

2019 Annual Investment Risk Management Review

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Dimitry Shishkoff, Director of Risk Management

Melissa Jerkins, Ph.D., Quantitative Analyst II

Ryan Conner, Data Analyst



Outline

I. Plan for Addressing Key Risk Related Needs in 2019

1. Improved modeling of long-term Alternative Asset Class risks
 - For risk measurement and asset allocation
2. Introduction of Total Fund Strategies
 - To take advantage of risk management and return opportunities not available when only using strategic allocations to asset classes

II. Review of Current Risk Reporting

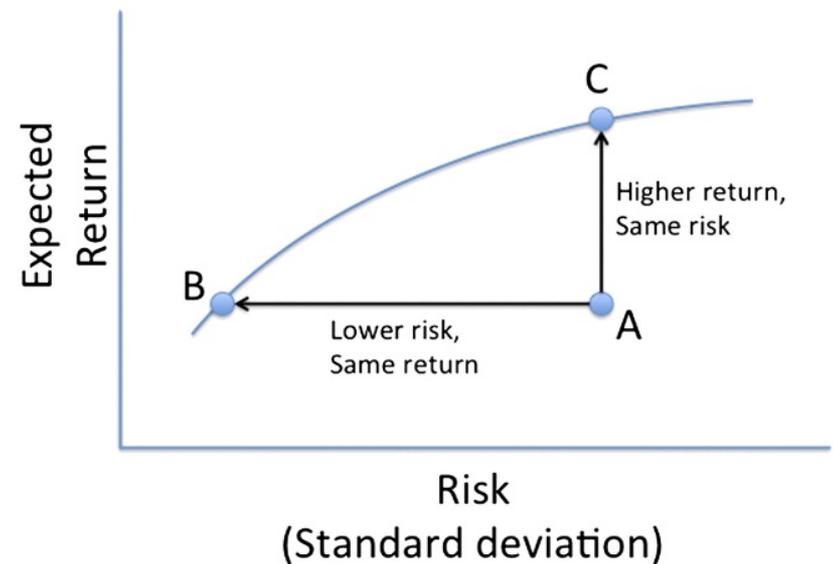
1. Quarterly Board Risk Report
2. Internal Risk Analysis

I. Plan for Addressing Key Risk Management Needs in 2019

1. Improved modeling of long term
Alternative Asset Class risks
(for risk measurement and asset allocation)

The Current Asset Allocation Framework Is Based On Modern Portfolio Theory (MPT)

- ❖ All asset classes are assumed to be liquid and can be rebalanced instantaneously
- ❖ Asset Class assumptions (return, standard deviation and correlations) fully describe the behavior of an asset class
- ❖ Asset Class assumptions do not vary over time or time periods
- ❖ Optimal portfolios are identified as those with the highest expected return for a given standard deviation (Efficient Frontiers)



MPT was not designed to handle risks introduced by Alternative Asset Classes

❖ Illiquidity risks:

- Much slower rebalancing in response to market moves, decreases diversification
- Sensitivity to market conditions of liquidity demand and supply makes the rebalancing problem worse

❖ Illiquidity costs:

- Slower rebalancing can also affect returns
- Responding to liquidity risks has costs (for example: higher cash reserves, forced sales)

❖ Volatility of assets with appraisal based pricing increases over longer time periods

- For short time periods (quarterly), volatility appears low due to smoothing effect of appraisal pricing
- For longer time horizons (3 years), smoothing effect decreases and volatility increases

