Re-Thinking the Wealth Management Advisory Cycle through Advanced Analytics & Risk Management tools

Dan Rosen, CEO, d1g1t

The world of wealth management is undergoing a revolution
Advisors are under immense pressure...

A new type of client
- Investors questioning value of advice, level of services, user experience, transparency, fees
- Change in demographics – greater emphasis on real-time information, accessed through multiple platforms (mobile, web)

Regulation
- Tighter regulatory environment placing much higher demands on client interactions, disclosure and transparency

Fee compression
- Downward pressure from clients, increased competition, low-fee products, robo-advisors

Complex markets
- Looming correction, lower returns & alpha, talks of recession...

Technology Gap & Operational Inefficiencies

Wealth management firms have been underserved by technology

Compared to institutional money & banking

1990s Banks
- Risk management & trading platforms
- Banking regulation

2000s Buy Side
- Asset managers & hedge funds
- Risk & portfolio analytics, trading strategies

2015+ Wealth Management
- Goal-based investment & portfolio management
- Risk & performance
- Communications: advisors & individual investors
And the Pressure is Mounting ...

Morgan Stanley launches new advisory technology platform

Morgan Stanley: We’ll Outspend Rivals on Tech

November 15, 2019

The online advisor platform, WealthDesk, brings to a single dashboard a consolidated view of client relationships and portfolios... it integrates portfolio advice, portfolio risk measurement, fee and pricing information and consolidated view of clients’ plans and portfolios updated each quarter...

A New Advisory Model

The new advisory model based on

a transparent value add practice which redefines and builds long-term trust...

Digitally driven

- End-to-end workflow and enhanced client communication

Client-focused automated business processes

- PM, compliance, and communication defined by client’s goals and portfolios... not the firm’s products

Investment sophistication

- Technology-driven investment process guided by analytics and rigorous risk management

High-touch services

- Personalized high-value, interactive client engagement, increased communication and trust
It All Starts with a Client/Family – Example...

Multiple actors, risk tolerance/appetite, knowledge, interests, subjective views...

Multiple Dreams, wishes and needs → Goals (and horizons):
- College for kids, reno house, retirement at 65?, charity projects, etc…

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It’s all about Risk…

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The Wealth Management Risk Cycle

Risk Policy
Required Risk Consumption
Risk Appetite & Capacity
Onboarding & KYC
Analytics
Manage Clients
Manage Portfolios
Manage the Business
Risk Taking
Risk Monitoring & Management
Risk Policy
Investment Mandates, IPS, Accounts
Investment Portfolios, Construction & Rebalancing
Performance, Exposures, Risk & Stress Scenarios

Aligning Risks across the Cycle

1 2 3 4 5 6 7 8 9 10

Risk Tolerance
Risk Capacity
Portfolio Risk Mapping
Goal Based Risk (required consumption)
Actual Portfolio's Risk

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The Wealth Management Risk Cycle

- Risk Policy
  - Investment Mandates, IPS, Accounts
- Risk Appetite
  - & Capacity
  - Onboarding & KYC
- Required Risk Consumption
  - Personalized Goals & Financial Plan
- Risk Taking
  - Investment Portfolios, Construction & Rebalancing
- Risk Monitoring
  - & Management
  - Performance, Exposures, Risk & Stress Scenarios

Manage Clients

Manage Portfolios

Manage the Business

Enterprise Risk Management

Enterprise Wealth Management Powered by Analytics

Firm

Advisor

Household

Client

Account

holdings

Advisor

Household

Client

Account

Advisor

Household

Client

Account

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Analytics to Manage The Wealth Management Risk Cycle

The modern Wealth Management analytics toolkit integrates

- Data Science / Machine Learning
- Behavioural finance
- Goal Based financial Planning
- Modern Portfolio Theory, Portfolio Optimization
- Risk management tools

