How Quants Can Power the Future of Wealth Management & Financial Advice

Dr. Dan Rosen
CEO, d1g1t

AR PM Quant Bootcamp®

NYU, July 9th 2025

Over the next 20 years, $124 trillion will be passed on to heirs and charities

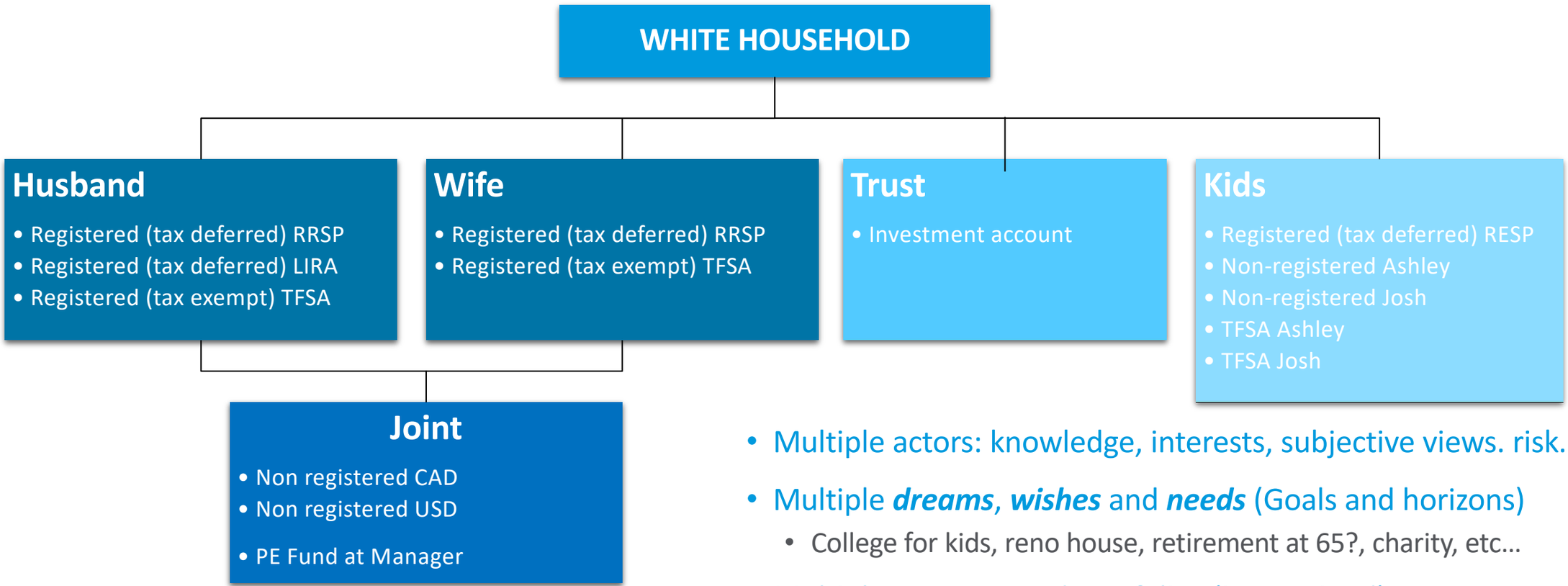
"Financial advisors will need to develop specific business strategies to avoid letting the flood of planning opportunities slip through their fingers."

Source: **The Cerulli Report**
High-Net-Worth and Ultra-High-Net-Worth Markets 2024

Quant in Wealth Management

Building Robots or Empowering Advisors?

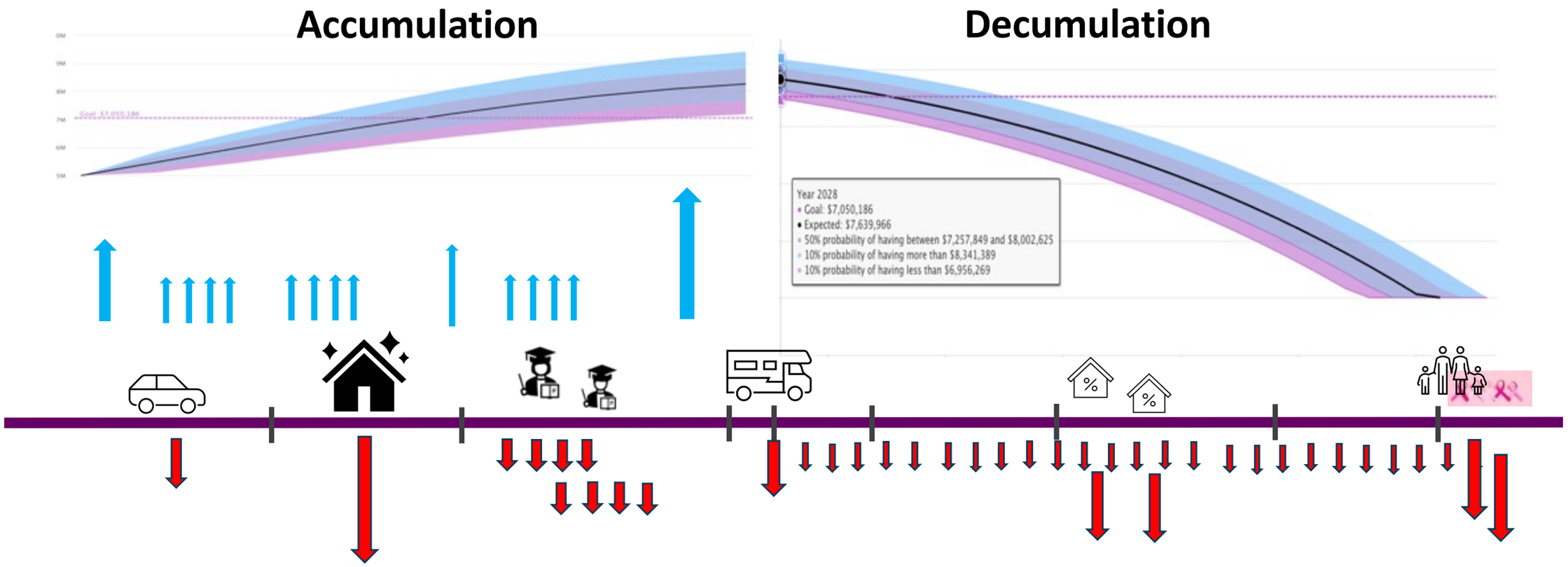
It All Starts with a Client/Family



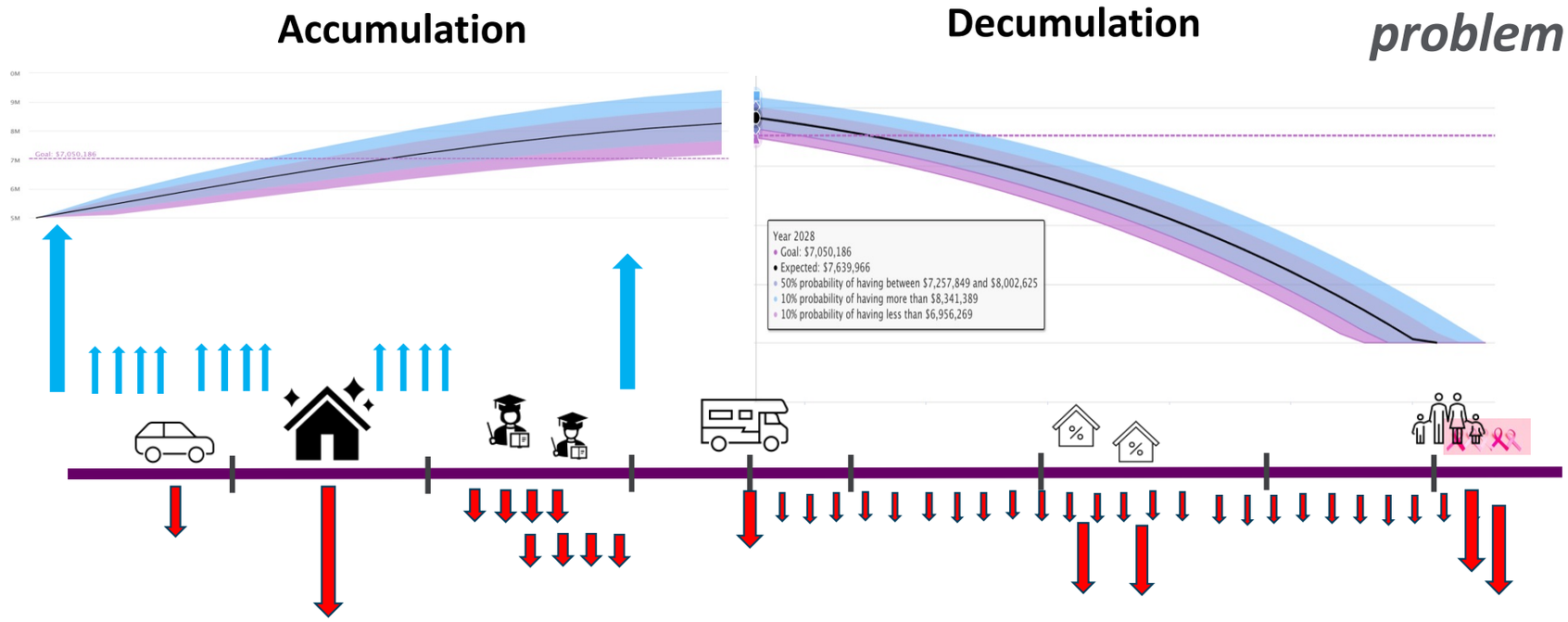
- Multiple actors: knowledge, interests, subjective views. risk…
- Multiple ***dreams***, ***wishes*** and ***needs*** (Goals and horizons)
  - College for kids, reno house, retirement at 65?, charity, etc…
- Multiple accounts and portfolios (intertwined)
- Multiple tax aspects: accounts, assets, legal entities, timing,…

