Using Morningstar's Risk Model to Drive Investment Decision Making

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Agenda

- Intro to the Quant team
- What are risk Models
- An expose on exposures
- Sources of risk and return
- 3 ways to skin a scenario

Quant Team

Morningstar Quantitative Research: Who We Are

51 data scientists, researchers, technologists, engineers and analysts around the globe.

PhDs:
Bioinformatics
Computer Science
Electrical Engineering
Finance
Fracture Mechanics
Information Technology
Mathematics
Mechanical Engineering
Policy Analysis
Statistics
Systems Science

Other:
1 Concrete Nuclear Building Code Author
1 Published Poet
1 Undefeated Fantasy Football Gambler
1 Violinist
1 Anti Ketogenic
1 FIFA champion

What are risk models?

What questions do risk models help to answer?

- What factors is this portfolio exposed to?
- Where is my portfolio’s alpha coming from?
- What type of active risk does my portfolio have?
- How does this portfolio hold up under stress?
- What macro events will my portfolio be insulated from?
- How do I build a portfolio to meet a specific objective?

Spotlight

| Risk

Global Risk Model Unravels Brexit Uncertainty 41

A New Way to Interpret Equity Risk

Our risk model helps investors spot the factors that influence returns.

Lee Davidson

The relationship between a financial advisor and his or her client is typically rooted in a conversation about risk. By studying factors such as age, financial health and well-being, and retirement goals, the advisor can assess just how much a client’s portfolio should be exposed to certain asset classes. After all, both parties want to create a portfolio that won’t need to be altered because a client couldn’t stomach the latest round of market turmoil.

But a true assessment of risk goes deeper than a simple gut check. In today’s global financial system, advisors — or any party that manages money, for that matter — must gauge risk on a myriad of levels, as events around the world such as the Brexit vote, terrorism, quantitative easing, slow economic growth, or sovereign debt crises ripple across markets. Portfolios from India to Iowa can eventually feel the pain, putting a dent in the checkbooks of millions of Main Street investors.

Morningstar is constantly working on tools to help advisers and institutions do their jobs more

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What Makes our model Unique?

- Fama-French models are time-series regressions
  - One asset over many time periods
  - Factor premia are *known*, exposures are *unknown*
- Risk models are cross-sectional regressions
  - Many assets over one time period
  - Factor premia are *unknown*, exposures are *known*
- Advantages of holdings-based approach
  - More accurate
  - Adapts to change – securities, managed products, portfolios

Model Definition - Return

We model daily returns at every period t as

$$\mathbf{R} = \mathbf{X} \cdot \mathbf{P}_F + \mathbf{S} \qquad (A.1)$$

N x 1 = N x K · K x 1 + N x1

7000x1 = 7000x36 · 36x1 +7000x1

Where $\mathbf{R}_{N \times 1} = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_N \end{bmatrix}$ $\mathbf{X}_{N \times K} = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1K} \\ X_{21} & X_{22} & \cdots & X_{2K} \\ \cdots & \cdots & \cdots & \cdots \\ X_{N1} & X_{N2} & \cdots & X_{NK} \end{bmatrix}$ $\mathbf{P}_{F\,K \times 1} = \begin{bmatrix} P_{F1} \\ P_{F2} \\ \vdots \\ P_{FK} \end{bmatrix}$ $\mathbf{S}_{N \times 1} = \begin{bmatrix} S_1 \\ S_2 \\ \vdots \\ S_N \end{bmatrix}$

where **R** is an Nx1 vector of asset returns, **X** is an N by K matrix of factor exposures, $\mathbf{P}_F$ is a Kx1 vector of factor returns (aka factor premia), and **S** is an Nx1 vector of specific returns (aka residual returns).

We assume that

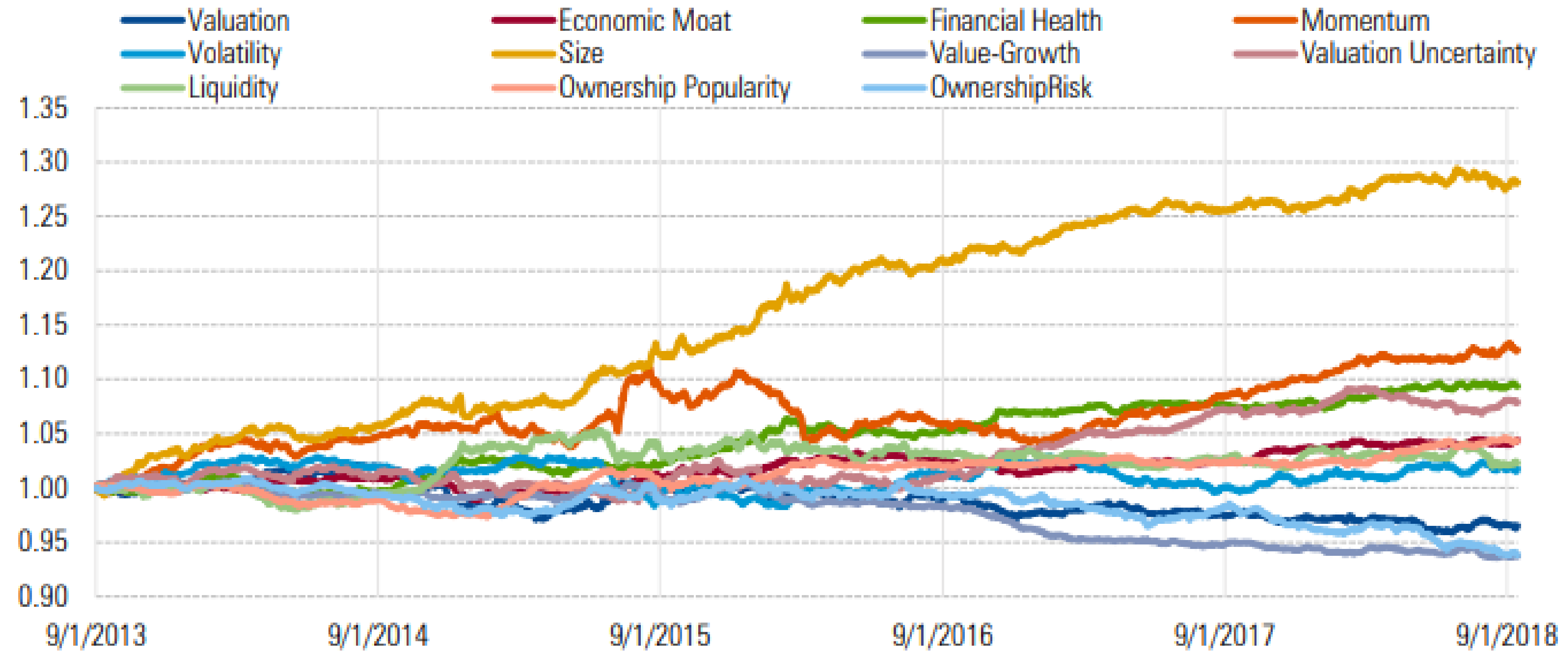
A1. The specific returns S are uncorrelated with the factor returns P_F, i.e., Cov $(s_i, p_{Fj}) = 0$ for all i and j.

