Corporate Model Governance & Validation

Corporate Credit Services

Validation Type: Full | *Model Risk Rank: 2*

Independent Technical Validation

Advice Track

Summary:

This document describes Corporate Model Governance and Validation (CMGV) group's validation of Advice Track (AT), an investment option offered by Wells Fargo's Wealth, Brokerage and Retirement (WBR) business line as an option to 401k plan sponsors. The model underlying AT is Morningstar Associates' (MA) proprietary risk assessment, asset allocation and portfolio construction model implemented in their Retirement Manager simulation tool. WBR's role is to collect the demographic and balance information and to execute the portfolio asset allocation and rebalancing as instructed by MA. In its review, CMGV assessed the capital market assumptions (CMAs) used in the model for their alignment with industry views and the Monte Carlo engine output for exhibiting the required properties. The CMAs are derived based on a blend between an econometric model and the quantitative framework of the Black-Litterman model (BLM). In combination with mean-variance optimization, the BLM leads to more stable and intuitive portfolios being built. Other assumptions employed in the asset allocation model, Retirement Management (RM), such as: (i) efficient market hypothesis for equity price behavior, (ii) use of arithmetic and real returns for evaluating asset performance, and (iii) a reference inflation rate of 2%, are customary for this type of model. CMGV performed statistical tests to verify that the outputs of the Monte Carlo simulation exhibit the required statistical properties. CMGV recommends the approval of AT for its intended use, with the caveats in the recommendations detailed herein.

Owner:	***Cristina Bucur-Drugan**, VP, CMGV*
Manager:	***Rafa Santander**, Director, CMGV*

Version Control:

Version	***Date***	***Owner***	***Description***
1.0	*February 23, 2010*	*Cristina Bucur-Drugan*	*Initial version*
1.1	*March 1, 2010*	*Cristina Bucur-Drugan*	*Comments by Rafa Santander*
1.2	*April 5, 2010*	*Cristina Bucur-Drugan*	*Comments by Doug Gardner*
1.3	*April 12, 2010*	*Cristina Bucur-Drugan*	*Comments by Rafa Santander*
1.4	*April 20, 2010*	*Cristina Bucur-Drugan*	*Comments by David Murphy*
1.5	*June 16, 2010*	*Cristina Bucur-Drugan*	*Comments by Morningstar Associates*
2.0	*June 17, 2010*	*Cristina Bucur-Drugan*	*Release version*

Contents

1 Executive Summary

1.1 Introduction

The Wealth, Brokerage, & Retirement (WBR) business line offers Advice Track as an investment option to 401(k) plan sponsors. This investment option automatically allocates the participant's assets among mutual funds and/or collective investment funds with varying degrees of investment risk, based on the demographics of the participant such as the individual's age and expected retirement date. As of February 2010, WBR has approximately 3,700 clients (401(k) plan sponsors) equating to a total of approximately several million plan participants who could elect to use Advice Track as one of their investment choices. To date, 664 out of the 3,700 clients have actually added Advice Track to their line-up, covering approximately 54,000 participants with aggregate assets totaling approximately $700 million.

1.2 Model Description

Advice Track (AT) is a tool that provides investment advice for defined contribution retirement plans. AT's underpinning fundament is Morningstar Associates' (MA) own proprietary asset allocation and portfolio construction methodology, composed of three main elements:

1. Risk Assessment and Asset Allocation. This component assesses the risk tolerance and risk capacity of the participant and recommends an appropriate asset mix. The risk assessment is based on up to three factors: (a) investment horizon, the number of years until retirement (b) risk capacity, the participant's capacity for taking on risk using an asset/liability model, and (c) outside assets, any retirement assets held outside of the plan. MA's methodology enables that the participant's risk tolerance be evaluated with a risk questionnaire that can impact the allocation to stock by +/-10%. However,

this capability is not used by WBR as part of Advice Track.

In order to avoid peculiarities of any single asset allocation approach, MA's methodology is based on a combination of heuristics. The pre-retirement equity allocation is determined by combining the investment horizon approach with the human capital with liabilities framework. The value of human capital is defined as the fair value of a bond with cash flows equal to a person's future stream of labor income. For example taking a loan from a 401(k) plan is a cash outflow, while repaying a loan from a 401(k) or the net proceeds from downsizing a home before retirement is a cash inflow (modeled as negative cash outflow). MA's methodology considers a person's subsistence needs as liabilities and any human capital surplus allocated toward retirement savings. Therefore, the net human capital (human capital net of liabilities) is calculated as the present discounted value of all contributions (including partner and/or employer) to all retirement accounts held by the participant.

For post-retirement, an asset/liabilities framework is employed as well. The assets consist of current balances in retirement accounts, the streams of future savings to retirement accounts, projected Social Security benefits, and other future cash inflows (such as payments from defined benefit retirement plans). The liabilities are the annual retirement goal dollar amounts. All cash flows are calculated in real, current dollar terms. Cash flows in retirement years are adjusted by the probability of being alive during the years in which they occur. Only in the managed by MA option the participant's allocations are updated and rebalanced quarterly, as needed.

2. Income and Wealth Projection. This component provides a probabilistic assessment of the participant's prospects for accumulated wealth at retirement. Using an enhanced Monte Carlo simulation technique, MA models the probability distribution of the participant's accumulated wealth during the pre-retirement years. The simulation includes the balances and cash flows of all retirement accounts for which the participant has provided information. The simulated returns on each account are

based on asset mix, expenses, and MA's probabilistic model of asset class returns. For the accounts on which MA makes asset mix recommendations, during the pre-retirement years, the asset mix is varied during the simulation by applying the risk assessment and asset allocation model discussed above to the simulated data. During retirement, the participant is assumed to continue to invest at the final asset mix and to draw down the portfolio until either death or exhausting the retirement assets. For each possible year of death, the probability of success is calculated as the percentage of simulations that have a successful outcome for the year. The overall probability of success is calculated as the weighted average of these probabilities, where the weight for each year is the probability that death occurs that year. Death probabilities are obtained from RP-2000 standard mortality tables.

3. Portfolio Construction. Once the asset mix has been determined, a portfolio of the plan investment options is constructed that executes the assigned asset mix. The projections used by MA assume certain rates of return, correlation, and standard deviation for two major asset classes, stocks and bonds, based on an analysis of historical returns and forward-looking expectations. The forward-looking expectations are based on a multi-factor model that connects the real returns of each asset class to macroeconomic and market factors such as the interest rate curve and the premium historically accorded to small-cap stocks. Nineteen fund investment options covering bonds, large and small cap equity, real estate and international asset categories are available to plan participants for portfolio allocation.

1.3 Business Purpose

WBR submits to MA the demographics information, investment amount, deferral rate, salary, outside assets and pension information for each participant of the client. MA then runs the information through their asset allocation model (Retirement Manager (RM)) and submits a report back to WBR. WBR takes the instructions from MA on how to invest (asset allocate) and/or rebalance the participant's portfolio and executes the instructions. In other words, MA runs their proprietary model to determine asset allocations for WBR clients.

1.4 Validation Scope and Methodology

This model has no impact on Wells Fargo's books. The assets are in a trust for each client and are not part of Wells Fargo's financial statement reporting. The model has no impact on economic and regulatory capital either since no capital is allocated for these portfolios. However, AT has an impact in tactical decision making due to the frequent use in investment rebalancing decisions for 401(k) participants of existing clients and investment allocation decisions for 401(k) participants of new clients. There is reputational risk associated with the model if a client experiences large losses in their asset base because of the investment allocation decisions implemented via the AT process.

CMGV's validation consisted of the review of documents submitted by MA (refer to the Bibliography) combined with independent statistical tests. The purpose of the validation was to evaluate the overall conceptual soundness of the model and specifics of how the model operates. The Capital Market Assumptions (CMA) were reviewed as to their alignment with industry and academia views. In addition, CMGV performed a variety of statistical tests to verify that the outputs to the Monte Carlo simulation exhibit the required statistical properties.

1.5 Critical Analysis

As stated in the validation scope section, CMGV's review focused on the CMAs and the Monte Carlo engine. The results of statistical tests performed by CMGV are presented.

Comments are also made on other components of the model, such as salary projection and glide-path function. A few test cases were reviewed to assess the reasonableness of model output.

1.5.1 Asset Class Universe

The universe employed for portfolio asset allocation consists of the three broad categories employed in the industry: equities, fixed income and cash. These are further divided by market, capitalization and risk (value vs. growth), resulting into 12 asset sub-classes. CMGV reviewed other pension funds' asset mix and notes that those include inflation-sensitive assets, such as real estate, inflation-linked bonds, commodities and infrastructure, as an expansion to the range of investment options (refer to [7], [25], [31], and [30]).

1.5.2 Risk Assessment and Asset Allocation

MA's asset allocation methodology is based on a combination of heuristics. The pre-retirement equity allocation is determined by combining the investment horizon approach with the human capital with liabilities framework. The value of human capital is the fair value of a bond with cash flows equal to a person's future stream of labor income. MA's methodology also incorporates a person's subsistence needs which are considered as liabilities, any surplus being allocated toward retirement savings. For example taking a loan from a 401(k) plan is a cash outflow, while repaying a loan from a 401(k) or the net proceeds from downsizing a home before retirement is a cash inflow (modeled as negative cash outflow). MA then calculates the net human capital (human capital net of liabilities) as the present discounted value of all contributions (including partner and/or employer) to all retirement accounts held by the participant.

Post-retirement, an asset/liabilities framework is employed as well. The assets consist of current balances in retirement accounts, the streams of future savings to retirement accounts, projected Social Security benefits, and other future cash inflows such as payments from defined benefit retirement plans. The liabilities are the annual retirement goal dollar amounts (80% of pre-retirement salary). All cash flows are calculated in real, current dollar terms. Cash flows in retirement years are adjusted by the probability of being alive during the years in which they occur.

A recent study on retirement risks (refer to [22]) on US middle class concludes that, compared to younger generations, they hold more wealth in housing. The challenge is to convert these non-financial assets into income sources for retirement. The study was based on data collected in a Survey of Consumer Finances performed in 2004. The survey shows that housing values are treated as assets (net equity only) and not as income.

1.5.3 Capital Market Assumptions

The Capital Market Assumptions (CMA) stem from the use of the Black-Litterman Model (BLM) (refer to [6]). The BLM methodology's novel approach to asset allocation is that it provides a quantitative framework for (i) specifying an intuitive prior based on the CAPM equilibrium market portfolio, as a starting point to the estimation of asset returns and (ii) incorporating investor's views about the outlook for his/her investment universe. The benefit of using BLM in combination with mean-variance optimization is that more stable and intuitive portfolios are built (refer to [6]).

The BLM is based on the assumptions of the weak Efficient Market Hypothesis (EMH) (which states that past price information is not informative in predicting future prices) and that expected returns are random variables for which a probability distribution can be inferred.

MA first develops an econometric model to forecast long-term asset log-returns and log standard deviation based on factors such as credit spread, term structure, value and size factors, and exchange rates. The model relies on historical, current and forecast market indices data representative of each asset class. Multifactor models have the advantage of modeling the returns of all assets accounting for a set of common return drivers and estimating the covariances between asset returns. Other statistical methods used in industry are based on Monte Carlo simulations of risk and return using historical data ([26]), historical statistical approaches (e.g., sample estimators) and time series estimators (refer to [16]).