- ... Long-term investment focus

Analytics – The Investment Light Cone
The Investment Light Cone

Creation and maintenance of an accurate and detailed representation of
• Clients & portfolios (and benchmarks) – positions, transactions, prices, returns
• Exposures
• The markets and
• The economy in general

Portfolio Exposures – Example

<table>
<thead>
<tr>
<th>$ USD (Million)</th>
<th>NMV</th>
<th>Long</th>
<th>Short</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio</td>
<td>457.5</td>
<td>567.8</td>
<td>110.3</td>
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<tr>
<td>EQ</td>
<td>221.4</td>
<td>225.5</td>
<td>4.1</td>
</tr>
<tr>
<td>IR</td>
<td>111.2</td>
<td>111.2</td>
<td>0.0</td>
</tr>
<tr>
<td>CR</td>
<td>124.9</td>
<td>231.1</td>
<td>106.2</td>
</tr>
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<table>
<thead>
<tr>
<th></th>
<th>USD</th>
<th>EUR</th>
<th>GBP</th>
<th>JPY</th>
<th>Total</th>
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<tbody>
<tr>
<td>EQ</td>
<td>32%</td>
<td>11%</td>
<td>4%</td>
<td>5%</td>
<td>52%</td>
</tr>
<tr>
<td>IR</td>
<td>10%</td>
<td>14%</td>
<td></td>
<td></td>
<td>24%</td>
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<tr>
<td>CR</td>
<td>18%</td>
<td>7%</td>
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<td>24%</td>
</tr>
<tr>
<td>Total</td>
<td>59%</td>
<td>32%</td>
<td>4%</td>
<td>5%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: S&P Capital IQ. For illustrative purposes only.
The Investment Light Cone

Deep understanding of our history:
- Portfolio performance – and attribution
- Historical markets
- Our past actions (cash-flows, transactions, etc.)

Performance Attribution – Example

Risk-Free Rate: \( r_{RF} \)

Risk Premium: \( \sum_{k=1}^{N} \beta_{k} \cdot F_{k} \)

Security Selection: \( \sum_{i=1}^{I} W_{i} \cdot \alpha_{i} \)

Factor Timing: \( \sum_{k=1}^{N} \text{Cor}(\beta_{k}, F_{k}) \)

Security Timing: \( \sum_{i=1}^{I} \text{Cor}(\alpha_{i}, r_{i}) \)
Learning from History – Example: Regression Engine

Objectives:
• Provide on-the-fly knowledge and attribution (what, how, & why) about client engagement
• Understand overall Enterprise Business Drivers
• Test and construct strategies

ML Engine is a combination of:
• Data generation and normalization: return computation and financial modeling (multiple sources)
  • Detailed client information (over time)
  • Client portfolios: multiple portfolios, hierarchies and holdings level information
    • Positions, transactions, prices – detailed feature generation and segmentation: e.g. currency, capital gains, realized-unrealized, taxes, dividends and cash-flows, …)
• Market information (external portfolio/benchmarks), as well as events/news etc.
• Factor analysis and economic indicators
• Econometrics and Machine Learning toolkit (unsupervised learning, regression, NNs, RL)

The Investment Light Cone

Making an updated representation of future scenarios, how they affect our portfolios, and how we may react in such conditions
This is the basis for Risk & Investment Decisions
The Investment Light Cone

- Measure risk and potential returns
- Attribute potential losses
  - Market Risk, Credit Risk, Liquidity Risk
- Scenario analysis, stress testing and portfolio simulation
- Risk and capital allocation

Risk Measurement

Stress testing

P&L

Time

VaR

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Risk and Performance Measurement

Portfolio Risk

<table>
<thead>
<tr>
<th>$ USD (Million)</th>
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<th>VaR</th>
<th>VaR (Marginal)</th>
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<td><strong>Portfolio</strong></td>
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<tr>
<td><strong>US-EQ</strong></td>
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<td>37%</td>
<td>21%</td>
<td>4%</td>
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<td>65%</td>
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<tr>
<td><strong>IR</strong></td>
<td>3%</td>
<td>13%</td>
<td>4%</td>
<td>2%</td>
<td>19%</td>
</tr>
<tr>
<td><strong>CR</strong></td>
<td>13%</td>
<td>7%</td>
<td>4%</td>
<td>2%</td>
<td>100%</td>
</tr>
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The Investment Light Cone

