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The relative asset pricing model: implications for asset allocation, rebalancing and asset pricing

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The relative asset pricing model: implications for asset allocation, rebalancing and asset pricing

Arun Muralidhar
Adjunct Professor of Finance, George Washington University, Founder, Mcube Investment Technologies and AlphaEngine Global Investment Solutions

Kazuhiko Ohashi
Professor of Finance, Graduate School of International Corporate Strategy (ICS), Hitotsubashi University, Tokyo, Japan

Sunghwan Shin
Professor of Finance, Hongik University, Seoul, Korea

Abstract
The Capital Asset Pricing Model (CAPM) has been the backbone of asset market finance, even though many academic studies have revealed its limitations, both theoretical and empirical. This paper argues that including liability or benchmark considerations in investment decisions may provide a credible explanation for some of the limitations. In effect, the CAPM is an “absolute wealth”-centric model, driven by the assumption that investors derive utility from absolute wealth. In reality, investors first make investment decisions to ensure sufficient assets to meet obligations, such as future pension payment or future consumption (i.e., liabilities), and focus on relative wealth. Thereafter, many investors hire external managers and evaluate them on performance relative to assigned benchmarks. Interestingly, existing robust literature on, and product offerings for, “liability driven investing,” have not led to a shift in academic theories of asset pricing to reflect the liability perspective. After all, if asset owners choose investments to service liabilities (proxied by benchmarks), it is expected that liabilities or these benchmark proxies will impact asset prices.

These are the personal views of the authors and do not reflect the views of any of the organizations to which they belong. We would like to thank Lester Seigel for his unique insight on RAPM and to Prof. Michael Brennan for his feedback on a related paper. Thanks also to Robert Savickas, Mehmet Gerz, Jean Luc Vila, Robert Merton, John Cochrane, John Campbell, Claude Erb, Dimitri Vayanos, Yegin Chen and Alexandre Baptista for their comments on this general idea. All errors are ours.
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Therefore, a shift from an “absolute wealth”-centric to a “liability-centric” or “relative wealth” perspective will create a Relative Asset Pricing Model (RAPM), with the CAPM as a very specialized case of this model. Hence, by examining how liabilities are proxied in practice, the many tests that found the need for additional factors to explain asset behavior might now be rationalized and explained. In this vein, even some behavioral criticisms leveled at CAPM can fit under this liability-centric CAPM-like paradigm. Finally, the asset allocation and portfolio rebalancing implications of this model may better explain some of the risky asset return characteristics such as momentum observed in the market. Therefore, if future research is directed to this compelling liability-centric facet embedded in practitioner behavior and explores this new dimension, RAPM may complement traditional CAPM, and help investors and academicians alike to develop better approaches to asset allocation, rebalancing as well as to asset pricing.

Introduction
A recent spat between Dempsey (2013), who argues that the Capital Asset Pricing Model (CAPM) is largely dead and incorrect as it does not test well, hence should not be used by investors, and Partington (2013) 2, who suggests no better model exists and people use it for all its flaws, hence CAPM reigns supreme, encapsulates the two extreme factions of the past 50 years in academic asset market finance. The lack of consensus on the appropriate model to price and allocate assets poses problems for global chief investment officers (CIOs) who have to invest trillions of dollars and also complicates what we teach the next generation of finance professionals [Shojai and Feiger (2009)]. If investment products and advice are not rooted in robust theory, it also complicates the development and marketing efforts of executives at investment consulting firms, asset management companies, and investment banks.

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2 Levy (2011) makes a similar argument.
Could the two views represented by Dempsey (2013) and Partington (2013) be consistent with each other? Could it be that CAPM proponents, and those who propose alternatives—like Black (1972), who argues for a Zero-Beta CAPM, albeit without clarity on the exact specifics of the zero-beta portfolio; Fama-French (2004) or Chen et al. (1986), who argue that additional factors beyond “market” beta are needed to explain asset returns, minus a model to explain what the factors might be;3 or even Kahneman-Tversky (1979), who argue that Modern Portfolio Theory (MPT) is wrong because it lacks a reference point and investors appear to exhibit loss aversion and utility from changes in wealth, yet do not articulate a clear reference point—provide meaningful and reconcilable insights through their models? The simple resolution may lie in developing a theory that is rooted in how institutions and individuals make investment decisions; namely, wealth is valuable not for its own sake but in helping us meet some liability or obligation.4 This paper makes the very bold claim that the seemingly contradictory theories could be consistent with each other by shifting the view of asset pricing and asset allocation, from an “absolute wealth”-centric view to a “liability” or “benchmark”-centric view, focusing on “relative wealth.” The reconciliation we provide in this paper may explain empirical anomalies, in turn justifying specific investment approaches.

The paper is structured as follows: Section 1 makes the case for the “liability” or “benchmark”-centric approach based on existing investment practice, and proceeds to present a simple Relative Asset Pricing Model (RAPM) to show the impact of this liability-centric view of asset pricing. It very summarily discusses how this approach may help provide a basis for Black’s Zero-Beta CAPM. Section 2 presents two possible variants to incorporating liabilities into such a model, and for simplicity this paper focuses on funded status (asset-liability ratio) rather than surplus maximization (assets minus liabilities), though the latter provides more tractable models and has been the staple of previous research. Section 3 ties this work to the key critique of Prospect Theory that MPT is missing a reference point and shows how the liability is a relevant reference point in investments.

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3 We only reference Fama-French, but clearly this encompasses the many factors that Dempsey (2013) highlights have been found to be academically relevant.

4 Cochrane and Culp (2003) make a similar statement; namely, “[I]nvestors do not value money directly. The theory adopts a more sophisticated approach and recognizes that the pleasure or ‘utility’ of consumption that money can buy is really what matters.”
Section 4 demonstrates how RAPM provides a theoretical perspective to Fama–French findings, but also potentially other liability-related factors. Section 5 briefly discusses the flexibility of this generic model in accommodating other relative models of agency, home/firm bias investing or background risk, and Section 6 highlights the behavior of liability-aware investors to demonstrate that these investors adopt Three Fund Separation, forecasted by such a model. This section also discusses some opportunities for CIOs of funds to improve investment processes, and CEOs of financial institutions to create new products. Section 7 concludes by suggesting how this approach provides interesting and useful avenues for future research.