Given the covariance matrix and an a priori defined optimal portfolio based on market capitalization (assuming equilibrium and normally distributed arithmetic returns), the set of implied expected excess returns are backed out (this process is called “reverse optimization”). The average risk aversion factor set at 2.5 is in line with industry assumptions (see [12]). The market capitalization portfolio can be replaced with a reference portfolio that is weighted (“biased”) such that is practical for the investor (refer to [11], [15], and [5]).

The estimated implied excess returns are then combined with a set of investor “views” on the market outlook within Theil-Goldberger’s mixed estimation framework. The BLM “views” are developed using quantitative and/or qualitative methods and include associated probabilities that show the investor’s confidence in his/her beliefs about the market’s future performance. Based on the implied returns and the investor “views”, a set of a posteriori expected excess returns and covariance matrix are estimated. The set of BLM outputs are input into an optimization engine to generate the efficient frontier and an efficient portfolio is selected. Unlike a standard mean-variance optimization, the BLM, if properly implemented, will always generate an optimal portfolio whose weights are relatively easy to understand ([12]).

The main challenges of the BLM are related to acquiring some of the input data (for example index data for illiquid asset classes) and the formulation of the investor’s “views” on the market ([32]). Some criticism was expressed about the "reverse optimization" method in [10]. The paper notes that the validity of the implied expected returns depends on the covariance matrix used as an input and provides examples for which the error magnitude is measured.

1.5.4 Monte Carlo Engine

The purpose of CMGV's statistical testing was to examine the statistical properties of the Monte Carlo engine output. The characteristics of interest are the expected returns and the volatility of the 12 asset classes considered in AT. In addition, the expected return and volatility of three portfolios of various risk profiles (low, medium and high equity) were analyzed.

The Monte Carlo simulation scenarios are generated based on the assumption that the log asset returns have a multivariate normal distribution. Based on statistical tests (Kolmogorov-Smirnov, Anderson-Darling, Mardia's skewness and kurtosis) performed by CMGV, the hypotheses that the 12 asset classes return series follow a joint multivariate normal distribution and that each of the asset class returns is normally distributed at the 1% significance level was rejected.

The returns produced by the Monte Carlo engine were evaluated against the CMAs. Based on t-test results, CMGV concludes that the returns estimated for the 12-asset classes based on 50,001 runs are not statistically significantly different from the expected returns at the 1% confidence level. In addition, three test portfolios with various risk profiles (low, medium and high) were run through the Monte Carlo engine. CMGV calculated portfolio estimated returns and standard deviation and concludes that the estimated values align closely with the expected values, respectively.

The Monte Carlo engines generates random numbers from a multivariate normal distribution by first generating independent normal distributions that are correlated using the Cholesky decomposition of the correlation matrix. For this to be possible, the correlation matrix has to be positive semi-definite, that is, all eigenvalues have to be positive. CMGV examined the eigenvalues and concludes that the correlation matrix is positive semi-definite.

As part of the validation process, CMGV asked MA to run a few test cases to assess the reasonableness of the RM output. For comparison purposes, four cases with various demographic profiles, balances and retirement horizons were run with and without outside assets of $1MM.

The use of arithmetic asset returns, real returns and a reference inflation rate of 2% are in line with standard industry practice and with market-implied inflation from TIPS (Treasury Inflation Protected Securities).

1.5.5 The Glide-Path

The glide-path is how a portfolio's asset allocation changes over time, and is usually associated with Target-Date Funds (TDFs). It is important to understand not only how a glide-path was developed, but how it is managed and rebalanced ([13]). RM's glide-path is characterized by an equity target that decreases with the investment horizon and remains at 40% through retirement. Recent research argues that a single glide-path for each target date does not serve the participant best, and that mutliple glide-paths taking into account varying levels of wealth accumulation ('undersaved' or 'oversaved') are needed closer to retirement.

The effectiveness of glide-path choices can be assessed by benchmarking. Current approaches include comparisons of the performance of TDF to peer groups,[1] but recent research suggests two additional benchmarks: one that focuses on the return required to ensure sufficient retirement savings and a second that compares the fund performance

[1] For example Lipper peer group, a custom peer-group benchmark, a custom index benchmark, and TDF indices.

to the fund manager's return expectations (refer to [26]).

1.5.6 Documentation

During the course of the review, CMGV found that the documentation about RM was described in multiple documents, which in some instances contained inconsistencies and outdated model parameters or assumptions information.

1.6 Recommendations

CMGV is issuing the following recommendation at this time:

1. WBR should ensure that the documentation for AT is consolidated and includes the current CMAs and other details pertinent to the RM methodology on an ongoings basis.

1.7 Conclusion

From the information and methodology documents received from MA, CMGV concludes that the models used in AT is conceptually sound, theoretically supported and align with standard theory sanctioned in academia and generally utilized in industry. Specifically, CMGV has the following comments:

- The use of the Black-Litterman model to derive the CMAs leads to building more stable and intuitive portfolios than plain mean-variance optimization. It also allows incorporating investor views with prior information.
- Instead of relying on any one methodology, MA employs a variety of heuristics to determine the portfolio asset allocation.
- The Monte Carlo engine output exhibits the expected statistical properties.

2 Retirement Management Model Methodology

2.1 Data

The plan participant provides to WBR demographics and balance information related to retirement accounts. These inputs include age, salary, retirement contribution rate and balance of the employer-sponsored retirement plan, outstanding loans from the retirement plan, balances and contribution of outside retirement accounts, and expected pensions. In addition, the participant completes a questionnaire that outlines his/her risk profile. Historical asset return data from MA's database is used for the asset class return model.

2.2 Capital Market Assumptions

The assumptions about rates of return, correlation and standard deviation for the main two asset classes - stocks and bonds - are based on analysis of historical returns in MA's database and forward-looking expectations. The forward looking expectation is modeled with a multi-factor (econometric) model in which the real returns (net of inflation) of each asset class are predicted by market and macroeconomic factors, such as credit spread, term structure, value, size factors and exchange rates. Asset-class returns are assumed log-normally, independently and identically distributed.

Table 1 lists the asset classes index proxies, risk and return assumptions implemented for the AT process and provided by MA to CMGV (refer to [4]):

2.3 Risk Assessment and Asset Allocation

MA's asset allocation methodology is based on a combination of heuristics. The pre-retirement equity allocation is determined by combining the investment horizon approach with the human capital with liabilities framework. The value of human capital is the fair

Asset Class	Proxy	Expt'd Real Return (%)	Std. Deviation (%)
Large-Cap Growth	Russell LCG	7.06063400%	20.26%
Large-Cap Value	Russell LCV	6.39065640%	16.10%
Mid-Cap Growth	Russell MCG	8.02925170%	24.53%
Mid-Cap Value	Russell MCV	6.91212890%	18.49%
Small-Cap Growth	Russell SCG	9.80270090%	27.53%
Small-Cap Value	Russell SCV	8.39938990%	20.53%
Foreign Developed	MSCI EAFE	7.49988390%	19.49%
Emerg Mkts	MSCI Emerging Markets	10.38842540%	26.59%
Inv. Gr. Bonds	BarCap 1-3, Interm. & LT Govt Credit	2.35000960%	5.20%
Foreign Bonds	CITI Non US world govt bond	3.47570720%	8.99%
High Yield Bonds	BarCap Corp HY	3.48350640%	9.62%
Cash	91-day T Bill	0.89586760%	1.35%

Table 1: Risk and Return Estimates by Asset Class (Source: MA)

value of a bond with cash flows equal to a person's future stream of labor income. MA's methodology also incorporates a person's subsistence needs which are considered as liabilities, any surplus being allocated toward retirement savings. For example taking a loan from a 401(k) plan is a cash outflow, while repaying a loan from a 401(k) or the net proceeds from downsizing a home before retirement is a cash inflow (modeled as negative cash outflow). MA then calculates the net human capital (human capital net of liabilities) as the present discounted value of all contributions (including partner and/or employer) to all retirement accounts held by the participant.

Post-retirement, an asset/liabilities framework is employed as well. The assets consist of current balances in retirement accounts, the streams of future savings to retirement accounts, projected Social Security benefits, and other future cash inflows such as payments from defined benefit retirement plans. The liabilities are the annual retirement goal dollar amounts (80% of pre-retirement salary). All cash flows are calculated in real, current dollar terms. Cash flows in retirement years are adjusted by the probability of being alive during the years in which they occur.

Recommended asset mixes run from 100% to 2% fixed income (0% to 98% stock) and are determined based on the investment horizon, risk capacity and retirement assets outside the plan (refer to Figure 1). Each participant is assigned to one of 99 possible risk points that are mapped to an asset mix. The baseline allocation to stocks, derived from the investment horizon, is adjusted +/- 15% based on the plan participant's existing retirement accounts' stock holdings and then further adjusted to account for outside accounts.

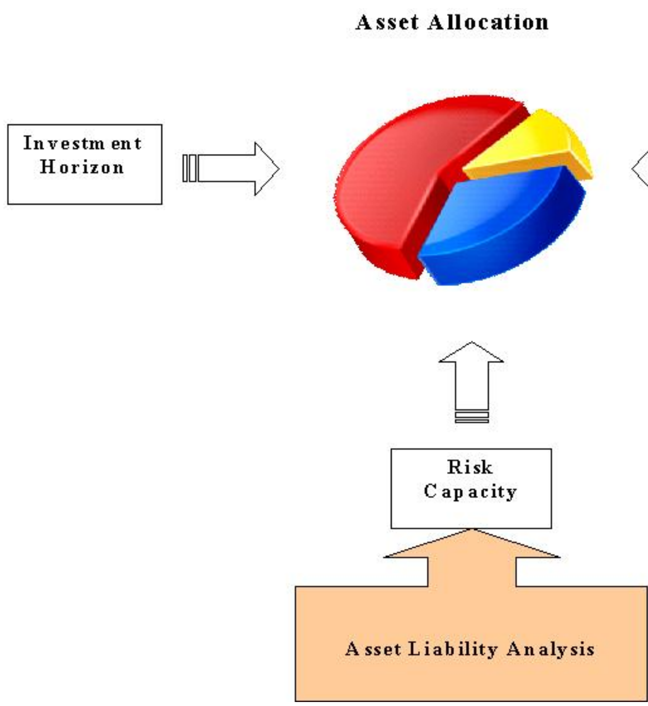

Figure 1: Asset Allocation Process (Source: CMGV)

Custom funds included in the plan for which MA does not have data will not be included in the investment strategy managed by them. If the funds are managed by the participant, the funds' asset allocation to equity will be considered in the asset allocation process developed by MA (refer to [18]).

The 12 asset classes and sub-classes (based on type, capitalization[2] companies , and growth[3]) to which portfolio dollars are allocated in the current implementation of RM are listed in Table 2 below. Stock is allocated among the shown percentages based on an

[2] For purposes of classifying US stock investments, MA assigns large-capitalization, mid-cap and small-cap stocks their approximate market weightings, allocating 70% to large-cap, 20% to mid-cap, and 10% to small-cap.

[3] This is based on market weightings dividing assets equally between value and growth styles.

equilibrium model. The distribution of investment options in the portfolio among the three broad categories of stock, bond and cash are assessed at the fund level holdings. Refer to [18] for more details.