❖ Correlations are not static and increase in turbulent markets

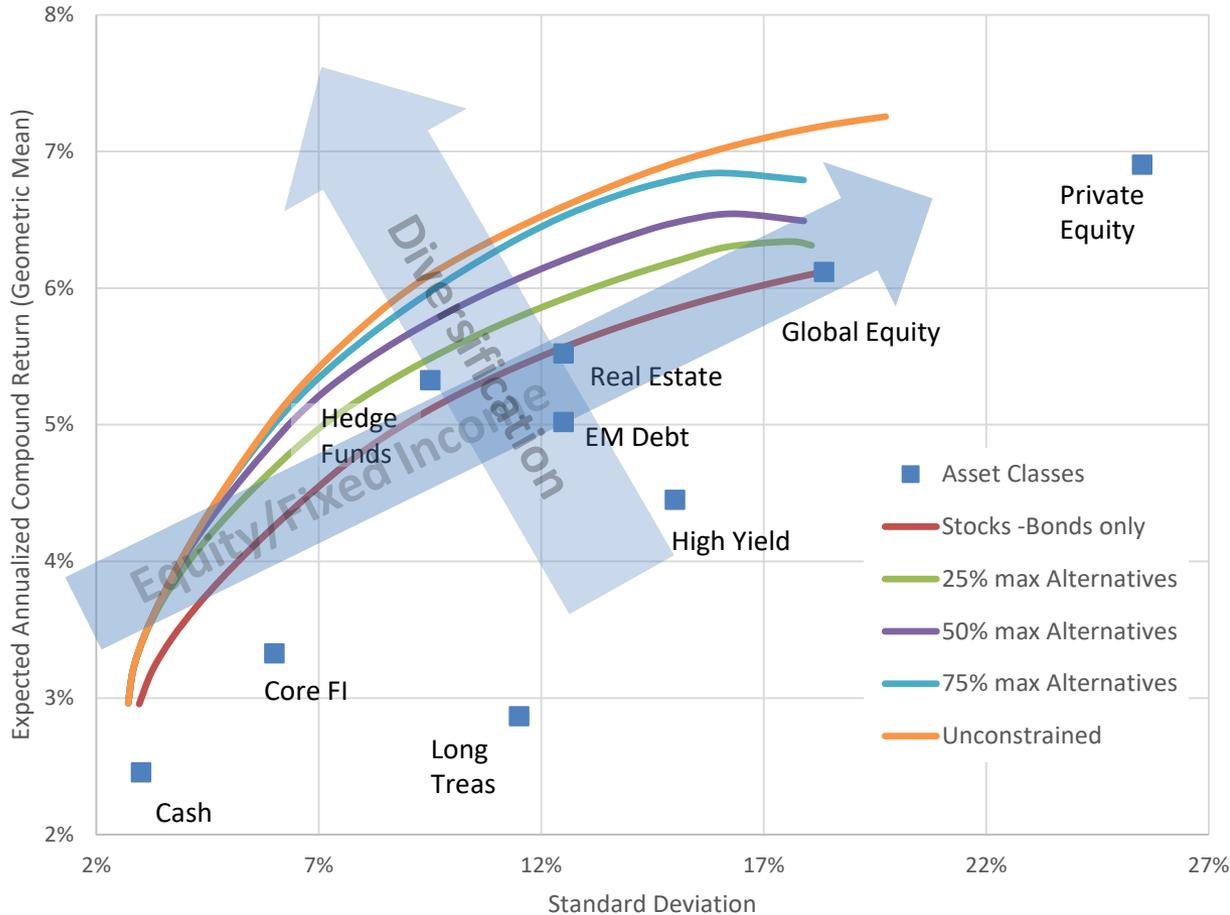
- Diversifying effect in general, and for alternatives specifically, can be less than expected



Observed investor behaviors in response to risks introduced by Alternative Asset Classes

- ❖ Setting Alternative Asset Class risk assumptions much higher than historical return volatility
- ❖ Perceiving Risk in two dimensions:
 - Balance of Equity and Fixed Income (Return Volatility)
 - How much in Alternatives (Financial risks not captured by a single volatility assumption)
- ❖ Applying a primarily subjective basis for allocation decisions regarding alternatives

Current Asset Allocation Framework



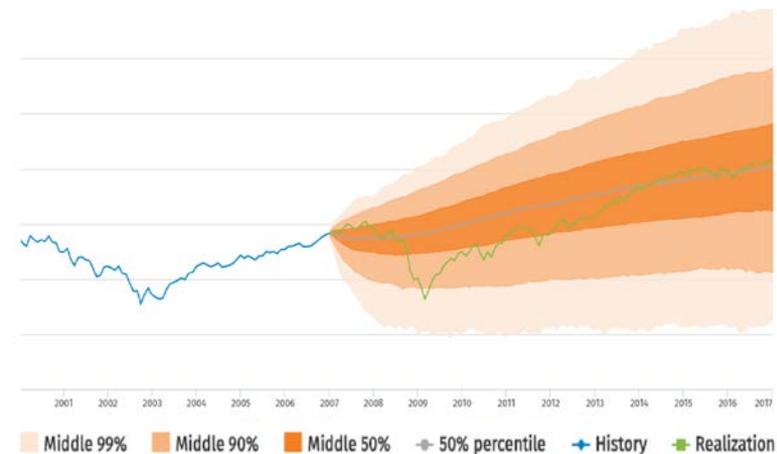
- ❖ The chart on the left shows multiple Frontiers, each allowing an increasing allocation to alternatives
- ❖ From a simple MPT perspective, we should pick a portfolio from the unconstrained frontier
- ❖ However, we also recognize that Alternatives introduce many risks that MPT simply does not reflect
- ❖ So we are left to judge qualitatively how significant these risks are and how much that matters to us
- ❖ This decision framework would be significantly improved if we could measure the alternative risks that are currently being evaluated only qualitatively

Improving the Asset Allocation Framework to Better Measure Risks In Alternatives

- ❖ In 2019, the Risk Management team will conduct portfolio analysis that explicitly measures risks of Alternatives

- **Use ORTEC capital market simulation model to:**

- Simulate market cycle behavior
- Simulate historically observed term structure of volatility for all asset classes including alternatives
- Simulate time-varying conditional correlations (to measure the risk of not getting diversification when most needed)
- Generate 2000 simulations of asset class returns over 10 years representing the full distribution of possible behavior



- **Run the TMRS private fund cash flow simulation model in each of the market simulations**

- Model dependence of simulated private market cash flows on market conditions
- Measure risk consequences and cost of responding to liquidity risks (e.g. higher cash reserves, forced sales)
- Measure cost of slower rebalancing and allocation drift (away from target allocation) that is larger and lasts longer

