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The recent novel coronavirus pandemic and its devastating impact on economies and markets begs an interesting question: Is it time for a novel investment approach?

Markowitz (1952) laid the foundation for current investment theory and practice by articulating that portfolio selection can be partitioned into two stages. The first starts with observation and experience and ends with setting beliefs about available securities (essentially, expected returns, correlations, and volatilities). The second starts with beliefs and ends with the selection of the portfolio through what we now define as mean-variance optimization or MVO.

The entire argument, however, is predicated on the assumption that "the investor does consider expected return a desirable thing *and* variance of returns an undesirable thing" (Markowitz 1952). Today, this objective is labeled mean-variance preferences; this approach essentially assumes that investors maximize the expected utility of wealth.

As markets collapse and investors are struggling with market volatility, imagine instead if this classic paper had started with a more practical than theoretical approach to the challenge investors face—namely, how do they ensure that they will achieve (or guarantee) the set of cash flows needed for their various goals? Goals-based investing (GBI) is now mainstream and recognizes that investors have many goals (retirement, saving for college, health savings, saving for a house), and each has a unique cash-flow profile. This article argues that focusing on the cash flows as opposed to expected returns might have mitigated some of the challenges that investors face right now (and in the future).

For example, Merton (2007) noted that, when planning for retirement, individuals should not maximize (the expected utility of) wealth but rather should try to guarantee a level of retirement income that is consistent with their pre-retirement lifestyle. In effect, this example is equivalent to the objective of ensuring cash-flow matching for retirement. Similarly, when planning for a child's education, individuals should not maximize (the expected utility of) wealth but rather need to ensure they can make tuition payments when a child enters college.

This is not a trivial switch of the problem; rather, it has enormous practical (and academic) implications. One can argue that focusing on expected returns rather than required cash flows potentially has led to pension funds having insufficient resources to pay their obligations (Muralidhar 2018), risky assets being considered safe for various goals (Merton 2007), and risky products being deemed safe by regulators (Bodie et al. 2010). More importantly, individuals (and professionals) have little to no idea what the target expected return is for a particular goal, especially with the high market volatility being experienced in 2020. This follows because fluctuating interest rates and other factors are constantly changing the expected return. In other words, the expected-return target is always moving. On the other hand, individuals can reasonably estimate the cash flow (in today's currency) needed to maintain a current lifestyle in retirement or finance a child's education. If an individual can enjoy a certain quality of life on $75,000 per year in today's dollars, it isn't unreasonable to assume that this real value is largely unchanged with market volatility as long as the payments are indexed to an appropriate nominal adjustment. Similarly, one might set a child's college education budget at $50,000 per year (for four years) in today's dollars. At a minimum, the greater stability of the expression of the goal argues for a novel approach (to focus on cash flows as opposed to expected returns).

The recent crisis caused by the coronavirus also has shown how uncertainties about the future make forecasting expected returns of assets (and other variables) a relatively arbitrary exercise. Therefore, it is imperative that we develop new and novel approaches that play to what people are capable of doing (Merton 2012) rather than what is academically popular and accepted.

This article explores what might have transpired had Markowitz (1952) focused on cash-flow achievement rather than maximizing expected returns subject to an aversion for variance. The article first demonstrates the unexpected challenges of the expected return lens and then transitions to the implications of the cash-flow driven investing (or GBI) approach for asset pricing, asset allocation and rebalancing, regulation, and financial innovation.

UNEXPECTED CHALLENGES

Markowitz (1952) focuses on the second stage of the process, the MVO. It also considers an alternative objective specification (i.e., maximizing the discounted expected value of future returns), but then rejects it because the alternative specification does not lead to diversification. Markowitz (1952) also notes the importance of correct specification of means and variances and suggests that statistical techniques be combined with the "judgment of practical men." Now, 70 years later, it is worth asking: How has the industry fared in the critical first stage of the portfolio selection process?