<table>
<tr><th colspan="3">Asset Class/Sub-Class</th></tr>
<tr><td rowspan="8">Stock</td><td>US Large Growth (24.5%)</td><td>US Large Cap Growth</td></tr>
<tr><td rowspan="2">US Mid or Small Cap growth (10.5%)</td><td>US Mid Cap Growth</td></tr>
<tr><td>US Small Cap Growth</td></tr>
<tr><td>US Large Value (24.5%)</td><td>US Large Cap Value</td></tr>
<tr><td rowspan="2">US Mid or Small Cap (10.5%)</td><td>US Mid Cap Value</td></tr>
<tr><td>US Small Cap Value</td></tr>
<tr><td rowspan="2">International Stock (30%)</td><td>Non-US Developed Market Stocks</td></tr>
<tr><td>Emerging Markets Stock</td></tr>
<tr><td colspan="2" rowspan="3">Fixed Income</td><td>Investment Grade Bonds</td></tr>
<tr><td>High Yield Bonds</td></tr>
<tr><td>Non-US Bonds</td></tr>
<tr><td colspan="3">Cash</td></tr>
</table>

Table 2: Asset Class Allocation (Source: MA)

As of 10/12/2009, 83.3% of participants were allocated to equity by more than 61% (refer to Figure 2).

In some configurations of RM there is a managed by participant option, in which case MA will suggest a sub-asset class allocation, as follows: US large-cap stocks - 49%, US mid/small cap stocks - 21%, and internation stocks - 30%. However, it is at the participant's latitude to follow the suggestions (see [18]). Only in the managed by MA option the participantŠs allocations are updated and rebalanced quarterly.

2.3.1 The Glide-Path

Assuming mean-reverting markets, higher risk is favorable for longer-horizon investors. As the investment horizon contracts, the risk should decrease. The basic approach of target maturity funds is a "shifting" asset allocation, which over time, moves the investor from a portfolio with a higher-than-average risk to a portfolio with lower-than-average risk.

Percentage Equity	Percentage of Participants	Average Age
0 – 10	0.03	54
11 – 20	0.00	N/A
21 – 30	0.19	63
31 – 40	3.05	62
41 – 50	6.09	61
51 – 60	7.79	54
61 – 70	32.16	39
71 – 80	14.50	35
81 – 90	29.24	33
>90	6.94	28

Note: This chart is for illustrative purposes only.

Figure 2: Advice Track Participant Allocation as of October 2009 (Source: MA)

The path over which the fund's asset allocation travels is commonly referred as the "equity glide-path". MA's glide-path is developed such that it is applicable to the largest possible pool of investors and has the following characteristics:

- Uses actual investor data, including factors like age, life expectancy, salary, expected social security benefits and contribution rate.
- The goal is the income target as opposed to the investor's individual risk tolerance.
- Is stress-tested with actual investor profiles under various market conditions.

The data, consisting of MA's defined-contribution investors, is segmented into three age groups: 25-35, 36-45, and 46-60. Each such group is treated as a "composite investor" with its own age, salary, future assets, future liabilities and risk capacity, based on the assumptions:

- The age is the average age of investors in the segment.
- The salary is the median salary of investors in the segment.

- The social security income and mortality rates are considered for a retirement age of 65 (no mortality risk is assumed prior to age 65).
- Savings rate is assumed at 10%.
- The retirement income goal is set at 70% of final pre-retirement salary.

The equity target for a given investment horizon is defined as

$$x(h) = x_0 + (x_T - x_0)\left(\frac{min(h, h_T)}{h_T}\right)^{\omega},$$

where h is number of years until retirement, x_0 is the allocation to equities at retirement, h_T is the largest horizon for which x varies with age, x_T is the allocation to equities h_T years before retirement, and ω is a parameter between 0 and 1 that controls the curvature of the relationship. For each "composite investor" a glide-path function is defined and a simulation of the investor's experience from the beginning of the wealth accumulation through retirement is analyzed over 1,000 market scenarios. From the several glide-path configurations studied, the one with the chance of 95% success for all three "composite investors" is selected[4]. Figure 3 shows the final glide-path profile:[5]

2.4 Income and Wealth Projection

Distributions of accumulated wealth (during pre-retirement years) and sustainable retirement income, respectively, and probabilities of achieving retirement goals are estimated in RM using a model based on the Monte Carlo simulation technique. The inputs to the model are balances and cash flows of all retirement accounts reported by the participant. Each account's return is simulated using the asset mix, expenses and MA's probabilistic model of asset class returns (net of expenses).

[4] In the cases of tied glide-paths at the 95% confidence level, the one with the best results at 50th percentile was chosen.

[5] The following parameter set was used to calculate the final path: $x_0 = 40$, $h_T = 20$, $x_T = 85$, $\omega = 0.834$.

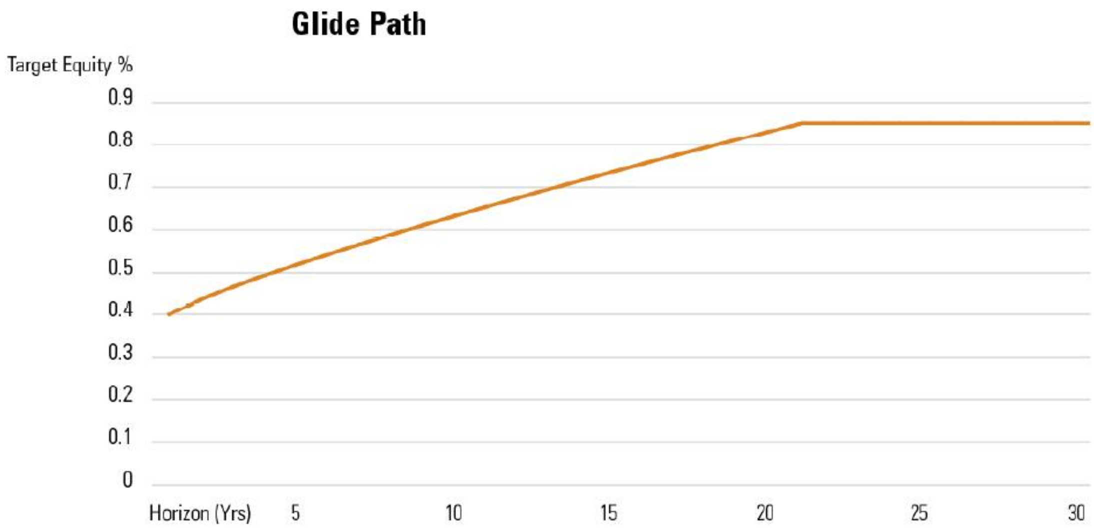

Figure 3: The RM Glide-Path (Source: MA)

For the pre-retirement years, a simulation of asset mix is run by applying the risk assessment and the asset allocation described in the previous section. Two assumptions are made during retirement: (i) that the participant will continue to invest at the final asset mix and (ii) that withdrawals will be made until depletion of the retirement assets or death. A strategy is successful if it generates enough income for the remaining lifetime of the plan's participant. The probability of success

$$p_s^i = 100 * n_s^i / n,$$

where n_s^i is the number of simulations for which a successful outcome for the year is obtained and n is the number of total simulations. Then, the overall probability of success (p_s) is defined as a weighted average of the probability of success for each year, with the probability of death[6] for each year (p_d^i) as weights:

$$p_s = \Sigma p_d^i * p_s^i.$$

[6] Death probabilities are calculated from standard mortality tables (refer to [23]).

Salary growth is projected based on a fourth degree polynomial model as a function of age:

$$SalaryIndex(t) = \begin{cases} a_1 + a_2 t + a_3 t^2 + a_4 t^3 + a_5 t^4, & \text{if } t_0 \leq t \leq t_1 \\ a_1 + a_2 t_1 + a_3 t_1^2 + a_4 t_1^3 + a_5 t_1^4, & \text{if } t_1 \leq t, \end{cases}$$

where $t_0 = 16$ is the the minimum working age and $t_1 = 51$ represents the age at which the salary stops growing in real terms and remains steady.

Social Security benefits are calculated based on an algorithm published by the Social Security Administration (refer to [28]).

2.5 Portfolio Construction

Once the asset mix has been designed, a portfolio is constructed with investment options that execute the assigned asset mix. The target is to provide exposure to stocks across the full capitalization range (small, mid, and large) while also achieving a balance between value and growth stocks. A similar diversification is attempted, whenever possible, in the international-equity and fixed-income exposures. Then a fund manager selection is performed based on a numerical score that is developed using quantitative and qualitative assessments (factors such as performance, style or tenure are considered). The final step is selecting the funds such that holdings are complementary and diversification is maximized. Nineteen fund investment options covering bonds, large and small cap equity, real estate and international asset categories are available to plan participants for portfolio allocation. In addition, five target date fund equivalent portfolios were built by MA and are used for comparison purposes to show portfolio performance. Refer to [19], [27] and [20] for full details.

2.5.1 MA Quantitative Score

In order to build the most appropriate portfolio that aligns with the participant's retirement goal, a quantitative score is attached to each investment. This score is a weighted average of three qualitative scores (ranging from minus 5 to plus 5) assigned based on MA's evaluation of the investment's performance (p), risk (r) and cost (c):

$$s = 40\% * p + 30\% * r + 30\% * c.$$

The performance score rates the performance of an investment relative to other investment, giving more weight for recent performance and accounting for the fund manager's tenure (refer to [18]). The risk score is a weighted average of three volatility scores that assess the historical relative performance (through monthly returns) of the investment vs. its category during the last 36 months, 37-72 months and 73-108 months, respectively. Again more weight is given to recent periods. The cost score is based on the most current expense ratio and compares the investment with peers in its category.

Portfolios managed by MA are reviewed quarterly and rebalanced if needed, at least annually, taking into account any significant changes in the participant's situation.

3 Critical Analysis

Relative to the scope of the validation as stated in Section 1.4, CMGV reviewed the model methodology's overall conceptual soundness, the model assumptions and the Monte Carlo engine. The results of statistical tests performed by CMGV are presented. Comments are also made on other components of the model, such as salary projection and glide-path function. A few test cases were reviewed to assess the reasonableness of model output.

3.1 Asset Class Universe

The universe employed for portfolio asset allocation consists of the three broad categories employed in the industry: equities, fixed income and cash. These are further divided by market, capitalization and risk (value vs. growth), resulting into 12 asset sub-classes. CMGV reviewed other pension funds' asset mix and notes that these include inflation-sensitive assets, such as real estate, inflation-linked bonds, commodities and infrastructure, as an expansion to the range of investment options (refer to [7], [25], [31], and [30]).

3.2 Risk Assessment and Asset Allocation

The asset allocation is based on a combinations of heuristics, such as time diversification, risk capacity, decreasing risk tolerance, and human capital. By using a mix, MA does not rely on the peculiarities of any single one approach.

The equity in a home represents a big part of one's wealth. The non-financial assets represent approximately 70% of total assets (excluding Social Security and traditional pension plan benefits) finds a recent actuarial study on retirement risks and solution for the US middle class (refer to [22]). The study concludes that, compared to younger generations, this US population segment holds more wealth in housing. The study was based on data collected in a Survey of Consumer Finances performed in 2004. The survey shows that the industry standard in retirement planning treat housing values as assets (net equity only) and not as income. The challenge is to convert these non-financial assets into income sources for retirement.