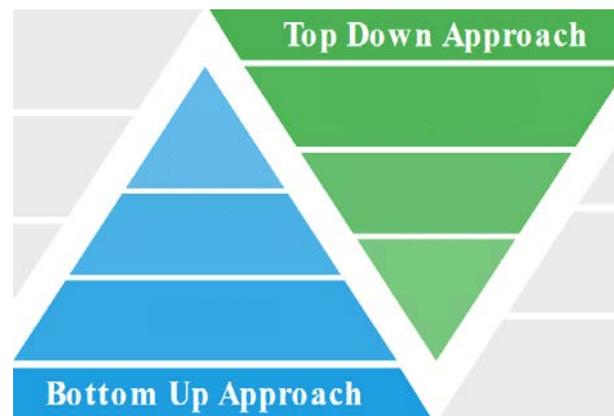
I. Plan for Addressing Key Risk Management Needs in 2019

2. Introduction of Total Fund Strategies

To take advantage of risk management and return opportunities not available when only using strategic allocations to asset classes

What are Total Fund Strategies?

- ❖ Once asset classes are “rolled up” into an efficient portfolio, there is more we can do to improve the risk adjusted performance of the portfolio.
- ❖ Top down focus on Total Fund performance
- ❖ Total fund level management of:
 - Crisis Risk
 - Dynamic Asset Class Risk Premiums
 - Foreign Exchange risk exposures
- ❖ Not part of any TMRS Asset Class



Why Would a Strategy Fall Outside of the Existing TMRS Asset Classes?

- ❖ Choosing an Asset Allocation is essentially a “bottom up” exercise
 - The capital markets are divided up into Asset Classes based on some common aspect
 - Each Asset Class has unique return and risk objectives (if they are not unique the asset class becomes redundant)
 - The performance of each asset class is measured against its unique return and risk objectives
- ❖ Total Fund Strategies take a “top down” perspective
 - No common aspect
 - Have Total Fund return and risk objectives (6.75 return target, 10.5 risk target)
 - Performance is measured against total fund risk and return objectives

Tail Risk¹ Hedging

- ❖ Tail risk hedging mitigates crisis risk, which is not diversifiable.
 - Market crisis risk is not diversifiable within a market (like US stocks)
 - Market crisis risk is typically not diversifiable across markets (or asset classes) either
 - In the Global Financial Crisis (GFC) everything (except short treasuries) went down together
 - After the GFC, many in the industry complained that when you need it most, diversification doesn't work

- ❖ “Passive” tail risk hedging:
 - Uses derivative options to buy protection against losses beyond a specific downside limit
 - We could buy a one month “put” option that protects us against losses greater than 15% in the US equity market
 - In a crisis, we could lose 15% (but not more than that)
 - Such an option would cost us between 1.5% and 2% a year, so simplistic hedging is quite expensive

- ❖ Active tail risk hedging:
 - Can incorporate return enhancing components² so that the overall cost of the hedge is affordable
 - Can adjust amount of protection in excess of a “loss floor” so that if the market declines below the “loss floor” the portfolio is made whole
 - In normal markets, these strategies should have a small, predictable cost. Over long periods containing a large market decline, the strategies should more than pay for the costs

1. Tail Risk refers to large market declines that can occur but with very low probability. The name comes from the extreme left side of a bell shaped distribution graph, which is called a “tail” of the distribution.
2. For example, volatility capture

Why is Tail Risk Hedging a Total Fund Strategy?

- ❖ Tail risk hedging does not reduce risk by simply lowering the volatility; it dramatically changes the shape (i.e. distribution) of the risk outcomes
 - Upside potential is unchanged, but downside risk is truncated below a certain level
 - Evaluating an asymmetric distribution of potential outcomes is challenging; all existing TMRS Asset Classes have nearly symmetric¹ risk
- ❖ The proportion of expected return is conditional on equity market performance
 - Active asset class strategies have a constant amount by which they are expected to outperform a benchmark; for tail risk hedging, the amount of expected return varies significantly
 - The varying proportion of expected return requires complex performance measurement not consistent with any asset class
 - Mitigating downside risk for an affordable cost has obvious benefits to TMRS's total fund objectives, but no single asset class is incentivized to evaluate or recommend a tail risk strategy
- ❖ Depending on size, an equity tail risk hedge can change the optimal asset allocation for the balance of the portfolio
 - Allocation to “capital preservation” assets partially depends on the size of the crisis risk hedge
 - Limiting severe drawdowns can significantly improve long-term geometric return expectations

1. The natural logarithm of the distribution is normally distributed and thus symmetric

Dynamic Asset Allocation

- ❖ Dynamic/Tactical Asset Allocation seeks to reduce risk and improve returns by adjusting the allocations to liquid asset classes in response to market conditions.
 - All markets/asset classes go through valuation (pricing) and fundamental (cash flow growth and/or quality) cycles
 - Relative extremes (i.e. highs or lows in the cycle) are generally clear to most in the market
 - When those extremes will reverse, however, is not clear at all
- ❖ Older rules based models:
 - Use relative valuation measures to over-allocate to assets that are cheap relative to historical valuation levels
 - Use a variety of “momentum” signals to over-allocate to assets that have done well recently and are likely to continue to do well
- ❖ Advancements over the last 20 years:
 - Use sophisticated quantitative models to form views of how expected economic growth and inflation dynamics are likely to be reflected in asset classes
 - Typically have a strong risk-management orientation and generate a significant portion of their return by knowing when to take risk off the table
 - Strategies that are rules based, proprietary, complex and continue to “evolve” with new market behavior

Why is Dynamic Asset Allocation a Total Fund Strategy?