Goals-Based Wealth Management

The General Problem



Goals-Based Wealth Management – The Problem

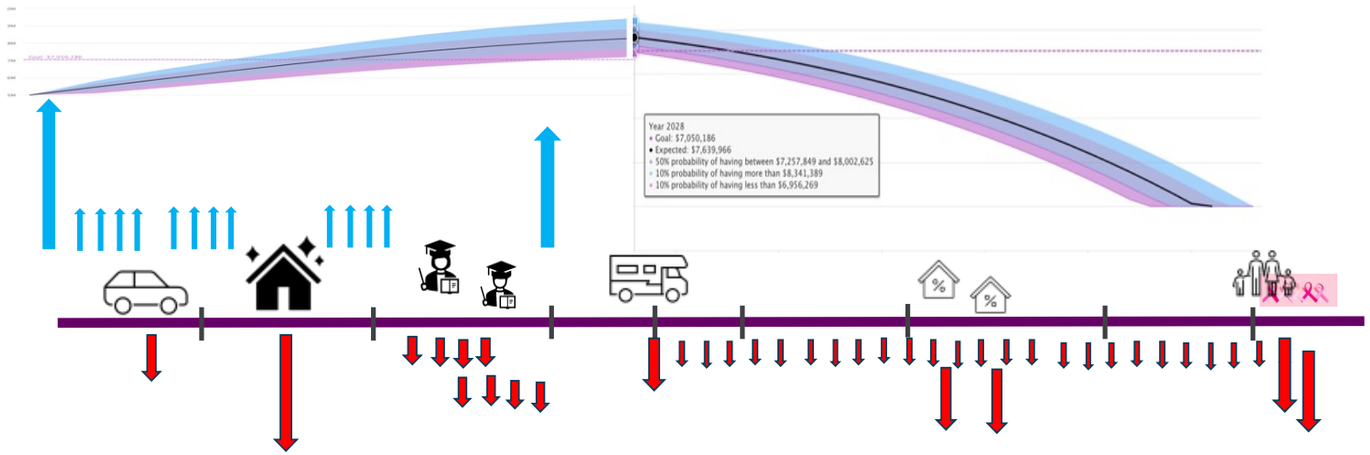


William Sharpe famously coined **decumulation** to be

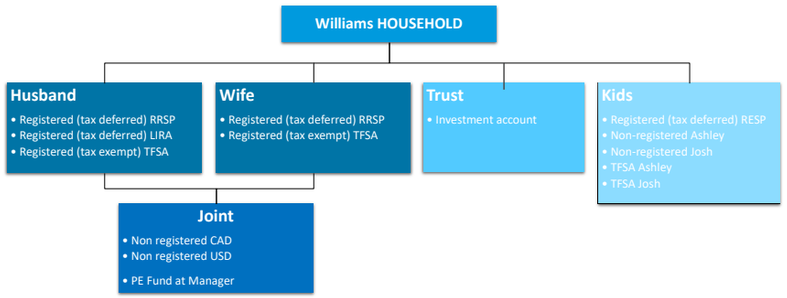
"the nastiest, hardest problem in finance"

(Ritholz 2017)

Goals Based WM: Household Asset-Liability Management



Find the "Optimal" overall portfolio strategy for the Household



- Asset (risk-factor) allocation now
  - Across all members (legal-entities) and accounts (location)
- Dynamic allocation over time (long horizon)
- Dynamic decision making on funding or fulfilling goals (accumulation and decumulation)
- Alignment with clients' risk profiles… over lifecycle

In Practice… Financial Advice… for *Humans*

The actual problem is very complex!

Financial Advisors work with ***people*** (individuals, families) with human goals, emotions, fears, and (*not so rational*) reactions… and in the real (complex financial) world

- Truly hard to define precisely the problem to optimize (goals, risk tolerance, trade-offs, reactions)
- Multiple stakeholders, goals, times, levels (utility)
- Constantly changing over time
- Very sensitive to changing individual life circumstances, unexpected life events, markets (ups-downs)
- The “subject/client” itself is changing constantly: Individuals’ tolerance, appetite and understanding of risk (education, experience, life events, a financial crisis,…)
- The advice itself may create an important feedback loop!
- Difficult to capture complete picture – optimization is very sensitive to these assumptions and definitions
- Model assumptions… over long horizons

The Wealth Management Risk Cycle

Investor's Risk Profile

Multiple metrics are needed to characterize an "Investor's Risk"

- **Risk Capacity** – how much risk you can handle financially
- **Risk Tolerance** – how much risk you can withstand emotionally
- **Risk Appetite** – willingness to bear financial risk (with expectation of generating a potential profit)

- Financial knowledge
- Information appetite

Risk return trade-off / risk aversion

Tools include: Behavioural Finance and Psychometrics

Goals & Risk

Goals reflect an investor's (individual or household) **needs**, **wants**, **wishes** and **dreams**

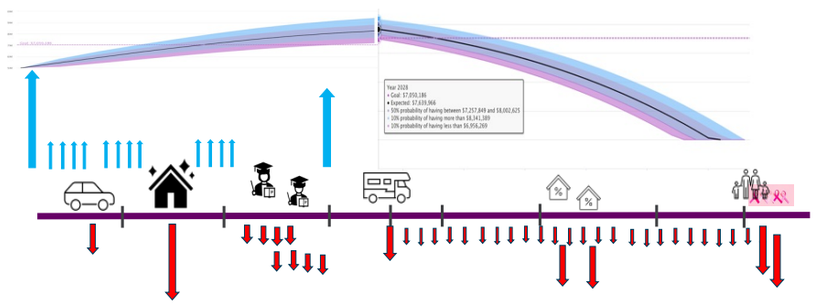
Typical risk measures reflecting future short-term portfolios losses do not relate to goals

- e.g. VaR, expected shortfall, volatility, drawdown…

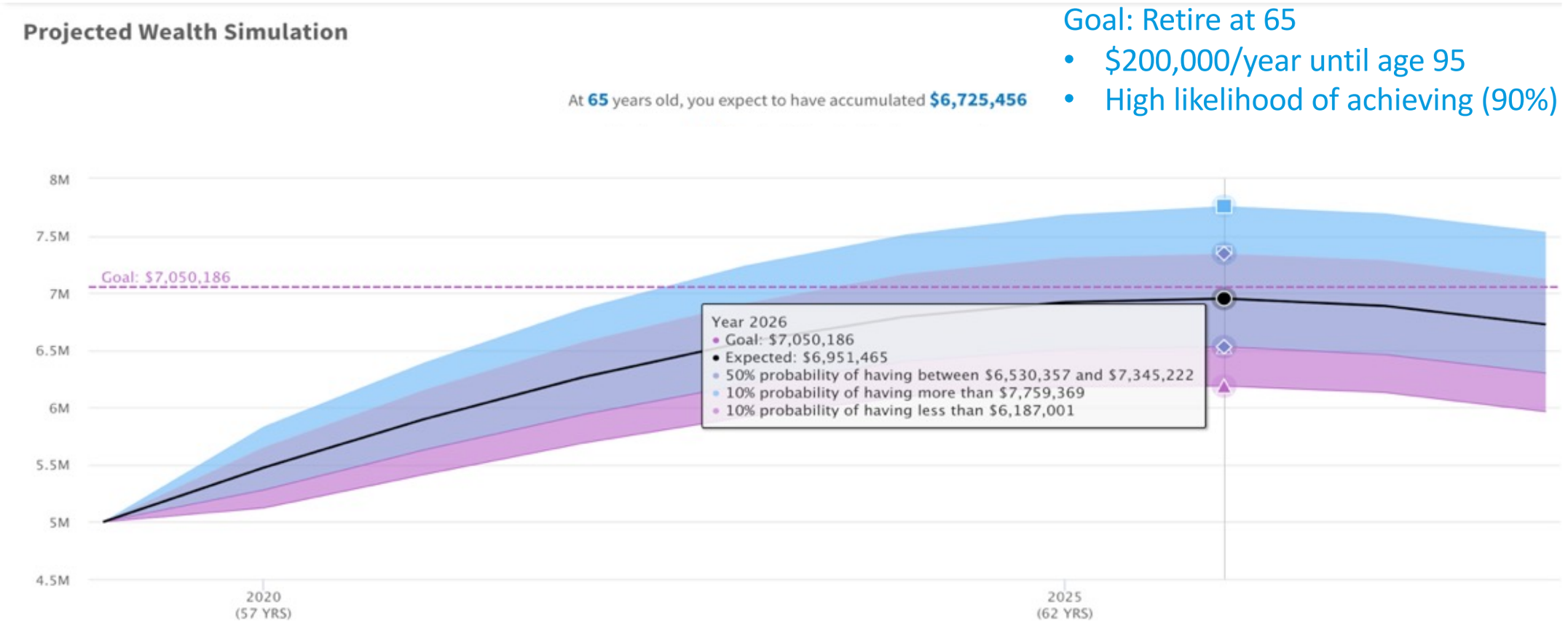
Goal-based Risk → the possibility of not achieving goal(s) in the future, how far we will be, and the severity/consequences (for an investment strategy over time)

Relevant metrics

- Probability of meeting goal(s)
- Distance to meet goal (for a given strategy and scenarios)
- Expected shortfall (conditional on not meeting goal)
- Trade-offs between competing goals (of different importance)



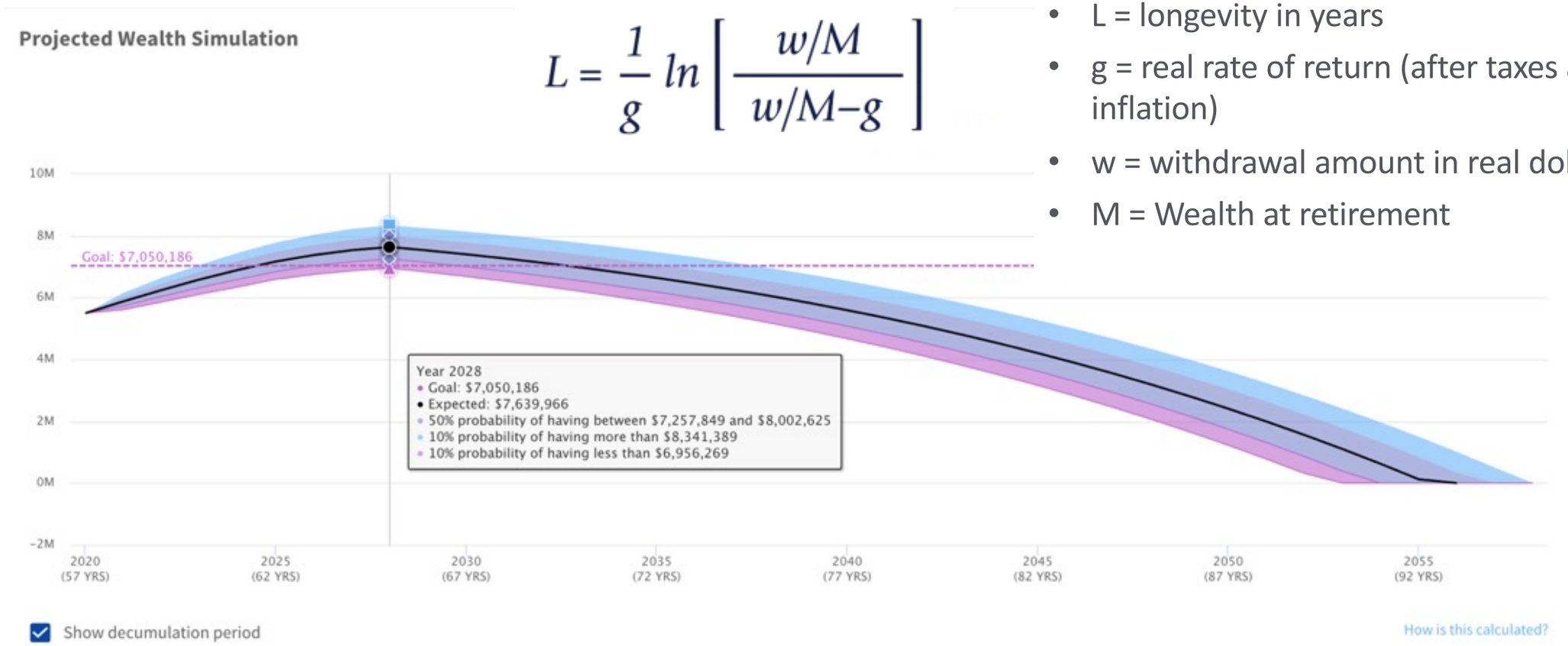
Long-Term Wealth Simulation – Example



Goal: Retire at 65

- $200,000/year until age 95
- High likelihood of achieving (90%)

