Equity Risk Modeling: Innovations in Methods and Best Practices

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Northfield Information Services, Inc.

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Topics for Today

- Motivation for Changes
  - Best practices approach
  - Market phenomena in the 1990s
- Nature of Current Changes
  - Hybrid factor structure
  - New way of defining value/growth
  - Including Option Implied Volatility
  - Conditional mean variance estimation
  - Parkinson Volatility
  - Exponential Weighting
- Testing and validation procedures

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Motivation for Changes

- Best practices approach
  - Northfield produces more than a dozen risk models for different markets. Four distinct models for US equities alone
  - Each model was designed for different investors
    - Long term or Short Term time horizon
    - Concentrated or diverse portfolios
    - Maximize accuracy for absolute risk or relative risk prediction
- We've tried to take the best features of each model, and propagate that procedure through all models

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Additional Motivation

- Equity markets during the late 1990s had some unique features
  - Hugely important new factors such as the Internet effect, and the massive corporate restructuring in Japan arose rapidly, creating the need for adaptive factor structures to manage risk
  - Cross-section volatility of large cap stock returns peaked at three times historic average levels in some markets (such as the US), and has now declined to below long-term norms

Summary of the Model Changes

	US Fundamental	US Macroeconomic	Single Market	Global/Everything Everywhere
Parkinson Volatility	Already There	Yes	Yes	Yes
Factor Variance Calculation	Yes	Yes	Yes	Yes
Exponential Weighting Factor Covariance	Yes	Yes	Yes	Yes
Redefined Growth/Value Yield Factor	NA	NA	Yes	Yes
Hybrid “Blind Factors in Residual”	No	No	Already There	Yes
Reinsert Dead Currencies	No	No	Yes (2)	Yes
New Countries Added	NA	NA	Yes (2)	Yes
Credit Risk Premium Factor Calculation	NA	Yes	NA	NA
Improved Industry Assignments	Yes	Yes (1)	No	No
Price Volatility Factor Calculation	Changed	NA	NA	NA
Narrow Estimation Universe	Already There	NA	Yes (3)	Yes
Fixed Income Factor Units	NA	NA	NA	Yes

(1) The Macroeconomic Model uses industry classifications only as descriptive data
(2) European Model only
(3) US Single Country Model only

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Parkinson Volatility

- Alternative estimator of stock volatility based on the range between highest and lowest prices during an observation period. Volatile stocks should have a big range, low volatility stocks a small range

- Portfolio theory assumes that returns are normally distributed random walks. If there is no kurtosis, skew, or serial correlation you get the same estimate of volatility from this method, as the standard deviation of returns. If these conditions are present the values will differ

- We use the “hi-lo” volatility to adjust the asset specific risk of a stock upward if the traditional and Parkinson measures do not agree

Conditional Factor Variance Estimation

- Market efficiency theory would suggest that mean alphas (returns net of market risk) to a particular factor should be close to zero over long time periods.
- In a bubble or trending market, a particular factor may exhibit a high mean return, with low variance around the mean for a substantial period of time. Internet stocks went straight up (for the first 20 months or so).
- We adjust for this failure of our assumptions by assuming that the mean factor return is zero, and computing second moments (variance) from zero, rather than sample mean.
- For typical factor return time series with means near zero, this doesn't do anything.
- For factors like the Internet effect, it increases the estimated risk as compared to the conventional variance computation

