LOW VOLATILITY IN PERSPECTIVE

June 2012
Agenda

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2. Risk Control Page 07
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4. Minimum Variance Page 13
5. Conclusion Page 19
1. Introduction
Low volatility strategies have become important to investors

There are at least 3 reasons for investor interest

<table>
<thead>
<tr>
<th>Draw-down</th>
<th>Low volatility portfolios draw-down less than higher volatility portfolios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return compounding</td>
<td>Long term rates of return are higher with less volatility</td>
</tr>
<tr>
<td>Forecasting</td>
<td>It is easier for advisors and plan sponsors to make forecasts with portfolios that have lower volatility</td>
</tr>
</tbody>
</table>
Controlling volatility matters

**Compounding example**

- Two funds: Fund 1 & Fund 2 each have assets of $100 on day 1
- 3 day time horizon
- Fund 2 has 2x volatility of Fund 1
- Fund 1 loses 25% in day 2 then makes 25% in day 3 losing $6
- Fund 2 loses 50% in day 2 then makes 50% in day 3 losing $25
- Fund 2 has a funding gap almost 5 times that of fund 1

<table>
<thead>
<tr>
<th>Day</th>
<th>Fund 1</th>
<th>Rate of Return</th>
<th>Fund 2</th>
<th>Rate of Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$100</td>
<td>--</td>
<td>$100</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>$75</td>
<td>-25%</td>
<td>$50</td>
<td>-50%</td>
</tr>
<tr>
<td>3</td>
<td>$94</td>
<td>25%</td>
<td>$75</td>
<td>50%</td>
</tr>
<tr>
<td>Funding Gap</td>
<td>$6</td>
<td></td>
<td>$25</td>
<td></td>
</tr>
</tbody>
</table>
Compounding is not exciting but can work better than heroic investing

Why?

**12 Periods**

Portfolio with 10% drift and 5% oscillations
Portfolio with 10% drift and 20% oscillations

**Investor Use Cases**

- When returns are compounded over multiple periods, lower volatility portfolios will consistently outperform similar but riskier portfolios since they are compounding from a higher base value
  - Negative returns have greater effect on a portfolio than positive returns:
    \[
    100 \times (1 - X\%) \times (1 + X\%) < 100
    \]
  - Win by losing less
  - Widely accepted that volatility is undesirable
    - Reduces Sharpe ratio
    - Increases Value at risk
    - Unpredictability, etc.

Volatility, in the long run has a negative impact on performance
Three approaches have become prominent in investor’s minds

**Minimum Variance**
- Approach is designed to provide investors the lowest volatility portfolio for a universe of securities. Since it’s on the efficient frontier, this approach also provides the highest return for its level of volatility.
  - Significant academic support for this approach – Nobel Prize winning theory

**Risk Weighted**
- Approach is designed to create a low volatility portfolio using asset characteristics like beta or variance.

**Risk Control**
- Approach is designed to provide investors an asset with constant realized risk.
2. Risk Control
Risk Controlled Investment Strategies Target a Level of Volatility

Risk Control

**Composition**

» The index portfolio consists of:
  » Equity investment
  » An overnight money-market investment
» The risk level is a predefined target
» Generally available for different levels of risk (5%, 10%, 15%, 20%)

**How it works:**

» Index rebalancing makes the index work
» Money is allocated between the risky asset and the riskless asset proportionately to maintain target level

» Not necessarily low volatility, as volatility level can be chosen
» Use latest market information to dynamically adjust risk
» Well behaved over different market cycles
» Strong Sharpe ratios
» Not fully invested
» Requires high notional turnover
Risk control has an attractive risk-return profile

Backtest of performance

**Consistent results**

Better performance, less risk

- Risk is maintained around the pre-determined level
- Easily projected Value at Risk and risk planning

<table>
<thead>
<tr>
<th></th>
<th>STOXX Canada 50</th>
<th>STOXX Canada 50 Risk Control 15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annualized returns</td>
<td>6.3%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Volatility</td>
<td>20.2%</td>
<td>12.9%</td>
</tr>
<tr>
<td>Sharpe ratio</td>
<td>0.31</td>
<td>0.55</td>
</tr>
<tr>
<td>Maximum Drawdown</td>
<td>-47.3%</td>
<td>-22.7%</td>
</tr>
</tbody>
</table>