Aubry et al. (2018) hint at the answer in an examination of 180 public defined benefit (DB) pension plans during 2001–2017: "[O]ver this same 17-year period, all plans, regardless of their cohort, have underperformed relative to their actuarial investment assumptions, with underperformance being greater for the lower-funded plans." In other words, the 180 pension funds underperformed expected returns over a 17-year period. These funds were professionally managed by investment teams, and in most cases the expected-return estimations were provided (or supported) by some of the largest and most sophisticated investment consulting firms. Therefore, it appears that professional investors with extensive training and resources struggle with this key first stage, which the MVO depends upon. Others, such as Housel (2015) and *The Economist* (2017), point to the inability of professional investors to forecast returns of individual assets. In summary, our track record of conducting the first stage, especially with myriad inputs (e.g., expected returns, volatilities, and even correlations across all assets) as the number of assets increases, is less than stellar.

What is the fallout of this inability to accurately forecast expected returns? In the case of the DB pension industry, it has led to pensions being underfunded globally, with potential pension cuts looming in such countries as the Netherlands (Cumbo and Wigglesworth 2019). But it has raised an additional challenge—a fairly heated discussion about the regulation of these funds.

A joint task force of the American Academy of Actuaries and the Society of Actuaries convened to examine the appropriate discount rate for public DB pensions but disbanded over disagreement about what expected rate of return to use (Malanga 2016; *Pensions & Investments* 2016). Some wanted the current practice of discounting liabilities with the expected return of assets to continue; others wanted a market rate of return to be applied (much like the rate applied to corporate DB plans). We speculate that because the foundational papers of modern portfolio theory (MPT) assumed that investors seek to maximize the utility of wealth (i.e., the goal or liability is deterministic) (Muralidhar et al. 2014)—and many practitioners did not appreciate and understand the implications of this assumption—that a debate rages today about what expected return to use. Clearly, the goals and liabilities of DB pensions and even individuals are stochastic, which foundational MPT papers did not consider. This stochasticity of goals impacts the choice of asset-pricing model, the risk-free or safe asset, asset allocation and rebalancing, and as noted above, regulation. We examine each below.

Asset pricing. For example, Markowitz (1952) also led to the capital asset pricing model (CAPM), with a focus on estimating an asset's expected return and with the continued focus on maximizing expected utility of wealth. CAPM sought to address the first stage of the two-stage problem. In the most popular representation of this model (Sharpe 1964), the expected return of an asset is driven entirely by its beta to a diversified market portfolio and nothing else. One can imagine that if it is hard to forecast the inputs to this model, the output is likely to be unreliable as well.

Risk-free/safe asset/regulation. In CAPM/MPT, the safe asset has a positive expected return, zero volatility, and zero correlation to all other assets. In practice, investors use a short-term Treasury bill (T-bill) as a proxy because it protects wealth and has relatively low absolute volatility. But as Merton (2007) notes, for a retirement investor, a T-bill is very risky because it delivers highly variable retirement income. This follows because the cash flows required by a retirement investor (potentially a high-duration cash-flow stream) are dramatically different from the cash flows of a single T-bill or even a portfolio of T-bills. The same is true of target-date funds (TDFs), accounting for close to $1 trillion of defined contribution assets (Correia 2019), that have safe harbor status from U.S. regulators. Bodie et al. (2010) demonstrate that just because these products rotate into bonds (ostensibly instruments that protect principal and have low volatility of wealth) as one ages, they still deliver risky retirement outcomes and therefore may not be safe. In short, by focusing on expected returns and volatility of expected returns, retirement investors may load up on a highly risky asset (T-bills) to achieve their goals and regulators have blessed such products with no recourse to investors if they do not achieve their goals. The recent market correction because of the coronavirus may have exposed this mismatch because the present value of the desired retirement cash flow has risen (as long-term interest rates declined), but TDFs have declined in value. Merton (1983) would go one step further and argue that even long-dated Treasury instruments, including those linked to inflation, would be risky for a retirement investor because these instruments do not protect retirees from standard-of-living risk (and would further argue that this risk is the primary risk in retirement). The same case can be made for individuals saving for a child's college fund, where the cash-flow risk from a T-bill or inflation-protected security is exacerbated by the fact that tuition inflation is markedly different from consumer or wholesale price inflation. One can see

that focusing solely on the beta of these assets relative to a market portfolio is likely to lead to poor portfolio selection and likely non-achievement of goals.