(Isn't it already an Absolute Return Strategy?)

- ❖ Most dynamic asset allocation strategies are structured as hedge funds, so one might expect to put them in the Absolute Return Strategy asset class
 - We do already have Absolute Return funds (e.g. Global Macro) that use dynamic asset allocation
- ❖ The Absolute Return Strategy asset class has a different return and risk objective than the Total Fund
 - Absolute Return has a specific asset class return objective of LIBOR + 4%, and a specific risk objective of 8.5% volatility with low correlations to other TMRS Asset Classes
 - Total Fund Objectives are different, return objective is 6.75% and Risk objective is 10.5%
- ❖ Sizing a dynamic allocation strategy within the context of the Absolute Return Strategies asset class will be very different from the sizing that would be optimal if it were considered as an overlay to the Total Fund

Currency Hedging

- ❖ Currency hedging mitigates the impact of currency risk on non-dollar international investment returns
- ❖ Currency risk is generally considered an unrewarded (but diversifiable) risk
 - Currency returns have volatility, but their long-term expected return is zero
 - Return volatility slightly reduces geometric returns over time
 - Currency returns have, for a large part of history, had low correlations with asset returns
- ❖ Possible Responses
 - Accept currency risk: If future currency returns have low correlations incremental risk will be very low
 - Passive currency hedge: Hedge of a fixed percent (50%, 75%, 100%) of currency exposure; can be very expensive at times
 - Active dynamic currency hedging: Employs active dynamic hedging strategies to increase hedging when it is most needed and save hedging costs when the hedge is not needed

Current Currency Risk Posture:

- Accept currency risk in our passive allocations
- Outsource currency risk management in our active allocations

Why is Currency Hedging a Total Fund Strategy?

- ❖ A fund's approach to currency risk management should be consistent across asset classes and be related to a fund's investment beliefs
- ❖ Currency exposure produces the same risk regardless of the asset classes
- ❖ A hedging program is much more efficient if implemented from a total fund exposure perspective

- Prioritizing based on Total Fund impact, Risk Management is not currently monitoring any currency hedging strategies
- If/when we do evaluate such strategies, a structure like "Total Fund Strategies" would provide the necessary framework for us to bring it to the Board for consideration

Why Now?

- ❖ TMRS has reached the size, maturity and institutional capacity necessary to consider these opportunities
 - The Board has overseen the largely completed implementation of a highly diversified asset class structure
 - We have developed significant internal expertise and consulting relationships for conducting complex due diligence
 - Integrated investment team will allow for sourcing of relevant skills
 - Public asset classes – currency risks
 - Absolute return strategies – complexity
 - Operationally we are capable of designing and implementing complex performance evaluation methodology

Practical Considerations

- ❖ With the addition of Total Fund Strategies, our asset class structure would span the entire space of investment opportunities so that we are considering all strategies that might benefit TMRS
- ❖ Some well-known plans have implemented Total Fund Strategies¹ as they have developed the resources to prudently do so:
 - Evaluate unique value creation models
 - Conduct complex due diligence
 - Hold complex performance expectations
 - Consider strategies that don't fit in an Asset Class box
- ❖ Total Fund Strategies are often implemented as a new Asset Class with 0% target allocation
 - It is not part of the Policy Benchmark and requires no actuarial return assumption
 - Manager performance evaluation standards can be complex, and those can be rolled up as necessary to evaluate the performance of Total Fund Strategies

1. Also sometimes called Total Portfolio Strategies, Risk Mitigation Strategies, Trust Level Portfolio Management, etc.

II. Review of Risk Reporting

1. Quarterly Board Risk Report

Board Level Risk Governance

- ❖ Define the Board's Risk Intentions
- ❖ Ensure that management mechanisms are created and supported to:
 - Implement the Board's intent
 - Monitor adherence to that intent

Purpose of Quarterly Board Risk Report

Allows Board to confirm that material risks taken in the investment portfolio are in line with Board intent as expressed in the Investment Policy Statement and related Asset Allocation and Asset/Liability Studies