A2. The covariance of asset i's specific return si with asset j's specific return sj is zero all if i≠j, i.e. Cov $(i_n, j_m) = 0$ if i≠j .

Expose on Exposures

What are the factors?

- Valuation
- Economic Moat
- Momentum
- Financial Health
- Value-Growth
- Size
- Liquidity
- Volatility
- Valuation Uncertainty
- Ownership Risk
- Ownership Popularity



Source: Morningstar.

Partial economic exposures for sectors, regions, currencies

Relying on categorical classification to assess sector, regional, or currency risk can be quite limiting as classifications are a binary yes or no. As a consequence, risk may be under- or overstated for many large conglomerates that operate multiple business lines across geographies.

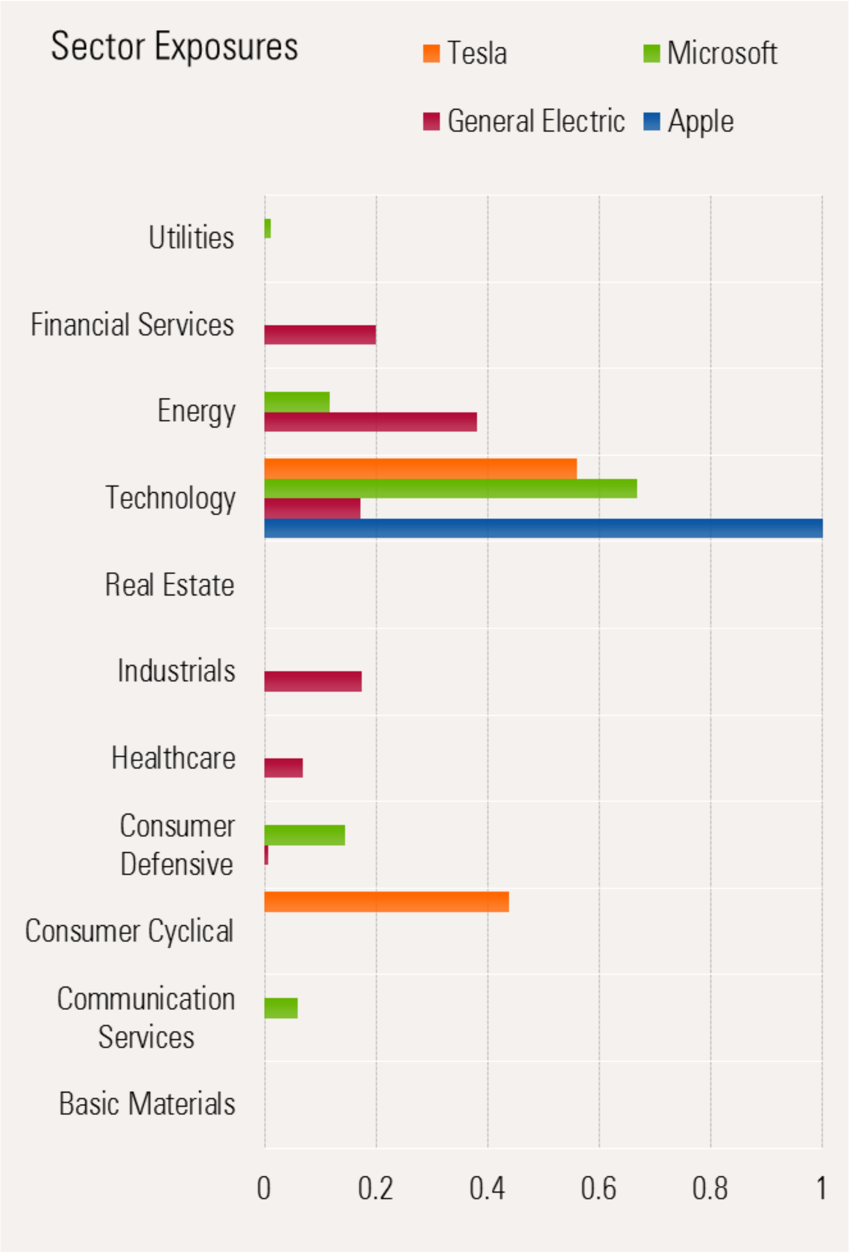
$$r_t^i - r_t^f = \alpha^i + \beta_1^i(r_t^1 - r_t^f) + \cdots + \beta_k^i(r_t^{11} - r_t^f) + \varepsilon_t^i$$

