

The goal of this research was to examine the extent to which public pension programs allocate assets in a manner that is consistent with an optimal portfolio, as defined by MPT. Based on a statistical analysis of 94 DB pension plans the result suggests that the majority of the plans in the sample are incurring far more risk in their portfolios than is optimal given their target rates of return and that this risk level is a result of nonprudent allocation across asset classes, including insufficient diversification across alternative asset classes. The most telling examples of this are the proportion of assets that are allocated in equities and real estate. The pension funds in the sample have portfolios which are far more heavily invested in equities (i.e., a traditional asset) than the optimal portfolios. Because of the relatively high volatilities in equities, the volatility of fund portfolios is between three and six times greater than optimal. Furthermore, the pension funds have portfolios which are far less invested in real estate (i.e., an alternative asset) than the optimal portfolios. These findings are consistent across all target rates and suggest that a broader allocation across alternative assets will reduce the risk for any given target rate of return.

These findings suggest that there might be opportunities to improve the long-term performance of DB plans by way of adjusting asset allocation targets and legal lists in a manner that is more consistent with MPT. As noted above, a large number of government-administered DB pension plans are currently facing significant financial challenges. Prudent allocations across asset classes are not panacea for dealing with this funding gap. However, they are an important factor to the creation of fiscally sustainable public pension systems. Other factors also have to be considered including the failure of states and localities to make sufficient annual contribution to meet benefit promises. For several states this failure is partly a result of legislation enacted by States that lowered the statutory required contribution levels for a large number of state and local government administered pension funds. It is also a result of overly optimistic assumptions about expected rate of returns, which has exacerbated the problem by way of reducing annual required contribution levels.

Future research will need to examine the role of formal investment policies in more detail. In this research it is implied that these contribute to nonprudent diversification across asset classes. Furthermore, it is important to note that MPT should not be viewed as an end itself. In the context of this article, it should be viewed as a useful framework for highlighting challenges and potential improvements to the management of public pension funds.