Reasons for having two types of Risk Reports

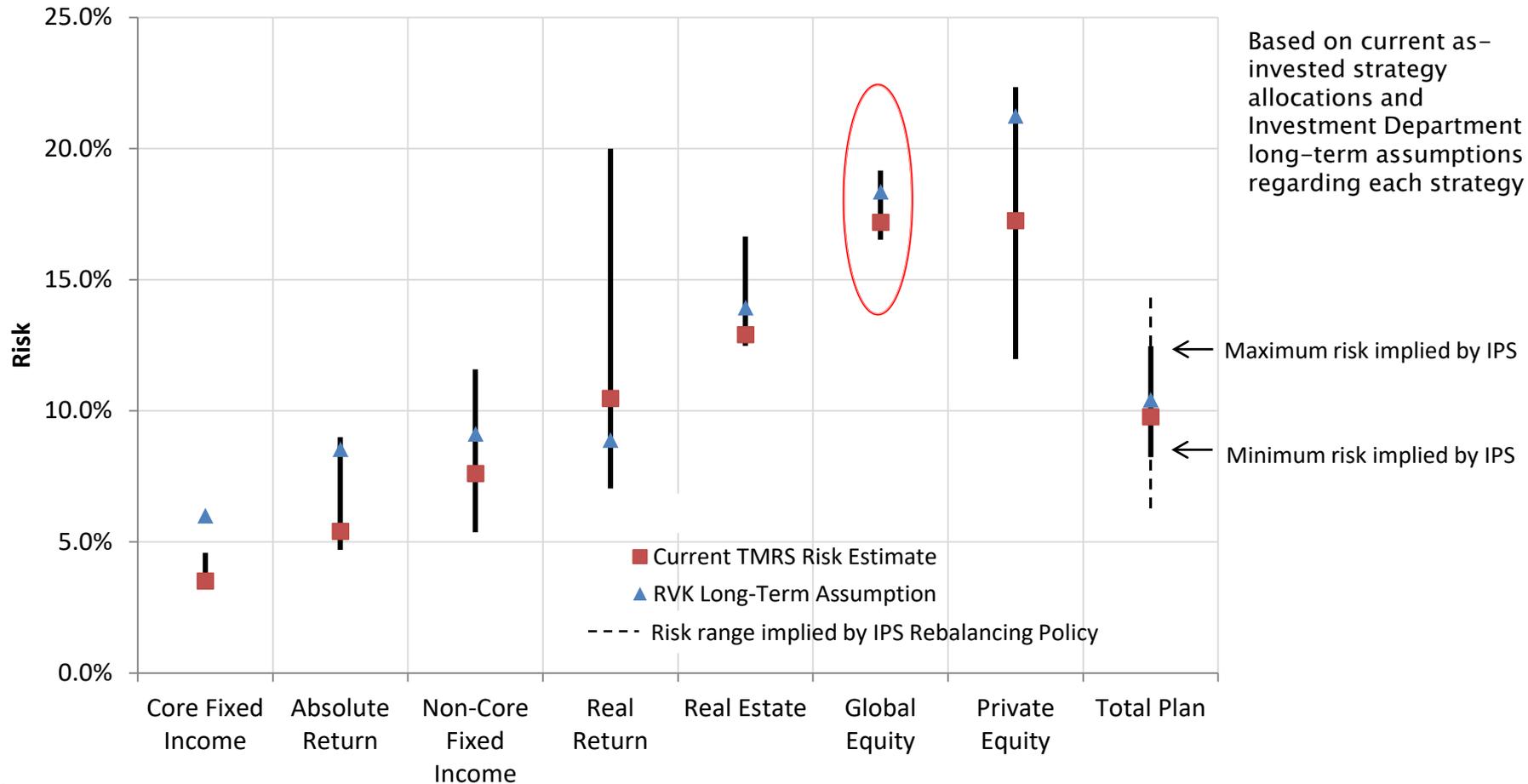
		Time Horizon	
		Short	Long
Portfolio View	More Granular	Security Level Holdings provide an exposure and risk view that is: <ul style="list-style-type: none"> • Objective • Meaningful 	 Security Level Holdings provide an exposure and risk view that is: <ul style="list-style-type: none"> • Objective • Not meaningful
	Less Granular	 Asset Class Strategy¹ level exposures provide a risk view that is: <ul style="list-style-type: none"> • Subjective • Meaningful 	Asset Class Strategy ¹ level exposures provide a risk view that is: <ul style="list-style-type: none"> • Subjective • Meaningful

1. Conceptually analogous to sub-asset class market risk premiums like: credit, rates, real estate, complexity, asymmetric knowledge, etc.)