$$r_t^i = \text{weekly return on the } i\text{th stock}$$

$$r_t^f = \text{weekly return on 3} - \text{mo US TBill}$$

$$r_t^k = \text{weekly return on the } k\text{th sector or region or currency benchmark}$$

$$\text{constraints:}\ \ 0 < \beta_k^i < 1;\ \sum_k \beta_k^i = 1$$



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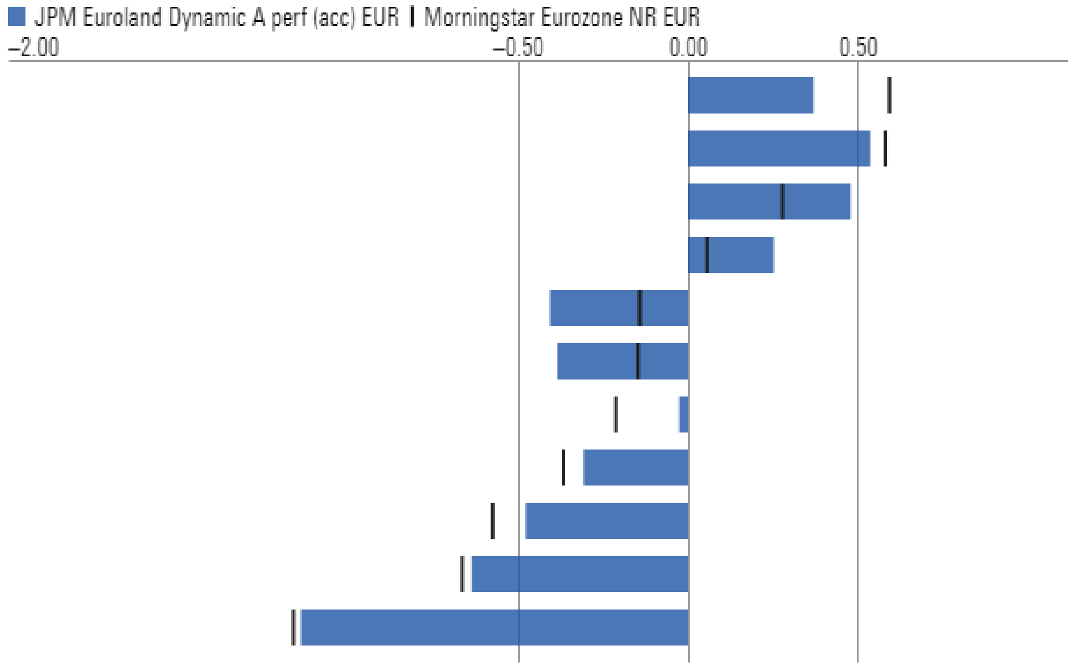
Manager Due Diligence example

- JPM Euroland Dynamic A perf (acc) EUR
- Benchmark: Morningstar Eurozone NR EUR
- Portfolio Date: 7/31/2018
- **Momentum exposure +0.205** suggest that this fund might be pursuing a momentum tilt to generate alpha

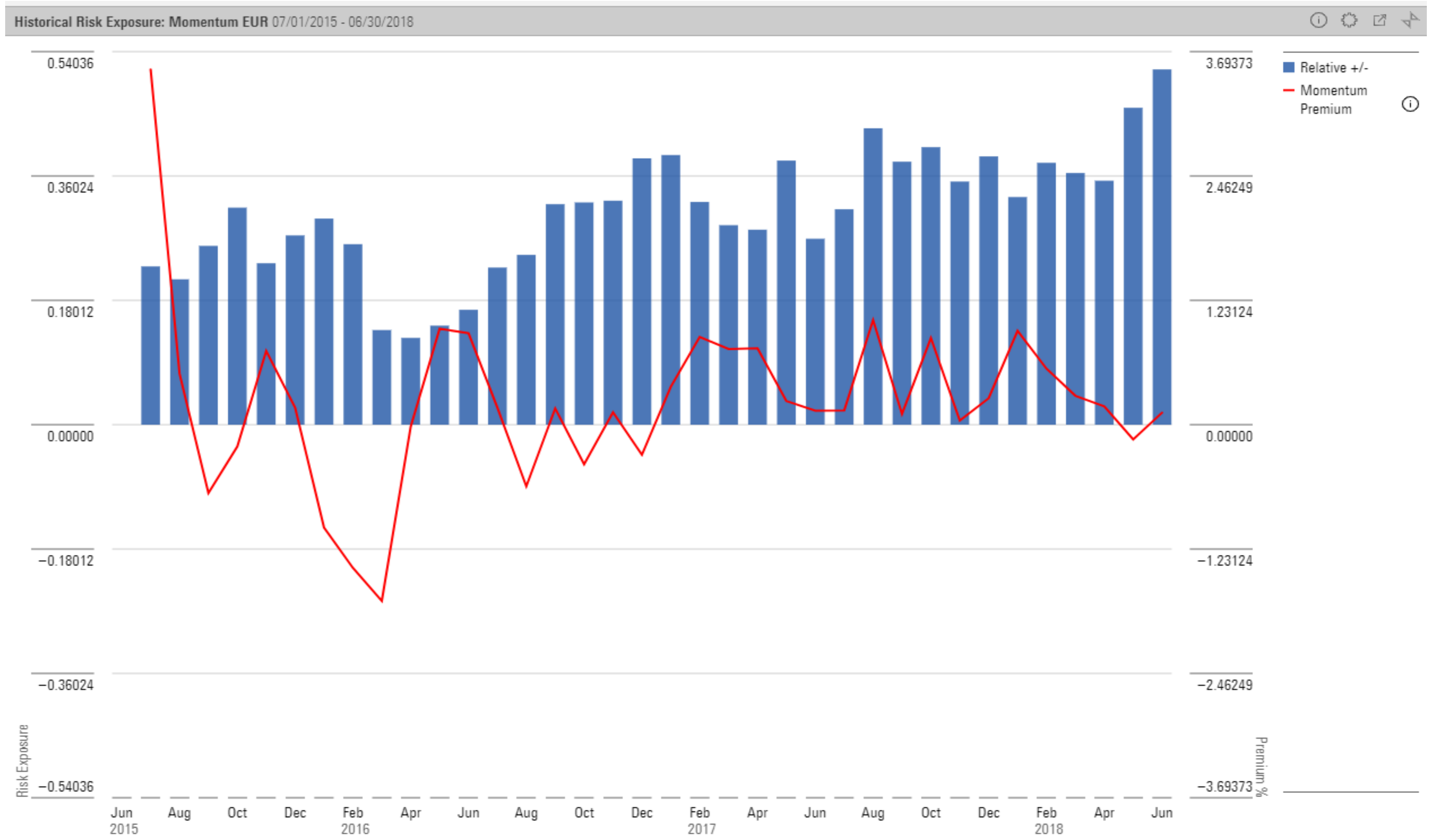
Risk Exposure Snapshot: Style EUR 07/31/2018