1. The Relative Asset Pricing Model – the role of liabilities

Most finance professionals are familiar with the basic asset pricing formula from CAPM, whereby the expected return on an asset depends on its relationship to a “market” portfolio of all risky assets, with the return defined as r(M), as shown in equation 1, and where the “beta” is defined in equation (2) – calculated as the covariance of the returns of an asset to the returns of the market portfolio divided by the variance of the returns of the market portfolio. The variable F is a risk-free asset, with zero volatility and zero correlation to other assets. E[*] is the expectations operator. One of the key assumptions of this model is that investors maximize their utility, which is an increasing function of expected return, and decreasing function of return variance.

\[
E[r(i)] - r(F) = \beta_i \cdot E[r(M) - r(F)] \quad (1)
\]

\[
\beta_i = \frac{\text{cov}[r(M), r(i)]}{\text{var}[r(M)]} \quad (2)
\]

There is one additional aspect to the relative paradigm; namely, principal investors delegate to agents whom they hope are skillful. We will not address this issue here, but Muralidhar and Shin (2013) propose a simple model to show how this aspect impacts the demand for various assets.
One very appealing and potentially useful recommendation derived from this model is how assets should be allocated. In a simple one period world, all investors allocate their assets between the risk-free asset and the market portfolio, with the only differences reflecting the investors' risk tolerance – a process termed Two Fund Separation.\(^6\) Another useful, and relevant in practice, outgrowth of this model is that one can derive measures of risk-adjusted performance with the Sharpe ratio being the most famous measure.\(^7\) Most other models do not embody all of these three useful facets (i.e., recommendations for asset pricing, asset allocation and risk-adjusted performance) for investors.

However, most institutional investors are not driven solely by the need to grow assets for the sake of increasing wealth, but make investment decisions to service specific liabilities or spending objectives.\(^8\) In a survey of 32 global CIOs of a range of institutional funds, 62.5% stated that maximizing funded status was their primary objective (with additionally one response for “Fulfill obligations,” another for “Provide for as much as possible inflation adjusted pensions” and one for “Minimize shortfall risk,” which one could argue are related concepts).\(^9\) For example, for pension funds the liability is the promise of a future pension; for insurance companies, it is future claims that need to be paid out if an event occurs; for endowments and foundations, it is faculty salaries, charitable works/scholarships or faculty research they seek to fund [Merton (1993)]. Even retail investors save and invest to achieve some future spending objective, that could broadly be termed a liability [Merton (2014)], or it could be segmented into multiple sub-liabilities if the investment is for different needs.\(^10\)

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\(^6\) This result is from Tobin (1958). Merton (1973) offers an inter-temporal model with a bequest motive and results in Three Fund Separation with the third portfolio hedging the dynamic opportunity set.

\(^7\) Sharpe (1994). Interestingly, Modigliani-Modigliani (1997) provides a related measure which is more appealing in practice because it shows the tie between risk-adjusted performance and portfolio structuring.

\(^8\) Some of the earliest research on this specific topic of investing relative to liabilities can be traced to Leibowitz (1986) and Sharpe-Tint (1990).

\(^9\) Muralidhar (2014).

\(^10\) Das et al. (2010) refer to these as mental accounts. Janssen-Kramer and Boender (2013) demonstrate how these various goals of individuals (for expenses, one-time cash flows, capital targets or conditional cash flows) can be converted into cash flow projections, thereby allowing researchers to apply “private asset-liability management” techniques to determine optimal investment strategies. Step one in the process is converting goals into projected liabilities.
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When a regulator imposes strict rules on what an entity must do to recognize and mark-to-market liabilities (even specify corrective actions, depending on whether they are funded or underfunded), these liabilities are explicitly proxied, modeled, measured and monitored.\footnote{Muralidhar and van Stuijvenberg (2005) demonstrate how Dutch pension liabilities can be proxied with a range of fixed-income swaps, but the concept is generic. Leibowitz (1986) shows how pension liabilities can be proxied with bonds. Merton (2014) suggests that deferred annuities would be the liability proxy for retail investors in defined contribution plans.}

There are plenty of research papers and a whole industry solely focused on Liability Driven Investing (LDI), and this approach is a mainstream for a large class of investors.

For the rest of the investment community, the liability is implicit, and effectively nothing more than the Strategic Asset Allocation (SAA) to which to benchmark the portfolio (often a different proxy from the true liability). Depending on the type of regulation and investor, these explicit or implicit liabilities may be largely fixed-income instruments (pension funds or insurance companies with explicit liabilities) or some mix of stocks, bonds, commodities and illiquid assets (endowments, U.S. public pension plans, sovereign wealth funds, and retail investors with implicit liabilities). Through a unique accounting ruling, U.S. public pension funds have their expected target rate of return, say 7.5\% per annum, as their effective but implicit liability, which is then translated back to an SAA of multiple assets;\footnote{There is an active debate in the U.S. about whether this is the right way to discount liabilities, as U.S. corporate pension funds are required to discount liabilities with a long-duration bond index with credit risk, and we discuss the implications of any changes to this approach in Section 8.} retail investors behave much the same.\footnote{See for example how www.wealthfront.com establishes an investment policy for a retail client.}

Therefore, all these approaches can be seen as nothing more than creating a liability proxy for investors, against which investment performance is measured. Regardless of how these liabilities are treated by regulators or investors, if one takes a generic CAPM-type model and adjusts for the fact that investors derive utility from wealth relative to liabilities, it is possible to offer a “linear” model of the form suggested in equation (3A) and (3B), which we refer to as the RAPM.\footnote{Muralidhar et al. (2014a, b). The model is derived following Reisman-Lauterbach (2004) and replacing peer benchmarks with the liability portfolio. The model is also derived from a consumption CAPM approach.}
In this model, L refers to the global Liability replicating proxy portfolio (with returns $r(L)$ and non-zero volatility) — which would be a long-duration bond portfolio (with credit) if all investors behaved like U.S. corporate pension funds, or a mix of stocks, bonds, commodities and alternative assets (or an aggregate of all notional SAAs) if all investors behaved like U.S. public pension plans, endowments and foundations.

