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CUSTOM HYBRID RISK MODELS

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Northfield Webinar

April 2016

STANDARD RISK MODELS

- Off-the-shelf or standard equity risk models can be used to forecast portfolio risk and tracking error, to show the split between factor risk and stock specific risk, and to show the contributions of each holding to the overall portfolio risk
- They can also provide a factor risk decomposition of the risk structure of a portfolio based on the particular set of factors used in the risk model
- However, active fund managers very often use their own (possibly proprietary) factors to do their stock selection and portfolio rebalancing, and these may be very different from the factors in a standard risk model
  - Different definitions, different classifications, different horizon, ...
- The only way to produce a portfolio risk analysis expressed in terms of the manager's own factors is to build a customised risk model (N.B. this is <u>not</u> the same thing as a customised version of somebody else's standard model . .)

CUSTOM RISK MODELS

- In this presentation, we will review the many different ways in which linear, multi-factor equity risk models can be constructed to different purposes
- In particular, we will cover
  - Different types of factors that may be included
  - Different ways in which factors can be constructed
  - The effects of ordering the factors in different ways
  - The effect of adding Statistical factors to a set of Defined factors
  - The effects of time-weighting the historic stock return data and the relationship to the investment horizon of a portfolio
  - The Universe of securities that can be included in a custom risk model
  - Specialisation & multi-asset class models

CURRENCY FACTORS - 1

- Currency risk obviously arises from holding foreign securities, even if they are ADRs or GDRs traded on a domestic exchange
- However, Currency risk can also come from domestic securities such as Apple or Microsoft, or other multi-national companies
- Portfolio managers need to decide what to do about these Currency exposures; ignoring them is usually a bad idea!
- Currency hedging is essentially Currency risk management, so any fund manager who uses Currency Hedging needs to have Currency factors in their risk model to find out how much they need to hedge
- Some active managers use multi-factor models to forecast the expected returns to Currencies; in these cases, the Currency forecasting model factors need to be included in the risk model

CURRENCY FACTORS - 2

- Currency exposures can be treated in several different ways :
  - Using dummy variables as currency betas; this is equivalent to assuming that currency risk is determined by currency of denomination, and also means that the rest of the risk model is all in local currency terms
  - Currency betas derived from time-series regressions will give a better estimate of the true portfolio currency exposures, to avoid over-hedging
    - One way to do this is to allow only priors, meaning that foreign stocks only get a currency beta on their home currency
    - Alternatively, stocks can also be allowed to get secondary currency betas
- Global risk models can also be built without any Currency factors at all: in these cases, the stock returns are all in base currency terms, and the fund manager thinks of them and the various markets all in base currency terms

STYLE FACTORS - 1

- The best portfolio risk forecasts are obtained when factor betas are estimated by regressing stock returns on factor returns (see Scowcroft & Sefton)
- However, this can only be done when we can reasonably assume that the betas are stable over time: this is true for many factors, such as Currencies, Markets, Countries, Industries and Sectors, but it is not true for Style factors
- In this case, we must derive the Style betas for each stock, and then estimate the Style factor returns with cross-sectional regressions for each period
- The resulting Style factor returns will therefore be conditioned on the other factor returns being estimated simultaneously
  - Ideally, we would only estimate a set of Style factors together
  - Some models estimate all the model factors simultaneously, so the Style factors will be conditioned by the presence of industry factors, for example

STYLE FACTORS - 2

- One concern fund managers sometimes have is that their Style factor betas may be proprietary
- However, Style factor betas are nearly always given as normalised z-scores, so if they are given anonymous names, such as M1 to M8, we can build a CHRM including them, without ever knowing what they actually are
- Managers can also choose how many Style factors to include:
  - We have built models with 4 or 5 Style factors
  - We have also built a model with over 600 Style factors
    - This arose because the manager believed that their Value factor, for example, behaved differently in different Markets and Industries
    - The danger always that if you fragment Style factors too far, you end up with a factor covariance matrix that can't be used to optimise

MARKET or COUNTRY FACTORS - 1

- Market factors (a.k.a. Country factors in a regional or global risk model) will typically explain the largest part of most stocks variance
  - A single factor Market model has an average R-Squared of 20% to 25%