Long-Term Wealth Simulation (Retirement Income & Decumulation)



$$L = \frac{1}{g} \ln\left[\frac{w/M}{w/M - g}\right]$$

Simple Longevity formula (Fibonacci)

- L = longevity in years
- g = real rate of return (after taxes and inflation)
- w = withdrawal amount in real dollars
- M = Wealth at retirement

Investment Plans, Mandates, IPSs

In practice, this needs to be realistic

- Multiple goals and timelines
- Multiple actors: different risk profiles and timelines
- Multiple sources of funding (different rules, taxes)

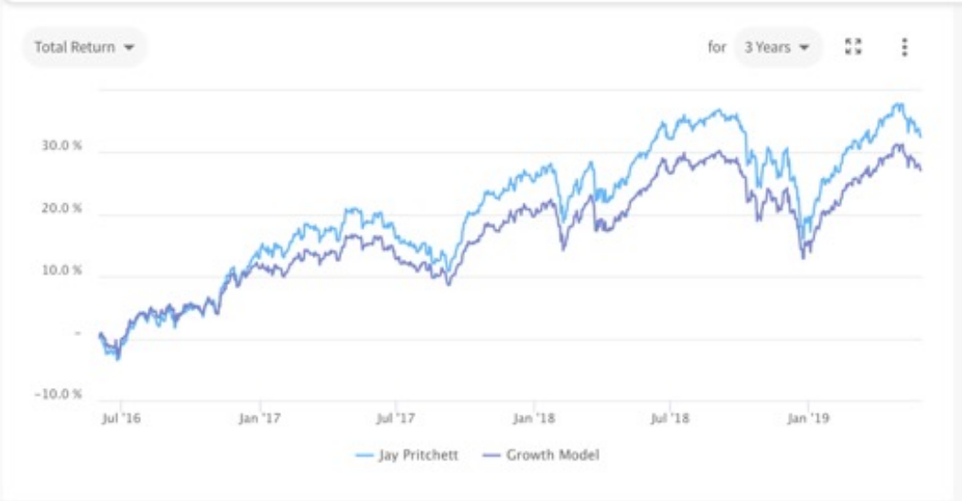
Solution must be actionable: easy to execute, track, and communicate

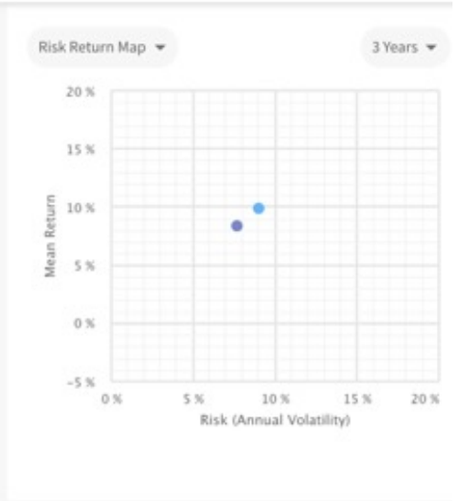
- Multiple mandates/sub-mandates acting together
- Funded through multiple accounts and financial vehicles (e.g. trusts and insurance)

Constructing & Rebalancing Portfolios

IPS – Model Portfolio's Risk

Actual Portfolio's Risk



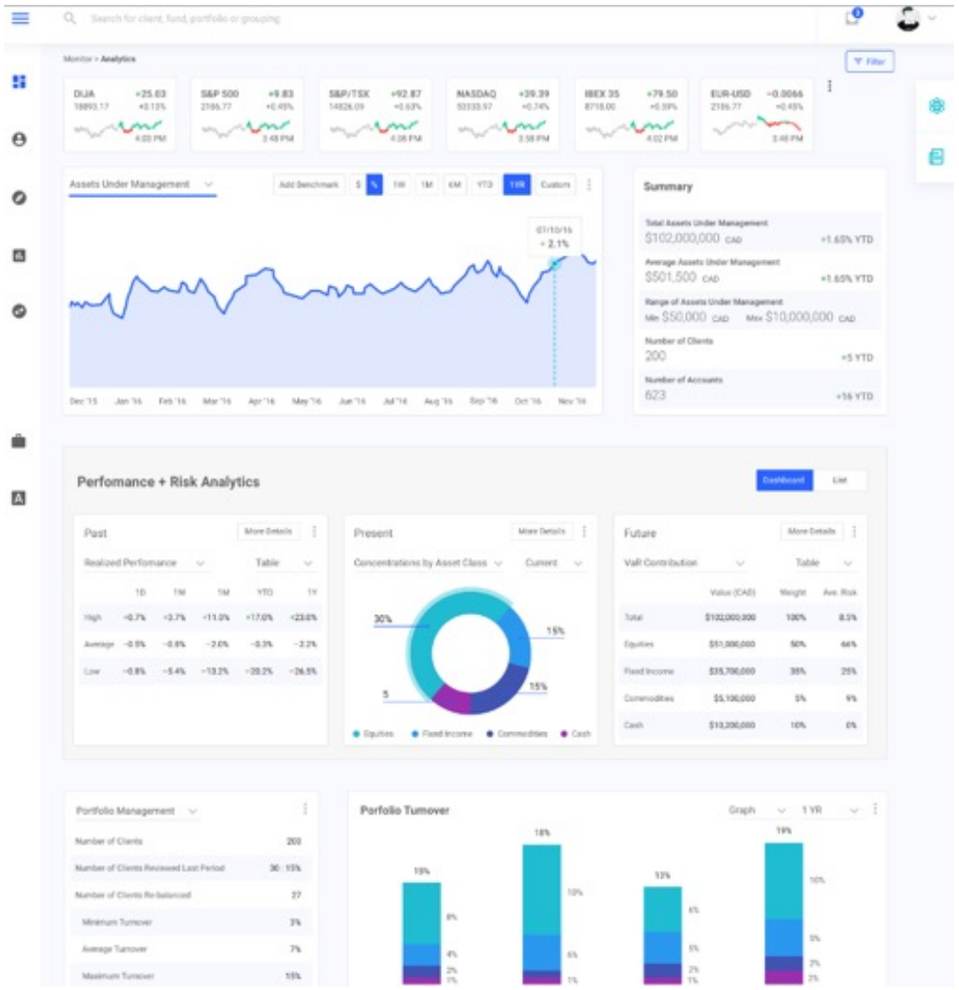


Search for data containing...

Portfolio View

Security Name	Return (YtD)	Return (1Y)	Return (3Y)	Volatility (3Y)	VaR (90%)	Drawdown (3Y)	% of Portfolio collapse: Total	Cash & Cash Equivalent	Equity	Fixed Income
Jay Pritchett	10.9 %	2.3 %	9.6 %	9.9 %	5.2 %	13.6 %	100.0 %	8.8 %	90.0 %	1.2 %
Growth Model	10.0 %	2.5 %	8.4 %	8.6 %	4.4 %	12.0 %	100.0 %	2.8 %	77.1 %	20.1 %

Monitoring Portfolios: Exposures, Performance, Risk



Tracking Portfolios…
and understanding causes:

- Exposures: slice & dice
- Performance attribution
- Risk contributions
- Scenario Analysis
- Risk factor analysis and decomposition
- Cashflow forecasts

Wealth Management **Risk** and **Performance** Metrics

Behavioural

- Risk Tolerance
- Risk Capacity
- Risk Appetite

Longevity Risk

- LTC (Long Term Care)

ALM/Household Treasury

- Prob of achieving goal
- Gap Risk
  (distance to Goal)
- Shortfall
- Liquidity

- Exposures

- Performance & attribution

- Portfolio Risk & diversification

- Market Risk (short & long-horizon)
- Credit Risk
- Liquidity Risk
- Inflation

- Stress Scenarios

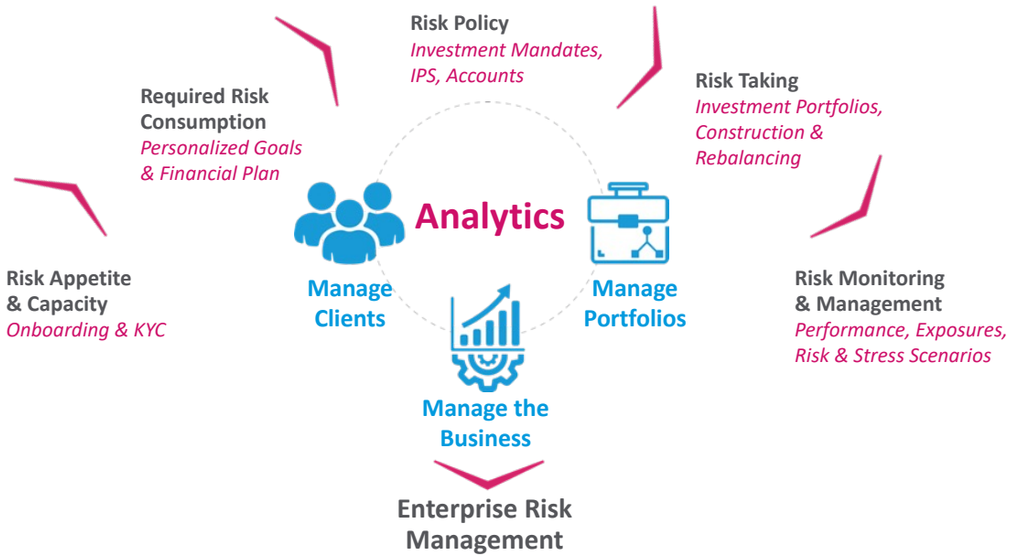
Wealth Portfolio Optimization

.... at Scale

d1g1t

Wealth Portfolio Optimization

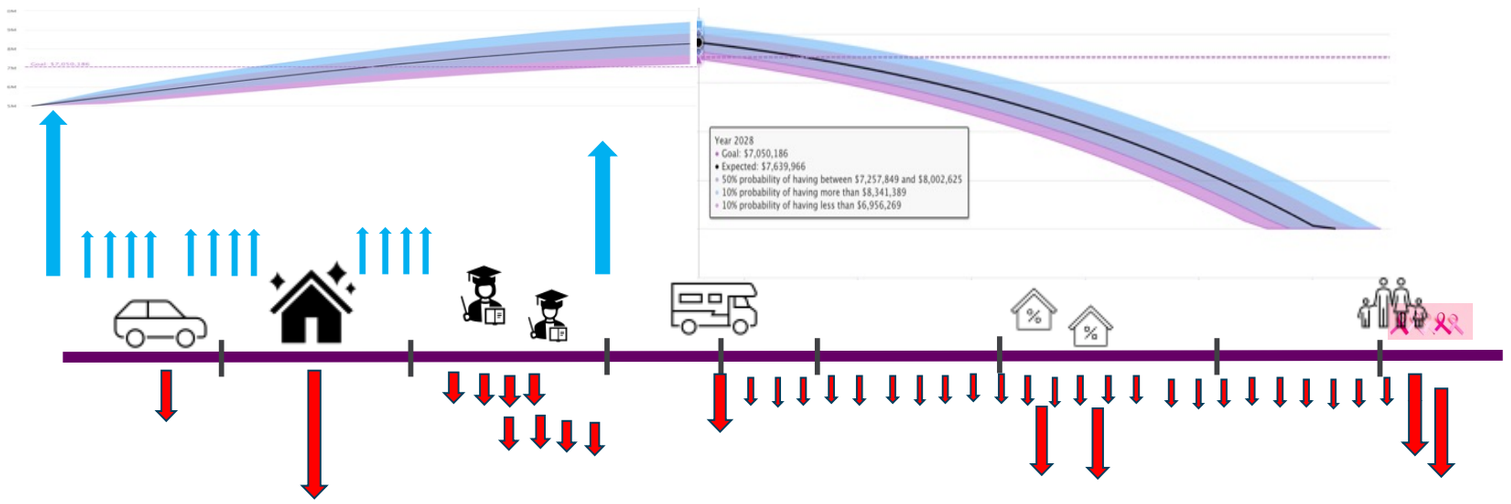
Efficient Portfolio Manufacturing and Client Management at Scale!