Define $M^*$ as the market portfolio of all assets including risky and risk-free assets, $M$ as the market portfolio of all risky assets (as in MPT), $F$ to be the traditional risk-free asset, and $w$ to be the market value weight of $M$ in $M^*$, i.e., $r(M^*)=w*r(M)+(1-w)*r(F)$. Then (3A) can be restated as in (3B) below to make it compatible with CAPM.

$$E[r(i)] - r(F) = \frac{\text{cov}[r(M^*), r(i)] - \text{cov}[r(L), r(i)]}{\text{var}[r(M^*) - r(L)]} \cdot E[r(M^*) - r(L)] = \Gamma_{M^*-L} \cdot E[r(M^*) - r(L)], \quad (3A)$$

where $\Gamma_{M^*-L} = \frac{\text{cov}[w \cdot r(M) - r(L), r(i)]}{\text{var}[w \cdot r(M) - r(L)]}$ can be seen as a “relative beta.”

Define $M^*$ as the market portfolio of all assets including risky and risk-free assets, $M$ as the market portfolio of all risky assets (as in MPT), $F$ to be the traditional risk-free asset, and $w$ to be the market value weight of $M$ in $M^*$, i.e., $r(M^*)=w*r(M)+(1-w)*r(F)$. Then (3A) can be restated as in (3B) below to make it compatible with CAPM.

$$E[r(i)] - r(F) = \Gamma_{M^*-L} \cdot E[w \cdot r(M) + (1 - w) \cdot r(F) - r(L)], \quad (3B)$$

One will quickly note the similarities between equations (1) and (3A). In a simplistic world, where liabilities do not matter or are deterministic, $r(L) = r(F)$, the CAPM model in equation (1) is retrieved. A major difference between equations (1) and (3A) is that the “beta” is replaced in equations (3A) or (3B) with the “relative beta.” Note also that if the liability portfolio is a linear combination of multiple assets, as in a typical SAA, one might expand the “L” in the equation as needed to give additional terms. We discuss this aspect of the equation in Section 4, in the context of explaining Fama-French [or Chen et al. (1986)]. However, this adjustment of focusing not just on assets (or wealth), but rather the ratio of assets/liabilities (or funded status), reveals many of the reconciling aspects of RAPM.

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15 Recall that relative to $L$, $F$ is a risky asset, even though it has no volatility or correlation to other assets/securities.
16 In a deterministic world, the liability should grow at the risk-free rate to prevent arbitrage opportunities.
When early tests of CAPM suggested a higher intercept and a lower slope than indicated in the CAPM in equation 1 (suggesting low/high beta assets had a systematically higher/lower return than the model predicted), Black (1972) suggested a revised model where the traditional theoretical risk-free rate is replaced by a zero-beta asset, Z, which would have a higher return than F. The Z portfolio would also have non-zero volatility and correlations with other assets (but a zero correlation to the market portfolio, hence its zero-beta moniker) and Two Fund Separation would hold. However, the paper is silent on the exact details of this zero-beta asset or portfolio. Viewed from the broader RAPM paradigm, the liability proxy portfolio is a candidate for the zero-beta “asset,” and shows how Black (1972) is possibly correct, though it requires a strong assumption on the correlation between the liability and risky portfolios. In contrast, RAPM is a less constrained model.

Just like CAPM, this asset pricing model can be used to derive asset-allocation recommendations consistent with LDI practice, and there is prior research to demonstrate the appropriate risk-adjusted performance measure in this relative world.

2. Two ways to incorporate liabilities (funded status and surplus/deficits)
This paper has briefly made the case for incorporating liabilities into the core asset-pricing framework, as opposed to including assets only (as is the case in existing literature). However, there are two approaches through which liabilities can be incorporated into the model, which begs the question: should the focus be on surplus and deficits (assets minus liabilities) or funded status (asset-liability ratio or funded ratio), to derive RAPM above? A strong case can be made for both approaches depending on how investors behave and Merton (2014) argues for funded status.
Note, however, that the RAPM model suggested in equation (3A) above is derived from maximizing the objective function, which focuses on maximizing funded status, but makes a simplifying assumption to solve the model in a linear form, that \( \frac{r(assets)}{r(liabilities)} \) can be approximated by \( r(assets) - r(liabilities) \). The choice of funded status as the key objective is driven by our survey responses of real CIOs as noted earlier.

Even though Sharpe and Tint (1990) and others consider surplus maximization as the key objective in their models of asset allocation in the presence of liabilities, a convincing case can be made for changing the objective function to funded status maximization. Because the funded status perspective is under represented in the literature, we emphasize its impact here. All the regulations and reporting in most countries are on assets/liabilities (funded ratio) and not assets-liabilities (assets minus liabilities). With respect to regulations, in the Netherlands, once the funded ratio falls below 105%, asset owners undergo a lot of stress and headache with respect to regulator audits, having to write recovery plans, increase contributions, potentially lowering benefits and revising asset allocation strategies. U.S. regulations require corrective action, but much less strict and onerous than the Netherlands. Today, with more than 90% of U.S. (corporate and public) pension funds operating with less than 100% funding, and regulators requiring that corporate funds make up the funding gap in three years, there is still substantial allocation to non-liability assets (or risky behavior in a RAPM context). On the flip side, consumption-based asset pricing models are well established in finance, and one must question the value of a model that is based upon utility defined by a ratio. In this regard, the surplus may be a better target to optimize and we are agnostic to the choice. Our version of RAPM in equation (3A) is a linearized model of a probably more complex three-dimensional model, as described below in Section 4. Appendix 1 provides a contrast in the asset pricing and allocation implications between maximizing surplus versus funded status.