Quarterly Board Risk Report – Long Time Horizon

Implementation Risk Ranges Implied by IPS Asset Class Guidelines

September 2018



Quarterly Board Risk Report – Short Time Horizon

Comparing Recent Volatility to Long-Term Assumptions

Total Fund Risk by Asset Class

September 2018

	Holdings-Based Risk Model: Short-term outlook based on recent volatility of actual holdings ¹						Strategy Implementation Risk: Long-term outlook based on TMRS Staff expectations			RVK Long-term outlook
	Portfolio			Policy Benchmark			Minimum Risk Implied by IPS	Current Portfolio Risk	Maximum Risk Implied by IPS	
	Weight (%)	Risk	Contribution to Total Risk	Weight (%)	Risk	Contribution to Total Risk				Benchmark Risk
Total	100.0%	6.2	100.0%	100.0%	6.3	100.0%	8.2	9.8	12.5	10.4
Cash Assets	0.1%	0.0	0.0%	0.0%	0.0	0.0%	--	0.0	--	3.0
Global Equity	38.9%	10.2	62.3%	35.0%	10.5	56.0%	16.5	17.2	19.2	18.4
Core Fixed Income	13.8%	3.9	0.4%	10.0%	3.6	-0.2%	3.5	3.5	4.6	6.0
Non-Core Fixed Income	17.1%	5.2	12.0%	20.0%	5.5	13.0%	5.4	7.6	11.6	9.1
Real Estate	8.5%	9.9	8.9%	10.0%	9.8	9.2%	12.5	12.9	16.6	13.9
Real Return	10.2%	6.6	9.8%	10.0%	6.9	9.3%	7.0	10.5	20.0	8.9
Absolute Return	9.7%	2.9	3.9%	10.0%	3.0	3.7%	4.7	5.4	9.0	8.5
Private Equity	1.5%	15.9	2.7%	5.0%	15.5	8.9%	12.0	17.3	22.3	21.3

Portfolio risk should be similar to benchmark risk

Note which asset classes contribute more/less to risk than their weight in the portfolio (e.g. Equity)

Note risk ranges relative to assumptions used in Asset Allocation; more details on the next page

Note where current strategic positioning falls within the range, which is indicative of where we see the best risk/return trade off

1. Short-term risk numbers are based on the recent past and can be significantly different than long-term averages

I. Review of Risk Reporting

2. Internal Risk Analytics

Board Risk Reports That Require Action Suggest Risk Management Failure

- ❖ In our Three Lines of Defense Risk Governance Model¹
 - Investment (Asset Class) Teams are the First Line of Defense
 - The CIO, Risk Management, and Compliance are the Second Line of Defense
 - Independent and/or external sources provide the Third Line of Defense
- ❖ The Risk Management function is explicitly tasked to “Independently monitor and report on the level of risk against established risk appetite as expressed in IPS Guidelines”
- ❖ To help support and not just monitor the achievement of desired results, the Risk Management function provides detailed internal analytics with the goal of identifying potential problems while there is still time to avoid them

Internal Analysis and Monitoring Conducted by Risk Management

❖ Cash Flow

- Records all private market fund capital calls and distributions
- Projects expected future fund cash flows for asset class pacing planning and total fund liquidity management
- Provides input to liquidity risk simulation model

❖ Account Allocation and Rebalancing

- Used by the CIO to review allocations and funding sources for new accounts

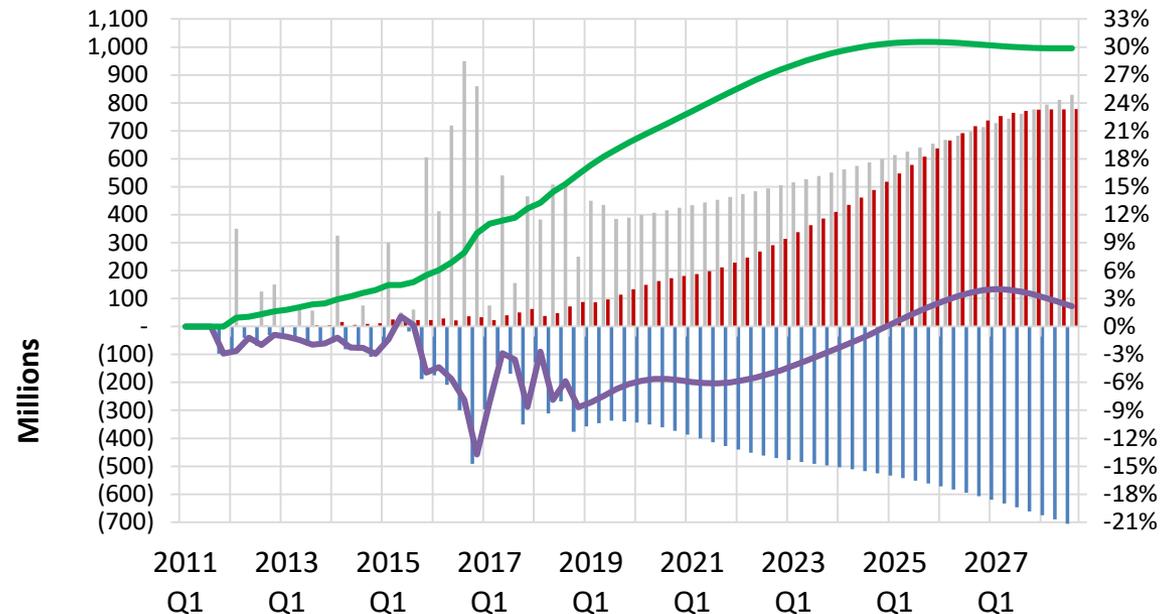
❖ Liquidity & Leverage

- Aggregates liquidity and leverage expectations for each account to the Total Fund level