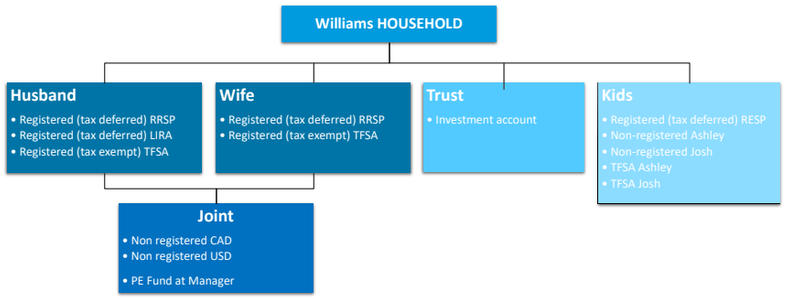


Objective: provide **personalized**, and **high-touch** portfolio investment programs for 100s or 1,000s of clients in an efficient manner

- Understand the entire book of business
  - Pro-actively (instead of reactively) address which clients
    - Require more attention
    - Can take advantage of an opportunity
    - Are more affected by a given market event…
- Interactive, dynamic engagement with a client to define what is important and understand trade-offs
- Realistic: account for uncertainties and lack of precise definition and changes over time

Portfolio Optimization in Wealth Management

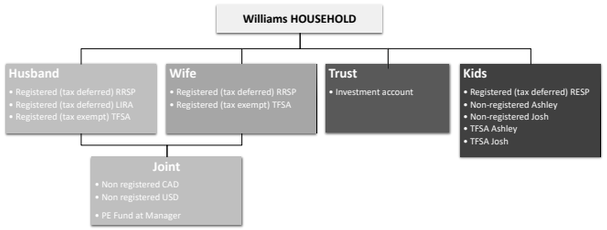


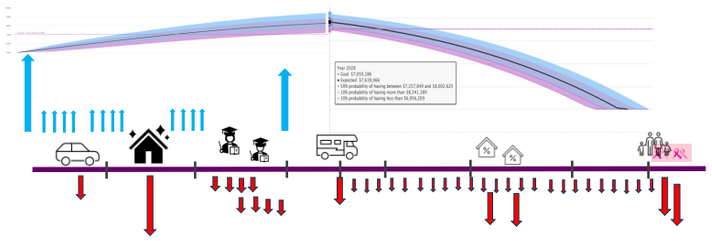


Find the "Optimal" overall portfolio strategy for the Household

- Asset (risk-factor) allocation now
  - Across all members (legal-entities) and accounts (location)
- Dynamic allocation over time (long horizon)
- Dynamic decision making on funding or fulfilling goals (accumulation and decumulation)

Portfolio Optimization in Wealth Management





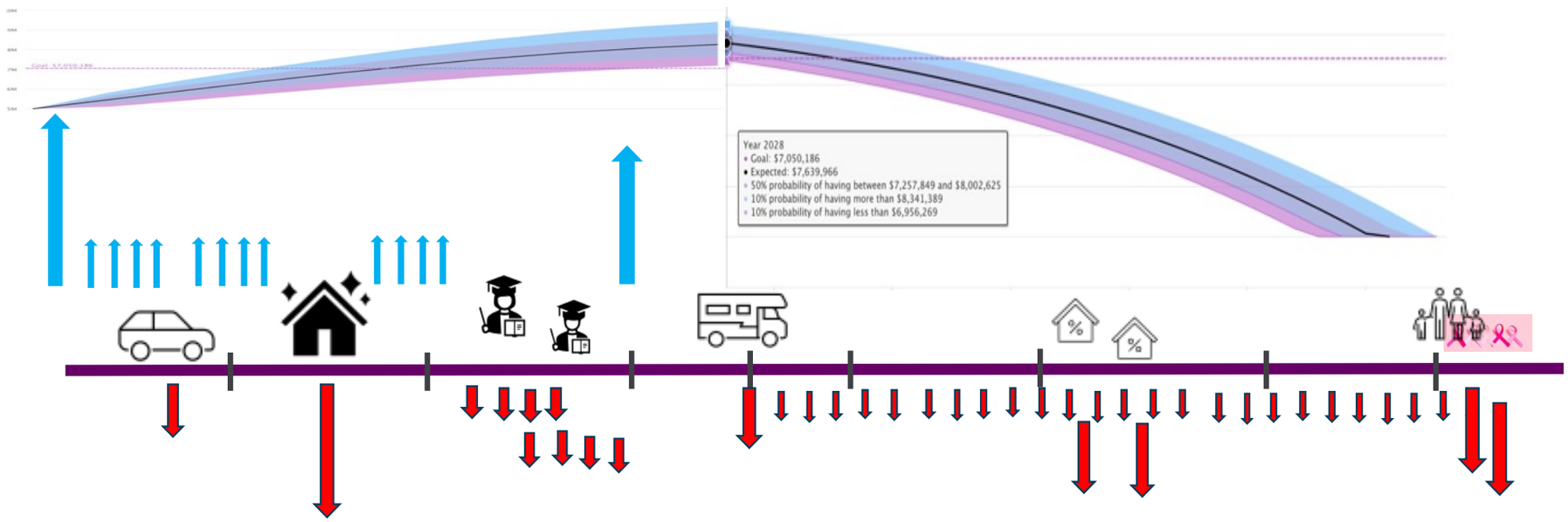
Security	CUSIP	Price	Curr	USD
JAPAN-164(10 YEAR ISSUE) JGB 4.1 12/22/03	GG7174376	101.64	JPY	0.92
JAPAN GOVT COUPON STRIPS JGBS 0 12/20/21	EC8297581	77.83	JPY	0.70
JAPAN- 12(3 YEAR DISC) JDGB 0 09/20/05	EC6650773	99.75	JPY	0.90
CANARY WHARF FIN II PLC CANWHA 0 01/24/22	EC3985388	100.00	EUR	115.80
YORKSHIRE BUILDING SOC YBS 0 01/15/04	EC0873579	100.00	GBP	166.38
PACIFIC LIFE FUNDING LLC PACLIF 5.153 07/15/09	EC0076942	107.35	NLG	56.42
YAHOO! INC	984332106	20.00	USD	20.00
US TREASURY N/B T 1 1/2 07/31/05	912828BE9	99.92	USD	99.92
US TREASURY N/B T 1 1/8 06/30/05	912828BC3	99.23	USD	99.23
US TREASURY N/B T 3 02/15/08	912828AT7	100.59	USD	100.59
TYCO INTERNATIONAL LTD TYC 6 3/8 01/15/04	902120AF1	85.00	USD	85.00
RGS (AEGCO) FUNDING CO AEP 9.81 12/07/21	74955DAA9	133.36	USD	133.36
PRIVATE EXPORT FUNDING PEFCO 5.73 01/15/04	742651CK6	103.89	USD	103.89
PAINE WEBBER GROUP INC UBS 0 03/15/05	69563AKU4	100.00	USD	100.00
GOVT TRUST CERT GTC 7.33 05/15/06	383751AA2	100.00	USD	100.00
GOVERNMENT EXPRT GOVEXP 6 03/15/05	383731AE6	104.40	USD	104.40
GTE NORTH INC VZ 6 01/15/04	362337AD9	103.64	USD	103.64
COCA-COLA ENTERPRISES CCE 8 1/2 02/01/22	191219AP9	130.44	USD	130.44
CITIZENS COMMUNICATIONS CZN 7.45 01/15/04	177342AH5	101.80	USD	101.80
CANADA GENERIC STRIP CANCDS 0 12/01/21	13508ZYV8	34.22	CAD	25.46
BERKLEY (WR) CORPORATION BER 8.7 01/01/22	084423AC6	112.05	USD	112.05

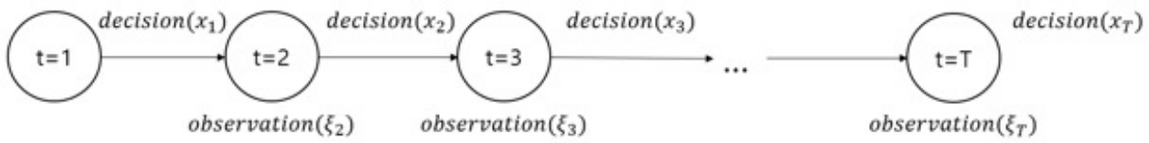
“Optimal” Household portfolio strategy

- **Maximize multi-criteria (utility) function**: multiple goals over time
  - Inflows and outflows (consumption), terminal wealth
- Long horizon (covering accumulation and decumulation)
- Takes best advantage of investment universe available (“efficient portfolios”)
- Accounting for taxes, risk profiles, stochastic markets
- Complex constraints: consistent with multiple client risk/investment preferences, liquidity, compliance/regulatory (tax)
- Rich scenario set (multi-factor forecasting model)

General Formulation: Multistage Stochastic Optimization

Find the “Optimal” overall portfolio strategy for the Household

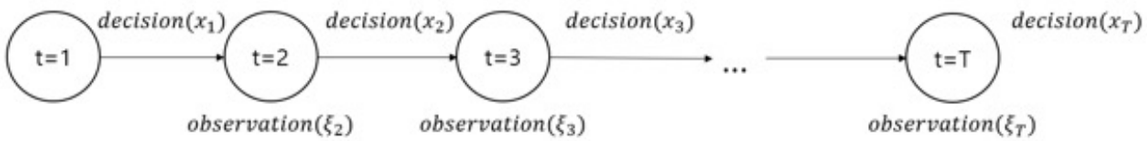




Decision Process $\boldsymbol{x}$: allocations, in/out-flows, fulfil goals

Stochastic Process ξ: evolution over t of all investments

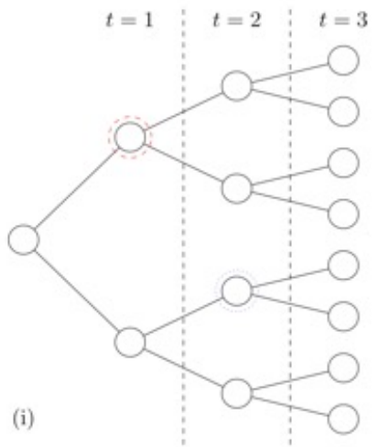
General Formulation: Multistage Stochastic Optimization



Decision Process x: allocations, in/out-flows, fulfil goals

Stochastic Process ξ: evolution over time of all investments

$$\min_{x_1 \in \mathcal{X}_1} f_1(x_1) + \mathbb{E}_{\xi_2}\left[\inf_{x_2 \in \mathcal{X}_2(x_1,\xi_1)} f_2(x_2,\xi_2) + \mathbb{E}_{\xi_3}\left[\cdots + \mathbb{E}_{\xi_T}\left[\inf_{x_T \in \mathcal{X}_T(x_{T-1},\xi_T)} f_T(x_T,\xi_T)\right]\right]\right].$$



Multi-stage Stochastic Programing approach (e.g. Dempster et al, Mulvey et al)

1. Scenario tree approximates the stochastic process ξ (finite number of realizations)
2. Solve large equivalent deterministic convex optimization problem under realized scenario tree

   Curse of dimensionality (may lead to intractable problem)

   - Number of scenarios increases exponentially with the number of stages and nodes per stage (dimensionality of process….)

