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Accounting for Heterogeneity of Security Behavior with "Bottom Up" Asset Allocation

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Introduction

- The dominant construct for allocating to the various assets within a portfolio is the classic Markowitz Modern Portfolio Theory (1952). This process requires formulating expected returns and covariances among the assets defined.
- An important nuance that most investors overlook is the distinction between allocation among singular assets (i.e. individual securities, currencies, etc.) and collective assets such as the set of singular assets included in a financial market index, which is then used as a representation of an asset class.
- Even a cursory examination would make clear that the S&P 500 of 1974 (energy crisis), 1999 (tech bubble), 2006 (pre-GFC) and 2010 (post GFC) are quite different and these differences must be taken into account.
- Estimating asset class volatility and correlations from the "bottom up" (i.e. from current security compositions) provides material advantages relative to traditional time series methods when applied to collective assets.

Collective Assets and Volatility

- While many techniques have been developed for forecast the parameters of the allocation problem most are applied uniformly to both singular and collective assets. This omission materially increases estimation error for common asset (and ETF) allocation problems where collective assets are the primary vehicles.
  - For example, consider estimating the ex-ante volatility of the S&P 500 as of December 31, 2018 (after a sharp drop of around 11% during December).
  - Time series approaches such as ARCH and GARCH would suggest that ex-ante volatility estimates should increase in the wake of a volatile period.
  - But operating only on the times series of index returns misses the material role of the *heterogeneity of the securities within the index.*

Cross-Sectional Dispersion and Ex-Ante Volatility

- In a sharp decline, high volatility (high beta) securities fall more and low volatility (low beta) securities fall less in value.
- Accordingly, the riskier securities are now a smaller portion and low risk securities are now a larger portion of this capitalization weighted index. This shift of weights within the index composition will mute the expected increase in volatility.
- A sharp increase in market valuation would have the opposite effect, increasing the weight of riskier securities thereby expanding any expectation of increased volatility.
- In relatively concentrated indices (smaller markets or high average correlation) this effect can be sufficiently strong to actually decrease expected volatility after a large market decline, contrary to most investors intuition.
- diBartolomeo, Dan. 2007 "Applications of Portfolio Variety", in J. Knight and S. Satchell Editors, Forecasting Volatility, Butterworth-Heinemann.

A Stylized Illustration

- Let's start with a very basic calculation: Assume
  - We have a market index with historic volatility of 15% per annum over a 60 month sample period.
  - In the current period the return to the index is -7%
- A reasonable guess for an ex-ante volatility would be:

$$\text{Volatility (new)} = (15^2 * (60/12) + (-7)^2 - (15^2/12))^{.5} = 15.20$$

- So we've added what we know about the new month and subtracted out an "average" month, all assuming the average return on the asset is zero (which is what is assumed for Northfield factors under the efficient market hypothesis).

Let's Account for the Cross-Sectional Effects

- But now we have to account for the fact that our "market" isn't an asset, it is a portfolio with cross-sectional variation of the returns.
- Let's assume that our portfolio consists of two equally weighted assets, "A" which has beta 1.5 and "B" with beta .5. To keep the math simple at this point, we will assume that the idiosyncratic risk of both assets is zero and the risk free rate is zero as well.
- In a hypothetical -7% event, asset A will be expected to decline -10.5% while B would decline -3.5%. At this point, the weights are no longer 50/50, but 49%, 51% and the beta of the portfolio is .99 relative to former market portfolio rather than one.
- Applying this new beta value to the revised estimate of volatility we get a portfolio volatility of 15.06 = (15.20 *.99)
- The reverse would also be true with a +7% event raising the ex-ante volatility estimate to around 15.35.