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20. See also Elton and Gruber (1992) who focus on maximizing the return on net worth, where net worth is defined as assets - liabilities. Their paper has many prescient insights on investment strategies to follow for liability-aware investors.

21. Though we show in Muralidhar et al. (2014b) how RAPM can be derived using the Consumption CAPM with respect to Reference Levels literature by amending the reference level to be the liability proxy.

22. We thank Professor Michael Brennan for this observation.
3. Prospect theory reconciliation

Kahneman-Tversky examined human behavior and found it hard to believe that an individual with U.S.$10,000 in wealth would be indifferent to gaining U.S.$500 (from starting with U.S.$9,500) or losing U.S.$500 (from U.S.$10,500). They suggested MPT was missing a reference point, and this paper highlights liabilities as the appropriate reference point, as wealth must be measured relative to liabilities. Kahneman-Tversky speculated that the reference point might be the “current asset position,” but they felt investors appear to derive value from changes in wealth, not levels of absolute wealth as assumed in MPT. Barberis et al. (2001), in an excellent paper, attempt to capture Prospect Theory in a utility theory framework. In addition to the utility of consumption, they first add a utility of changes in financial wealth to incorporate the missing Prospect Theory aspect. The utility of changes in financial wealth is based on the performance of risky assets, and on the assumption of loss aversion. More importantly, this loss aversion is based on some reference benchmark level of stocks (e.g., some past historical price) and that becomes the state/exogenous variable and reference point. Should the reference point be the stock market, as suggested by Barberis et al. (2001), or liabilities? Interestingly, while Kahneman and Tversky (1979) (KT) attempt to anchor their questions to some relevant notion of wealth in society (i.e., tying the questions to values meaningful to average Israeli monthly income), they may have unintentionally touched on the importance of liabilities without explicitly realizing it when they stated, “[F]or example, the utility function of an individual who needs U.S.$60,000 to purchase a house may reveal an exceptionally steep rise near the critical value.” In our parlance, this “critical value” of U.S.$60,000 is the liability!

A recent IMF analysis of institutional investors shows that the case may even be stronger for the liability-centric model. While arguably KT were examining the behavior of individuals, and our data pertains to institutions so there may be a disconnect unless we assume a representative investor, Figure 1 provides an interesting analysis of risk aversion of a select group of institutional investors, based on their funded status from 2001-11.

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23 They note that “[T]he same level of wealth, for example, may imply abject poverty for one person and great riches for another—depending on their current assets,” which in effect is nothing more than a normalization for different liabilities.
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**Figure 1: Contrasting funded status and risk aversion (2001-11)**

Sources: Boston College Center for Retirement Research; and IMF staff estimates.
Note: Size of bubble represents allocation to alternative investments; 2011 is 25.5%.

This data from IMF (2013), based on allocation information of the weakest 10% of U.S. public pension plans, demonstrates a few interesting characteristics.

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First, as the funded status of public pension plans began to decline from 2001 onward, their allocation to risky assets generally increased in the following year. In finance parlance, risk aversion declined with funded status, with a marked increase in allocation to alternative assets as represented by the size of the bubbles. Second, clearly risk aversion is also dynamic in time, as suggested by Barberis et al. (2001). Third and most interesting, which potentially contradicts an assumption made in the utility function in Barberis et al. (2001), there was a generally upward trend in stock markets from 2003–07. Therefore, from their model, one would assume that as equity prices rise, risk aversion would also increase; but in this subset of funds, risk aversion actually declines, and substantially so. The reason may be because, over this period, the value of liabilities for most pensions worldwide rose more than the value of assets in which the funds were invested (driven in large part by central banks depressing interest rates and an additional phenomenon described below in Section 7). This opens the door to the alternative approach that links risk aversion to funded status, as opposed to equity levels, reinforcing the importance of a liability-centric approach and a better understanding of how investors make decisions. From the perspective of prospect theory, this observation could be heuristically explained by the investors' behavior of loss aversion. This behavior, linking risk aversion to funded status, is also validated in a more recent study of 126 U.S. public pension plans covering U.S.$2.6 trillion in assets as of FY 2012 — we see the same trend in increased riskiness of portfolios as funded status declined (even in periods where asset values rose).25 A recent survey in the November 2014 issue of CIO magazine demonstrates the opposite effect; as funded status rose 8% over 2011-14 (coincident with rising stock markets) on a PPA basis, investors increased their allocation to long duration fixed income by 8% and narrowed the gap between liability and asset duration from 2.8 years to 2.6 years (i.e., risk averse behavior).26 This rotation in-and-out of risky assets has interesting implications for CEOs at investment firms as they can estimate demand for their products based on the trend in funded status.

25 http://www.publicfundsurvey.org/publicfundsurvey/summaryoffindings.html. Figures A and B show how the funded status (A/L) has changed over the years. Figure O shows the change in asset allocation over the same window and one can see how bonds declined and alternatives increased (i.e., risk aversion declined as funded status fell).

In summary, incorporating liabilities as the reference point may resolve some of the Prospect Theory critiques of MPT, which proves the earlier point that both perspectives have merit when viewed through the appropriate lens. Also, we suggest a much more relevant and appropriate reference portfolio than just the stock market, which appears to be backed up by the simple evidence shown here. Clearly, a more detailed analysis needs to be conducted to finalize these findings [Muralidhar (2014)].

4. Fama-French and the search for more factors
CAPM has been heavily tested and many additional variables have been proposed for inclusion in the model (e.g., Harvey et al. (2014) test as many as 312 factors), though not always with a model to justify their inclusion. Equations (3A) and (3B) may add one possible explanation for additional factors to the model, ignoring the fact that the coefficient on the variables differs from traditional beta, based on how liabilities have been explicitly or implicitly proxied.