Stochastic Dynamic Programing (e.g Das et al)

- Markov processes, explicit conditional probabilities, low dimensionality

Machine Learning methods: Reinforcement Learning, Neural Networks (e.g. Dixon & Halperin, Forsyth et al)

- Applicable to general setting, non-parametric data-driven processes… but may be slow and lack explanation

Stochastic Optimization for GBWM – Key Features

Objective Function

- The standard approach: ***Max Expected Utility*** (consumption over time & final wealth)

In GBWM, some intuitive objective functions (e.g. Das et al, Forsyth et al):

- Maximize Probability of achieving the goal:

$$\max \Pr\{W(T) > G\}$$

- Minimize the Distance to achieving the goal (or to underperforming goal):

$$\min E\{ ||W(T) - G||\_ \}$$ (typically the 2-norm)

Multiple goals → multi-criteria utility function

- Assigning a cost and utility (importance) to each investor's goal: full or partial fulfilment

Quant Portfolio Manufacturing Process

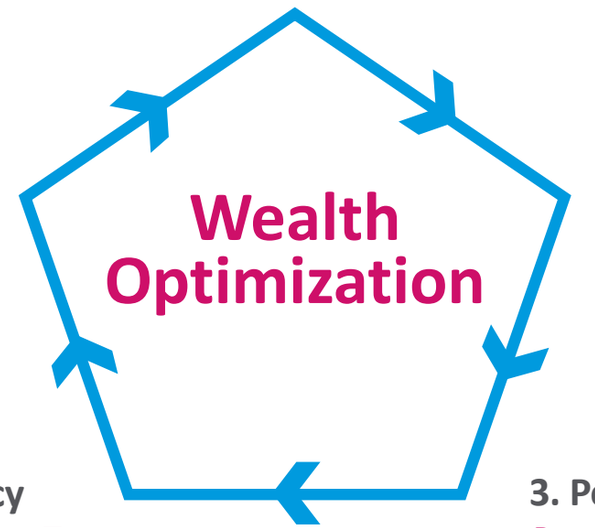
1. Product Manufacturing
Efficient Portfolios/ Model Portfolios

2. Dynamic Risk Allocation
Consumption & Funding: Goals, Liquidity Management

3. Portfolio Customization
Personalized, Client Specific Portfolios

4. Tax efficiency
Account Location, Tax Harvesting, etc…

5. Risk Monitoring & Management
Performance Attribution, Exposures, Risk & Stress Scenarios



Scalable process to construct ***Effective*** Portfolio management strategies for all clients

We achieve this by:

- Breaking the process into a set of steps that are

  Manageable & ***Repeatable***

- Taking advantage of the best financial optimization, risk management and ML tools available

Quantitative Portfolio Manufacturing Process

1. Product Manufacturing
Efficient Portfolios/ Model Portfolios

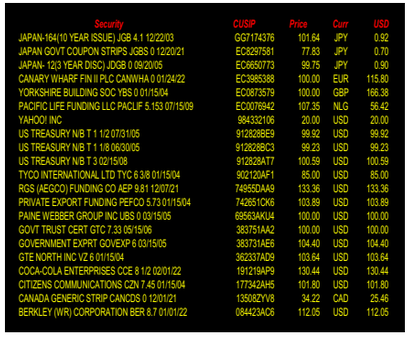
Efficient Portfolios & Model Portfolios

Construct set of optimal model portfolios or investment programs, based on available investment vehicles and expertise (available for all clients… segmented)

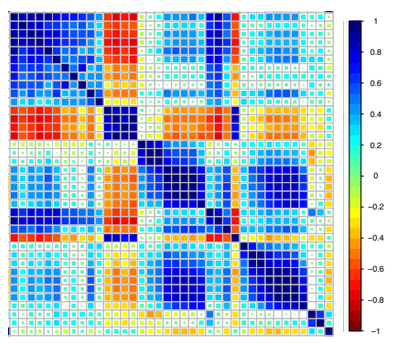
- Define *Investment Universe* (opportunities)
- Asset allocation, risk factor allocation, diversification
- Advanced optimization toolkit: e.g. Black-Litterman, Bayesian, HRP, etc…

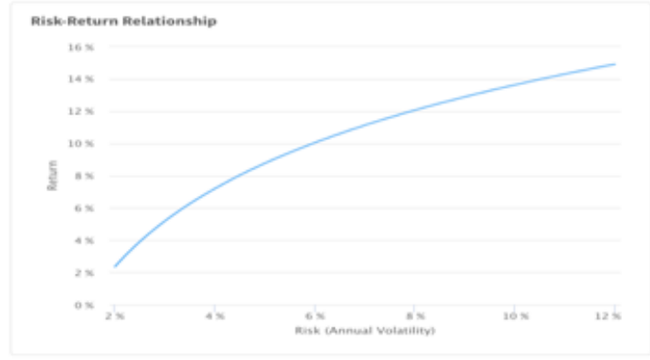
Output: full set(s) of "efficient" **general Model Portfolios**

Investment Universe



Security	CUSIP	Price	Curr	USD
JAPAN-164(10 YEAR ISSUE) JGB 4.1 12/22/03	GG7174376	101.64	JPY	0.92
JAPAN GOVT COUPON STRIPS JGBS 0 12/20/21	EC8297561	77.83	JPY	0.70
JAPAN- 12(3 YEAR DISC) JDGB 0 09/20/05	EC9650773	99.75	JPY	0.90
CANARY WHARF FIN II PLC CANWHA 0 01/24/22	EC3985388	100.00	EUR	115.80
YORKSHIRE BUILDING SOC YBS 0 01/15/04	EC3873579	100.00	GBP	166.38
PACIFIC LIFE FUNDING LLC PACLIF 5.153 07/15/09	EC3076942	107.35	N.G	56.42
YAHOO! INC	984332106	20.00	USD	20.00
US TREASURY N/B T 1 1/2 07/31/05	912828BE9	99.92	USD	99.92
US TREASURY N/B T 1 1/8 06/30/05	912828BC3	99.23	USD	99.23
US TREASURY N/B T 3 02/15/08	912828AT7	100.59	USD	100.59
TYCO INTERNATIONAL LTD TYC 6 3/8 01/15/04	902120AF1	85.00	USD	85.00
RGS (AEGCC) FUNDING CO AEP 9.81 12/07/21	74955DAA9	133.36	USD	133.36
PRIVATE EXPORT FUNDING PEFCO 5.73 01/15/04	742651CK6	103.89	USD	103.89
PAINE WEBBER GROUP INC UBS 0 03/15/05	69563AKU4	100.00	USD	100.00
GOVT TRUST CERT GTC 7.33 05/15/06	383751AA2	100.00	USD	100.00
GOVERNMENT EXPRT GOVEXP 6 03/15/05	383731AE6	104.40	USD	104.40
GTE NORTH INC VZ 6 01/15/04	362337AD9	103.64	USD	103.64
COCA-COLA ENTERPRISES CCE 8 1/2 02/01/22	191219AP9	130.44	USD	130.44
CITIZENS COMMUNICATIONS CZN 7.45 01/15/04	177342AH5	101.80	USD	101.80
CANADA GENERIC STRIP CANCDS 0 12/01/21	13508ZYV8	34.22	CAD	25.46
BERKLEY (WR) CORPORATION BER 8.7 01/01/22	084423AC6	112.05	USD	112.05





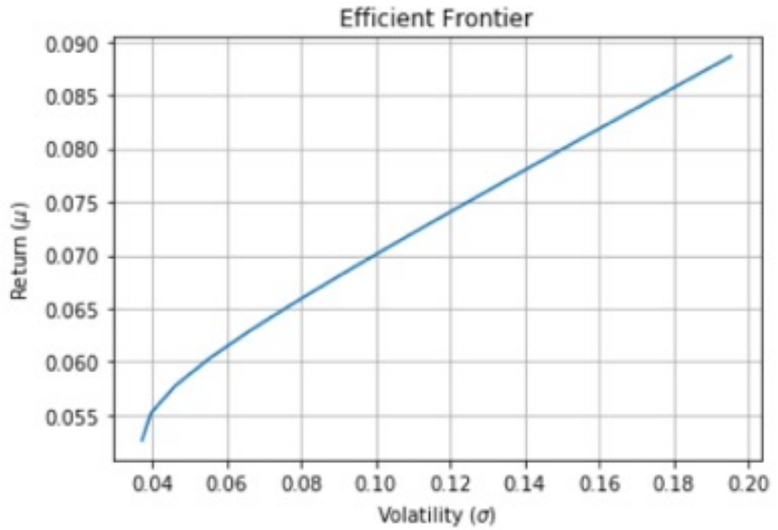
Quantitative Portfolio Manufacturing Process

1. Product Manufacturing
Efficient Portfolios/ Model Portfolios

2. Dynamic Risk Allocation
Consumption & Funding: Goals, Liquidity Management

How do we pick a given Model portfolio? ("what's Lambda")

Which portfolios or asset/risk factor allocations do we invest in now… and over time (rebalancing)



Quantitative Portfolio Manufacturing Process

1. Product Manufacturing
Efficient Portfolios/ Model Portfolios

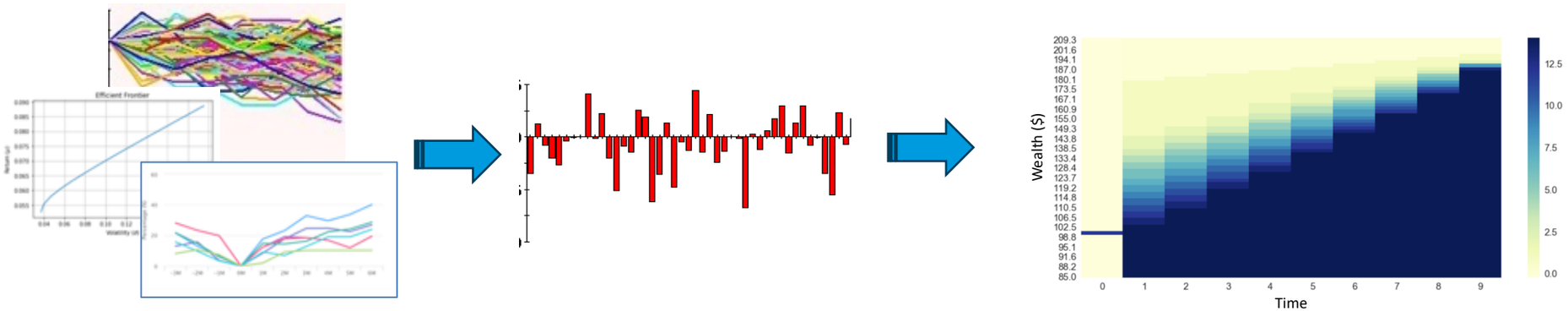
2. Dynamic Risk Allocation
Consumption & Funding: Goals, Liquidity Management