3.3 Capital Market Assumptions

Markowitz's asset allocation model assumes that the critical parameters which define market state (expected returns, volatilities and correlations of assets) are known. This assumption together with the common practice of replacing these values with their sample counterparts leads to unjustifiably risky portfolios with weights concentrated in a small number of assets. As a result, in the real world, portfolios obtained in such a way often perform quite poorly (see [6]). In order to estimate expected returns, MA pools the estimates from an econometric model with the Black-Litterman framework.

3.3.1 The Econometric Model

The first step in estimating the expected asset returns, MA develops an econometric model to forecast long-term asset log-returns and log standard deviations based on factors such as credit spread, term structure, value and size factors, and exchange rates. The model relies on historic, current and forecasted data. Multifactor models have the advantage of modeling the returns of all assets accounting for a set of common return drivers and estimating the covariances between asset returns. Other statistical methods used in the industry are based on Monte Carlo simulations of risk and return using historical data ([26]), historical statistical approaches (e.g., sample estimators) and time series estimators (refer to [16]).

3.3.2 The Black-Litterman Model

The BLM is based on the assumptions of the weak Efficient Market Hypothesis (EMH) (which states that past price information is not informative in predicting future prices) and that expected returns are random variables for which a probability distribution can be inferred. While dominating economic theory since Fama (1970), the EMH has been challenged in the last 20 years. MA's stated position is that while believing in the market's efficiency in the long run, they are not strong proponents of the EMH (refer to [17]).

MA's expected return estimation methodology employs the Black-Litterman Model (BLM), developed by Fischer Black and Robert Litterman in 1990. The BLM methodology provides a quantitative framework for (i) specifying an intuitive prior, the CAPM equilibrium market portfolio, as a starting point to the estimation of asset returns and (ii) incorporating investor's views about the outlook for his/her investment universe. By using BLM in combination with mean-variance optimization, more stable portfolios are built (refer to [6]).

Given the covariance matrix and an and an a priori defined optimal portfolio based on market capitalization (assuming equilibrium and normally distributed arithmetic returns), the set of implied expected excess returns are backed out (this process is called "reverse optimization"). Assuming that the market consists of asset classes such as equities, bonds, currencies, by taking the representative indices corresponding to each class, the covariance matrix of these asset classes returns is obtained in this case using the econometric model. Given the returns covariance matrix V, the average risk aversion factor λ (usually set at 2.5) and an a priori defined optimal portfolio based on market capitalization (assuming equilibrium and normally distributed arithmetic returns) with weights w_{eq}, the set of implied expected excess returns are backed out (this process is called "reverse optimization") as

$$E_r = \frac{2}{\lambda} V w_{eq}.$$

The assumptions of λ equal to 2.5 is in line with industry assumptions (see [12]). The market capitalization portfolio can be replaced with a reference portfolio that is weighted ("biased") such that is practical for the investor (refer to [11], [15], and [5]).

The estimated implied excess returns are then combined with a set of investor "views" on the market outlook within Theil-Goldberger's mixed estimation framework. The principle behind the Theil and Goldberger method is to incorporate alternative information, that can be even partial (incomplete) or contradicting, into the classical regression parameter estimation process. The resulting parameter estimates are “credibility weighted” (refer to [8]). A complete description of the mixed estimation method can be found in to ([14]).

The BLM “views” are developed using quantitative and/or qualitative methods and include associated probabilities that show the investor’s confidence in his/her beliefs about the market’s future performance. Based on the implied returns and the investor’s “views”, a set of a posteriori expected excess returns and covariance matrix are then estimated. The set of BLM outputs are input into an optimization engine to build the policy frontier. Unlike a standard mean-variance optimization, the BLM, if properly implemented, will always generate a mathematically optimal portfolio subject to constraints, whose weights are relatively easy to understand ([12]).

The main challenges of the BLM are related to acquiring some of the input data (for example index data for illiquid asset classes) and the formulation of the investor’s “views” on the market ([32]). Some criticism was expressed in [10] about the “reverse optimization” method as it is ignoring the dependence of the validity of the implied returns on the validity of the covariance matrix used. To the extent that the covariance matrix includes an error, the implied expected return also includes the error. The magnitude of the bias in the implied expected market returns, estimated using a simulation, can be compared to the long-term average return of the market, which is around 2%. This is a large error in relative terms.

AT’s CMAs were compared to those assumed in Envision, another retirement planning tool employed in Wells Fargo (legacy Wachovia). The returns used by Advice Track are slightly more conservative.

3.4 Monte Carlo Engine

Recently, Monte Carlo simulation methodologies are frequently being used for retirement planning purposes. The simulation is the process by which probability distributions are arrayed to create path-dependent scenarios to predict outcome results. The methodology is useful when trying to forecast future results that depend on multiple variables (such as asset returns, inflation) with various degrees of volatility. The simulation determines the percentage of times that the investment capital lasts over the retirement horizon (can be 30 o4 40 years) or longer, and determines if the plan will be successful.

The purpose of CMGV's statistical testing was to examine the statistical properties of the Monte Carlo engine output. The characteristics of interest are the expected returns and the volatility of the 12 asset classes considered in AT. In addition, the expected return and volatility of three portfolios of various risk profiles (low, medium and high equity) were analyzed.

3.4.1 Data Received for Validation

The data received from MA for the Monte Carlo engine review consisted of:

- the expected returns and volatilities for the 12 asset classes employed in the CMAs
- the return covariance matrix of those 12 asset classes
- the portfolio compositions of 3 test portfolios: low risk (40% equity), medium risk (60% equity) and high risk (80% equity)
- a Monte Carlo simulation run of 50,001 scenarios.

3.4.2 Asset Return Distribution

The Monte Carlo simulation scenarios are generated based on the assumption that the log asset returns have a multivariate normal distribution. CMGV performed various statistical tests to check for a joint multivariate distribution of the 12 asset classes return series, as well as for marginal normal distribution for each or the return series.

Table 3 lists the Kolmogorov-Smirnov (K-S) normality tests of the 50,001 Monte Carlo scenarios for the 12 asset classes. Based on all the test statistics (including Cramer-von Mises and Anderson-Darling, which were not reported here) the normality of the 12 return series is not rejected. In addition, the results of a joint normality test performed using Mardia's skewness, Mardia Kurtosis and Henze-Zirkler T do not reject the multivariate normality of the system.

Asset Class	K-S	Prob
Cash	0.0020	>0.15
Emerging Markets	0.0030	>0.15
Foreign Bonds	0.0021	>0.15
Foreign Developed	0.0024	>0.15
High Yield Bonds	0.0025	>0.15
Inv. Gr. Bonds	0.0021	>0.15
Large-Cap Growth	0.0016	>0.15
Large-Cap Value	0.0020	>0.15
Mid-Cap Growth	0.0018	>0.15
Mid-Cap Value	0.0020	>0.15
Small-Cap Growth	0.0021	>0.15
Small-Cap Value	0.0022	>0.15

Table 3: Kolmogorov-Smirnov Normality Test for MC Output Scenarios (Source: CMGV)

In addition to the statistical tests listed above, CMGV produced histograms and qq-plots for the 12 asset classes (refer to Figures 4 to 27) located in the Appendix). The plot of the Mahalanobis distance used in testing the multivariate normality of the 12-asset system is included in the Appendix (refer to Figure 28).

The returns produced by the Monte Carlo engine were evaluated against the CMAs. Based on t-test results listed in Table 4, CMGV concludes that the returns estimated based on 50,001 runs are not statistically significantly different from the expected returns at the 1% confidence level.

Asset Class	Estimated Return	Std. Dev.	Std. Error	Statistic	p-value
Large-Cap Growth	0.0706	0.2029	0.0009	-0.01	0.9911
Large-Cap Value	0.0639	0.1613	0.0007	-0.01	0.9912
Mid-Cap Growth	0.0803	0.2453	0.0011	0.00	0.9988
Mid-Cap Value	0.0691	0.1854	0.0008	-0.03	0.9778
Small-Cap Growth	0.098	0.2752	0.0012	-0.03	0.9784
Small-Cap Value	0.084	0.2055	0.0009	0.00	0.9966
Foreign Developed	0.075	0.1955	0.0009	-0.00	0.9986
Emerging Markets	0.1039	0.2661	0.0012	0.01	0.9945
Inv. Gr.Bonds	0.0235	0.052	0.0002	0.00	0.9966
Foreign Bonds	0.0348	0.0902	0.0004	0.11	0.9124
High Yield Bonds	0.0348	0.0962	0.0004	-0.08	0.9384
Cash	0.009	0.0134	601*E-7	0.69	0.4918

Table 4: T-Test Results (Source: CMGV)

3.4.3 Portfolio Return Distribution

Three test portfolios with various risk profiles were run through the Monte Carlo engine. The composition of these portfolios, shown in Table 5, was determined to achieve, respectively, a low, a medium and a high risk portfolio. CMGV calculated portfolio estimated returns and standard deviation and concludes that the estimated values align closely with the expected values, respectively.

3.4.4 Return Correlations

The Monte Carlo engines generates random numbers from a multivariate normal distribution by first generating independent normal distributions that are correlated using the Cholesky decomposition of the correlation matrix (refer to Table 12 in the Appendix). For this to be possible, the correlation matrix has to be positive semi-definite, that is that all eigenvalues have to be positive. CMGV examined the eigenvalues (listed in Table 6) and concludes that the correlation matrix is positive semi-definite.

The correlation matrix calculated using the 50,001 scenarios is identical to the CMA correlation matrix up to the 9th decimal digit (refer to Table 13 in the Appendix).

Asset Class	Allocation %		
	Low Risk	Medium Risk	High Risk
Large-Cap Growth	9.34%	14.51%	19.18%
Large-Cap Value	9.34%	14.51%	19.18%
Mid-Cap Growth	2.67%	4.14%	5.48%
Mid-Cap Value	2.67%	4.14%	5.48%
Small-Cap Growth	1.33%	2.07%	2.74%
Small-Cap Value	1.33%	2.07%	2.74%
Foreign Developed	10.01%	14.12%	19.62%
Emerging Mkts	3.34%	4.71%	6.54%
Inv. Gr. Bonds	34.32%	25.36%	12.14%
Foreign Bonds	7.03%	5.19%	2.49%
High Yield Bonds	4.14%	9.17%	4.39%
Cash	14.47%	0.00%	0.00%
Expected Portfolio Return	4.3203%	5.5920%	6.5745%
Estimated Portfolio Return	4.3208%	5.5915%	6.5739%
Expected Portfolio Std. Dev.	8.1741%	11.4946%	14.6197%
Estimated Portfolio Std. Dev.	8.1937%	11.5222%	14.6512%

Table 5: Test Portfolios Asset Allocation (Source: MA)

Eigenvalues			
6.8577913	2.0299919	0.7823251	0.6641825
0.5565104	0.4278742	0.2611276	0.2468543
0.1201585	0.0327066	0.0146104	0.0058673

Table 6: Eigenvalues of the Correlation Matrix (Source: CMGV)

3.5 Test Cases

As part of the validation process, CMGV asked MA to run a few test cases to assess the reasonableness of the RM output. Table 7 lists the profiles of the four test cases. For comparison purposes, the same four cases were run assuming that each of the participant has outside accounts with a balance of $1MM.