For example, as noted in Dempsey (2013) in reviewing Fama–French model, “the expected return on portfolio j is expressed as

$$E[r(j) \cdot r(F)] = b_i \cdot E[r(M) \cdot r(F)] + s_i \cdot E[r(SMB)] + h_i \cdot E[r(HML)] \quad (4)$$

where SMB = portfolio of small capitalization (S) stocks minus large capitalization (B) and HML = portfolio of high-book-to-market (H) stocks minus low-book-to-market (L) stocks.” Now, it is clear that if the liability return in (3A) can be proxied by the combination of the risk-free rate, the size factor and the book-to-market factor, then the equation (3A) can be expanded to (4). That is, additional factors can be interpreted as proxies of the liability factor in RAPM.\textsuperscript{27} To see this point, one may revert to the evolution of investment approaches, noting that through the late 1990s, most U.S. funds proxied their liabilities via their SAA, with portfolios composed of equities (typically large cap and growth, and with allocations in the 60%+ range, accounting for 80%-90% of the portfolio's volatility) and short duration, high quality credit bonds.

\textsuperscript{27} Brennan et al. (2012) make a similar argument, but in the context of agency. We would argue that the liability impact is more dramatic than the effect of agent benchmarks.
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So it is possible that the value and size effect reflect the fact that “liability” in our equation adds a premium to value and small cap stocks (because they are excluded assets), and all they were capturing is that the primary risk factor in proxy liabilities was large-growth stocks.

Liabilities may affect other factors, too. For example, post the tech bubble meltdown, and a severe decline in funded status among all funds globally, many pension funds began to adopt a more LDI approach under pressure from regulators, thereby providing an additional bid to long-term rates (beyond what the Federal Reserve was trying to achieve). This trend accelerated post-2008, as the second equity meltdown in a decade further damaged funded status.

In this sense, RAPM becomes even more interesting when broadening the fact that liabilities are proxied with non-equity assets, especially bonds (discussed in more detail in Section 7). One can make a similar case with the results of Chen et al. (1986) and Duarte (2013). Chen et al. (1986) include at least two variables that could be candidates for inclusion in the liability portfolio: UTS = long term bonds - short term bonds; UPR = long term corporate bonds - long term government bonds. Jagannathan and Wang (1996) offer at least one fixed income variable (yield spread between BAA- and AAA-rated bonds). Again, most liabilities, especially in pension funds, have a component tied to economic growth/industrial production, because pensions depend on wages (and most university endowments have a spending policy that assumes 5% growth); insurance portfolios are more often “bond heavy” reflecting their perception that the liability is bond-like. The fact that there are fixed income terms as additional factors in an asset pricing model again syncs up with the fact that most pension fund and insurance liabilities can be replicated by a long-duration bond, though many funds included short-duration high-quality bond benchmarks in their SAA for many years. One interesting factor that requires an explanation outside RAPM is “momentum” [Carhart (1997)]. Our explanation derives from investor behavior, as most funds have rebalancing strategies around the liability proxy/SAA, to account for the relative risk caused by drift away from the SAA. In effect, rebalancing strategies are “mean-reverting” and counter-trend, in that it sells the winning asset and buys the losing asset in order to rebalance. The momentum effect probably captured this tendency of investors to rebalance and is validated in Sharpe (2010), as he demonstrates how it can be profitable to use a momentum strategy when everyone else is counter-trending.
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In summary, depending on how liabilities used to be, and are currently proxied, one may have a model-based hypothesis of what factors can and should be added to the model, and still preserve the risk-return trade-off from CAPM, as represented by the coefficients in equation (3A). However, since liability proxying practices have changed so much over time, the relative importance of these factors will be dynamic. As noted earlier, investors who went from using implicit proxies (or large, growth equity allocations in the SAA) to explicit proxies (long-duration bonds with credit risk) would have changed their investment behavior, thereby affecting asset prices over the test period.

5. Other models of asset pricing – home bias, benchmarking, agency, background risk

The broader RAPM paradigm also explains other related aspects of finance literature, including the home-market bias or firm-bias allocations in portfolios (derived from the “Keeping up with the Joneses” utility).28 Other literature focused on agency issues in investment management29 and the impact of benchmarking investors30 are also interpreted as merely simple variants of the notion of relative asset pricing, with each paper effectively changing RAPM’s “liability.” While it is still early, there are indications that this type of model might even be able to provide a basis for the equity risk premium puzzle31 and some of the findings of the theory of background risk32.

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29 Brennan (1993) is the path-breaking work in this area.
30 Gomez and Zapatero (2003) suggest a two factor CAPM in the presence of benchmarking, which can be seen as early work validating Fama-French with a model. The difference between this approach and RAPM or Reisman-Lauterbach is that in this model the agent holds a portfolio composed of all the securities in the market portfolio but just weighted differently from market weight. Our model assumes that the liability portfolio is carved out of the market portfolio.
31 Mehra and Prescott (1985). The puzzle relates to the fact that it is hard to explain why investors hold government bonds in as high a proportion as they do, plus the fact that “the historical U.S. equity premium is an order of magnitude greater than can be rationalized in the context of the standard neoclassical paradigm of financial economics.” In RAPM, the demand for bonds can be driven solely by their liability hedging benefit. The premium can also be rationalized by the fact that we offer a different model of the size of the premium under RAPM.
32 Background risk pertains to a theory that tries to explain the portfolio allocation decisions of individuals that do not fit the typical MPT recommendations. For example, those who have risky income or wealth characteristics (termed high “background risk”), tend to hold less stock (and also less diversified portfolios). In our model, L is modeled generically so it could even potentially be used to capture a background risk process.
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6. Relationship with reality – asset allocation and asset pricing and implications for investors

6.1 Asset allocation

One issue with CAPM was that investors did not appear to engage in Two Fund Separation. In contrast, among LDI-aware investors and consultants advising such funds, there is an increasing tendency to split assets into three buckets: liability hedge (LHP), risk seeking or growth portfolio (RSP), and cash. This fits reasonably well with the RAPM framework, as one would expect a form of Three Fund Separation, with investments in L (LHP), M-L (RSP) and F (cash). The tougher issue is to reconcile the investment behavior of investors with implicit liability portfolios, a similar conundrum faced by CAPM.