Dynamic Portfolio Investment Strategies: meet goals manage liquidity (long horizons, 10-50 years) and align with clients' behavioural risk profiles

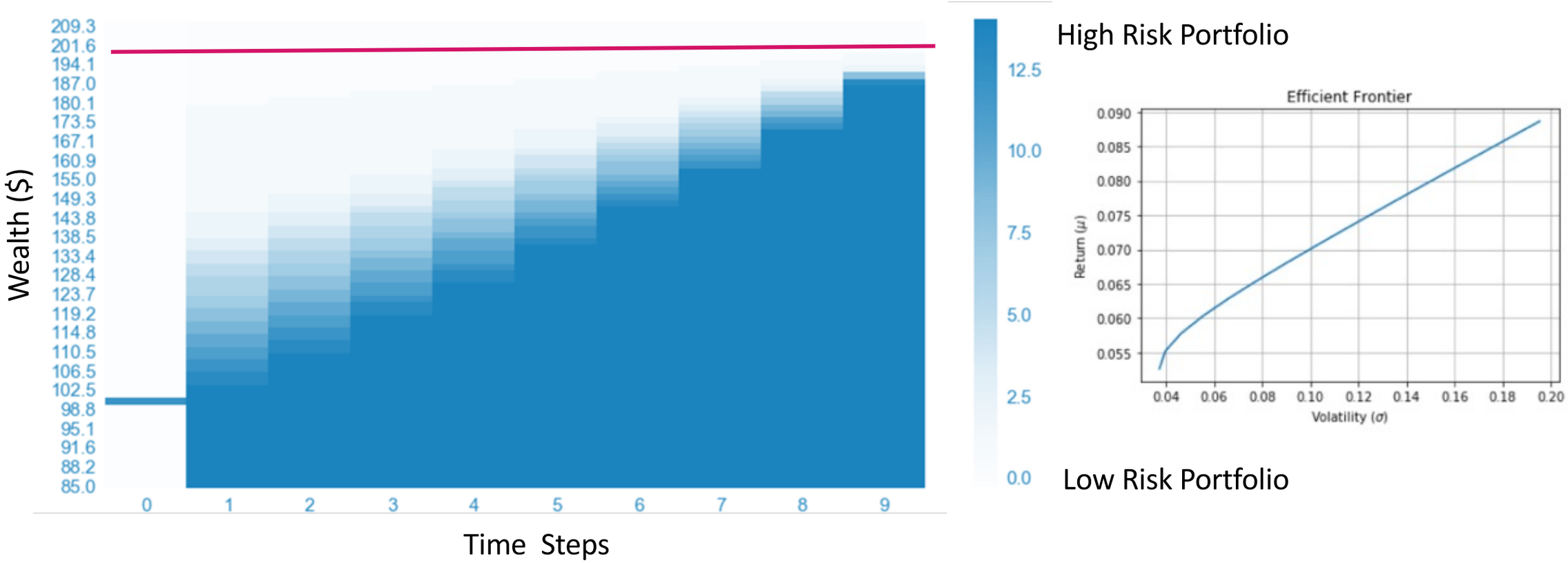
Goal-based Wealth Management (*Household ALM*)

- Includes accumulation, liquidity management (inflows, outflows, capital calls, etc…) and decumulation/wealth transition (post retirement)
- **Stochastic Dynamic Portfolio Optimization**: dynamic programing and machine learning tools (Reinforcement Learning, Neural Networks)

Output: **dynamic allocation** (of efficient portfolios) of over time based on goals, sensitivities and what-if analysis



Goals-Based Dynamic Portfolio Optimization – Example

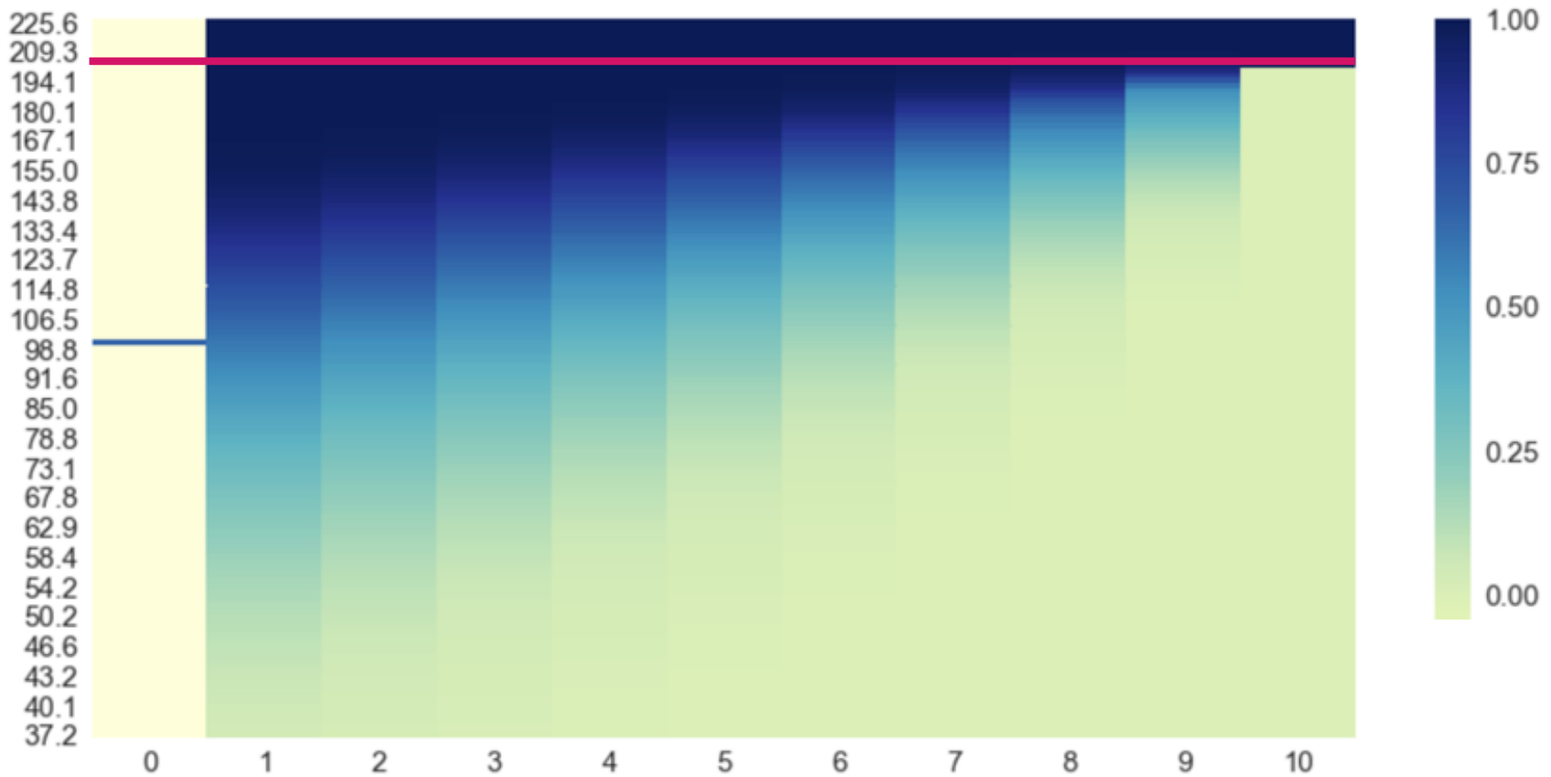


Optimal dynamic portfolio strategy – grid corresponding to each wealth node and time

W_0 = $100 and Wealth Goal: G = $200 after 10 periods

Reference: Das et al.

Dynamic Portfolio Optimization – Example



Optimal probability (of reaching the goal), at each wealth node and time

Wealth Goal: G = $200 after 10 periods

Modelling Dynamic GBWM

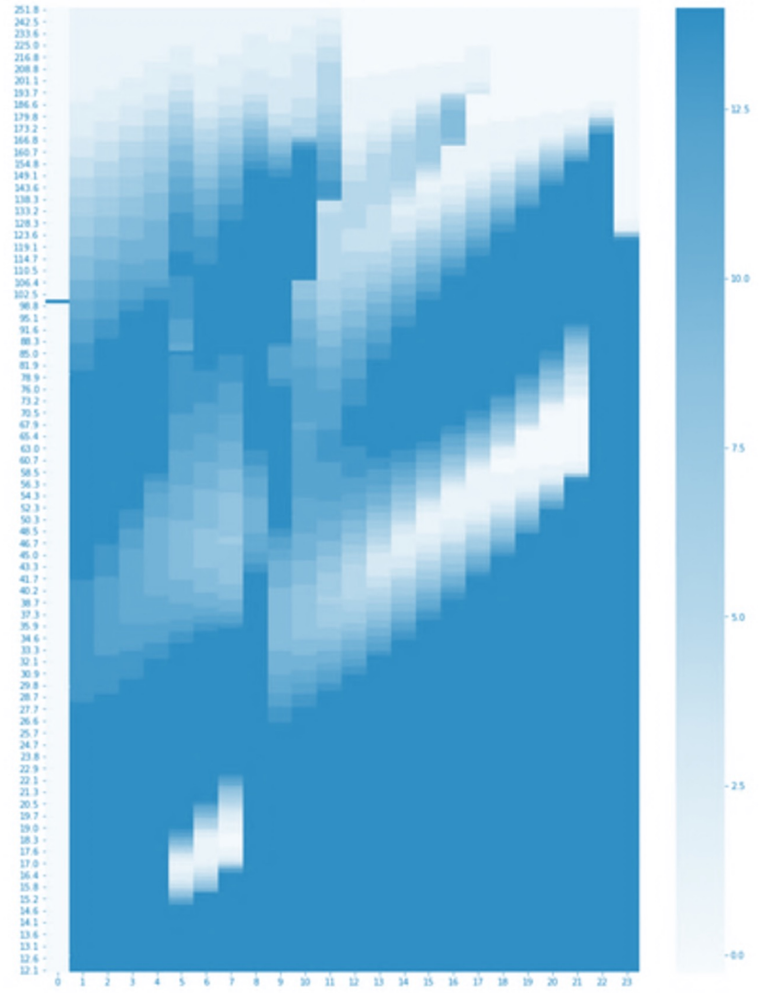
The dynamic setting further allows to make the problem more realistic

- Handle multiple (competing) goals at different points in in time: e.g. buying a cottage in 2 years, vs. retirement vs. leaving inheritance
  - Handling different priorities and level of importance (via utility function)
- Goals at different level of the family hierarchy and multiple ways of funding
- Uncertain cashflows (inflows and outflows)
- Realistic financial details: e.g. tax assumptions
- Realistic economic model and stress scenarios…

The optimization setting also allows us solve for

- Sensitivities, what-if analyses, trade-offs
- Inverse problem: Find most likely scenario(s) or actions that may affect our goals – severity, timing…

Example: Multiple Goals in Dynamic Portfolio Optimization



Example: Grid of optimal portfolios for multiple goals at different times

- Multi-criteria optimization using a utility function (weighting function for multiple goals)