❖ Asset Class Specific

- Risk reporting as appropriate
- Manager performance attribution analysis as appropriate

Cash Flow Model Quarterly Projections



Conclusions

- ❖ Current methodology for risk measurement and asset allocation (MPT) was not designed to handle issues specific to Alternative Asset Classes
 - In 2019, the Risk Management team will conduct portfolio analysis that improves our ability to measure Alternative Asset Class risk

- ❖ Significant investment opportunities exist for TMRS that do not fit into our current asset class framework:
 - TMRS is reaching the size and institutional capacity necessary to engage these opportunities
 - The 2019 Asset/Liability Study could be a good opportunity to present Total Fund Strategies for the Board's consideration

- ❖ Quarterly Board Risk Reporting allows the Board to confirm that risks taken in the investment portfolio are in line with the Board's intent
 - Compares short horizon, Holdings Based, Risk to Investment Policy Benchmarks
 - Compares Implementation Risk to long term policy risk guidance ranges

- ❖ Internal Risk Analytics are produced, and continue to be developed, with the goal of helping the investment teams identify potential problems while there is still time to avoid them

Appendix

Active Risk Due to: Allocation Decisions

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Active risk (i.e. risk of being different from the benchmark) can be divided into Allocation and Selection decisions

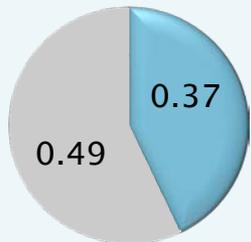
Note that a large part of our active risk is due to not yet fully implementing our Strategic Target Allocation

Note that a very small part of our risk is due to active allocation decisions to deviate from our Strategic Target Allocation

Total Active Risk = 0.86

Active Risk from Allocation

Active Risk from Selection



Asset Class	Policy Benchmark	Strategic Target Allocation (%)	Portfolio Allocation (%)	Allocation Difference (%)	Pending Policy Allocations	Active Risk from Allocation Decisions:	
						Contribution of Pending Policy Allocation Decisions ¹	Contribution of Investment Allocation Decisions ²
Cash Assets	30 Day T- Bill	0.00%	0.13%	0.13%		0.00	0.00
Global Equity	MSCI ACWI IMI	35.00%	38.93%	3.93%	-3.50%	0.01	0.00
Core Fixed Income	Barclays U.S. Agg	10.00%	13.83%	3.83%	-4.00%	0.11	0.00
Non-Core Fixed Income	50% High Yield, 50% Levered Loan	20.00%	17.08%	-2.92%	3.00%	0.01	0.00
Real Estate	NCREIF ODCE	10.00%	8.52%	-1.48%	1.00%	0.01	0.00
Real Return	Manager Benchmark Rollup	10.00%	10.25%	0.25%		0.00	0.00
Absolute Return	HFRI FOF Diversified Index	10.00%	9.73%	-0.27%		0.00	0.00
Private Equity	Custom risk proxy	5.00%	1.53%	-3.47%	3.50%	0.23	0.00
Total Active Allocation Risk		100.00%	100.00%	0.00%		0.37	0.00

Active Risk Due to: Selection Decisions

September 2018

For alternatives, the best available benchmarks do not satisfy all of TMRS's benchmarking criteria, so active risk measurements are less precise

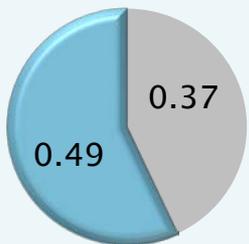
Note how much of our active risk is due to choosing manager benchmarks different from policy benchmarks

Note how much of our active risk is due to managers holding portfolios different from their benchmarks