Risk Factors	Portfolio Exposure	Benchmark Exposure	+/-
Economic Moat	0.36853	0.58643	−0.21790
Financial Health	0.53482	0.57380	−0.03897
Momentum	0.47743	0.27162	0.20582
Ownership Popularity	0.25075	0.05061	0.20013
Valuation	−0.40593	−0.14759	−0.25834
Value Growth	−0.38587	−0.15313	−0.23274
Liquidity	−0.02764	−0.21852	0.19088
Ownership Risk	−0.30869	−0.37215	0.06346
Volatility	−0.47892	−0.57994	0.10102
Valuation Uncertainty	−0.63672	−0.66997	0.03325
Size	−1.13983	−1.16566	0.02583



Manager Due Diligence example

- JPM Euroland Dynamic A perf (acc) EUR
- Benchmark: Morningstar Eurozone NR EUR
- Date Range: 7/1/2015 - 6/30/2018
- **Momentum exposure** has been consistently greater than the benchmark for the past three years.
- Meanwhile, **momentum premia** has been positive. Suggesting that this tilt is paying off.



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Sources of risk and return

Where do returns come from?

- Portfolio attribution tells you where a portfolio's *returns* come from by decomposing a return stream into component pieces.

- This is useful to know the importance of specific factor tilts and their impact on returns.

Portfolio Return Attribution

A portfolio is described by an Nx1 vector $\boldsymbol{w_P}$ that gives the portfolio's holding-weights in N assets. The portfolio's factor exposures are given by the product of the asset-level factor exposures $\mathbf{X}^T$ and the holding weights $\boldsymbol{w_P}$.

$$\mathbf{x}_P = \mathbf{X}^T \cdot \mathbf{w}_P \qquad (A.6)$$

K x 1 = K x N · N x 1

36 x1 = 36 x7000 ·7000x1

The portfolio return is given by

$$r_P = \mathbf{x}_P \cdot \mathbf{P}_F + \mathbf{w}_P \cdot \mathbf{S} \qquad (A.7)$$

1 x 1 = 1 x K · K x 1 + 1x N · N x1

1 x 1 = 1x36 ·36 x1 + 1 x7000 ·7000 x1

The active return (portfolio – benchmark) is given by

$$r_{PA} = \mathbf{x}_{PA} \cdot \mathbf{P}_F + \mathbf{w}_{PA} \cdot \mathbf{S} = (\mathbf{x}_P - \mathbf{x}_B) \cdot \mathbf{P}_F + (\mathbf{w}_P - \mathbf{w}_B) \cdot \mathbf{S} \qquad (A.8)$$

1 x 1 = 1 x K · K x 1 + 1x N · N x 1 = (1 x K - 1 x K) · K x 1 + (1x N - 1x N) · N x1

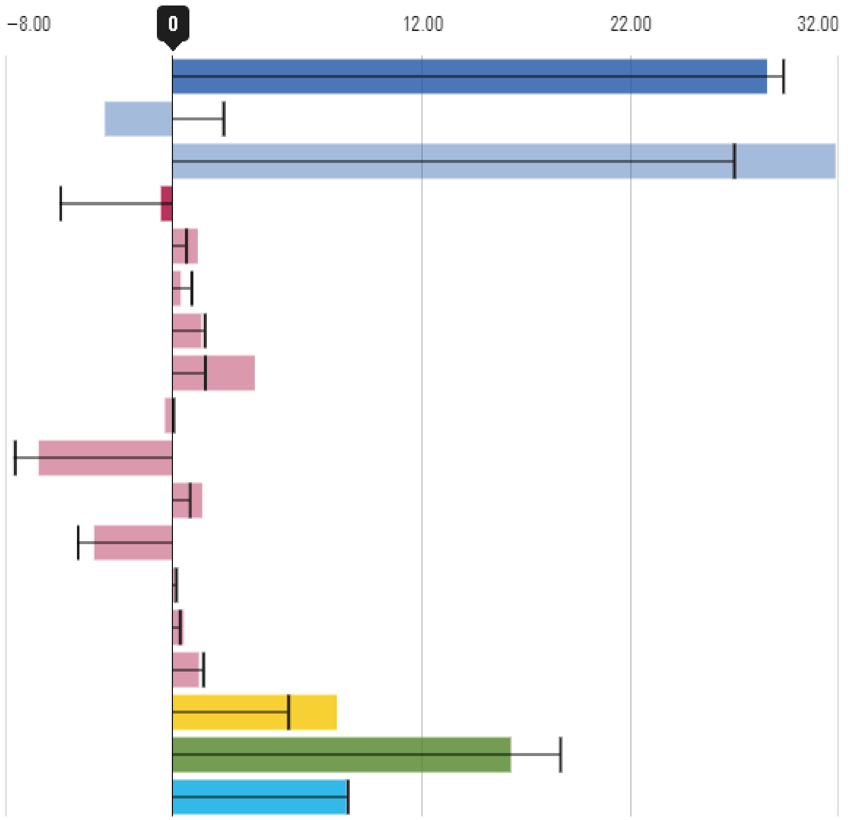
1 x 1 = 1x36 ·36 x1 + 1 x7000 ·7000 x1 = (1x36 - 1x36) · 36 x1 + (1x 7000 - 1x7000) · 7000 x1