The results of the RM output, including the asset allocation, the retirement lump sums and annual distributions at different levels of confidence as well as the probability of success in meeting the annual goal amount are listed in Tables 8 and Table 11. CMGV makes the following observations:

Case	Description	Gender DOB (Age)	Partner	Salary	Retirement Age	Inside Plan Max Contrib.	Inside Plan Contrib.	Employer Match	Balance	Goal ($)
1	SIMPLE CASE	M 1/1/1976 (34)	N	$35,000	65	30%	15%	100% of first 7%	$15,000	$28,231
2	RETIRE AT 55	M 1/1/1976 (34)	N	$35,000	55	30%	15%	100% of first 7%	$15,000	$28,231
3	NO MATCH	F 1/1/1960 (50)	N	$80,000	65	30%	12%	No match	$100,000	$56,136
4	2 TIER MATCH	F 1/1/1960 (50)	N	$80,000	65	30%	12%	100% of first 6% 50% of next 6%	$100,000	$56,136

Table 7: Test Cases Description (Source: MA)

- For all cases except the first, the asset allocation to equity increases when the participant has $1MM outside assets.
- It is not intuitive why in the "simple case" the inside equity allocation is identical if outside assets are present or not.
- The inside allocation to equity is higher when participant has $1MM outside assets.
- As expected, in the presence of outside assets, the probability of achieving the retirement goal amount increases dramatically.
- Earlier retirement leads to lower allocation to equity if no outside assets are invested, but is the same if $1MM outside investment assets are held.
- A slightly higher percent is allocated to equity if employer has a two tier match vs. no match, when no outside investment assets are held.

Case	Goal	Overall Equity Target	Inside Equity Target	Household Equity Target	SS Income	Lump Sum at Retirement (Prob. Level)					Probability To Achieve Goal
						90%	75%	50%	25%	10%	
1	$28,231	98%	98%	98%	$18,497	$387,932	$507,162	$670,130	$895,353	$1,214,706	100%
2	$28,231	70%	70%	70%	$18,497	$231,648	$268,055	$328,913	$396,574	$475,779	41%
3	$56,136	62%	62%	62%	$26,719	$281,134	$321,362	$380,661	$458,800	$558,159	29%
4	$56,136	64%	64%	64%	$26,719	$399,738	$460,456	$539,477	$643,646	$786,756	59%

Table 8: RM Output for Test Cases Without Outside Assets (Source: MA)

Case	Goal	Annual Income at Retirement (Probability Level)				
		90%	75%	50%	25%	10%
1	$28,231	$41,941	$51,737	$68,208	$100,439	$156,232
2	$28,231	$20,621	$23,178	$26,923	$32,617	$42,394
3	$56,136	$38,718	$42,516	$48,331	$58,014	$74,937
4	$56,136	$45,316	$50,702	$59,131	$73,156	$98,233

Table 9: RM Annual Retirement Income for Test Cases Without Outside Assets (Source: MA)

Case	Goal	Overall Equity Target	Inside Equity Target	Household Equity Target	SS Income	Lump Sum at Retirement (Prob. Level)					Probability To Achieve Goal
						90%	75%	50%	25%	10%	
1	$28,231	87%	98%	50%	$18,497	$1,579,905	$2,185,586	$3,128,878	$4,304,826	$5,839,783	100%
2	$28,231	83%	98%	50%	$18,497	$1,253,151	$1,630,769	$2,207,972	$2,962,710	$3,718,320	100%
3	$56,136	74%	92%	53%	$26,719	$1,222,697	$1,504,290	$1,943,926	$2,461,396	$3,093,338	100%
4	$56,136	75%	92%	53%	$26,719	$1,358,695	$1,634,009	$2,107,863	$2,643,449	$3,335,034	100%

Table 10: RM Output for Test Cases With $1MM Outside Assets (Source: MA)

Case	Goal	Annual Income at Retirement (Probability Level)				
		90%	75%	50%	25%	10%
1	$28,231	$115,354	$160,657	$240,572	$391,782	$670,395
2	$28,231	$68,627	$91,036	$127,313	$184,580	$284,900
3	$56,136	$88,082	$110,962	$146,397	$205,127	$307,210
4	$56,136	$94,557	$118,985	$156,523	$219,265	$328,506

Table 11: RM Output for Test Cases With $1MM Outside Assets (Source: MA)

3.6 Asset Returns and Inflation

Arithmetic returns are used as a standard approach for the simulation engine. As it is well known, arithmetic returns tend to overstate actual investment performance and geometric ones tend to understate. Refer to [1] for papers that discuss this issue. CMGV believes this effect is counteracted by the choice of a conservative portfolio. Actually, the wealth and income projections that are displayed to the participants are at a very conservative 90% and 75% chance of better scenarios (to achieve retirement goal amount).

In line with the standard approach for calculating returns, real vs. nominal returns are employed. A reference inflation rate of 2% falls into the range of target inflation rates of central banks (refer to [1] for a discussion).

3.7 The Glide-Path Methodology

The glide-path is how a portfolio's asset allocation changes over time. This term is frequently used in conjunction with Target-Date Funds[7] (TDF), and is key to understanding

[7] A mutual fund in the hybrid category that automatically resets the asset mix (stocks, bonds, cash equivalents) in its portfolio according to a selected time frame that is appropriate for a particular investor. A target-date fund is similar to a life-cycle fund except that a target-date fund is structured to address some date in the future, such as retirement. A study of investors in retirement TDFs (refer to [3]) finds that TDF glide-paths should be matched to plan demographics. Several stylized equity glide-paths are compared

a fund's investment philosophy and process. It is important to understand not only how a glide-path was developed, but how it is managed and rebalanced ([13]). MA's glide-path methodology starts with three age-based composite investor profiles and selects a single glide-path, optimal (based on retirement income goal) for all three profiles. The glide-path is characterized by an equity target that decreases with the investment horizon and remains at 40% through retirement.

Recent research argues that a single glide-path for each target date does not serve participant best, and that multiple glide-paths taking into account varying levels of wealth accumulation ('undersaved' or 'oversaved') are needed closer to retirement. That is, five to 10 years prior to retirement is a good time frame when an individual can decide if he (she) is undersaved or oversaved and needs to become more aggressive or not in his/her investment strategy. In addition, glide-paths are designed so that the equity allocation continues to change even after participants enter and go through retirement (refer to [9]). A flexible glide-path that factors in time, withdrawal needs and market conditions allows the manager to balance the conflicting goals of managing capital risk, inflation risk and longevity risk ([2]).

The effectiveness of glide-path choices can be assessed by benchmarking. Current approaches include comparisons of the performance of TDF to peer groups,[8] but recent research suggests two additional benchmarks: one that focuses on the return required to ensure sufficient retirement savings and a second that compares the fund performance

for different demographics groups to show the interaction between the two and the effect on on success rates for meeting retirement income targets. However, the author notes that in light of the 2006 Pension Protection Act (increased utilization of automatic enrollment and automatic contribution escalations) it is likely that contribution rates among the participants may become more homogeneous and a single equity glide-path would meet a wide range of demographic profiles (see [24]). Figure 29 in the Appendix shows an example of glide-path for a fund that is "through" vs. "to" retirement. It can be seen that the "to" fund ends in 0% equity at retirement, since its role is to bring the participant to its retirement target date. The "through" approach is exemplified by the peer industry average allocation through time. The "to" approach is represented by the Plan Sponsor On-Target Defensive Index (refer to [29]).

[8] For example Lipper peer group, a custom peer-group benchmark, a custom index benchmark, and TDF indices.

to the fund manager's return expectations (refer to [26]).

3.8 Salary Growth Model

The retirement goal is determined as 80% of the salary at retirement. MA's salary growth model is based on a quartic function specification of income with age as predictor. Research in labour economics (refer to [21]) concludes that the quartic function specification is superior to the quadratic (which is the most widely accepted empirical specification in economics), as it removes most of the bias.

3.9 Documentation

During the course of the review, CMGV found that the documentation about RM was described in multiple documents, which in some instances contained inconsistencies and outdated model parameters or assumptions information.

4 Recommendations

CMGV is issuing the following recommendation at this time:

1. WBR should ensure that the documentation for AT is consolidated and includes the current CMAs and other details pertinent to the RM methodology on an ongoings basis.

5 Conclusion

From the information and methodology documents received from MA, CMGV concludes that the models used in AT is conceptually sound, theoretically supported and align with standard theory sanctioned in academia and generally utilized in industry. Specifically, CMGV has the following comments:

- The use of the Black-Litterman model to derive the CMAs leads to building more stable and intuitive portfolios than plain mean-variance optimization. It also allows incorporating investor views with prior information.
- Instead of relying on any one methodology, MA employs a variety of heuristics to determine the portfolio asset allocation.
- The Monte Carlo engine output exhibits the expected statistical properties.

6 Appendix

Asset Class	Large-Cap Growth	Large-Cap Value	Mid-Cap Growth	Mid-Cap Value	Small-Cap Growth	Small-Cap Value	Foreign Developed	Emerging Markets	Inv. Gr. Bonds	Foreign Bonds	High Yield Bonds	Cash
Large-Cap Growth	1.00000	0.820852926	0.920605359	0.704079773	0.908952706	0.670768161	0.649264601	0.632961789	0.13640047	0.505072592	0.165007823	0.12703661
Large-Cap Value	0.820852926	1	0.813074575	0.93586932	0.81673742	0.90468561	0.691211448	0.637861312	0.196054345	0.601501043	0.14588389	0.184299454
Mid-Cap Growth	0.920605359	0.813074575	1	0.774378435	0.986267388	0.763870138	0.637003425	0.693780021	0.081907025	0.510540523	0.123489258	0.053633527
Mid-Cap Value	0.704079773	0.93586932	0.774378435	1	0.790244933	0.982362305	0.639237817	0.641130746	0.181537477	0.619518883	0.128351695	0.148825994
Small-Cap Growth	0.908952706	0.81673742	0.986267388	0.790244933	1	0.795726363	0.644720956	0.708662747	0.063027946	0.553574248	0.101642731	0.05986362
Small-Cap Value	0.670768161	0.90468561	0.763870138	0.982362305	0.795726363	1	0.611259981	0.654639461	0.136166861	0.632153479	0.103380607	0.150825895
Foreign Developed	0.649264601	0.691211448	0.637003425	0.639237817	0.644720956	0.611259981	1	0.662281676	0.127100979	0.457613345	0.362041565	0.124740415
Emerging Markets	0.632961789	0.637861312	0.693780021	0.641130746	0.708662747	0.654639461	0.662281676	1	0.028880229	0.508405156	0.16057635	0.051775348
Inv. Gr. Bonds	0.13640047	0.196054345	0.081907025	0.181537477	0.063027946	0.136166861	0.127100979	0.028880229	1	0.504474409	0.63964757	0.402798378
Foreign Bonds	0.505072592	0.601501043	0.510540523	0.619518883	0.553574248	0.632153479	0.457613345	0.508405156	0.504474409	1	0.409800022	0.283163613
High Yield Bonds	0.165007823	0.14588389	0.123489258	0.128351695	0.101642731	0.103380607	0.362041565	0.16057635	0.63964757	0.409800022	1	0.361486253
Cash	0.12703661	0.184299454	0.053633527	0.148825994	0.05986362	0.150825895	0.124740415	0.051775348	0.402798378	0.283163613	0.361486253	1