- Market or Country factors are typically capitalisation-weighted
  - If we use an index such as the S&P 500, TOPIX or FTSE 100 as a market proxy, the capitalisation weights will vary through time
  - Although this will represent the actual behaviour of the market historically, it may not necessarily give the best portfolio risk forecasts into the future
  - A better alternative is to use current capitalisation weighting; the risk of such a factor will be a much better forecast of the actual risk of the market in the immediate future, as it has the same composition

MARKET or COUNTRY FACTORS - 2

- In a Global or Regional model, each Country can be used as a separate factor, or they can be grouped together in some way
- Sometimes this is done because neighbouring Countries each only have very small stock markets; an example would be a Baltic Region factor, consisting of Estonia, Latvia and Lithuania
- Sometimes a larger Country is paired with a neighbouring small Country, such as Greece & Cyprus, Spain & Portugal, Australia & New Zealand
- However, it is also possible to build a model with regional factors, such as Europe (with or without the UK!), the Eurozone, a Nordic Region, and so on
- The real point is that the factor structure of a custom risk model should reflect the way the manager thinks about the universe of possible investments
- There is no "right answer"!

MARKET or COUNTRY FACTORS - 3

- Risk models should be able to identify SIZE tilts in a portfolio
- Some models have SIZE as a Style factor, using some version of normalised/log/square root of market capitalisation as the SIZE beta
- It is also possible to create a composite SIZE Style beta, including other measures of company SIZE, such as Total Revenues or Book Value
- Alternatively, Size effects can be captured with a Fama-French-type SIZE factor, such as using **SIZE = Russell 2,000 - Russell 1,000**
- Another alternative, available in Northfield's XRD risk models, is to have both a Large Market factor and a Small Market factor
  - In the US XRD model, the US Large Market factor is the top 500 stocks by capitalisation; we then skip the next 500 (think mid-caps) and use the next 2,000 stocks for US Small Market factor

SECTOR or INDUSTRY FACTORS - 1

- Some models may have 60+ Industry factors; some may have 20 or so Industry Group factors. Others may have only 8 or 10 Sector factors, and it is also possible to build risk models which don't have any Industry or Sector factors
  - NB : this is not really a very good idea; the Sector effects don't somehow disappear - they simply show up in the Statistical factors!
- The point is that a Custom model can use whatever Industry classification scheme the fund manager wants, with as much granularity as desired
- Note also that the Industry classification may be one of the standard ones (GICS, FTSE, FactSet), or it can be proprietary classification
- A more recent development has been to create Custom risk models in which some Industries were treated as Global Industry factors, while others were treated as Country or Regional Industry factors

SECTOR or INDUSTRY FACTORS - 2

- The only limiting factor is that each Industry or Sector factor has to have enough constituents to make a reasonably well-diversified factor
- In addition, we sometimes set a maximum weight that any single stock can have in a capitalisation-weighted factor
  - For instance, in the Northfield XRD risk models, the maximum weight for all Market, Country, Sector or Industry factors is set at 30%
- Note also that the distribution of stocks by Industry varies considerably from market to market
  - Thus, although we have 20 GICS Industry factors in the US XRD model, in the Japan XRD model we combine Aerospace & Defence with Industrials, while in the Latin America XRD model we combine Biotechnology and Pharmaceuticals with Health Care

FACTOR CONSTRUCTION

- As we have already seen, Market, Country, Sector and Industry factors are typically capitalisation-weighted (historic or current)
- However, they can also have other weighting schemes, such as equal-weights
- It is also possible to include or exclude particular securities from these factors
- In most custom risk models, we first create a Screened Universe from which we build the factors, which would typically exclude stocks :-
  - With low liquidity
  - With suspiciously low volatility
  - With suspiciously high volatility
  - ADRs, GDRs and similar related securities
  - With very short return histories, and so on
- All these filters can be customised to suit the fund manager

FACTOR ORDER - 1

- In some risk models, some factors are orthogonalised on other factors
- For example, if we have a dominant Market factor, the Industry factors will represent residual Industry risk after Market-related risk has been taken out
- This does have the advantage of making the factor covariance matrix more sparse (i.e. lots of zeroes)
- However, it also has the big disadvantage that a risk contribution ("bet") on a particular Industry factor now doesn't mean quite what most fund managers think it means
- Ideally, the factors in a risk model should correspond as closely as possible to the way the fund manager thinks about the various bets they are taking
- We therefore prefer not to orthogonalise factors on each other if possible, but to find other ways to deal with their natural correlation