Asset allocation/rebalancing. In a one-period model, an MVO approach results in say a 60-percent stock and 40-percent bond portfolio.[1] However, in a practical multi-period world, one can never be at this MVO portfolio because daily portfolio movements cause the portfolio to drift away from this 60/40 mix. To address this challenge, investors are told to rebalance regularly to the 60/40 mix, either on some calendar basis (monthly, quarterly, annually) or if some range (e.g., ±5 percent) around this mix is breached. However, it is shown easily that these rebalancing strategies are highly tactical trades based on arbitrary calendar windows and ranges that have no basis in theory, are unlikely to improve returns,[2] and have a tendency to worsen drawdown in secular bear markets at the worst possible time, such as the dot-com bubble unwind, the Great Financial Crisis, and today's coronavirus crisis. For example, in March 2020, the first 10-percent decline in equity markets (and partial rally in bonds), would have triggered a rebalancing as the portfolio would have breached the 55-percent equity lower bound of a 60/40 portfolio. A mechanistic investor, say a robo-advisor, would then buy equities and sell bonds to get back to the 60/40 mix—basically a tactical trade based on the assumption of mean reversion. The subsequent 10-percent equity decline would trigger the same sequence of events, followed by the third decline of 10 percent. One can see easily how these rebalancing trades can exacerbate the drawdown of the 60/40 portfolio.

In summary, the original statement of investment objectives in foundational MPT academic papers led to a focus on expected returns as the primary stage of an effective process and has driven subsequent theory and practice to miss the nuance of the implicit assumption in these papers. This has led to challenges in pension funding globally, challenges in regulation of such institutions and investment products, the treatment of risky assets as safe, and potentially incorrect asset allocations and arbitrary rebalancing for portfolios with stochastic goals or liabilities.

The challenge is that these models are focused on expected returns of the goals and portfolios, thereby carrying over the original challenge posed by Markowitz.

WHAT MIGHT HAVE BEEN

Suppose instead that Markowitz (1952) had considered a variation of the objective that was discarded. What might have happened if the problem had been stated as, "Maximize the likelihood of matching the cash flows needed to satisfy the investment goal while minimizing the variance of this difference." Interestingly, Breeden (1979) derives a Consumption CAPM, based on the assumption that individuals seek to consume a single good (a proxy for why one needs future cash flows) that is also a single-factor model with the primary variable being aggregate consumption. Subsequently Waring and Whitney (2009) and Muralidhar et al. (2014) ask a related question: How does CAPM change if asset allocation is goal-centric? Waring and Whitney (2009) create a single-factor model; Muralidhar et al. (2014) develop a two-factor model, with the two factors being the goal-replicating portfolio (the relative safe asset) and the relative market portfolio (the portfolio of relative risky assets). Das et al. (2010) extend the MVO approach to multiple goals. The challenge is that these models are focused on expected returns of the goals and portfolios, thereby carrying over the original challenge posed by Markowitz (1952). So, the novel approach has to move away from the expected returns lens.

If one considers a cash-flow matching approach to investment decision-making, the following conclusions can be derived about the risk-free asset, asset allocation/rebalancing, asset pricing, and regulation:

Risk-free/safe asset. Fisher and Weil (1971) and Leibowitz and Weinberger (1981) demonstrate that for a goal specified as a stream of future cash flows by a pension fund, a dedicated portfolio of bonds that meets these cash-flow needs would be the safe asset. For individual goals such as saving for college or for retirement, Muralidhar (2016) and Merton and Muralidhar (2017) argue for the creation of new bonds that exactly match the cash flows of the goals. They call these bonds "SeLFIES" or Standard-of-Living indexed, Forward-starting, Income-only Securities. SeLFIES would have no cash flows until the retirement date (i.e., forward-starting), and then pay coupons only for the duration of the goal (i.e., income-only), and be linked to a standard-of-living index, because standard-of-living is the primary risk in retirement (Merton 1983). Absent the existence of these assets, portfolios are risky and investors will bear unnecessarily high risks to achieve their goals. Consider the retirement goal and resulting cash-flow needs: An individual would like to receive a guaranteed set of target cash flows (e.g., $75,000 per year by today's standard-of-living) from date of retirement until death. SeLFIES were designed to match the cash-flow profile of the retirement goal, but investors would need to buy only the correct number of SeLFIES that start paying on the retirement date to ensure $75,000 per year for retirement. Because the relative risk-free asset does not exist for many goals (retirement, saving for college, health savings accounts, etc.), many of these new instruments should be created.