An interesting trend that makes the liability-centric view even more important is that many institutions will gradually move to much more explicit liability proxies. For example, U.S. public pension plans are currently allowed to use a technique (for determining contributions) that permits discounting their projected liability cash flows with the expected target return on the asset portfolio, and hence the SAA tends to have substantial equity allocations as a high target return leads to lower liability valuations and hence higher funded status estimates. However, going forward, there is incredible pressure to use discount rates similar to those used by U.S. corporate funds, U.K. funds, Dutch funds and Danish funds (to establish their funded status for contributions), namely, a long-duration bond-based discount rate reflecting the risk of pension cash flows. Even if the technique for determining contributions does not change, some rating agencies use this latter technique to evaluate the level of state and county underfunding, thereby affecting state/county credit ratings. If these efforts reach a tipping point, allocations to long-duration bonds among U.S. public plans will increase (because higher borrowing costs will hurt public funds, if credit ratings decline), and lead to a dramatic shift in asset allocation and to how liabilities are proxied. This, in turn, will affect asset prices as assets in the current SAAs, especially stocks, will be less favored as well to reflect this rebalancing.

33 Amenc et al. (2010) document this facet of LDI investing.
6.2 Applicability to all assets

Most tests of MPT are conducted largely on stocks, even though MPT assumes that the market portfolio includes all assets.\(^{34}\) This is most evident in the Fama-French and related research. Focusing on only stocks (or treating stocks the same as bonds) risks ignoring the unique characteristics of a substantial part of capital markets. To convey orders of magnitude, equities have declined from 50% of the estimated global market to about 35% [Doeswijk et al. (2012)] and bonds are increasingly the dominant asset in institutional portfolios. However, if the liability proxy portfolio strictly consists of bonds, then RAPM offers a different return driver for bonds from stocks.

RAPM highlights the tug-of-war in predicting returns between the reward required for pure asset risk and the compensation resulting from the liability hedge of a particular asset. In effect, assets with a strong correlation to liabilities, within the risky asset bucket, would earn a lower rate of return than those that do not have this attractive property. Large and growth stocks might be less rewarded than small and value stocks (as mentioned earlier), but one can extrapolate this exercise to all assets. This highlights the fact that the role of correlations in the asset pricing paradigm is more complex and simple mean-variance plots for assets are insufficient for a complete understanding of asset returns and that possibly a three-dimensional mean-variance-correlation analysis is required.

6.3 Asset pricing implications

RAPM provides a different model for asset pricing than CAPM, suggesting that investors might need to reassess assumptions made in their asset pricing and asset allocation models. Interestingly, this provides opportunities to sophisticated investors to capture risk premia and unique profits. For example, changing pension regulation will modify the required structure of the liability portfolio from one that includes stocks and short-duration bonds to one solely replicated by long-duration bonds (with a hint of credit risk in the U.S.). In the past, demand for long-duration bonds increased while the relative attractiveness of stocks declined when U.S. corporate and European regulation changed.

\(^{34}\) An exception would be Elton et al. (1995), which focuses on using APT approaches to explain bond fund performance. Bonds pose a problem because the instrument continually ages and matures, hence, it is easier to test for appropriate factors on bond funds that have a somewhat stable duration and focus.
A counter experiment presented itself in 2013, when long-term rates rose because of the Fed taper (lowering liabilities) and stocks rallied causing pension funds to close the funding gap, leading to increasing demand for bonds as investors moved from loss aversion to risk aversion, thereby lowering rates in early-mid 2014. This again provides an interesting avenue for research on the impact of changing liability compositions and reactions of investors to changes in funded status.

6.4 Investor implications
6.4.1 Impact from increased LDI adoption
For innovative investors who recognize the value of this paradigm, there are substantial profits to be made. Van den Brink (2012) discusses the European LDI experience and notes how his strategist, Patrick Groenendijk, saw the trend toward LDI in Europe taking root in 2003. His strategist suggested that the PME pension fund take a large position in longer-duration bonds to take advantage of declining future yields – van den Brink’s only regret being that he was meek in the size of the trade as it proved to be very profitable!

As van den Brink (2012) notes and RAPM validates, liability-driven, or equivalently benchmark-driven, investments may create short-horizon momentum in asset returns due to portfolio rebalancing activities. As explained in this paper, in liability or benchmark-driven investment approaches, investors will borrow and invest in liability hedging or benchmark assets, and then invest in risk-seeking assets with the balance of their portfolio so that the portfolio is optimized. If for some reason the value of the liability or benchmark increases (e.g., changes in regulation or some new information is introduced to the market), then investors will end up with insufficient borrowing relative to the liability value. This in turn should lead to an increase in borrowing and investment in the non-hedging portfolio.

35 Vayanos and Woolley (2012) explore the implications of agency on momentum strategies and our own approach is similar because both are relative paradigms.
36 Here, liability asset is assumed to have a perfect correlation with liability value. If not, then the implication will be slightly different.
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This will induce increased demand for assets and will drive asset prices up and vice versa. This process of changing values/changing demand and the potential for capturing value is demonstrated through three simple examples in Appendix 2. Interestingly enough, the implication of MPT is quite opposite in that when risky asset value increases, investors will sell some of the risky asset to maintain the same risky-riskless asset composition.

6.4.2 Exploiting “non-liability” assets
In addition, as Section 4 suggested, assets not included in the “liability” portfolio will earn a premium and typically, once these premia are discovered, investors tend to add these assets to the “liability” proxy. This was clearly the case with small and value stocks in the U.S. in the mid-1990s, leading to a dilution in the premia. A more recent trend has been to include low volatility stocks in portfolios because of the perceived anomaly that they provided a premium over high-volatility stocks [Baker et al. (2011)]. The clear message to the innovative investor is that trying to play at the margin by holding assets in the “liability” portfolio is not likely to lead to sustainable excess returns; rather, investing in assets excluded in the “liability” portfolio before they are recognized by the general market is the way to go, but this will engender relative/peer risk and needs to be managed carefully.