Design and testing of strategies, reactions and intervention measures (management, policy modelling, portfolio construction, governance)

Example: Linking Risk & Goal Based Wealth Management

Key points:

• We can consistently combine:
  • Goal Based financial Planning
  • Modern Portfolio Theory, Portfolio Optimization tools
  • Behavioural finance

• Focus on (long-term) risk measures related to
  • Probability of achieving Goal(s)
  • Distance to achieve goal(s)

• Create explicit link to portfolio risk measures (volatility, VaR, drawdown, etc…)

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Risk & Goal Based Wealth Management

Projected Wealth Simulation

At 65 years old, you expect to have accumulated $5,723,456.
You have a 20% probability of achieving your goal.

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The Future: Linking Financial Goals and Portfolio Management

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Risk & Goal Based Wealth Management

Align:
• Risk tolerance/capacity (Nature)
• Required Risk Consumption (Goals)
• Risk Policy (Plan)
• Risk Taking (Portfolios)

Goal base Wealth Management

Goal Based Portfolio Optimization – intuitive and actionable for financial advisors
• Maximize the likelihood of achieving the goal (or set of goals)
• Minimize a distance function (e.g. mean squared errors) to achieving goal

Key insight: integrate MPT by choosing portfolio set on the efficient portfolio (splitting optimal asset allocation and the required risk taking to achieve a goal)

Example – Das et al
• Static (constant risk) solution
• Dynamic goal based portfolios (using stochastic dynamic programming)
• Trading off Multiple goals
• Dynamic portfolios via Reinforcement Learning
Example: Dynamic Portfolio Optimization (Das et al.)

Optimal portfolio strategy at each wealth node and time
(lighter color corresponding to less risk and darker to higher risk portfolios in the Efficient Frontier)

The Investment Light Cone – Scenarios

The quality of risk analysis and the actions/decisions relies on our ability to generate relevant, plausible and comprehensive, forward-looking scenarios that properly represent the future.
**Risk and Scenarios**

Scenarios are the language of Risk

The quality of a risk management analysis depends on

1. Ability to generate relevant forward-looking scenarios (Scenario analytics)
2. How scenarios impact our specific portfolios (Portfolio risk analytics)

**Example: Historical Scenarios**

![Downturn Scenarios Graph]

- Asian Crisis/Russian Crisis/LTCM
- Tech Bubble
- Great Recession
- 9/11 Sell-Off
- Summer of 2010
- Summer of 2011
- 2015 - 2016 Global Growth Scare
The development of relevant forward-looking scenarios requires the combination of:

- Detailed understanding of portfolios, clients and goals
- Good economic analysis
- Grounded financial models
- Data science and econometrics

Example: Scenarios from Economic Report
GLOBAL ECONOMIC OUTLOOK
Gaining Traction, Gaining Balance

<table>
<thead>
<tr>
<th>GLOBAL Scenario</th>
<th>US</th>
<th>EURO</th>
<th>UK</th>
<th>JPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real GDP (% change)</td>
<td>3</td>
<td>1.5</td>
<td>2.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Inflation (% change)</td>
<td>-0.3</td>
<td>-0.3</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>IR Short</td>
<td>0.3</td>
<td>0.1</td>
<td>0.5</td>
<td>0.05</td>
</tr>
<tr>
<td>IR Long</td>
<td>2.3</td>
<td>0.3</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td>FX</td>
<td>0.9</td>
<td>0.7</td>
<td>120.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: Standard & Poor's Ratings Services economic research report dated April 22, 2015. Indexes are unmanaged, statistical composites and it is not possible to invest directly in an index. These results are inherently limited because they do not represent the results of actual trading and were constructed with the benefit of hindsight. The returns shown do not reflect payment of any sales charges or fees an investor would pay to purchase the securities they represent. The imposition of these fees and charges would cause actual and back tested performance to be lower than the performance shown. Returns exclude dividends.