1) Non-leveraged risk control methodology backtested on the STOXX Canada 50.
2) Source: Stoxx, daily from 25.03.2002 to 25.05.2012.
3. Risk-weighted
Risk-weighted strategies assign weights to each component based on the reciprocal of a volatility estimate

**Concept**

» Calculate each component historical volatility
  » Weight them according to the inverse of the result
  » One parameter only (beta, variance)
» Usually reduces risk since lower risk components take on a higher weight than more volatile ones
  » Highly subject to the initial composition of the selection universe
  » Under some circumstances, this concept can increase risk!
» Low realized volatility does not guarantee low future volatility, *poorly estimated parameters*

**Hypothetical simplistic example**

<table>
<thead>
<tr>
<th>Selection universe</th>
<th>Risk</th>
<th>Risk-weighted weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank A</td>
<td>5%</td>
<td>27%</td>
</tr>
<tr>
<td>Bank B</td>
<td>5%</td>
<td>27%</td>
</tr>
<tr>
<td>Bank C</td>
<td>5%</td>
<td>27%</td>
</tr>
<tr>
<td>Oil company</td>
<td>20%</td>
<td>7%</td>
</tr>
<tr>
<td>Tech company</td>
<td>20%</td>
<td>7%</td>
</tr>
<tr>
<td>Pharma company</td>
<td>30%</td>
<td>5%</td>
</tr>
</tbody>
</table>

» In this example, it is possible to have 81% of the portfolio in highly correlated names (e.g., BRK.A and BRK.B). We are concentrated in banks!
» Correlation is ignored in most implementations
  » Lack of overall portfolio management

Simple and should usually reduce risk, but there are no guarantees
4. Minimum Variance
Minimum Variance determines weights to get an optimal portfolio minimized for risk

**Concept**

» Risk is more easily estimated than returns
  » Minimum Variance is the most feasible optimal portfolio
  » Gives highest possible returns for given risk since on the efficient frontier

» Portfolio is constructed using an optimization taking variance-covariance into account
  » Reduce concentration risks

» Estimating the portfolio variance can be done multiple ways
  » Historical covariance, poor predictive power
  » Factor model based, more complex but better predictive power

» Empirical results show concept superiority
Usage of factor models reduces computational complexity, adds stability and allows factor based constraining of results

Optimization process

**Selection of basket**
- Determine starting portfolio (i.e. underlying index)
- \( n \) assets in portfolio (for STOXX North America 600, \( n = 600 \))

**Calculate variance / covariance matrix**
- Compute intercorrelation between each pair of assets
  - proportional to \( n^2 \) variables to be computed (>180k!)

**Optimize weights**
- Highly complex optimization due to high number of variables
- High likelihood of suboptimal and unstable results

**Historical Covariance Approach**
- Strong calculation models as basis for optimization
  - Additionally easy introduction of factor based constraints to optimize risk profile of the target portfolio in multiple dimensions

**STOXX+ Minimum Variance (factor based)**
- Determine starting portfolio (i.e. underlying index)
- \( n \) assets in portfolio (for STOXX North America 600, \( n = 600 \))
  - Calculate matrix based on factor exposure only
  - Massively reduces size makes accurate computation possible
  - Higher stability of results through better estimates
STOXX launches, in cooperation with Axioma, a wide array of indices to cater for various investor needs

Coverage

**Unconstrained**

» Full optimization to minimize risk

» With only very basic constraints, there is the freedom to provide increased optimality in resulting portfolio

» Resulting portfolio might have a bias towards certain properties (specific factor, geography etc.) as the aim is purely to minimize variance

» The freedom is expected to provide lower risk

» Cater for an investment in a minimum variance portfolio while not concerned about the underlying benchmark

**Regular**

» Optimization is constrained to limit bias of minimum variance index into a specific industry/country/factor when compared to the underlying index

» Most factors/attributes are constrained except for variance, resulting in a very similar index but with reduced risk

» Clear advantage if seeking to track a benchmark

» Cater for the need of a superior risk-return profile over the benchmark, or a risk minimized benchmark

Both index versions are available for a broad range of markets globally (Global, Regional, Single Countries)
Further proof of the model’s robustness and consistency is given by North American data

Backtest of performance

**Consistent results**

Consistent outperformance and lower risk

» The mandate of minimized risk has been accomplished successfully throughout time periods and geographies