A Bit More Discussion

- If we extend this example to incorporate idiosyncratic risk (which tends to be higher in high beta stocks and lower in low beta stocks) this will tend to drive estimated volatility of the index portfolio down rather than up due to a market decline (and vice versa).
  - As of 12/31/2018, in the Northfield US Fundamental Model the cross-sectional correlation of ex-ante beta and idiosyncratic risk values is 70.6% across the entire universe of 5349 firms.
  - The cross-sectional dispersion of the beta value is greater than .4 which suggests that our previous example is relatively realistic in magnitude.
  - As we create market indices that are more concentrated or have higher correlation across securities, this effect gets stronger.
- The intuition is simple. *Risk is in the future, not the past.* In a market decline, high risk stocks go down more than low risk stocks. As such, risky stocks are a smaller weight in the index and low risk stocks are a higher weight in the index after such an event. This means that the expected volatility of the index portfolio may actually decline rather than increase.

An Amplified Example: FAANG Stocks in an Index

- Let's just redo the arithmetic below with the assumption that the FAANG stocks have beta 2.4 (-17/-7) and are 20% of the index. The beta value of 2.4 * 20% = .48. Since we know that the beta of the market must be around 1, the beta of the other 80% of the market makes up the other .52/.8 so the beta on the other 80% of the market has to be .65. Here is the arithmetic redone for this example assuming the index underperforms the risk free rate by -7%
- The expected loss in the FAANG stocks would be -17%, which would reduce their weight in the index from 20 to 17.85%.
- The expected loss in the non-FAANG stocks would be -4.5%, increasing their weight to 82.15%.
- The new portfolio beta is .96 relative to the previous period "market portfolio" so the ex-ante volatility is (15.2 * .962) which is 14.63%
- The ex-ante volatility of the index drops enough to actually be below the previous estimate of 15, even before accounting for idiosyncratic risk.

Let's Check Some Actual Data

- At the request of a sovereign wealth fund client who uses our "bottom up" concept we compared the ex-ante and realized volatility for several equity market indices.
  - The information assumes a US dollar base currency
  - The sample period was from November 1, 2017 to October 31, 2018.
  - The forecasts were refreshed monthly using the Northfield Everything, Everywhere model.
- To the extent that the there was overlap between the sample period of the tests and the input data to the EE model for the relevant period, a "look ahead" bias is created.
  - To resolve this bias we weighted the forecasts to only pertain to the period between the date of the forecast and the end of the realization period
  - All of the estimates were very close to the realizations with errors far smaller than would be expected given random sampling error over the five year lookback of the EE model (about 14%).

Volatility Forecasts 2017/11/01-2018/10/31

	MSCI World	S&P 500	RUSSELL 2000	DAX	NIKKEI	HANG SENG
Average Forecast	10.51	10.27	13.40	13.98	11.09	20.48
Average Forecast Bias Adjusted	10.55	10.20	13.39	14.08	11.29	20.34
Realized	10.33	10.06	14.45	13.96	11.63	20.29

Cross-Sectional Dispersion and Correlation

- The same mechanisms impact the expected correlations across asset classes represented by market indices. We first discussed this issue in our client newsletter in September 2002 including these tables at the time.

Table 4: Historic Correlation of Market Indices as Computed Using PACO

ID	SP500	R2000	AsiaExJap	Nikkei	UK	CAC40	DAX30
SP500	100%	67%	56%	51%	73%	66%	68%
R2000	67%	100%	46%	39%	53%	60%	68%
AsiaExJap	56%	46%	100%	98%	57%	47%	40%
Nikkei	51%	39%	98%	100%	52%	42%	34%
UK	73%	53%	57%	52%	100%	73%	68%
CAC40	66%	60%	47%	42%	73%	100%	87%
DAX30	68%	68%	40%	34%	68%	87%	100%

Table 5: Difference between Correlations Calculated by EE Model and PACO

ID	SP500	R2000	AsiaExJap	Nikkei	UK	CAC40	DAX30
SP500	0%	22%	6%	1%	7%	15%	20%
R2000	22%	0%	26%	24%	30%	14%	13%
AsiaExJap	6%	26%	0%	-18%	-2%	6%	14%
Nikkei	1%	24%	-18%	0%	6%	10%	11%
UK	7%	30%	-2%	6%	0%	6%	13%
CAC40	16%	14%	6%	10%	6%	0%	-1%
DAX30	19%	13%	14%	11%	13%	-1%	0%