Joint Factor Simulation Model

Economic Research Scenarios

<table>
<thead>
<tr>
<th>Economic Factors</th>
<th>GLOBAL &amp; U.S. Scenario Factors</th>
<th>U.S.</th>
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<th>UK</th>
<th>JPN</th>
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<td>X</td>
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<td>X</td>
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<td>Unemployment</td>
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<td>IR Short</td>
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<tr>
<td>IR Long</td>
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<td>Oil (WTI)</td>
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<td>FX</td>
<td>X</td>
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Market Factors

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<th>Equity Indices</th>
<th>IR Curves</th>
<th>Credit</th>
<th>FX</th>
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<tr>
<td>XE</td>
<td>EUR Sov</td>
<td>EUR Spread HY</td>
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<tr>
<td>GB</td>
<td>GBP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JP</td>
<td>JPY</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Example: Joint Factor Simulation Model

Input: quarterly data for all the factors (20+ years)

1. Marginal processes for each factor: ARMA GARCH model (filtering)

\[ y_t = a_0 + a_1 y_{t-1} + b_1 e_{t-1} + \epsilon_t \]
\[ \epsilon_t = \sigma_t \eta_t, \quad \sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2. \]

2. Historical codependence of residuals (allows for non-Gaussian fat tails and tail dependence)

Joint Factor Simulation Model

Empirical (simulated) factor terminal distribution (horizon = 1 year)

- Monte Carlo simulation of \( N \) scenarios of the joint factor processes over 4 quarterly steps (\( N = 1K – 10K \))
Joint Factor Simulation Model

Example – Empirical and simulated factor terminal distribution

Historical Residuals
US GDP-Unemployment

Simulated Returns 1 Year
US GDP-Unemployment

Historical Residuals
Long Rates US-EUR

Simulated Returns 1 Year
Long Rates US-EUR

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Economic Scenarios – Model Mapping

Objective: express forecasted scenarios in the context of joint factor simulated distribution
- Standardized economic scenarios (expressed as number of standard deviations of factors, and also in terms of likelihood within the model)

Conditional Scenarios

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Conditional Scenarios

Economic Scenario
Economic Factors $X$
Fixed

$P(X)$

$P(Y|X)$

- Expected Conditional Scenario of $Y$
- Full Conditional Scenario Distribution

Conditional Scenarios: Analytical Methods

Conditional factor distributions are available analytically for certain joint distributions
e.g. Multi-variate Gaussian

\[
X = \begin{pmatrix} X^{(1)} \\ X^{(2)} \end{pmatrix} \sim N(\mu, \Sigma)
\]

\[
\mu = \begin{pmatrix} \mu^{(1)} \\ \mu^{(2)} \end{pmatrix}, \quad \Sigma = \begin{pmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{pmatrix}
\]

Conditional distribution of $X^{(2)}$ given $X^{(1)} = x^{(1)}$ is multivariate normal with mean $m$ and covariance matrix $B$

\[
m = \mu^{(2)} + \Sigma_{21} \Sigma_{11}^{-1}(x^{(1)} - \mu^{(1)})
\]

\[
B = \Sigma_{22} - \Sigma_{21} \Sigma_{11}^{-1} \Sigma_{12}
\]
Conditional Scenarios: Least Squares Stress Testing (LSST)

Regress Under Stress

_A Simple Least-Squares Method for Integrating Economic Scenarios with Risk Simulations_

Dan Rosen,¹ David Saunders²

*Journal of Risk Management in Financial Institutions, 9(4)*

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Key insight: conditional expectation of all the factors (and more generally the full conditional distribution) can be estimated directly from a pre-computed simulation using Least Squares Regression (LSR) or more sophisticated ML methods