» Results are in-line with the theoretical construction of the indices

<table>
<thead>
<tr>
<th></th>
<th>STOXX North America 600</th>
<th>STOXX N.A.600 Risk Control 15%</th>
<th>STOXX+ Min. Var.</th>
<th>STOXX+ Min. Var. Unc.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annualized returns</strong></td>
<td>0.1%</td>
<td>3.9%</td>
<td>7.4%</td>
<td>8.6%</td>
</tr>
<tr>
<td><strong>Volatility</strong></td>
<td>22.7%</td>
<td>12.3%</td>
<td>13.7%</td>
<td>12.2%</td>
</tr>
<tr>
<td><strong>Sharpe ratio</strong></td>
<td>0.00</td>
<td>0.32</td>
<td>0.54</td>
<td>0.70</td>
</tr>
<tr>
<td><strong>Maximum Drawdown</strong></td>
<td>-57.3%</td>
<td>-29.4%</td>
<td>-39.1%</td>
<td>-40.1%</td>
</tr>
</tbody>
</table>

**STOXX+ North America 600 Minimum Variance**

1) Non-leveraged risk control methodology backtested on the STOXX North America 600.

2) Source: Axioma, Stoxx, daily from 27.03.2001 to 02.05.2012.
The model’s robustness and consistency also holds up in the Global region

Backtest of performance

**Consistent results**

**Consistent outperformance and lower risk**

» Even on a global scale, the strategy outperforms while providing reduced risk

» The pattern of the offering is yet again consistent

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Annualized returns</td>
<td>0.3%</td>
<td>3.9%</td>
<td>9.9%</td>
<td>10.1%</td>
</tr>
<tr>
<td>Volatility</td>
<td>17.5%</td>
<td>12.7%</td>
<td>10.7%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Sharpe ratio</td>
<td>0.02</td>
<td>0.31</td>
<td>0.92</td>
<td>1.15</td>
</tr>
<tr>
<td>Maximum Drawdown</td>
<td>-53.1%</td>
<td>-32.8%</td>
<td>-39.1%</td>
<td>-31.2%</td>
</tr>
</tbody>
</table>

1) Non-leveraged risk control methodology backtested on the STOXX Global 1800.

2) Source: Axioma, Stoxx, daily from 27.03.2001 to 02.05.2012.
5. Conclusion
There are various approaches to create a risk-reduced portfolio, with varying complexity and quality

**Conclusions**

**Risk Control**
- Decide on a risk level and obtain a consistent portfolio
- High turnover, not fully invested
- Useful for a core mandate
- Can be used for risk allocation decisions

**Risk-weighted**
- Simple and somewhat effective
- Major pitfalls in theory with dangerous consequences
- Poor strategy if the aim is to reduce risk

**Minimum Variance**
- Optimal solution
- Gets the most out of the risk allocation
  - Best return for given risk level since on efficient frontier
- Very appropriate as a low risk benchmark or strategy index

Minimum Variance is the superior concept, especially with the use of a factor model
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STOXX
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Appendix
STOXX provides two different sets of minimum variance concepts

Difference STOXX Minimum Variance offering

**iSTOXX Europe Minimum Variance**

**Step 1**
- Usage of correlation model that determines the correlation between the components by using historical data

<table>
<thead>
<tr>
<th>Covariance matrix</th>
<th>Component A</th>
<th>Component B</th>
<th>Component C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component A</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Component B</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Component C etc.</td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**Step 2**
- Minimize variance using the covariance matrix, subject to certain constraints:
  - Component capping
  - Industry capping
  - Diversification in terms of effective assets

**STOXX+ Minimum Variance**

**Step 1**
- For each component the exposure to each factor is determined, and the factor covariances are calculated

<table>
<thead>
<tr>
<th>Covariance matrix component A</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 2</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Factor 3 etc</td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**Step 2a – constrained version**
- Applying of further constraints:
  - Component Capping
  - Diversification in terms of effective assets
  - Rebalancing and max turnover
  - Country and industry exposure
  - Factor exposure

**Step 2b – Unconstrained version**
- Applying of further constraints:
  - Component Capping
  - Diversification in terms of effective assets
  - Rebalancing and max turnover
The Axioma Optimization process

Technical Methodology

**Optimization**

- We use a Second-Order Cone Optimization (SOCP)
- With Branch-and-Bound
  - SOCP to model any quadratic term (in objective or constraint)
  - Branch-and-Bound to solve combinatorial constraints
- Additional proprietary methods used to improve quality of solution and speed of optimization
  - Specialized heuristics
  - Fine-tuned Branch-and-Bound algorithm
  - Proprietary reformulation techniques for combinatorial constraints