Total Active Risk = 0.86

■ Active Risk from Allocation

■ Active Risk from Selection

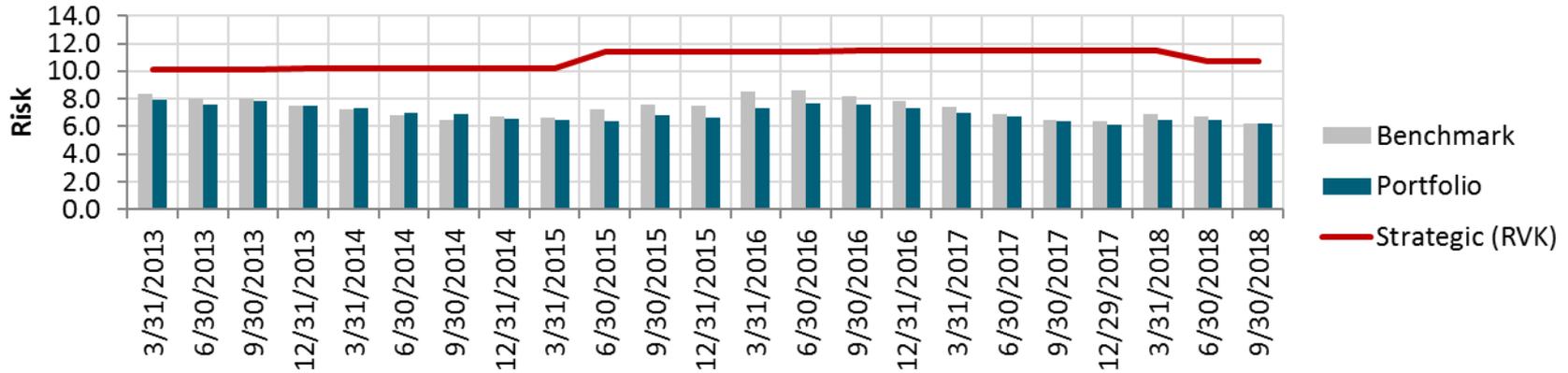


Asset Class	Policy Benchmark	Portfolio Allocation (%)	Active Risk from Selection Decisions	
			Contribution of Strategy Benchmark Decisions	Contribution of Active Manager Decisions
Public/Traditional Investments				
Cash Assets	30 Day T- Bill	0.13%	0.00	0.00
Global Equity	MSCI ACWI IMI	38.93%	0.06	-0.01
Core Fixed Income	Barclays U.S. Agg	13.83%	0.00	0.01
Public Non-Core Fixed Income	50% High Yield, 50% Levered Loan	10.81%	0.10	0.00
Public Real Return	Manager Benchmark Rollup	8.89%	0.06	0.01
Private/Alternative Investments				
Private Non-Core Fixed Income	50% High Yield, 50% Levered Loan	6.27%	0.00	0.03
Private Real Return	Manager Benchmark Rollup	1.36%	0.00	-0.03
Real Estate	NCREIF ODCE	8.52%	0.00	0.06
Absolute Return	HFRI FOF Diversified Index	9.73%	0.00	0.14
Private Equity	Custom risk proxy	1.53%	0.00	0.03
Total Active Selection Risk		100.00%	0.21	0.28

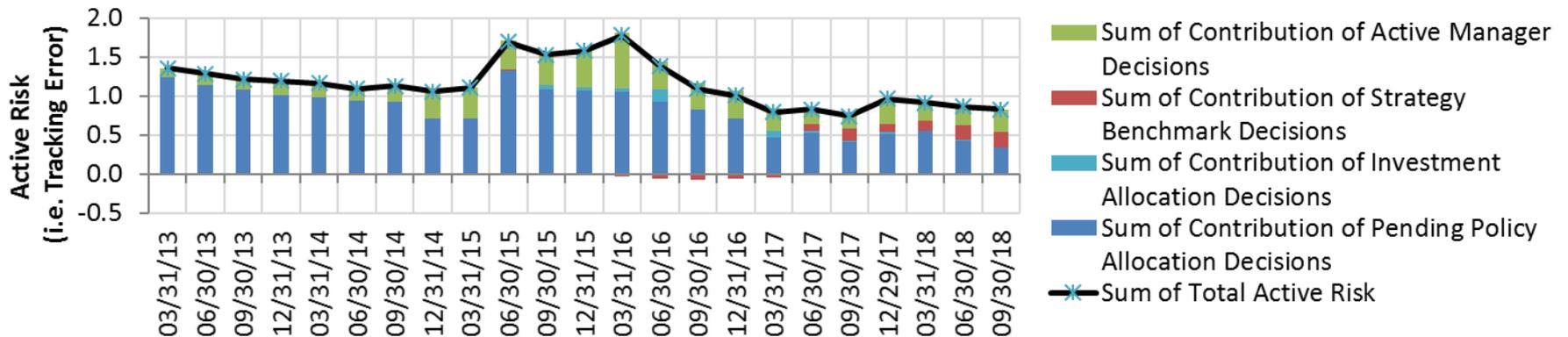
Evolution of Risk Over Time

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Total Risk



Active Risk



Total Fund & Asset Class Regional Exposures

September 2018

Note which asset classes are currently concentrated in the US

Note which asset classes are exposed to non-US developed markets

Note which asset classes are exposed to emerging markets

	Developed Americas	Developed Europe	Developed Asia & Pacific Rim	Emerging Americas	Emerging Europe	Emerging Asia & Pacific Rim	Middle East & Africa
Cash Assets	100%	0%	0%	0%	0%	0%	0%
Global Equity	58%	19%	11%	1%	1%	9%	1%
Core Fixed Income	88%	8%	1%	1%	0%	1%	1%
Non-Core Fixed Income	76%	9%	1%	5%	5%	3%	1%
Real Estate	95%	5%	0%	0%	0%	0%	0%
Real Return	67%	18%	10%	3%	1%	1%	0%
Absolute Return	45%	33%	7%	2%	6%	7%	0%
Private Equity	92%	6%	0%	1%	0%	1%	0%
Total Fund	69%	15%	6%	2%	2%	5%	1%

Are there any surprises in the total fund regional exposures?

NOTES: 1. Developed Americas consists almost entirely of the USA. Canada is a very small allocation.
 2. The Absolute Return regional breakdown is based on manager and ARS consultant estimates.

Three Lines of Defense Risk Governance