Table 12: CMA Correlation Matrix (Source: MA)

Asset Class	Large-Cap Growth	Large-Cap Value	Mid-Cap Growth	Mid-Cap Value	Small-Cap Growth	Small-Cap Value	Foreign Developed	Emerging Markets	Inv. Gr. Bonds	Foreign Bonds	High Yield Bonds	Cash
Large-Cap Growth	1.00000	0.820852926	0.920605359	0.704079773	0.908952706	0.670768161	0.649264601	0.632961789	0.13640047	0.505072592	0.165007823	0.12703661
Large-Cap Value	0.820852926	1	0.813074575	0.93586932	0.81673742	0.90468561	0.691211448	0.637861312	0.196054345	0.601501043	0.14588389	0.184299454
Mid-Cap Growth	0.920605359	0.813074575	1	0.774378435	0.986267388	0.763870138	0.637003425	0.693780021	0.081907025	0.510540523	0.123489258	0.053633527
Mid-Cap Value	0.704079773	0.93586932	0.774378435	1	0.790244933	0.982362305	0.639237817	0.641130746	0.181537477	0.619518883	0.128351695	0.148825994
Small-Cap Growth	0.908952706	0.81673742	0.986267388	0.790244933	1	0.795726363	0.644720956	0.708662747	0.063027946	0.553574248	0.101642731	0.05986362
Small-Cap Value	0.670768161	0.90468561	0.763870138	0.982362305	0.795726363	1	0.611259981	0.654639461	0.136166861	0.632153479	0.103380607	0.150825895
Foreign Developed	0.649264601	0.691211448	0.637003425	0.639237817	0.644720956	0.611259981	1	0.662281676	0.127100979	0.457613345	0.362041565	0.124740415
Emerging Markets	0.632961789	0.637861312	0.693780021	0.641130746	0.708662747	0.654639461	0.662281676	1	0.028880229	0.508405156	0.16057635	0.051775348
Inv. Gr. Bonds	0.13640047	0.196054345	0.081907025	0.181537477	0.063027946	0.136166861	0.127100979	0.028880229	1	0.504474409	0.63964757	0.402798378
Foreign Bonds	0.505072592	0.601501043	0.510540523	0.619518883	0.553574248	0.632153479	0.457613345	0.508405156	0.504474409	1	0.409800022	0.283163613
High Yield Bonds	0.165007823	0.14588389	0.123489258	0.128351695	0.101642731	0.103380607	0.362041565	0.16057635	0.63964757	0.409800022	1	0.361486253
Cash	0.12703661	0.184299454	0.053633527	0.148825994	0.05986362	0.150825895	0.124740415	0.051775348	0.402798378	0.283163613	0.361486253	1

Table 13: CMA Correlation Matrix (Source: CMGV)

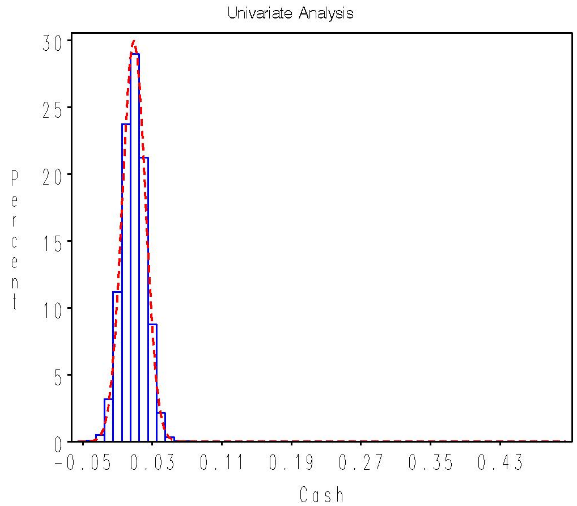

Figure 4: Cash Histogram (Source: CMGV)

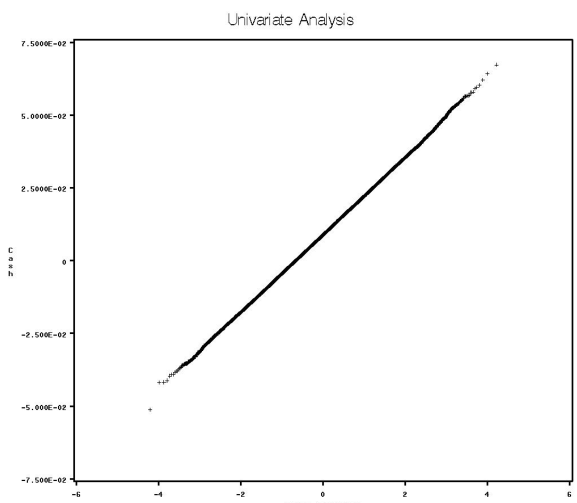

Figure 5: Cash QQ-Plot (Source: CMGV)

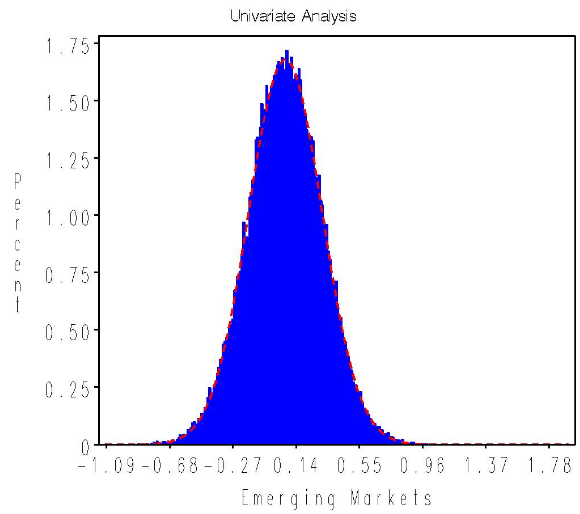

Figure 6: Emerging Markets Histogram (Source: CMGV)

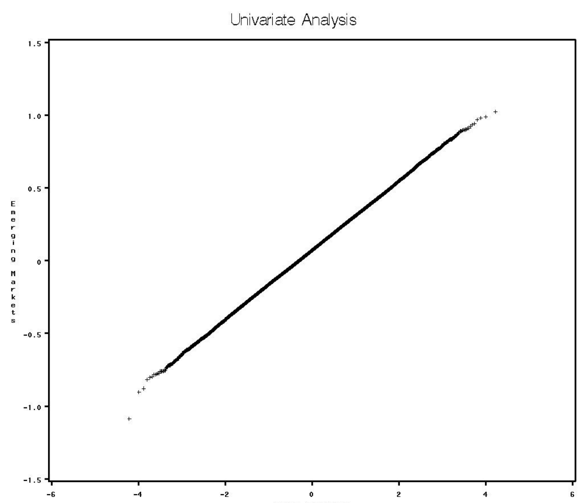

Figure 7: Emerging Markets QQ-Plot (Source: CMGV)

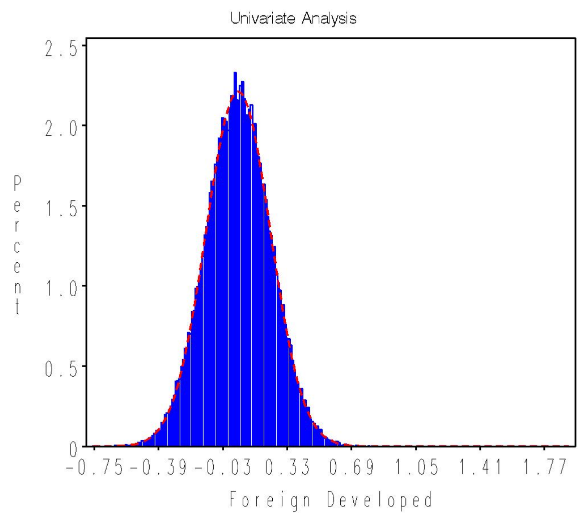

Figure 8: Foreign Developed Histogram (Source: CMGV)

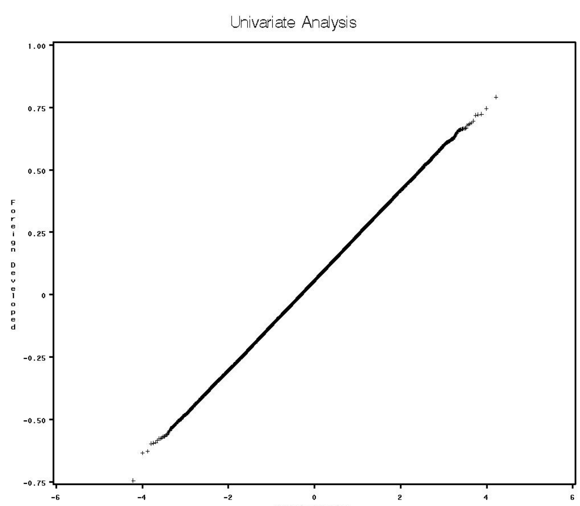

Figure 9: Foreign Developed QQ-Plot (Source: CMGV)

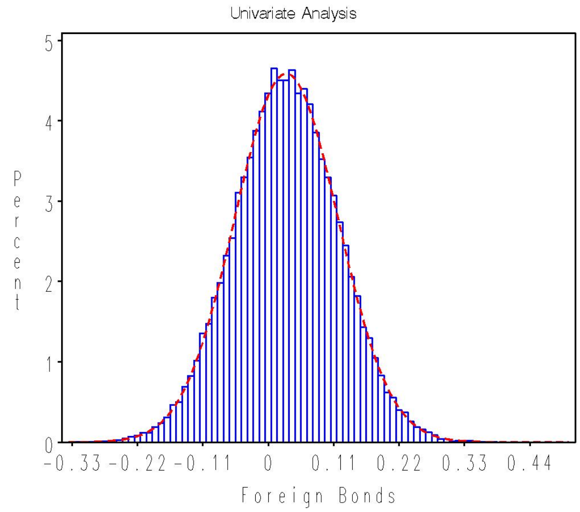

Figure 10: Foreign Bond Histogram (Source: CMGV)

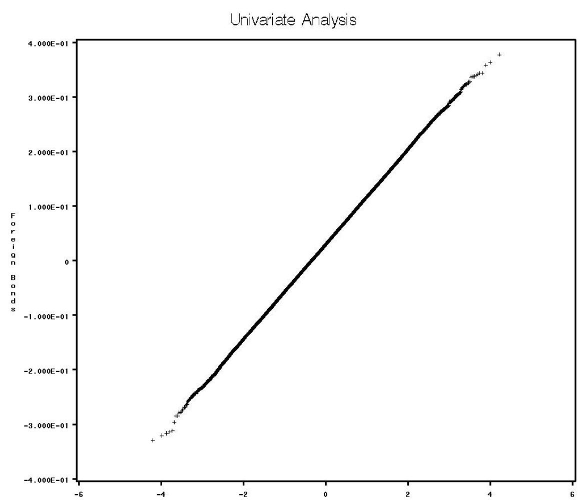

Figure 11: Foreign Bond QQ-Plot (Source: CMGV)