6.4.3 Need for adoption of innovative LDI processes and products
Moreover, there has been a tendency in the investment industry to follow certain fads, and as Warren Buffett noted back in 1975, “Wall Street is a succession of fashions.” Many of these were only investment focused: technology stocks in the late 1990s; private equity/venture capital and hedge funds/fund-of-funds post the market decline of 2000-02; 120-20 equity strategies in the mid-2000s; “risk parity” strategies post 2008, and more recently, “smart beta” strategies that seek to weight assets in an index typically with a valuation/momentum/volatility bias as opposed to market cap weighting. However, all of these innovations in investment products are largely investment focused and ignore the liabilities completely.

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Sadly, these strategies have had poor performance after clients had piled into the trade leaving funds worse off from a funded status perspective as liabilities did not experience similar performance (i.e., there was a poor correlation between these strategies and liabilities). This focus on just investments (as opposed to investments relative to liabilities), in some part caused by the fact that MPT focused on just investments and is still the basis of investment decision-making in many funds globally, has caused major problems, as noted by van den Brink (2012) in the context of the Netherlands. This focus on just assets in investment decision-making, as opposed to funded status, for the better part of the last two decades is probably part of the reason why many pension funds have declined from a position of full funding in the late 1990s to being severely underfunded by 2012, as shown in Figure 2 (data taken from the 2013 U.S. Public Fund Survey covering 126 pension funds with more than U.S.$2.6 trillion in assets).

Figure 2 plots the aggregate actuarial funding level among plans in the Survey since its inception in FY 2001. If RAPM had been the prevailing paradigm in the 1990s, there might have been greater focus/pressure on funds, possibly even driven by regulators, to adopt the types of strategies that Elton-Gruber (1992) proposed to hedge liability risk. Instead, by utilizing MPT/CAPM approaches to portfolio construction, funds took unintended relative risk — investing in equities when the liabilities resembled a bond exposure. This has left many funds in a tough position, especially since weak economic growth has put pressure on the sponsors (the state and local governments), preventing them from covering these losses with new contributions. Given the weak projections for economic growth globally, there is a critical need to improve investment approaches for these funds, as any further decline in funding will lead to the closure of these defined benefit schemes (as has been the case with many U.S. corporate pension funds), and in some extreme cases even reduced pensions in their retirement years (e.g., public fund retirees in the city of Detroit). Barrett et al. (2012) recommend a more dynamic approach to managing portfolios, rebalancing the asset allocation to reflect changing market conditions, but ensuring that this process produces a stream of returns that improves the asset-liability position of the fund. In short, the acknowledgement and acceptance of the RAPM paradigm is of utmost importance, not only to improve investment outcomes, but also to improve social outcomes.
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Figure 2: Decline in funded status of U.S. public pension plans

Source: Public Fund Survey, November 2013
6.4.4 Popularity of life cycle/target-date funds
Increasingly, investment products called life cycle funds or target date funds, where the allocation to equities and bonds change based on the age of the investor, are becoming popular default options and are gathering substantial assets. The World Bank is increasingly advocating such products for country-level social security systems [see, Price and Rudolph (2013)]. In the U.S., a target date fund (TDF) is considered Qualified Default Investment Alternative (QDIA), giving the employer safe-harbor protections from the Department of Labor, and the U.S. Congress recently passed regulation to make these funds the default option for the Federal Thrift Savings Plan.

RAPM and Merton (2014) would suggest that rather than changing allocations based on the age of the participant, which is easy to monitor, the allocation should change based on the achievement of some funded-status objective. The experience in 2008 with these TDFs was not positive as many such funds carried too much equity risk and a funded status-based rebalancing might lead to more secure social outcomes, especially since these funds are being made into default options on the assumption that this is the best alternative for unsophisticated investors. The ABN AMRO Pension Fund which rebalanced based on funded status weathered the crisis in 2008 much better than 99% of the funds globally [Muralidhar (2011)].

Therefore, it is our hope that the RAPM paradigm gradually helps replace the existing asset-only/absolute focus on portfolios and risk, and introduces a more “liability-centric” approach to portfolio construction. As more investors adopt an explicit liability proxy process, the RAPM framework becomes more interesting and relevant for asset pricing, asset allocation shifts as well as new methods for calculating risk-adjusted performance. As this transition takes place, there will be unique opportunities for the development of new investment products/processes (e.g., to dynamically improve the liability hedging process as the funded status of pension funds improves),38 and also opportunities to capture unique trend/momentum of various assets that could lead to one-time gains to portfolios.

38 Muralidhar (2011a) and (2011b) examine view neutral and view-based portfolio rebalancing. The former reference highlights how the ABN AMRO pension fund, by adopting view neutral ALM rebalancing, preserved its funded status in 2008 above the 105% threshold when most other Dutch funds suffered.
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7. Summary
In a liability-centric world of asset pricing, utility ought to be examined not just relative to wealth, but also relative to stochastic liabilities.

This paper postulates a simple RAPM anchored in a liability-centric world, to show how, if the seemingly contradictory theories and findings of various academics are reframed from this perspective, they might not all be so contradictory.

Reconciling these seemingly competing theories is important as it allows practitioners to adopt effective processes and not get confused as to which paradigm to adopt. It appears, by opening the relative tent wide enough, there may be a big enough platform to accommodate the traditional CAPM, Black’s CAPM, Prospect Theory, Fama-French and other factors, Agency Theory, Benchmarking Theory, and even the Home Bias or Background Risk phenomenon, thus providing fertile ground for some talented academic/s to develop a Unified Theory of Asset Pricing Finance [Muralidhar et al. (2014 a)].

It would seem paradoxical to invoke the name of the Buddha in a discussion of investment finance, but a simple couplet attributed to him in reconciling the views of the five blind men who examined an elephant and bickered over what it might be seems appropriate. Buddha is believed to have composed this verse to resolve the differences:

“O how they cling and wrangle, some who claim
For preacher and monk the honored name!
For, quarreling, each to his view they cling.
Such folk see only one side of a thing.”