- Conditional scenario analytics, including risk factor contributions, can be derived from the regression results
- The application of LSR on the cross-sectional information of a simulation to obtain conditional expectations is the key component of LSM to price American options (Longstaff and Schwartz 2001)
- Applied here to portfolio risk management and stress testing

Other ML examples: application of Neural Networks to simulate derivatives portfolios, compute greeks, etc…
Conditional Scenarios:
Least Squares Stress Testing

Regression model

\[ y_i = \beta_{10} + \sum_j \beta_j x_j + \epsilon_i \]

Conditional Expected Scenario of Y

\[ y_i = \beta_{10} + \sum_j \beta_j x_j + \epsilon_i \]

Conditional Scenario Distribution + \[ \sigma_i \epsilon_i \]

Non-Linear LSST – Example Credit Risk

Correlation of Credit Factor to Market Factor = 77%

Simulation of Portfolio Losses and Linear Regression

\[
PD(z) = G(a + b\ z) \\
= G\left(\frac{H^{-1}(PD) - \sqrt{\rho} z}{\sqrt{1 - \rho}}\right)
\]
Risk and Scenario Analytics through Regression (ML) Engine

Data generation and normalization: Pre-computed simulation Cubes (expensive step)
- Holdings- and factor-level simulations from risk engine
- Detailed portfolios: multiple portfolios, hierarchies and holdings level information
  - Positions, transactions and prices, with detailed feature generation and segmentation: e.g. currency, capital gains, realized-unrealized, taxes, dividends and cashflows, …)
- Enriched Cube: risk factors economic indicators

Full Machine Learning toolkit (unsupervised learning, regression models, reinforcement learning, …)

Applications: scenario analysis, strategy construction/validation, optimization, goals-based portfolios

Portfolio Simulation And Analysis – Global Scenario

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>NMV</th>
<th>VaR (Annual)</th>
<th>P&amp;L Mean</th>
<th>Global Scenario</th>
<th>Rel. Return</th>
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<tr>
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<td>457.5</td>
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GLOBAL ECONOMIC OUTLOOK
Gaining Traction, Gaining Balance

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Global Outlook – Conditional Scenarios

Portfolio Simulation And Analysis – Global Scenario

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<th>Portfolio</th>
<th>NMV</th>
<th>VaR (Annual)</th>
<th>P&amp;L Mean</th>
<th>Global Scenario</th>
<th>Rel. Return</th>
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<td>16.0%</td>
<td>3.7%</td>
<td>8.1%</td>
<td>4.4%</td>
</tr>
<tr>
<td>IR</td>
<td>221.4</td>
<td>29.0%</td>
<td>6.7%</td>
<td>17.1%</td>
<td>10.4%</td>
</tr>
<tr>
<td>CR</td>
<td>111.2</td>
<td>14.4%</td>
<td>1.6%</td>
<td>-0.1%</td>
<td>-1.8%</td>
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</table>

Portfolio P&L - Conditional Expected Scenario

Global Outlook

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<th>$US Million</th>
<th>NMV</th>
<th>P&amp;L Mean</th>
<th>Global Scenario</th>
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<td>37.0</td>
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<tr>
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<tr>
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<tr>
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<tr>
<td>JP EQ</td>
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<tr>
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Remarks: Scenario Analysis as Advisory Tool Over the Entire Cycle

- Elicit and define client’s risk appetite and tolerance, clarify goals, and design investment/risk policies and IPSs
- Portfolio management
  - Design specific client portfolios
  - Monitor and attribute risk
- Powerful communication tool to help engage and manage clients
  - On-going client communication around life events, market downfalls, crises, economic opportunities
- Engage prospects: investment and advisory proposals for new clients or new plans
Big Data, analytics, AI and other digital technologies will not eliminate, the need for the human touch....*

*...for now

Technology will empower wealth management firms to scale up the high-value, human services that can set them apart in an increasingly automated & digital world.