**Factor Constraints**

- Except for the Unconstrained versions, all STOXX+ Minimum Variance indices will be constrained to have factor exposure similar to its underlying index, with respect to the factors:
  - Value
  - Growth
  - Medium-Term Momentum
  - Short-Term Momentum
  - Leverage
  - Liquidity
  - Exchange rate Sensitivity
- Size is not used as the underlying index is a broad index and a size pre-selection has already been made
## Summary of Axioma’s competitive positioning (1/4)

### US risk model

<table>
<thead>
<tr>
<th></th>
<th>Axioma AXUS2</th>
<th>Northfield US Fundamental</th>
<th>Barra USE3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimation Universe</strong></td>
<td>~3,000</td>
<td>~3,000</td>
<td>~1800</td>
</tr>
<tr>
<td><strong>Model Variations</strong></td>
<td>Fundamental and Statistical</td>
<td>Fundamental Hybrid</td>
<td>Fundamental Only</td>
</tr>
<tr>
<td><strong>Estimation Frequency</strong></td>
<td>Daily on all Risk Model Components</td>
<td>Monthly</td>
<td>Monthly</td>
</tr>
</tbody>
</table>
### Summary of Axioma’s competitive positioning (2/4)

#### US risk model

<table>
<thead>
<tr>
<th>Timing of Release</th>
<th>Axioma AXUS2</th>
<th>Northfield US Fundamental</th>
<th>Barra USE3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Every Day (In advance of US Market Open)</td>
<td>Typically 5th Business day of the Month</td>
<td>Typically 1st Business Day of the Month</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Construction of Covariance Matrix</th>
<th>Axioma AXUS2</th>
<th>Northfield US Fundamental</th>
<th>Barra USE3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exponential Weighting + Newey-West + Dynamic Volatility Adjustment</td>
<td>Standard Exponential Weighting</td>
<td>Standard Exponential Weighting + Newey-West</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific Risk</th>
<th>Axioma AXUS2</th>
<th>Northfield US Fundamental</th>
<th>Barra USE3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Uses Daily Data with 125 day half life (60-day for SH) and updates are provided daily</td>
<td>Uses 60 Month historical monthly observations</td>
<td>Structural Model using Monthly Specific Return Data</td>
</tr>
</tbody>
</table>
## Summary of Axioma’s competitive positioning (3/4)

### Statistical risk model

<table>
<thead>
<tr>
<th>Axioma Statistical</th>
<th>APT</th>
</tr>
</thead>
<tbody>
<tr>
<td>~11,000 + Including ADRs</td>
<td>~8,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coverage</th>
</tr>
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<tbody>
<tr>
<td>~3,000</td>
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<thead>
<tr>
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<table>
<thead>
<tr>
<th>Model Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 Single Country</td>
</tr>
<tr>
<td>20 Global and Regional Models</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Forecast Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Variations</td>
</tr>
<tr>
<td>Medium Horizon (3-6 mo)</td>
</tr>
<tr>
<td>Short Horizon (1-3)</td>
</tr>
<tr>
<td>(MH) Exponential weighting of 125 days on variances and 250 on the correlations</td>
</tr>
<tr>
<td>(SH) Exponential Weighting of 60 days on the variances and 125 days on the correlations</td>
</tr>
<tr>
<td>12+ Months</td>
</tr>
<tr>
<td>Exponential weighting of 3 years of weekly data observations</td>
</tr>
</tbody>
</table>
### Summary of Axioma’s competitive positioning (4/4)

#### Statistical risk model

<table>
<thead>
<tr>
<th></th>
<th>Axioma Statistical</th>
<th>APT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model Variations</strong></td>
<td>Fundamental and Statistical</td>
<td>Statistical</td>
</tr>
<tr>
<td></td>
<td>Axioma uses Asymptotic Principal Components</td>
<td>APT uses traditional Principal Component Analysis</td>
</tr>
<tr>
<td><strong>Estimation Frequency</strong></td>
<td>Daily on all Risk Model Components</td>
<td>Monthly</td>
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<tr>
<td><strong>Timing of Release</strong></td>
<td>Every Day (In advance of US Market Open)</td>
<td>Typically 2nd Business day of the Month</td>
</tr>
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<td><strong>Construction of Covariance Matrix</strong></td>
<td>Exponential Weighting + Dynamic Volatility Adjustment</td>
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