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Appendix 1 – funded ratio versus surplus
As a relative measure inclusive of liabilities, two competing measures exist – surplus (or equivalently excess return) and funded ratio (or equivalently relative return index). Sharpe and Tint (1990), Leibowitz and Henrikson (1988), Rudolf and Ziemba (2004), and Cornell and Roll (2005) consider surplus as a relative measure, whereas Reisman and Lauterbach (2002) and many pension regulators consider the funded ratio (or relative return index) as the relative measure. RAPM discussed in Section 1 derives from assuming the funded ratio as a relative measure, but in this appendix, we show how the two different measures impact investors’ asset allocation decisions. Muralidhar et al. (2014b) develops RAPM based on both surplus and funded status as well from an investment and consumption approach.

Denote \( A_0 \) and \( L_0 \) as the asset and liability values at time 0, respectively, and \( r(A) \) and \( r(L) \) as the respective asset and liability returns. In the case of funded ratio optimization, the future funded ratio can be expressed as:

\[
\frac{A_0 (1 + r(A))}{L_0 (1 + r(L))} = \left(\frac{A_0}{L_0}\right) \cdot \left(1 + r(A)\right)\left(1 + r(L)^{-1}\right)
\]

Therefore, at time 0, the funded ratio plays the same role of an initial wealth in the asset-only optimization case. For log utility, for example, initial wealth does not matter in asset decisions and hence in RAPM using log utility, initial funded status will not matter in portfolio decisions. In the case of surplus optimization, future surplus can be expressed as:

\[
A_0 (1 + r(A)) - L_0 (1 + r(L)) = A_0 \left[ (1 + r(A)) - (L_0 / A_0) (1 + r(L)) \right]
\]

Therefore, the inverse of initial funded ratio, \( L_0 / A_0 \), acts as a scaling factor on liability portfolio return. For log utility in RAPM using surplus, for example, the initial funded ratio will matter in asset decisions.
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The two competing measures will result in different holdings of the liability portfolio. If, for example, $A_0$ and $L_0$ are U.S.$0.5 billion and U.S.$1 billion, respectively, the liability portfolio holdings will be U.S.$0.5 billion and U.S.$1 billion for the funded status and surplus approach, respectively. In other words, the liability holding amount for the funded ratio case will be the same as the asset value, whereas it will be the liability value in the surplus case. The RAPM in this paper does not have any funded ratio component because the relative measure is defined as the funded ratio. If, instead, it is defined as surplus, then the initial funded ratio will appear in the RAPM equation. This is explored in future research.

Appendix 2 - RAPM rebalancing based on funded status (versus surplus)

The following example may make the implications of the various approaches easier to follow. Suppose that we have three time points, $t=0, 1, 2$ and two periods, period 1 and period 2. At $t=0$, suppose that investor has assets valued at U.S.$100, and a liability valued at U.S.$80. Let us assume that there is a liability hedging asset and it has a perfect correlation with actual liability. For convenience, the borrowing rate is assumed to be 0%.

Case 1 (funded ratio utility): rebalancing because of a change in asset values

In our paradigm, the investor will borrow U.S.$100 (the initial asset value), and invest it in the liability hedge. Then, the investor will invest the asset pool of U.S.$100, without further consideration to the liability, in a “non-hedging portfolio” that is composed of riskless and risky assets according to the regular MPT approach. Suppose that during period 1 some positive news hits the market and the non-hedging portfolio value increases to U.S.$120 and the liability value increases to U.S.$110. Then the investor’s new endowment value at $t=1$ will be U.S.$130 (=U.S.$120+U.S.$110–U.S.$100), and new liability value will be U.S.$110. Therefore, the investor will borrow an additional U.S.$30 and invest U.S.$20 in the liability hedge and U.S.$10 in the non-hedging portfolio, which will result in price increase in risky assets in the non-hedging portfolio as well as in the liability hedge due to increased demand. Investors, who like van den Brink’s strategist, Patrick Groenendijk, can foresee such trends will be able to profit from such market movements as news hit the market.40

40 Barrett et al. (2011) discusses a form of dynamic beta management that rotates a portfolio’s asset allocation in response to data changes, but did not consider the implications of changes in investor behavior/rebalancing in response to these data changes.
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**Case 2: comparison to the case where investors focus on surplus**
The investor will borrow U.S.$80 (the liability value), and invest it in the liability hedge. Thereafter, as in Case 1, the investor will invest the asset pool of U.S.$100, in the non-hedging portfolio that is composed of riskless and risky assets. Suppose that during period 1, the same positive news hits the market and the non-hedging portfolio value increases to U.S.$120, as in Case 1, and the liability value increases to U.S.$90. Then the investor’s new endowment value at t=1 will be U.S.$130 (=U.S.$120+U.S.$90-U.S.$80), and new liability value will be U.S.$90. Therefore, the investor will borrow additional U.S.$10 and invest it in liability hedge, which will result in a price increase in liability hedge due to increased demand. This case will be more applicable to situations of benchmark-driven investment, but note the difference relative to Case 1.

**Case 3: change in regulation**
We examine the case where changes in regulation can impact how liabilities are valued and this is a potential live issue that could impact all U.S. public pension funds (from a reset in the discount rate) as noted earlier. Under such a situation, the instrument that was used to previously hedge the true liability may not change in value commensurate with the change in the true liability. In our example above, suppose that the change in regulation results in the value of the liability increasing to U.S.$110. Under the RAPM (funded status) approach, no further rebalancing is necessary because there is no change in size of the asset pool (=non-hedging portfolio value - borrowing + liability asset value). However, if an investor assumed that all funds were approaching their investments from a surplus perspective, as assumed in previous research, they would expect funds to be rebalancing (because the hedging amount is set according to liability value, which increased to U.S.$110 from U.S.$80). They would expect additional borrowing of U.S.$30 to be made and be invested in the liability hedge, which they expect will result in the price increase in liability assets. Therefore, investors who apply the wrong paradigm might potentially make the wrong expectation about future market movements.

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41 Alternatively, this could happen because of a new actuarial method being applied to the liabilities.
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