Manager Due Diligence example

- JPM Euroland Dynamic A perf (acc) EUR
- Benchmark: Morningstar Eurozone NR EUR
- Date Range: 7/1/2016 – 6/30/2018
- Due to the momentum tilt, an approximate 2.45% of alpha was generated
- Factor bets generated 4.9% of total alpha
- Stock specific bets detracted 5.6% of total alpha

LU0661985969 | Risk Factor Attribution: EUR 07/01/2016 - 06/30/2018

	Factor Premium %	Portfolio Contrib %	Benchmark Contrib %	Active Contrib %
Gross Return	–	28.56456	29.28116	−0.71660
Stock Specific ⓘ	–	−3.27689	2.36249	−5.63938
Factor Total ⓘ	–	31.84144	26.91867	4.92278
▼ Style	**20.43235**	**−0.58379**	**−5.46964**	**4.88585**
Valuation	−1.16899	1.18832	0.56795	0.62037
Economic Moat	1.10534	0.36493	0.84302	−0.47808
Financial Health	3.45544	1.36002	1.46057	−0.10055
Momentum	6.84203	3.92702	1.47642	2.45060
Volatility	−0.35536	−0.39372	−0.03138	−0.36233
Size	6.88138	−6.47048	−7.66054	1.19006
Value Growth	−3.79910	1.39733	0.75003	0.64730
Valuation Uncertainty	9.14168	−3.80389	−4.63135	0.82746
Liquidity	−0.42965	0.10245	0.09578	0.00667
Ownership Popularity	2.63340	0.50500	0.27035	0.23465
Ownership Risk	−3.87382	1.23923	1.38952	−0.15029
► Sector	**57.88778**	**7.86082**	**5.49078**	**2.37003**
► Region	**47.84137**	**16.24487**	**18.55959**	**−2.31471**
► Currency	**19.33444**	**8.31954**	**8.33794**	**−0.01840**



Where does risk come from?

- Portfolio risk decomposition tells you where a portfolio's *risk* comes from by decomposing a portfolio's realized volatility into component pieces.
- This is useful to know the importance of specific factor tilts and their impact on risk.

Portfolio Risk Decomposition

The portfolio variance is given by

$$\boldsymbol{\sigma}_P^2 = \mathbf{x}_P^T \cdot \mathbf{F} \cdot \mathbf{x}_P + \mathbf{w}_P^T \cdot \boldsymbol{\Delta} \cdot \mathbf{w}_P = \mathbf{w}_P^T \cdot \mathbf{V} \cdot \mathbf{w}_P \qquad (\mathrm{A.9})$$

$1 \times 1 = 1 \times K \cdot K \times K \cdot K \times 1 + 1 \times N \cdot N \times N \cdot N \times 1 = 1 \times N \cdot N \times N \cdot N \times 1$

$1 \times 1 = 1 \times 36 \cdot 36 \times 36 \cdot 36 \times 1 + 1 \times 7000 \cdot 7000 \times 7000 \cdot 7000 \times 1 = 1 \times 7000 \cdot 7000 \times 7000 \cdot 7000 \times 1$

(A.7) is derived from substituting $\mathbf{V} = \mathbf{X}\,\mathbf{F}\,\mathbf{X}^T + \boldsymbol{\Delta}$ (A.2) into $\boldsymbol{\sigma}_P^2 = \mathbf{w}_P^T \cdot \mathbf{V} \cdot \mathbf{w}_P = \mathbf{w}_P^T \cdot (\mathbf{X}\,\mathbf{F}\,\mathbf{X}^T + \boldsymbol{\Delta}) \cdot \mathbf{w}_P$

Where $\mathbf{x}_P\ {}_{K \times 1} = \begin{bmatrix} \mathbf{x}_{p1} \\ \mathbf{x}_{p2} \\ \vdots \\ \mathbf{x}_{pK} \end{bmatrix}$ $\mathbf{F}\ {}_{K \times K} = \begin{bmatrix} \sigma^2_{1(F)} & \sigma_{12(F)} \dots \dots & \sigma_{1K(F)} \\ \sigma_{21(F)} & \sigma^2_{2(F)} \dots \dots & \sigma_{2K(F)} \\ \sigma_{i1(F)} & \dots \sigma^2_{i(F)} \dots & \sigma_{iK(F)} \\ \sigma_{K1(F)} \dots & \dots \quad \dots & \sigma^2_{K(F)} \end{bmatrix}$ $\boldsymbol{\Delta}\ {}_{N \times N} = \begin{bmatrix} \sigma^2_{1(s)} & 0\ 0 \dots 0 \\ 0 & \sigma^2_{2(s)}\ 0 \dots 0 \\ 0 \dots & \sigma^2_{i(s)} \dots 0 \\ 0 \dots \dots \dots & \sigma^2_{N(s)} \end{bmatrix}$ $\mathbf{w}_P\ {}_{N \times 1} = \begin{bmatrix} \mathbf{w}_{p1} \\ \mathbf{w}_{p2} \\ \vdots \\ \mathbf{w}_{pN} \end{bmatrix}$

Notice that we have separated both total and active risk into common-factor and specific components. This works because factor risks and specific risks are uncorrelated.