Quantitative Portfolio Manufacturing Process

1. Product Manufacturing
Efficient Portfolios/ Model Portfolios

2. Dynamic Risk Allocation
Consumption & Funding: Goals, Liquidity Management

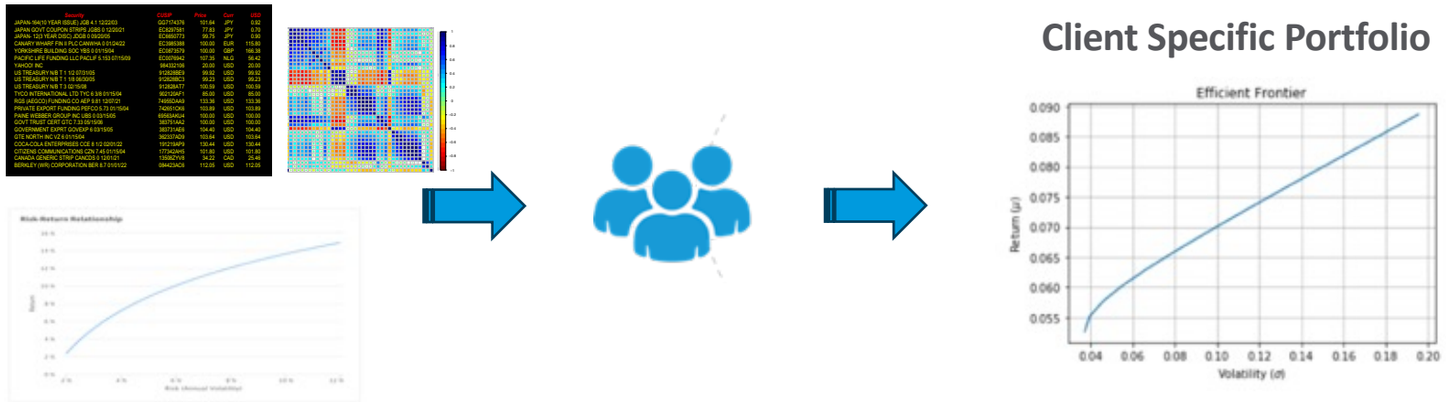
3. Portfolio Customization
Personalized, Client Specific Portfolios

Customized Client Model Portfolios

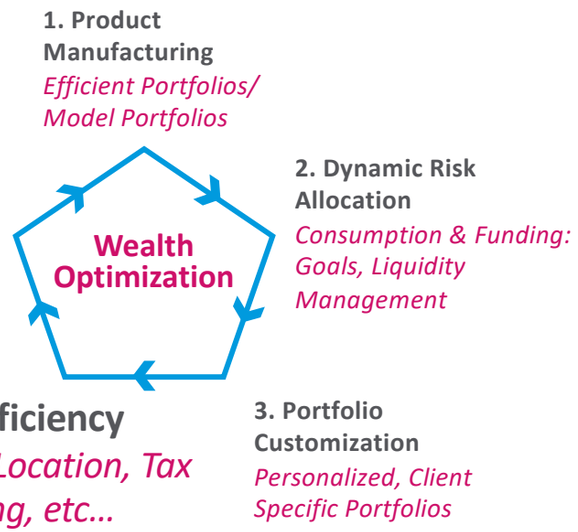
Adjust model portfolios to create a specific personalized strategies for each individual client

- Additional Inputs: client specific constraints, investment preferences
- Use of advanced optimization toolkit for asset/risk factor allocation, diversification

Output: adjusted **client-specific "efficient" Portfolios**



Quantitative Portfolio Manufacturing Process

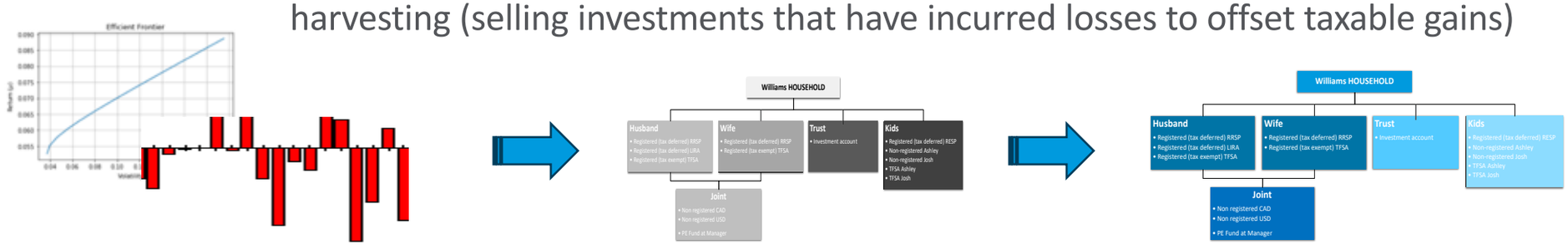


Optimize for Tax Efficiency (*maximize after-tax risk-adjusted returns*)

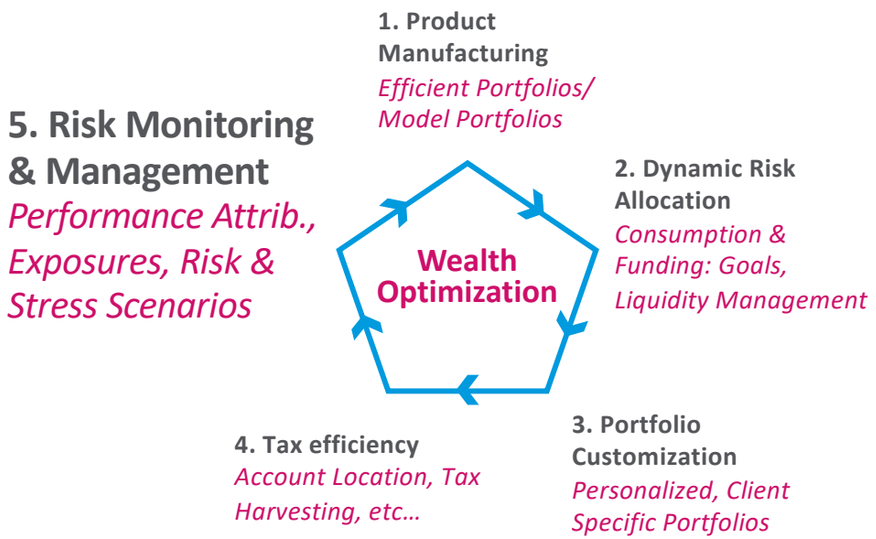
Detailed tax optimization to adjust portfolio location and sources of income streams

- Account for: different tax-advantaged accounts, marginal tax rates for different products, income sources, and legal entities, the timing of realized gains
- Optimization model incorporates details on:
  - Income thresholds, tax brackets, deduction limitations, specific rules related to tax-advantaged accounts, tax lots, etc..
  - Tax Rate Functions applicable to different income levels and types of income (e.g., ordinary income vs. capital gains)

Output: client and account location, income adjusted plan, tactical tax loss harvesting (selling investments that have incurred losses to offset taxable gains)

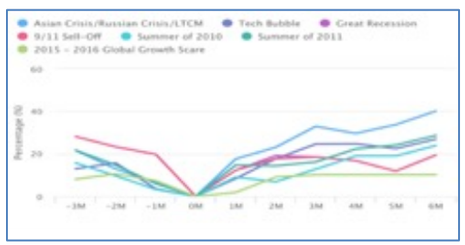


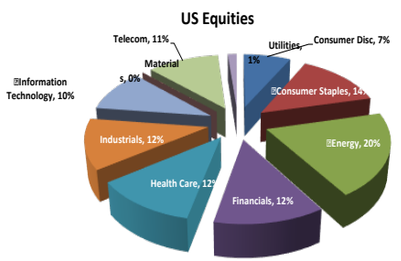
Quantitative Portfolio Manufacturing Process

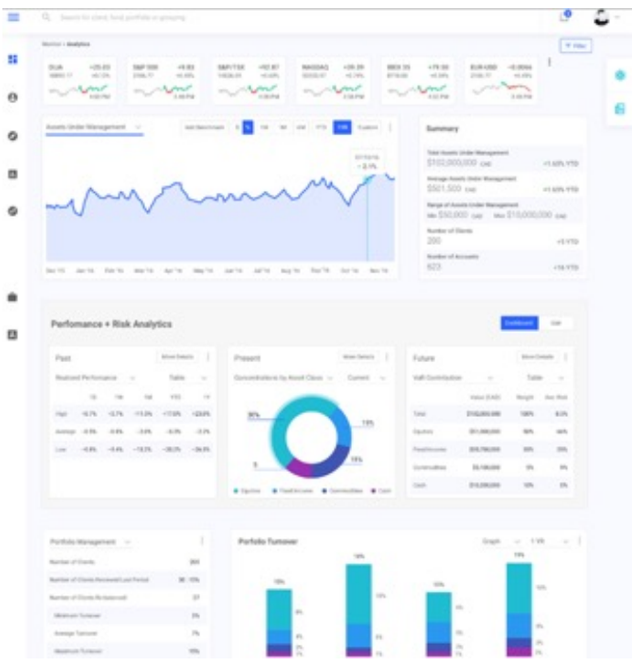


Actively Monitor and Understand Exposures, Performance and Risk

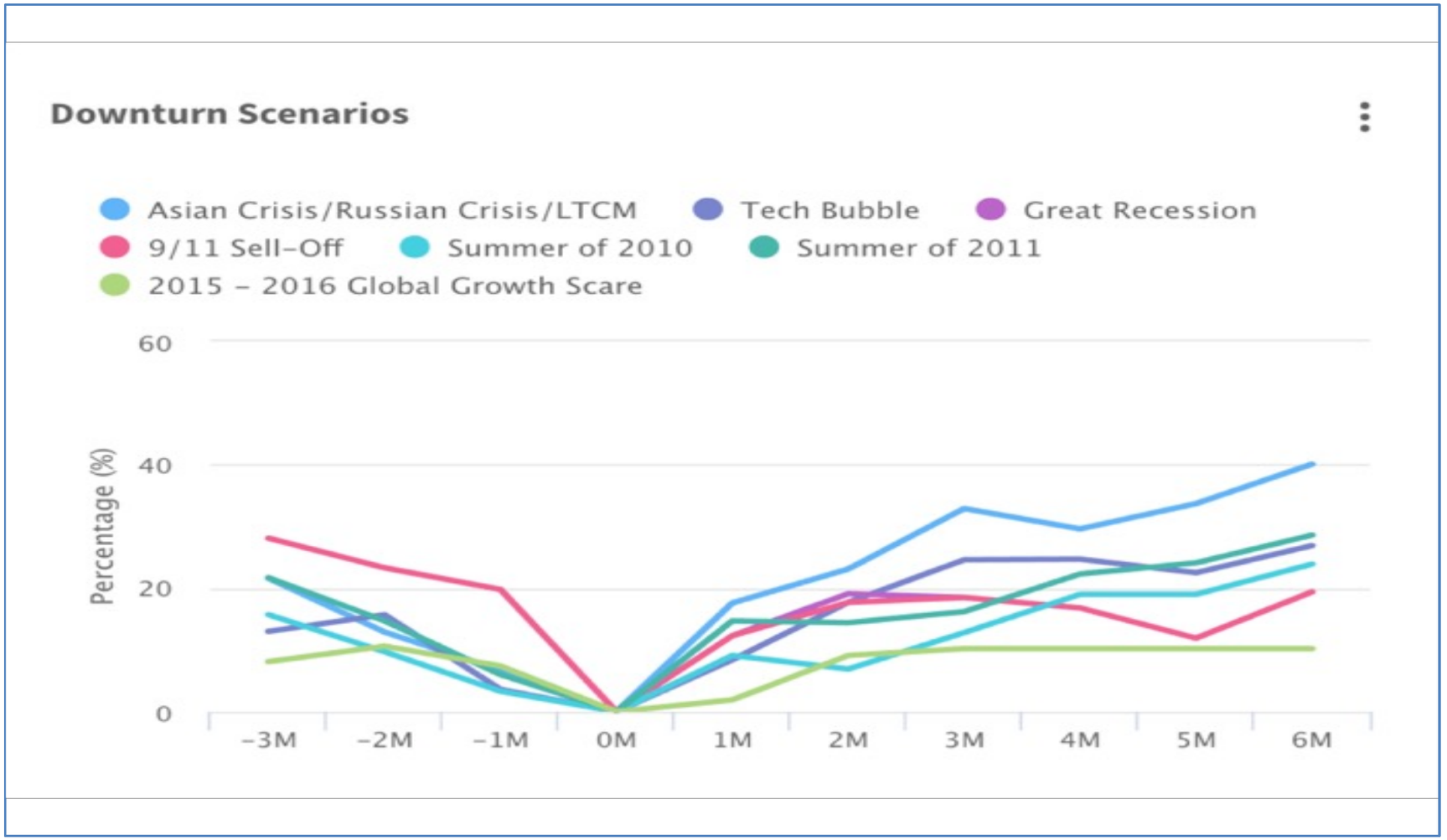
- Compliance with IPSs and client periodic reviews
- Changes in: markets, client's life circumstances, goals, regulation, …
- Performance attribution – how did we make money?
- What if – available new funds or investment opportunities
- Scenario analysis