Asset allocation/rebalancing. Analysts have focused on the asset allocation implications of this approach in a single-period model for many years. Sharpe and Tint (1990) show that in the presence of

stochastic liabilities, asset allocation must be liability centric (and the relative safe asset is the portfolio that replicates the goal cash flows). Elton and Gruber (1992) show that optimal portfolios for institutional investors would require a split between the goal-replicating portfolio and a risky mutual fund. But in a more practical, multi-period world, if an individual has immunized goal cash flows, then no additional transactions need to be conducted. Equity and bond market disruptions such as those caused by the coronavirus would require no portfolio management actions because cash-flow matching is unaffected by market volatility (unless the goal changes or a bond issuer defaults). This is one critical superiority of this approach. If investors have current assets that do not allow for full immunization of the goal then, Levitan and Merton (2015) argue, a dynamic strategy should rebalance between the safe and risky asset to ensure that the goal is achieved within the risk tolerance of the client. Kóbor and Muralidhar (2020) extend this approach and provide a simple goals-based, dynamic rebalancing formula that switches the allocations between the safe and risky assets without a forecast of returns (but on the assumption that the risky portfolio has better performance than the safe asset). They label this approach "GLIDeS" or Goals-based, Lifetime Income-focused, Dynamic Strategy. Further, Mantilla-Garcia et al. (2020) show that in a multi-period timeframe, where people can keep contributing to a goal over their working lives, a more complex rule can be expressed (without forecasting expected returns) that ensures that one never has a guaranteed cash flow that is below the level guaranteed in the immediately preceding period. In summary, a well-designed cash-flow matching-asset allocation strategy may require either no rebalancing or be focused entirely on goal achievement as opposed to arbitrary tactical trades.

Asset pricing. The novel asset-pricing model would be more in line with the Arrow-Debreu state-dependent cash-flow approach (Arrow 1964; Debreu 1959) or the stochastic discount factor approach of Cochrane (2014). In these models, the price of say the state-dependent security provides the current value of a future cash flow (as opposed to an expected return) experienced in a specific state of the world. In a GBI world, the value of an asset will depend on the timing of the cash flow(s) and the nature of the cash flow(s). But one complication is not anticipated in previous asset-pricing academic models because previous models also are focused on wealth maximization as the goal. The safe asset for one goal (e.g., retirement bonds or SeLFIES) would be risky for another goal (e.g., saving for a child's college) because the cash flows for college are completely different in terms of both timing (i.e., for four years when a child turns 18) and nature (i.e., tied to tuition inflation) from those of retirement. Das et al. (2018) examine asset allocation recommendations in a multi-goal setting, which may provide an interesting pathway to a multi-goal, cash-flow focused asset-pricing model. Therefore, it is critical to develop a new asset-pricing approach that is based on a world with multiple stochastic goals and focuses on providing stochastic discount factors that capture this nuance.

Regulation. Regulation needs to be based on goal achievement and not on arbitrary asset allocations that rotate into risky assets that guarantee neither a retirement wealth or income level. Safe harbor should be offered only to those instruments and products that deliver the desired level of goal-linked cash flows risk-free to investors. Regulation will need to be goal specific. An example of such enlightened regulation is to be found in Europe in the regulation of DB pensions. The Dutch Central Bank, for example, has extremely stringent cash-flow focused and potentially onerous regulations of DB pensions. The regulations can require additional contributions, changes in asset allocation, and even a reduction of pensions if the goal cannot be achieved. A pension fund's degree of riskiness is determined by its funded status and by the proportion of the goal that is hedged. Some of these measures might be considered draconian (and can have unintended consequences, such as discouraging innovation in pension fund management for fear of upsetting the regulator). But such regulations force investors to focus on goals rather than more-complex asset allocations that profess higher expected returns, which also exacerbates the riskiness of the portfolio in crisis events. It is probably no surprise that the funded status of Dutch and Danish DB pensions is closer to 100 percent (i.e., sufficient assets to fund liabilities) than DB pensions in countries such as the United States, the United Kingdom, or Japan. As described above, there is currently no agreement on how public DB pensions should be regulated in the United States. Moreover, the regulation of public DB plans is markedly different from the regulation of corporate plans. This difference also must be resolved to ensure both types of DB pensions are able to deliver retirement security to their participants who depend on guaranteed pensions in retirement (especially given how the coronavirus has negatively affected individual finances).