A similar formula is derived for active risk (aka tracking error) $\boldsymbol{\sigma}_{PA}$, which measures the relative risk of the portfolio to a selected benchmark:

$$\boldsymbol{\sigma}_{PA}^2 = \mathbf{x}_{PA}^T \cdot \mathbf{F} \cdot \mathbf{x}_{PA} + \mathbf{w}_{PA}^T \cdot \boldsymbol{\Delta} \cdot \mathbf{w}_{PA} = \mathbf{w}_{PA}^T \cdot \mathbf{V} \cdot \mathbf{w}_{PA} \qquad (\mathrm{A.10})$$

$1 \times 1 = 1 \times K \cdot K \times K \cdot K \times 1 + 1 \times N \cdot N \times N \cdot N \times 1 = 1 \times N \cdot N \times N \cdot N \times 1$

$1 \times 7000 = 1 \times 36 \cdot 36 \times 36 \cdot 36 \times 1 + 1 \times 7000 \cdot 7000 \times 7000 \cdot 7000 \times 1 = 1 \times 7000 \cdot 7000 \times 7000 \cdot 7000 \times 1$

Manager Due Diligence example

- JPM Euroland Dynamic A perf (acc) EUR
- Benchmark: Morningstar Eurozone NR EUR
- Date Range: 7/1/2017 – 6/30/2018
- Factors account for most risk
- Momentum contributed small amount of risk
- Developed Europe accounted for the majority of total risk (38.7%) and active risk (73.8%)

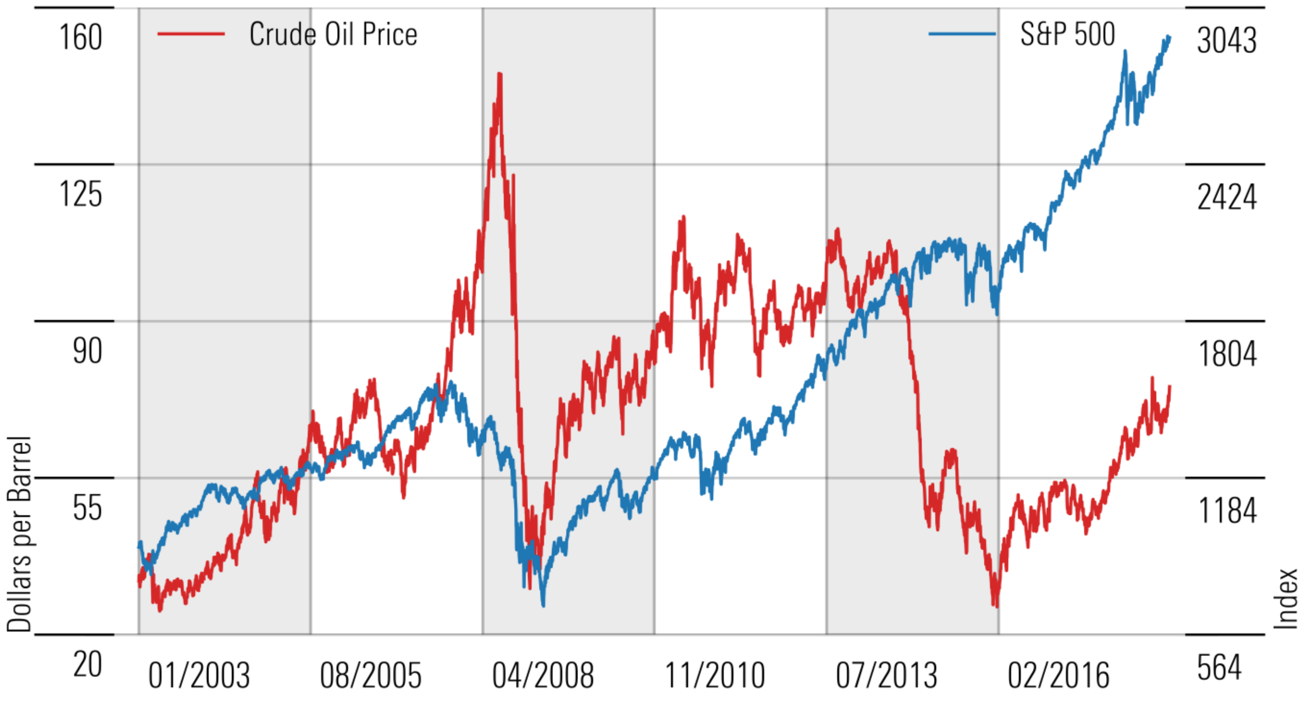
Risk Decomposition: Factors EUR 07/01/2017 - 05/31/2018

▼	Portfolio Exposure	Benchmark Exposure	Active Exposure	Marginal Contribution to Total Risk	Marginal Contribution to Active Risk	Contribution to Total Risk	Contribution to Total Risk %	Contribution to Active Risk	Contribution to Active Risk %
Total Risk						**10.04173**	**100.00000**	**2.63749**	**100.00000**
Total Factor Risk						**9.75364**	**94.34432**	**1.39377**	**27.92543**
Idiosyncratic Risk						**2.38809**	**5.65568**	**2.23914**	**72.07457**
Factors									
▼ Style									
Valuation	−0.32063	−0.01504	−0.30559	−0.09625	−0.11529	0.03086	0.30733	0.03523	1.33578
Economic Moat	0.35001	0.55272	−0.20271	0.08551	0.02799	0.02993	0.29806	−0.00567	−0.21515
Financial Health	0.54394	0.52102	0.02292	−0.18903	0.08876	−0.10282	−1.02396	0.00203	0.07714
Momentum	0.71840	0.40636	0.31205	0.38333	0.21193	0.27538	2.74239	0.06613	2.50734
Volatility	−0.09059	−0.36737	0.27677	0.15596	−0.08796	−0.01413	−0.14071	−0.02434	−0.92299
Size	−0.96094	−1.21616	0.25523	−0.31681	0.37416	0.30444	3.03172	0.09549	3.62067
Value Growth	−0.25852	−0.16687	−0.09165	−0.05942	0.05344	0.01536	0.15298	−0.00490	−0.18571
Valuation Uncertainty	−0.42822	−0.64612	0.21790	0.06062	−0.02305	−0.02596	−0.25849	−0.00502	−0.19047
Liquidity	−0.00116	−0.11577	0.11461	0.28639	−0.00176	−0.00033	−0.00331	−0.00020	−0.00766
Ownership Popularity	0.11823	0.06006	0.05817	0.20793	−0.13764	0.02458	0.24480	−0.00801	−0.30356
Ownership Risk	−0.28765	−0.32316	0.03551	−0.37419	0.14724	0.10763	1.07186	0.00523	0.19827