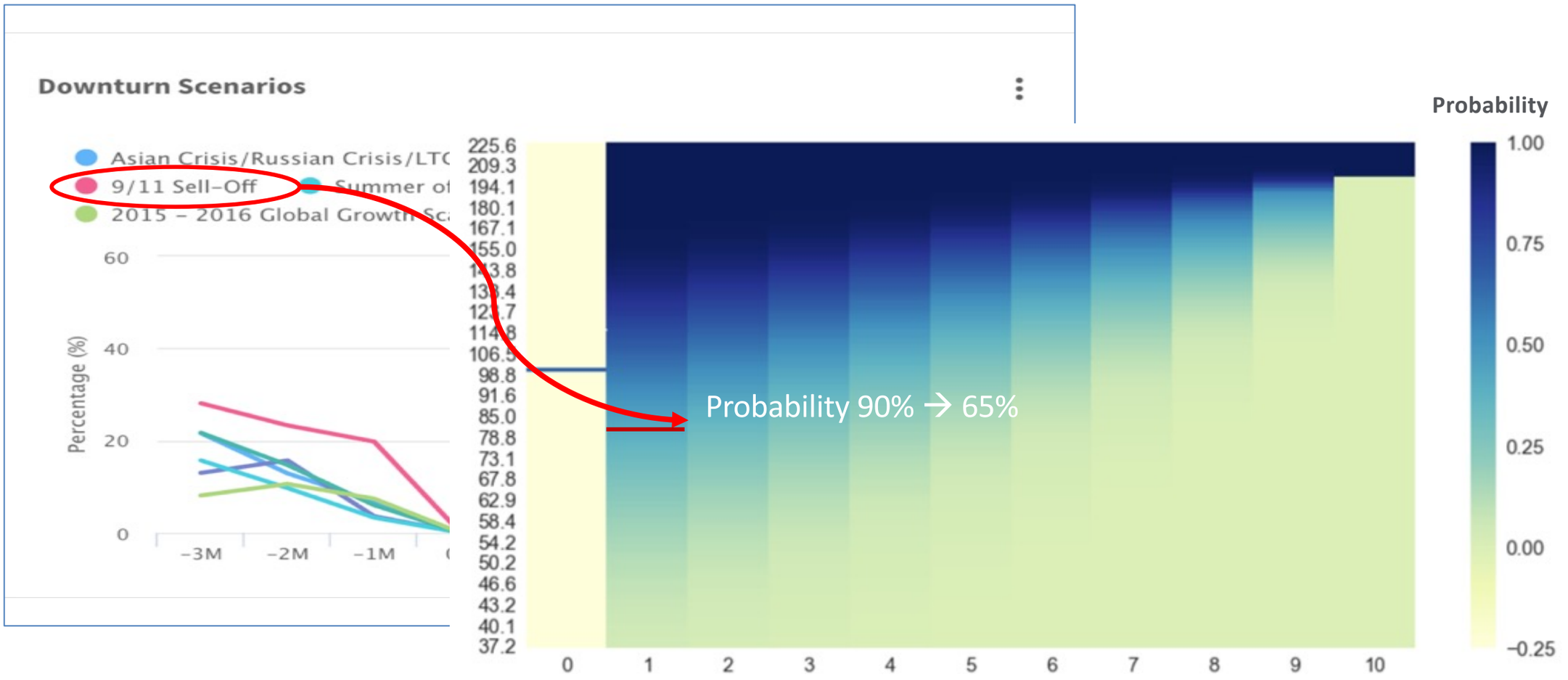




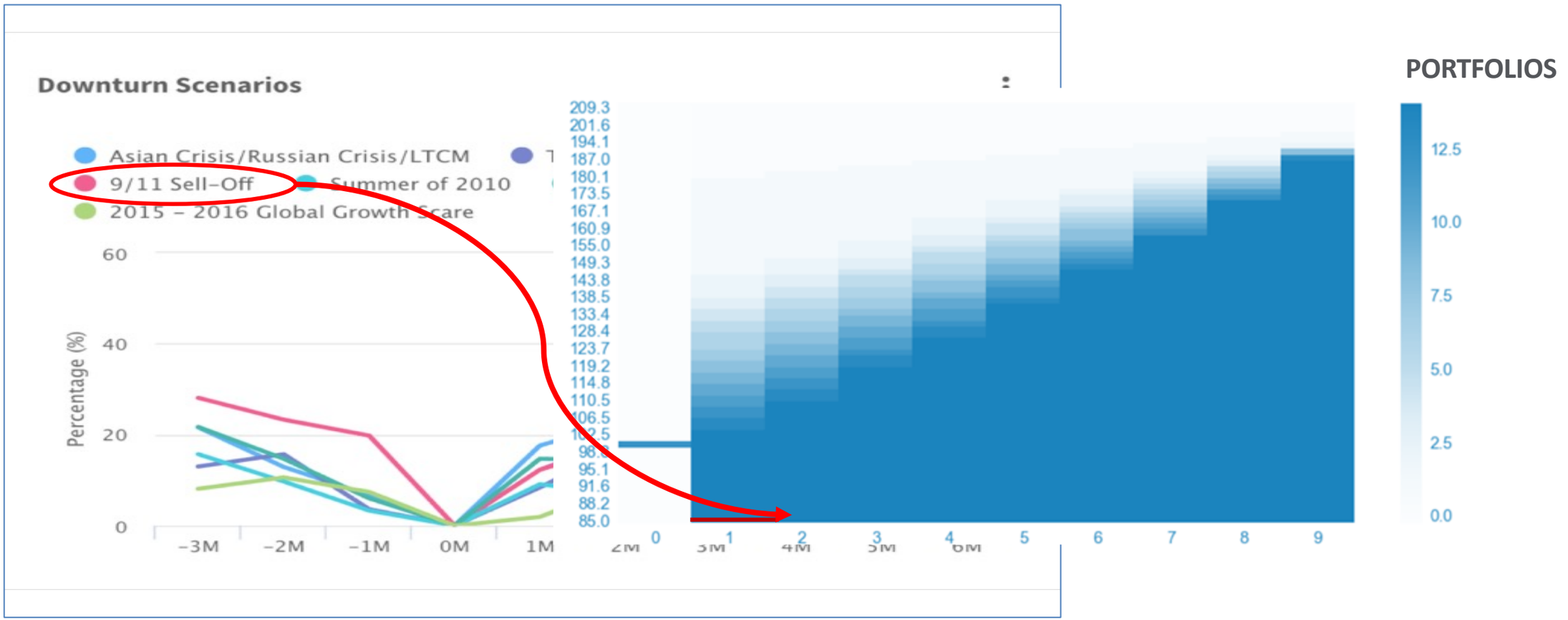
Example: Overlaying Historical Scenarios & Drawdowns



Example: Overlaying Historical Scenarios & Drawdowns



Example: Overlaying Historical Scenarios & Drawdowns



In Practice…

Financial Risk Management for Humans!

d1g1t

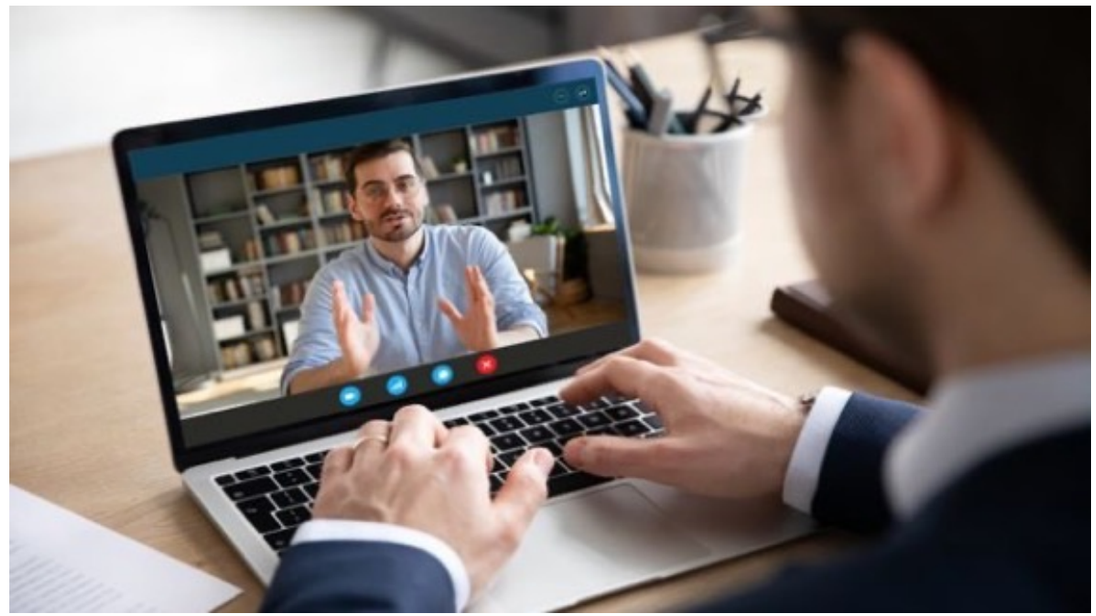
In Practice… Financial Advice & Risk Management for Humans

Interactive engagement and coaching – multiple goals & questions the client/investor relates to

- How does the likelihood of achieving the goal change with a drawdown?
- What's the max drawdown I can take? When do I need to worry?
- If I can't meet a goal precisely, how far are we?

  What are the trade-offs between multiple goals?
- How else can I fund the plan?
- When can I de-risk portfolio?

  How much can I take out and not affect goal?
- How much do I need to change goal/plan to be OK?




Big Data, analytics, AI
and other digital technologies
will not eliminate
the need for the human touch….

d1g1t

Thank you !

Dr. Dan Rosen
CEO *d1g1t*
dan.rosen@d1g1t.com

www.d1g1t.com