CONCLUSIONS

This article details how an assumption made in one of finance theory's seminal papers has led to interesting challenges in the achievement of individual and institutional investment goals. The assumption made in this seminal paper—that we can (potentially) accurately forecast future returns of assets, the author's caveats notwithstanding—has not been borne out in reality. The recent economic and market chaos created by the novel coronavirus highlights the need to recast the original investment problem with a novel twist.

By focusing on the fact that GBI is now the norm, and that investors have diverse stochastic goals with highly varied cash flows, this article recommends that the academic and practitioner communities need to focus on goal

achievement and matching cash flows rather than forecasts of expected returns, optimized portfolios, and naïve rebalancing. This requires rethinking the safe asset for each goal (including the need to innovate to create these instruments), a change in the dynamic rebalancing of portfolios (so that they are goal-focused based on the appropriate risk-free asset for each goal), creation of a new asset-pricing model (one that captures the fact that investors have many stochastic goals and one that is based on the timing and nature of an asset's cash flows), and enhanced regulations that are goal-focused. A novel coronavirus is one that has not been seen in humans before. Working with the dictum that one should "never let a crisis go to waste," maybe it is time for a novel investment approach.

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ENDNOTES

1. However, the theoretical recommendation from Tobin (1958) would suggest two-fund separation between the risk-free asset and the risky market portfolio, with each split determined by the investor's degree of risk aversion.
2. And if they do, they are based purely on luck and not a reliable process. See Baker et al. (2018).

REFERENCES

Arrow, K. J. 1964. The Role of Securities in the Optimal Allocation of Risk-bearing. *Review of Economic Studies* 31, no. 2: 91–96.

Aubry, J. P., C. Crawford, and K. Wandrei. 2018. Stability in Overall Pension Plan Funding Masks a Growing Divide. Issue brief, Center for State and Local Government Excellence.

Baker, B., M. Dieschbourg, D. McIntyre, and A. Muralidhar. 2018. The Mythology of Rebalancing: A Random Walk Down Performance and Risk Management. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2899422.

Bodie, Z., R. Fullmer, and J. Treussard. 2010. Unsafe at Any Speed? The Designed-in Risks of Target-Date Glide Paths. *Journal of Financial Planning* 23, no. 3: 42–48.

Breeden, D. T. 1979. An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities. *Journal of Financial* Economics 7, no. 3: 265–296

Cochrane, J. H. 2014. A Mean-Variance Benchmark for Intertemporal Portfolio Theory. *Journal of Finance* 69, no. 1 (February): 1–49.

Correia, Margarida. 2019. Target-Date Funds Fuel Healthy Growth. *Pensions & Investments* (October 28). https://www.pionline.com/special-report/target-date-funds-fuel-healthy-growth.

Cumbo, J., and R. Wigglesworth. 2019. 'Their House is on Fire': The Pension Crisis Sweeping the World. *Financial Times* (November 17). https://www.ft.com/content/c95deea4-03e2-11ea-9afa-d9e2401fa7ca.

Das, S., H. Markowitz, J. Scheid, and M. Statman. 2010. Portfolio Optimization with Mental Accounts. *Journal of Financial and Quantitative Analysis* 45, no. 2: 311–334.

Das, S., D. Ostrov, A. Radhakrishnan, and D. Srivastav. 2018. A New Approach to Goals-Based Wealth Management. *Journal of Investment Management* 16, no. 3: 1–27.

Debreu, G. 1959. *The Theory of Value: An Axiomatic Analysis of Economic Equilibrium*. Wiley: New York.

Elton, Edwin J., and Martin J. Gruber. 1992. Optimal Investment Strategies with Investor Liabilities. *Journal of Banking & Finance* 16, no. 5: 869–890.

Fisher, Lawrence, and Roman L. Weil. 1971. Coping with the Risk of Interest Rate Fluctuations: Returns to Bondholders from Naïve and Optimal Strategies. *Journal of Business* 44, no. 4: 408–431.