3 ways to skin a scenario

Our Scenario

- Oil prices experienced a sustained rise from around $40/bbl in January 2007 to just less than $150/bbl on July 15, 2008.
- If **oil prices** were to **rise by 375% in the next 17 months**, what is a plausible return outcome for the energy sector and the U.S. market?



Historical
Scenario Analysis

Macro-Financial
Scenario Analysis

Market-Driven
Scenario Analysis

Replay a historical scenario exactly as it occurred

/ aka. capture the full state of the world at a certain time

- 3 General Steps:
  - Take premia for a time period in the past
  - Use current exposures
  - Create return series using past premia and current exposures

A few scenarios...

- 2003 Bond Selloff
- 2006 Emerging Market Selloff
- 2007-2008 Oil Price Rise
- 2007-2009 Financial Crisis
- 2010 Greek Crisis
- 2014-2015 Oil Price Drop

Historical Scenario Analysis Outcome

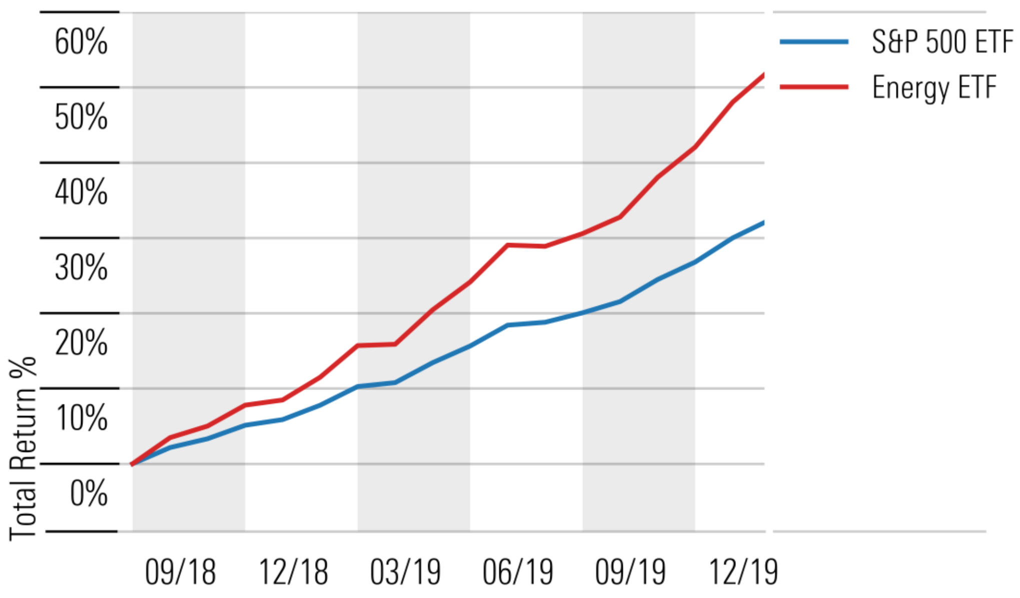
- Energy ETF return at 80% while S&P 500 ETF return at slight loss
- This takes into account market activities in 2007-2008 which not only had a significant oil price rise, but also market wide losses. This is somewhat unique occurrence.
- This scenario tells us "What would happen if we took our ETF's and replayed them back through the 2007-2008 Oil Price rise"

Shock multiple macro-financial variables at distinct future times

- 3 General Steps:
  - Create Macro-Financial model to represent economy
  - Link Macro-Financial model with Risk Model premia
  - Introduce Macro-Financial "shocks" to create scenario