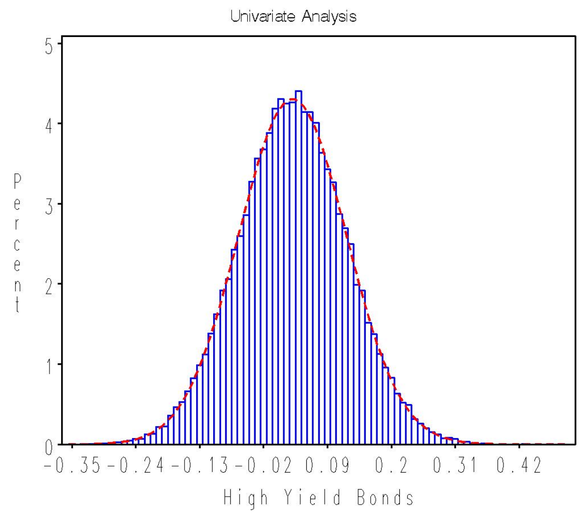

Figure 12: High Yield Bond Histogram (Source: CMGV)

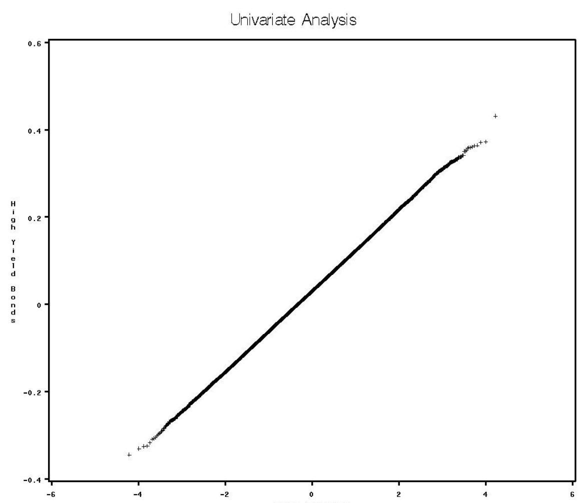

Figure 13: High Yield Bond QQ-Plot (Source: CMGV)

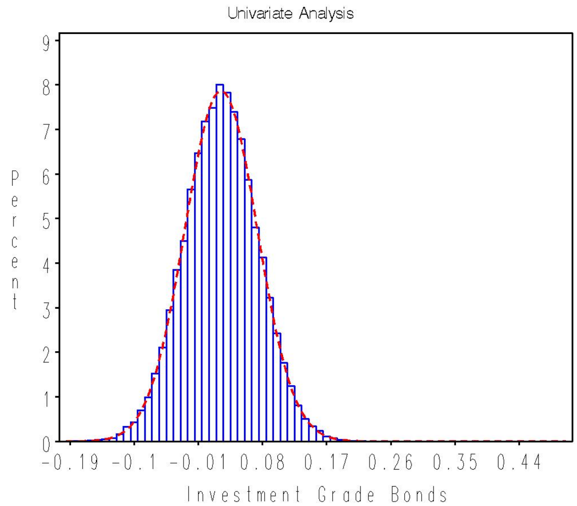

Figure 14: Inv. Grade Bond Histogram (Source: CMGV)

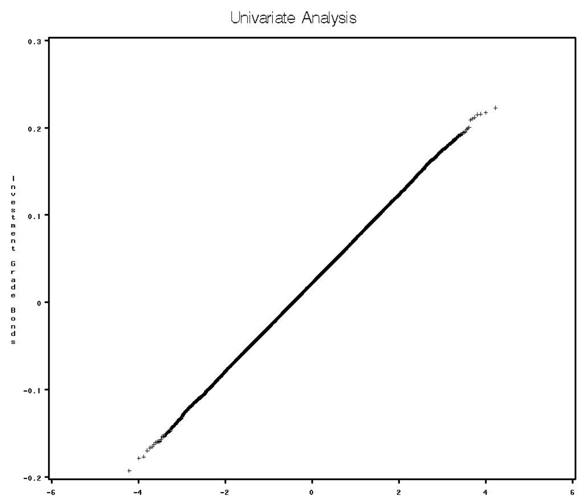

Figure 15: Inv. Grade Bond QQ-Plot (Source: CMGV)

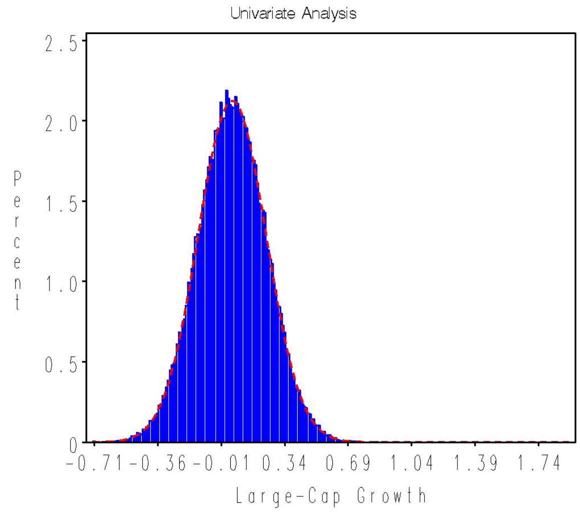

Figure 16: Large-Cap Growth Histogram (Source: CMGV)

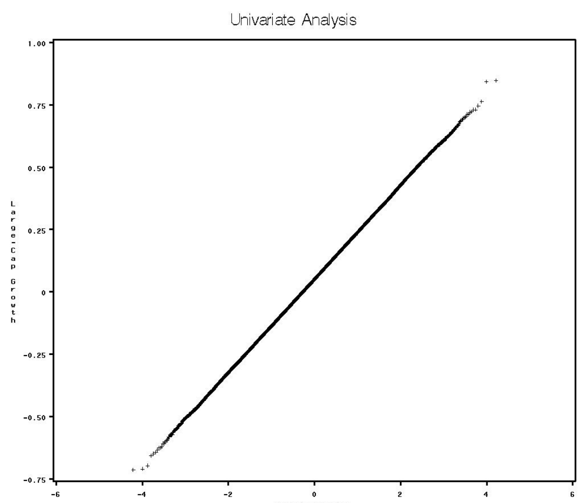

Figure 17: Large-Cap Growth QQ-Plot (Source: CMGV)

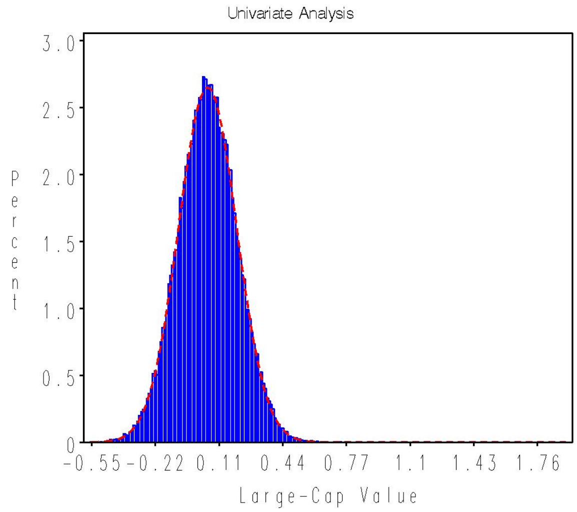

Figure 18: Large-Cap Value Histogram (Source: CMGV)

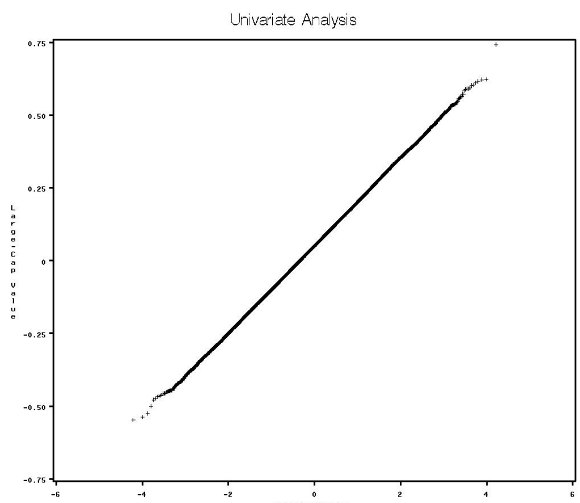

Figure 19: Large-Cap Value QQ-Plot (Source: CMGV)

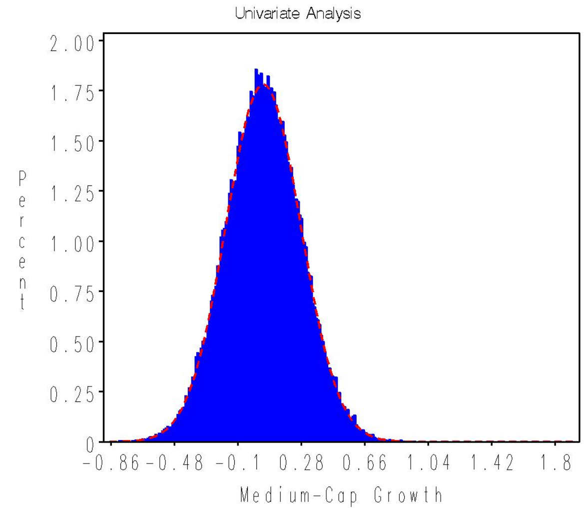

Figure 20: Mid-Cap Growth Histogram (Source: CMGV)

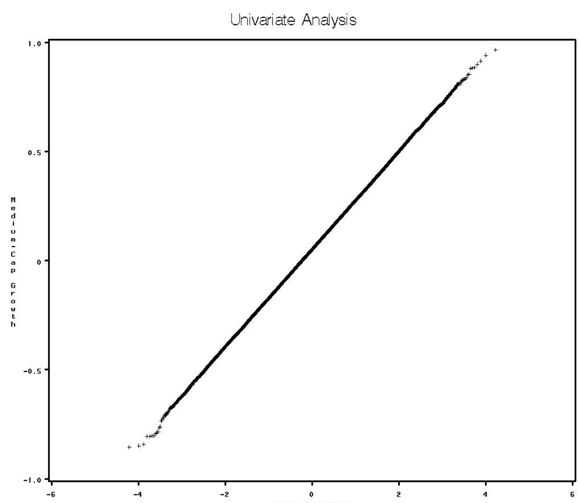

Figure 21: Mid-Cap Growth QQ-Plot (Source: CMGV)

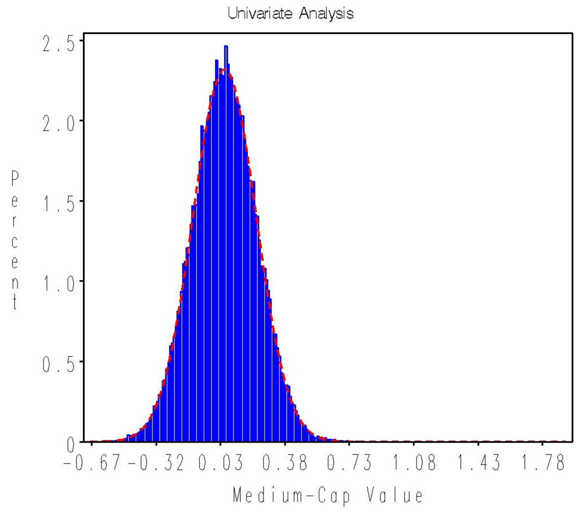

Figure 22: Mid-Cap Value Histogram (Source: CMGV)