FACTOR ORDER - 2

- Ultimately, the factor order can be whatever the fund manager wants
- However, we normally recommend putting Currency factors first, to achieve 'base currency invariance', which simply means that the non-currency part of a portfolio's risk is the same no matter what the base currency of the model is
- The Style factors usually come next, before the Market and Industry factors
- This is because nearly all factors are correlated with each other in their natural state, so that whichever factor block goes first will soak up the covariance of those factors with everything else
- If we allow multiple Currency betas in a model, the Currency risk will always seem larger, and the Market and Industry risk of a portfolio will seem smaller
- Most fund managers, however, prefer the Market and Industry factors to capture that covariance

STATISTICAL FACTORS - 1

- It is, of course, possible to build pure Statistical factor risk models
- Such models, by construction, will always have the highest R-Squared (in-sample) for any given set of stock returns
- In practical terms, their big advantage is that they provide confidence that what we call Stock Specific Risk really is uncorrelated with other stocks
- Their most obvious disadvantage is that it is very difficult to give any useful economic meaning to what the factors represent, although in a single Country universe, the first statistical factor often looks a bit like the market
- This is not a disadvantage in cases where the user doesn't care what the factors represent, but is only concerned with applications of the model
- For example, building tracking portfolios using only easily-tradeable and highly liquid instruments: the American Stock Exchange example

STATISTICAL FACTORS - 2

- For institutional investors who need to know what the factors in their risk model represent, statistical factors can still serve a useful purpose
- All models built from a defined set of factors suffer from the same potential weakness: we can never be completely sure that the chosen set of factors has captured all the systematic covariance in a given universe of stocks
- For that reason, we usually build **hybrid** risk models, meaning that after we have explained as much of the stocks' risks as we can with the defined factors, we then take the residual returns, form them into a residual covariance matrix, and build a statistical factor model of any significant remaining systematic covariance
- In practice, this means that we usually add a small number of statistical, or 'blind', factors to each risk model we build

TIME-WEIGHTING & PERIODICITY - 1

- Risk models are usually built from time series of historic stock returns
- The number of returns and their periodicity should be chosen to reflect the investment horizon of the fund manager
- In the good old days, risk models were built using 60 calendar month returns
- Models can now be built on monthly, 4-weekly, weekly or daily returns
- The very short-term statistical risk model we built for the American Stock Exchange used 40 minute returns, with a look-back of only 20 trading days!
- Since we are essentially using a sample of past data to estimate the risk model, it is always tempting to want more data; however, this then raises the question of whether the older data is really relevant to todays markets
- As a result, it is very common to time-weight the stock returns data

TIME-WEIGHTING & PERIODICITY - 2

- Time-weighting of stock returns is usually done exponentially, using a decay parameter such as 0.985
- Conceptually, this means the most recent return gets a weight of 1.000, the previous return gets a weight of 0.985, the one before that gets a weight of 0.985 squared, then 0.985 cubed, and so on.
- If we equally weight 80 returns, for example, the sum of the weights is 80
- If we time-weight the returns, we must also scale the weights so they sum to 80, the total number of returns in the time series
- In practice, therefore, the most recent return will actually have a weighting higher than 1.000, and somewhere in the return series the weighting will go from just over 1.000 to just under 1.000. This is called the Crossover point
- We can also report the Half-Life and Half-Weight of the time-weighting