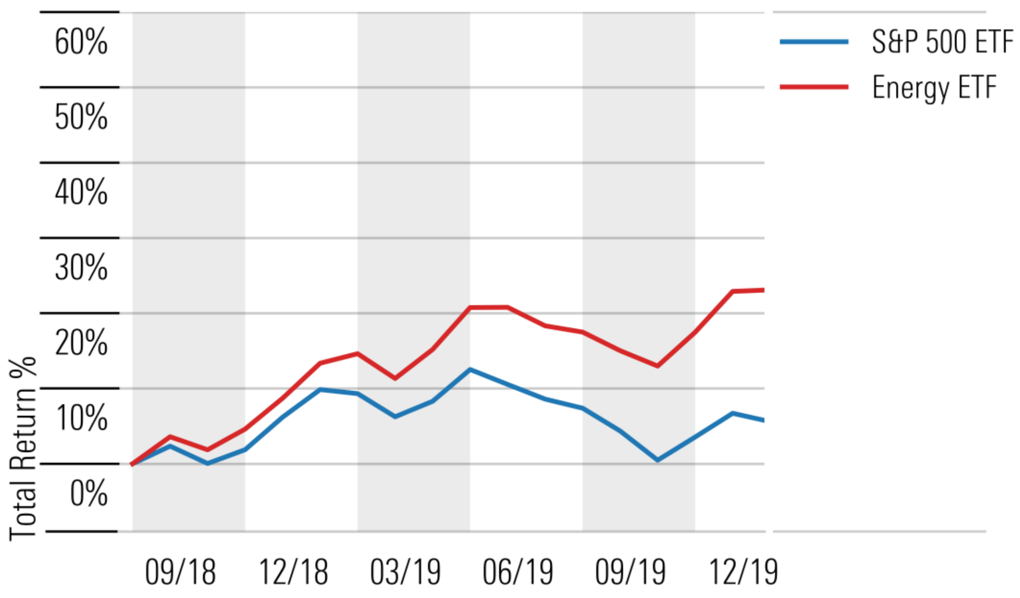
Date	Oil-Price Scale	Oil Price
9/30/2018	1.09	74.02
10/31/2018	1.11	75.46
11/30/2018	1.17	79.88
12/31/2018	1.16	79.23
1/31/2019	1.24	84.27
2/28/2019	1.36	92.54
3/31/2019	1.33	90.35
4/30/2019	1.47	99.79
5/31/2019	1.57	107.13
6/30/2019	1.74	118.33
7/31/2019	1.68	114.48
8/31/2019	1.71	116.08
9/30/2019	1.75	119.1
10/31/2019	1.93	131.66
11/30/2019	2.07	140.56
12/31/2019	2.3	156.57
1/31/2020	2.46	167.16

Macro-Financial Scenario Analysis Outcome



- Energy ETF return at 52% while S&P 500 ETF return at 32%
- Significantly different from Historical Scenario Analysis due to much different assumptions
- This scenario tells us “What would happen if we took our ETF’s and increased oil prices in the same manner as 2007-2008”

Macro-Financial Scenario Analysis Outcome (alternate)



- Flexibility of the tool allows us to add additional constraints. Now we also add S&P shock to match 2007-2008 time period.
- This has dampening effect on returns, as it should
- This scenario tells us “What would happen if we took our ETF’s and increased oil prices *and the S&P 500* acted in the same manner as 2007-2008”

Run Monte Carlo simulations in order to stress test

- 3 General Steps:
  - Select index to shock
  - Choose 2 of following parameters:
    - Percentile of index distribution
    - Magnitude of shock
    - Duration of shock
  - Run simulation of premia while taking into account volatility clustering

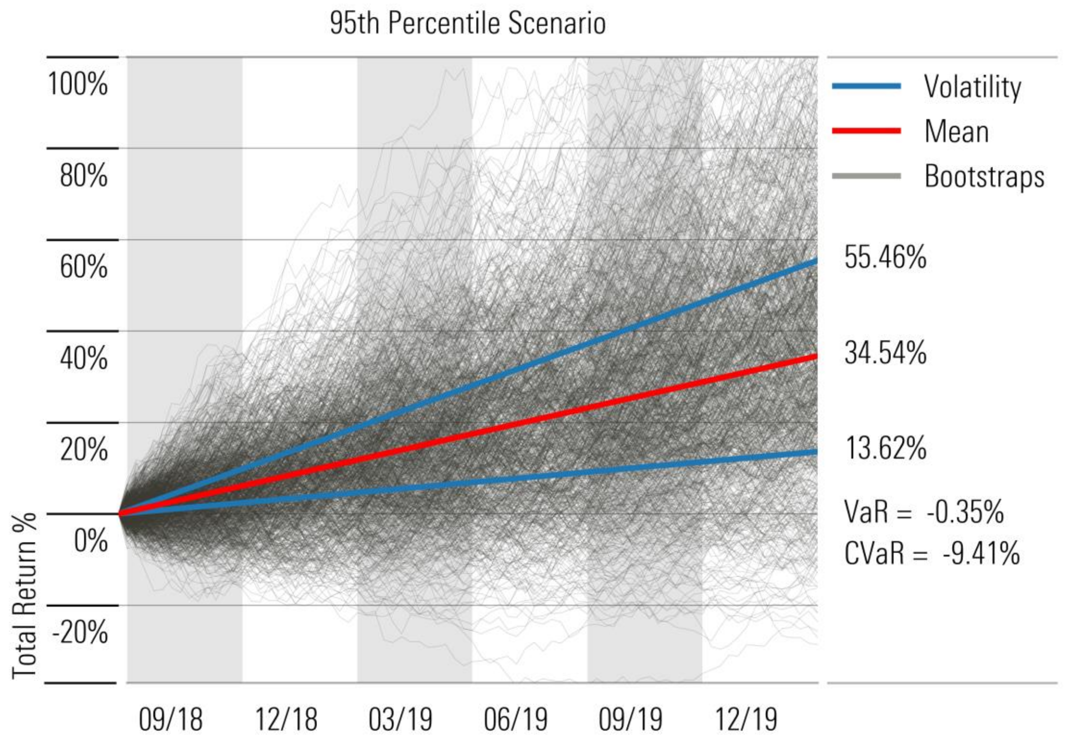
Our Model

Magnitude = 375% shock of oil prices

Percentile = 95^{th}

Market-Driven Scenario Analysis

- Mean Energy ETF return of 34% from all simulations
- 18 months to reach oil shock of 375% at 95th percentile



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Quick Comparison

Historical Scenario Analysis

- Replay historical premia that capture “full state of the world”
- “What would happen if we went through another financial crisis?”

Macro-Financial Scenario Analysis

- Shock multiple macro-financial variables at distinct future times
- “What would happen if unemployment rose 2% next month and GDP drops 1% each of the next 6 months?”

Market-Driven Scenario Analysis

- Run Monte-Carlo simulations in order to stress test
- “What would happen if the S&P500 dropped 30% over the next month?”