Calculating Bottom Up Correlations from 2002

Standard optimization reports can provide the expected absolute volatility of each market index, and the tracking error between any two market indices. To convert this information into an expected correlation coefficient, we can use the following formula (equation 1):

$$Q_{ab} = \frac{\sigma_a^2 + \sigma_b^2 - TE_{ab}^2}{2\sigma_a\sigma_b}$$

where:

Q_{ab} = implied correlation between asset A and asset B

σ_a^2 = variance of asset A

TE_{ab} = The tracking error: the standard deviation of a portfolio of asset A and minus asset B

This method is derived in "Optimization of Composite Assets Using Implied Covariance Matrices" (http://www.northinfo.com/documents/58.pdf)

Structural Breaks in Correlation History

- Over the years, many structural events have radically shifted the correlations of market indices.
- A few examples
  - The major revision by MSCI in the way it calculated weights for equity indices from simple market capitalization to "free float". This radically shifted the correlation of the Japanese and Korean markets due to the high cross-ownership in equity shares.
  - Fixed income indices are often impacted by decisions of major issuers such as the US government discontinuing callable Treasury bonds and starting to issue TIPS.
- Once again, estimating correlations "bottom up" from the current securities and weights resolves these problems.

The Effect of Base Currency

- Another important issue in estimating future asset class volatility and correlation is the base currency from which the investor views the world.

- Investors often miss the fact that the volatility of the FX changes in a currency pair are not symmetric when calculated from arithmetic returns.
  - For example, if we take the US$/JPY relationship and calculate the volatility, we will get a different value than if we use the JPY/US$ relationship.

- We can resolve this issue by using logarithmic returns but log returns are not easily added up across a multi-currency portfolio.

- For more information the details, see this presentation from our 2010 client conference, http://www.northinfo.com/documents/381.pdf

Volatility and Correlation in Taxable Portfolios

- Estimating asset class volatility and correlation for taxable portfolios also must capture important effects of heterogeneity across securities.
- In Markowitz and Blay (2016) show that previously realized taxable gains and losses have an important effect on expected returns of asset classes.
  - Taxes on net realized gains will have to paid out of the portfolio at the end of the tax year reducing returns. Net realized losses can be applied to other gains (if any) or carried forward into future tax years.
  - There is a positive economic value to tax losses which can be viewed as a reduction in the net economic loss. In effect, the tax authority becomes our partner and shares in economic loss reducing risk.
  - Many strategies have been developed to minimize the "effective tax rate" on various types of portfolios. For example, it has become routine for managers of taxable portfolios to implement strategies such as "tax loss harvesting" in order to defer or reduce the taxes payable by an investor.

Taxation and Cross-Sectional Dispersion

- The opportunity to pursue such tax reduction strategies is dependent on the *cross-sectional dispersion of security returns within an asset class.*
- For asset classes where the heterogeneity of returns is large, there will be likely be some securities within the index with losses even if the return of the overall index is positive.
  - We can selectively realize gains and losses on individual securities within our portfolio to minimize realized taxation.
- Conversely, if the dispersion of security returns is very low (e.g. five year US Treasury bonds), there is no opportunity to manage the tax effects.
- As such, high dispersion asset classes (e.g. small cap stocks) have effectively lower volatility than the same asset class for a tax exempt investor, while low dispersion asset classes experience their normal level of volatility.
- For more information, http://www.northinfo.com/Documents/275.pdf.

Conclusions

- Formulating expectations of asset class volatility and correlation must incorporate the basic difference between a singular asset (e.g. a stock or bond) and a collective asset such as market index contract or an ETF.
- The composition of market indices evolve over time. Over long periods this evolution can be very large.
- Any large magnitude return of an index implies dispersion of the returns of the securities within the index, with resultant changes in security weights.
- The shifting of weights as a result of a large magnitude market decline will tend to mute increases in volatility expectations, while large up moves will accentuate increases in volatility expectations. Related effects from idiosyncratic volatility, and currency also impact expectations all of which can be captured very effectively in a "bottom up" estimation process.
- Taxation effects also impact volatility expectations.