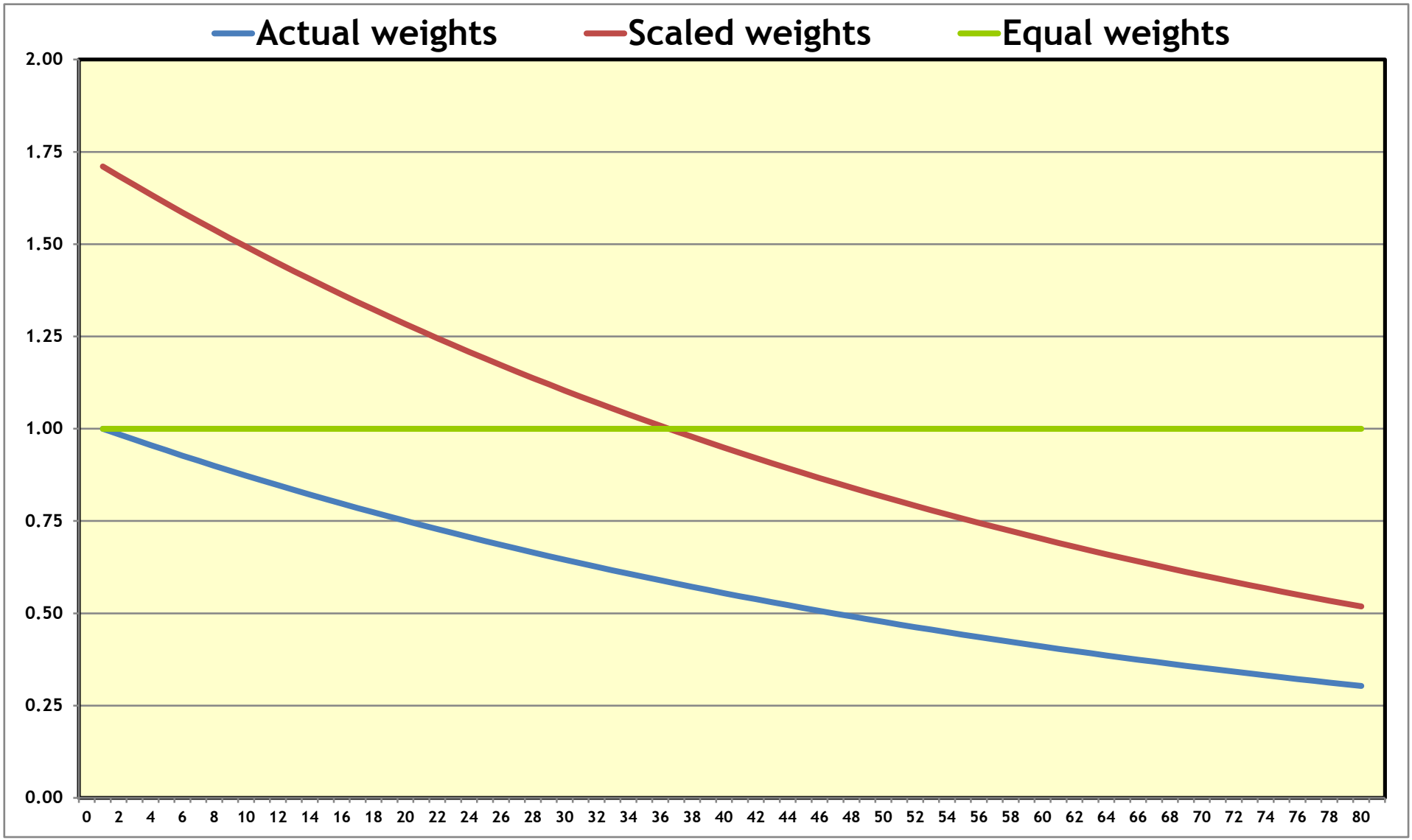
TIME-WEIGHTING & PERIODICITY - 3

- There are other forms of time-weighting, including Linear weighting and Custom weighting, in which the returns for certain periods can be given specific weights (possibly zero to eliminate an extreme period, for example)
- In this particular example, we have the following values :-

Half-weight =	**28.6**	*** 4 weeks =**	**2.19**	**years**	**35.7%**
Crossover =	**36.5**	*** 4 weeks =**	**2.80**	**years**	**45.7%**
Half-life =	**46.9**	*** 4 weeks =**	**3.59**	**years**	**58.6%**
Look-back =	**80.0**	*** 4 weeks =**	**6.13**	**years**	**100.0%**
Lambda = decay factor = 0.985					

- This time-weighting is shown on the following chart

TIME-WEIGHTING & PERIODICITY - 4



UNIVERSE COVERAGE

- Needless to say, the Universe itself can be customised, so that a custom risk model would only cover stocks the fund manager is interested in, including those in the fund benchmarks
- We can also include Indices, Futures, ETFs, ADRs, GDRs and so on, if they are of interest to the fund manager
- Another option is to include Macro-Economic variables in the Universe as if they were securities, so they are regressed on the various factors to get their statistically significant betas.
- Fund managers can then set any Macro-Economic variable as a benchmark, and derive the beta and R-squared of their portfolio to that M-E variable
- The next table illustrates the kind of Risk Report that can be generated if Macro-Economic variables are included in a Custom risk model