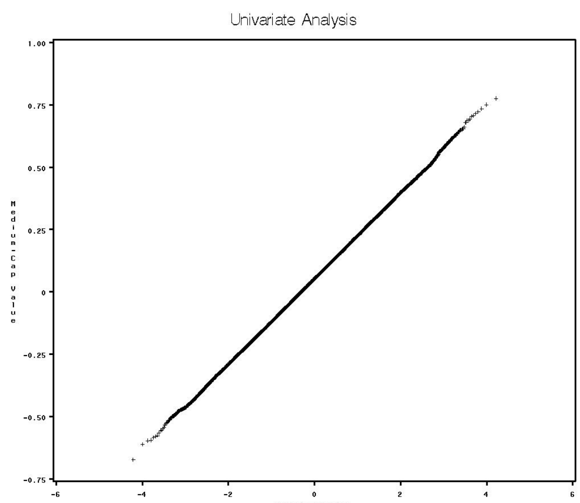

Figure 23: Mid-Cap Value QQ-Plot (Source: CMGV)

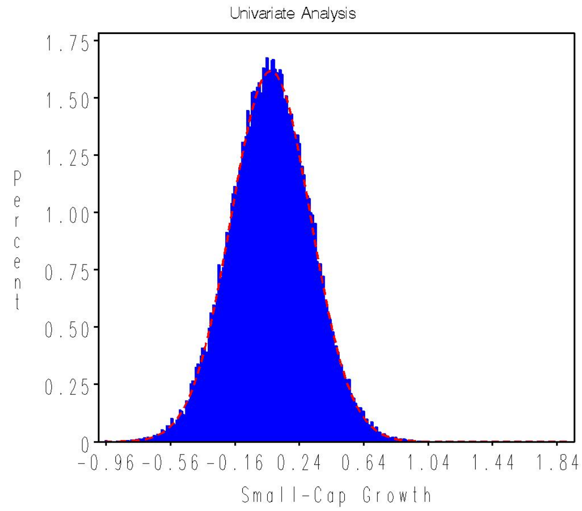

Figure 24: Small-Cap Growth Histogram (Source: CMGV)

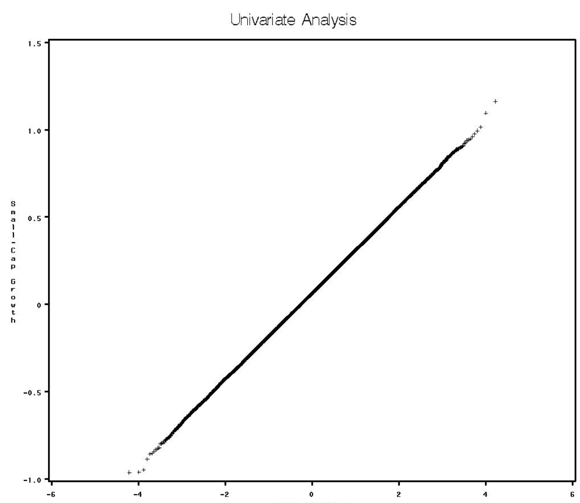

Figure 25: Small-Cap Growth QQ-Plot (Source: CMGV)

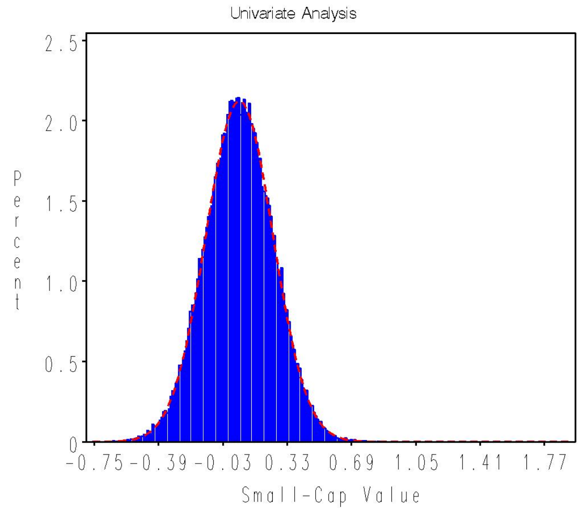

Figure 26: Small-Cap Value Histogram (Source: CMGV)

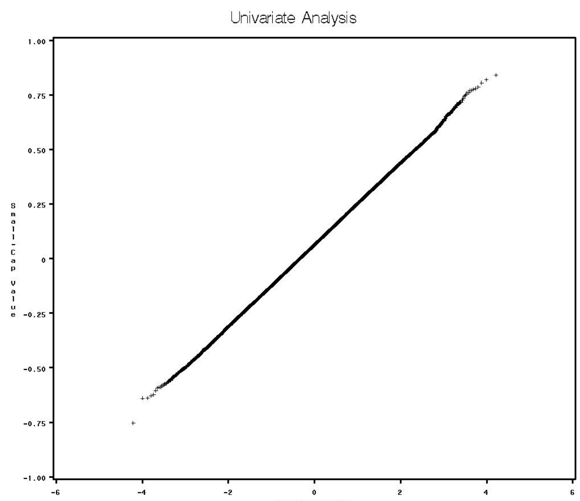

Figure 27: Small-Cap Value QQ-Plot (Source: CMGV)

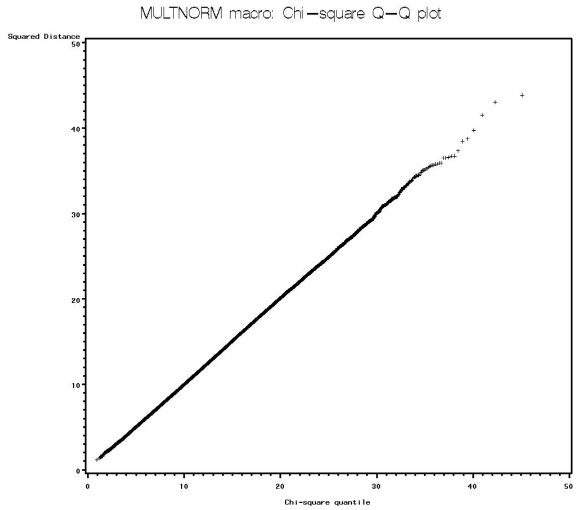

Figure 28: Multivariate Normal Q-Q Plot (Source: CMGV)

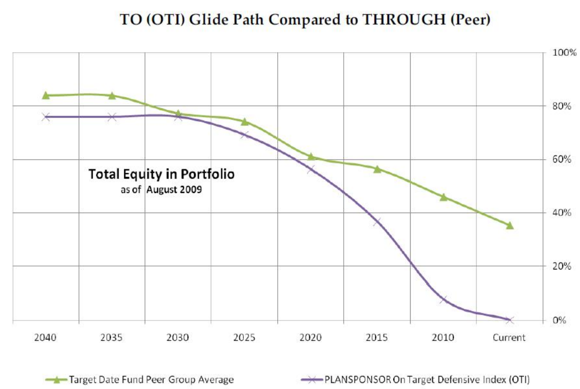

Figure 29: TDF Glide-Path (Source: [29]

References

[1] Sung-Ho Ahn. Independent Technical Validation Envision. February 2007.

[2] Inc. Asset International. Special Report: PLANSPONSOR 2009 Special Asset Allocation Issue: An Inside Look at Glide Paths. *http://www.plansponsor.com/*, June 2009.

[3] Inc. Asset International. Target-Date Glide Paths Should be Matched to Plan Demographics. *http://www.plansponsor.com/*, May 2009.

[4] Morningstar Associates. Wells Fargo Data Requests. Excel Spreadsheet, January 25, 2010.

[5] Geert Bekaert and Xiaozheng Wang. Home bias revisited. Available at SSRN: http://ssrn.com, February 2009.

[6] Fischer Black and Robert Litterman. Global Portfolio Optimization. *Financial Analysts Journal*, 5:28–43, September/October 1992. http://phys.columbia.edu/ oleg/economics/BlackLittermanOrig.pdf.

[7] CPP Investment Board. Asset Mix. http://www.cppib.ca/, 2010.

[8] Paul Brehm and Denis Guenthner. The Econometric Method of Mixed Estimation - An Application to the Credibility of Trend. http://www.casact.org/pubs/dpp/dpp90/90dpp171.pdf, May 1990.

[9] C. Chang. The Evolution of Target Maturity Portfolios - A Liability-Aware Approach To Investing For Retirement. *www.wilshire.com*, July 2007.

[10] Ludwig B. Chincarini and Daehwan Kim. Uses and Misuses of the Black-Litterman Model in Portfolio Construction. Available at SSRN: http://ssrn.com, February 2009.

[11] Kenneth French and James Poterba. Investor Diversification and International Equity Markets. In *The American Economic Review – Papers and Proceedings of the Hundred and Third Annual Meeting of the American Economic Association*, volume 81, pages 222–226, May 1991.

[12] Guanliang He and Robert Litterman. The Intuition Behind Black-Litterman Model Portfolios. Available at SSRN: http://ssrn.com, October 2002.

[13] Seligman Investments. DOL Press Release. http://www.seligman.com/, October, 24, 2007.

[14] Michael Johnston. *Econometrics*, pages 23–25. Athos, 1984.

[15] Beni Lauterbach and Hiam Reisman. Keeping Up with the Joneses and the Home Bias. *European Financial Management*, 10:225–234, 2004.

[16] J.L. Maginn. *Managing investment portfolios: a dynamic process*. Wiley, 2007.

[17] Morningstar Associates, LLC. *Morningstar Asset Allocation Methodology*, 2010.

[18] Morningstar Associates, LLC. *Morningstar Retirement Manager Methodology*, 2010.

[19] Morningstar Associates, LLC. *The Morningstar Associates Portfolio Construction Process*, 2010.

[20] Morningstar Associates, LLC. *Wachovia Allocations*, 2010.

[21] Kevin Murphy and Finis Welch. Empirical Age-Earnings Profiles. *Journal of Labour Economics*, 80, May 1990.

[22] Kevin Murphy and Finis Welch. Segmenting the Middle Market: RETIREMENT RISKS AND SOLUTIONS PHASE I REPORT. *Society of Actuaries*, April 2009.

[23] Society of Actuaries. RP-2000 Mortality Tables Report.

[24] Youngkyun Park. Plan Demographics, ParticipantsŠ Saving Behavior, and Target-Date Fund Investments. *Employee Benefit Research Institute - Issue Brief (www.ebri.org)*, May 2009.

[25] Teacher's Pension Plan. Asset-Mix Policy. http://www.otpp.com/, 2010.

[26] Vanguard Investment Counseling & Research. Target Date Funds and Goal-Based Benchmark. *https://institutional.vanguard.com/iip/pdf/TRFbenchmarks_WP.pdf*, 2007.

[27] Wachovia Retirement Services. Investment Results as of 3/31/2010. Powerpoint, March 31, 2010.

[28] Social Security Administration, SSA Publication No. 13-11700. *Annual Statistical Supplement to the Social Security Bulletin, 2008*, 2009.

[29] Ron Surz. Comparing the Risks and Returns of "To" versus "Through" Target Date Funds. *http://www.investment-performance.com*, September 2009.

[30] California Public Employees' Retirement System. Comprehensive Annual Financial Report. https://www.calpers.ca.gov/, 2009.

[31] Ontario Municipal Employees Retirement System. Asset Mix. http://www.omers.com/, 2009.

[32] Jay Walters. The Black-Litterman Model In Detail. Available at SSRN: http://ssrn.com, February 2009.