Housel, Morgan. 2015. The Blind Forecaster: Who Pays These People? *Motley Fool* (February 25). http://www.fool.com/investing/general/2015/02/25/the-blind-forecaster.aspx.

Kóbor, Ádám, and Arun Muralidhar. 2020. Ensuring Retirement Security with Simple GLIDeS (May 7, 2019). *Financial Analysts Journal*, forthcoming. https://ssrn.com/abstract=3384140.

Leibowitz, Martin L., and A. Weinberger. 1981. Optimal Cash Flow Matching: Minimum Risk Bond Portfolios for Fulfilling Prescribed Schedules of Liabilities. In *Investing: The Collected Works of Martin L. Leibowitz*, Frank J. Fabozzi (ed.). (Chicago: Probus Professional, 1992), 739–752. Originally published by Salomon Brothers, Inc., 1981.

Levitan, S. M., and R. C. Merton. 2015. Defined-Contribution Retirement Fund Investment Strategies: An Appropriate Default? Presented at the Actuarial Society of South Africa's 2015 Convention, November 17–18, 2015, Johannesburg, South Africa. http://www.colourfield.co.za/defined-contribution-retirement-fund-investment-strategies-an-appropriate-default/ every.

Malanga, Steve. 2016. Covering Up the Pension Crisis. *Wall Street Journal* (August 25). https://www.wsj.com/articles/covering-up-the-pension-crisis-1472164758.

Mantilla-Garcia, D., M. Martinez-Carrasco, M. Garcia-Huitron, and A. Muralidhar. 2020. From Defined-Contribution Towards Target-Income Retirement Systems (April 17). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3585154.

Markowitz, H. 1952. Portfolio Selection. *Journal of Finance* 7, no. 1: 77–91.

Merton, R. C. 1983. "On Consumption Indexed Public Plans." In *Financial Aspects of the United States Pension System*," Z. Bodie and J. Shoven (eds.). Chicago: University of Chicago Press.

———. 2007. "The Future of Retirement Planning." In *The Future of Life-Cycle Saving & Investing*, Z. Bodie, D. McLeavey, and L. B. Siegel (eds.). Charlottesville, VA: Research Foundation of the CFA Institute.

Merton, R. C. 2012. "Observations on Financial Education and Consumer Financial Protection." In *Life-Cycle Investing: Financial Education and Consumer Protection*, Z. Bodie, L. B. Siegel, and L. Stanton (eds.). Charlottesville, VA: Research Foundation of CFA Institute.

Merton, R. C., and A. Muralidhar. 2017. Time for Retirement 'SeLFIES'? *Investments and Pensions Europe* (April). https://www.ipe.com/ipe-at-20-time-for-retirement-selfies/10018263.article.

Muralidhar, A. 2016. GBI = Gimme Better Instruments. An Innovation to Simplify Complex Investment Approaches. *Investments & Wealth Monitor* 31, no. 3: 54–57.

Muralidhar, A. 2018. *Fifty States of Gray: An Innovative Approach to the Defined Contribution Retirement Crisis*. Greenwood Village, Colorado: Investments & Wealth Institute.

Muralidhar, A., K. Ohashi, and S. Shin. 2014. The Relative Asset Pricing Model: Implications for Asset Allocation, Rebalancing, and Asset Pricing. *Journal of Financial Perspectives* 3, no. 1: 197–224.

Pensions & Investments. 2016. Actuarial Overbearing (September 5). https://www.pionline.com/article/20160905/PRINT/309059999/actuarial-overbearing.

Sharpe, W. 1964. Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk. *Journal of Finance* 19, no. 3: 425–442.

Sharpe, W., and L. Tint. 1990. Liabilities—A New Approach. *Journal of Portfolio Management* 16, no. 2: 5–10.

The Economist. 2017. Analysts Struggle to Make Accurate Long-Term Market Forecasts (August 31). https://www.economist.com/finance-and-economics/2017/08/31/analysts-struggle-to-make-accurate-long-term-market-forecasts.

Tobin, James. 1958. Liquidity Preference as Behavior Towards Risk. *Review of Economic Studies* 25, no. 2): 65–86.

Waring, B., and D. Whitney. 2009. An Asset–Liability Version of the Capital Asset Pricing Model with a Multi-Period Two-Fund Theorem. *Journal of Portfolio Management* 35, no. 4: 111–130.

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