Example Macro-Economic Exposures report

US Large Cap Fund	Portfolio	28-Aug-15	Macro-Economic Exposures		
S&P 500 index	Benchmark	28-Aug-15			
RSQRM_US_v2_19_9	Risk Model	26-Aug-15			

Macro-Economic Variable	Portfolio Beta	Portfolio Systematic R-Squared %	Benchmark Beta	Benchmark Systematic R-Squared %	Relative Beta
Barclays Capital U.S. 1-3 Year Treasury Bond Index,United States	-4.476	51.03	-4.323	51.56	-0.153
Barclays Capital U.S. 1-3 Year Corporate Bond Index,United States	-3.231	39.89	-3.121	40.31	-0.111
S&P GSCI Index (SPGSCI) TOTAL RETURN NET	0.492	38.15	0.478	39.03	0.014
Rogers International Commodity Index (RICIX)	0.544	35.99	0.528	36.78	0.016
S&P GSCI Energy Index (SPGSEN) TOTAL RETURN NET USD	0.390	35.07	0.379	35.94	0.011
Barclays Capital U.S. Government Aggregate Bond Index,United States	-2.011	24.83	-1.942	25.09	-0.069
CBOE Volatility S&P 500 Index (VIX)	-2.958	10.93	-2.905	11.42	-0.053
Barclays Capital U.S. 5-7 Year Corporate Bond Index,United States	-0.825	10.19	-0.797	10.29	-0.028
TED Spread (LIBOR-USD-3Month - United States Treasury BillSecondary D	-0.040	2.89	-0.038	2.92	-0.001
United States Employment (Y-o-Y %) - Monthly,United States	-0.026	2.18	-0.025	2.20	-0.001
United States Exports (USD) - (Monthly),United States	0.063	0.52	0.061	0.53	0.002
Barclays Capital U.S. Treasury Bill Index,United States	-0.460	0.21	-0.443	0.22	-0.017
Gold (GC)	-0.000	0.00	-0.000	0.00	0.000

SPECIALISATION

- We have built many Global or Regional risk models (e.g. Latin America or Europe), as well as single Country risk models (e.g. USA, Japan, the UK)
- However, we have also built risk models that focus on particular, and sometimes quite narrow areas of investment
- Examples include
  - Emerging Market (only) risk models
  - USA REITs (only) risk model
  - Small Cap (different industry factors for Large & Small Cap stocks)
  - Statistical factor model for pricing Actively-managed ETFs without knowing the underlying holdings
  - Short-term Global equity risk model for a Multi-Asset Class product
  - China model with A and Z industry factors

MULTI-ASSET CLASS MODELS

- At the heart of most Multi-Asset Class risk models is a multi-factor equity risk model
- Apart from providing the risk forecasts for the equity portion of a multi-asset class portfolio, the equity model is also used to derive the risk of assets such as corporate bonds
- Northfield developed the first Multi-Asset Class risk model in 2004, called the Everything Everywhere model
- As an example of a Custom risk model, we developed the Short-term Global equity risk model that supports the FactSet MAC model
- We can also build customised versions of the Everything Everywhere risk model, which then incorporate a particular set of equity risk model factors to suit a particular fund management firm

SUMMARY & CONCLUSION

- Custom risk models can be built to reflect any reasonably well-defined investment process, and such a model will be able to identify clearly, and quantify, the bets the manager knows are being made in the portfolio
- **It is hard to manage risk if you can't quantify it!**
- Some years ago at QUANTEC, we developed the first Global Risk Model, and I once spent 25 minutes over lunch telling Jack Treynor about all the difficulties we had encountered, and all the clever ways in which we had solved them; then I sat back, feeling pleased with myself, and asked him what he thought
- He was quiet for a few minutes, and then said "Well, it's just another way of parsing the covariance matrix", and, as usual, he was right
- There is no single right answer; what really matters is that the risk model is useful to the fund manager

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USEFUL REFERENCES

- Northfield website
  - Numerous papers and articles
- Understanding Factor Models
  - Scowcroft & Sefton, UBS, January 2006
- The Structure of Risk Models
  - Jason MacQueen, Northfield