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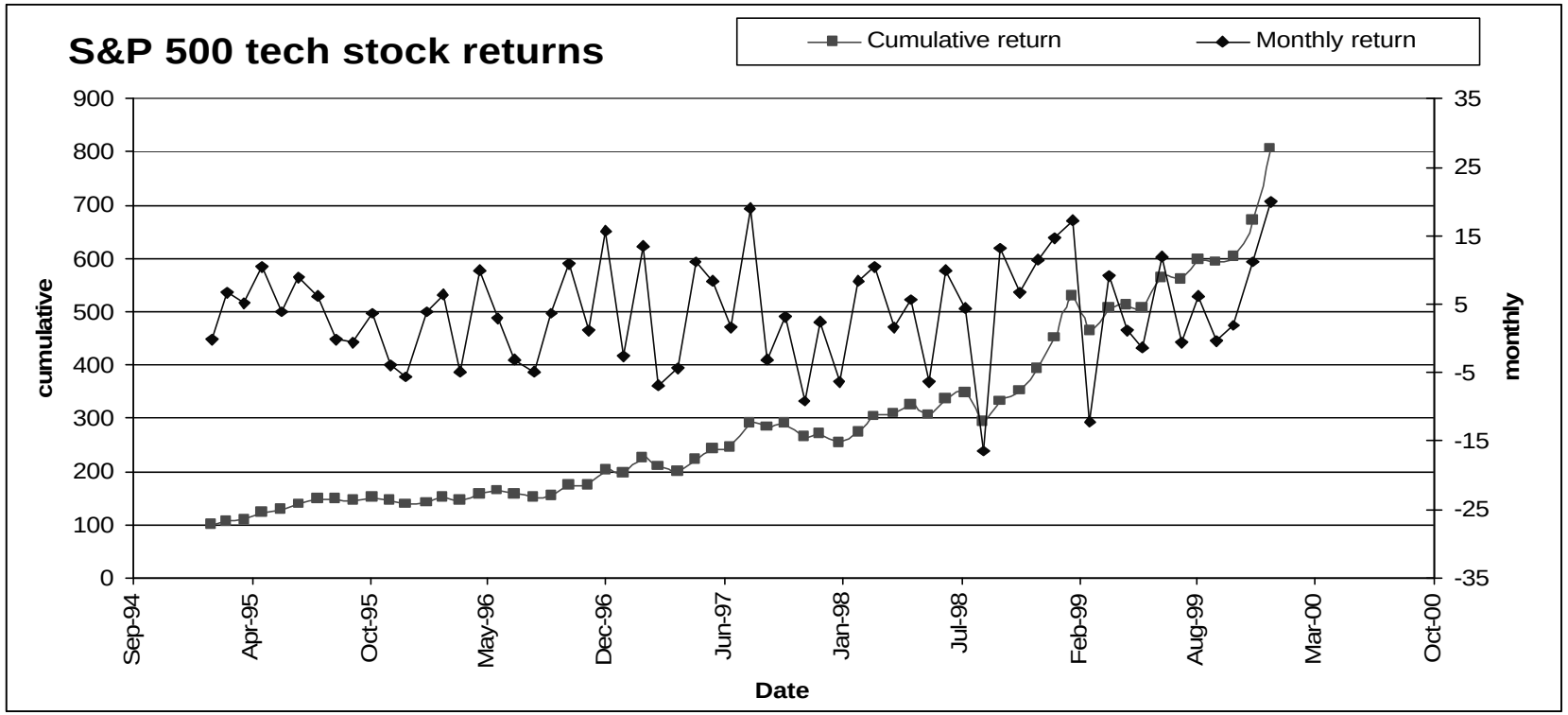
S&P 500 Tech Stock Returns

Variance = 700%^{2}, Conditional Variance 876%^{2}



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Exponential Weighting of the Factor Covariance Matrix

- Northfield normally uses a rolling 60 month estimation period. We are now using exponential weighting to put more emphasis on more recent, fresher data
- The usual e^{-nr} computation is used. The extent of the weighting is defined in units of “half-life”. How many periods do we have to go back in time such that this data point counts only half as much as the most recent
- The effect is every slight in developed markets such as US, UK, and Japan. Half-life = 35 months
- Effect is quite rapid in emerging markets such as People Republic of China. Half-life = 17 months
- Captures trends in risk levels

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Defining Value/Momentum in a New Way

"Price-sensitive active management strategies can be replicated by option payoffs"

Jarrod Wilcox, *Better Risk Management*, JPM, 2000

- Value approaches are often referred to among hedge funds and trading desks as "convergence strategies" as they depend on the convergence between the market price and a manager's definition of the fair price of some security. The greater the noise in the market environment, the more obfuscation and impediments to the convergence process.

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Momentum and Volatility

- Momentum strategies: buy stocks on price strength and sell on price weakness. This is similar to a Constant Proportion Portfolio Insurance (Black and Perold, 1992) applied to the cross-section of stock returns.

- CPPI mimics being long a put option on the underlying asset (plus a long position in the underlying). Option buyers are advantaged when realized volatility is greater than the volatility expected when the option was established

- If momentum strategies are comparable to being long an option, then anti-momentum strategies (value?) must be comparable to being short an option, so low volatility conditions would be most favorable

Defining Volatility as the Basis of Style

- We could just take the cross-sectional dispersion of securities in a particular market on a period by period basis
- Beta differences will cause cross-sectional dispersion in volatile (market index across time) conditions
- So let us define our dispersion measure as the cross-sectional standard deviation of alpha (residual returns, net of beta effect)
- Or think of it as the “excess standard deviation” (standard deviation of stock returns) minus (the product of the absolute value of the observed market risk premium times the cross-sectional dispersion of the beta values)
- diBartolomeo (2000) relates periods of high cross-sectional dispersion to positive serial correlation in stock returns (I.e. momentum strategies working)

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A Mathematical Treatment of Dispersion and Correlation

- Lilo, Mantegna, Bouchard and Potters[1] use the term “Variety” to describe cross-sectional dispersion of stock returns

- They call our measure “idiosyncratic variety” (noted as v(t))

- They find that the average correlation between stocks is approximately:

  $C(t) = 1 / [1 + (v^2(t)/r_m^2(t)]$

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Summing Up Value/Momentum

- Value strategies should work best in periods of low excess cross-sectional dispersion of stock returns. Another way to characterize this is periods when correlations among securities is highest
- Momentum/growth strategies should work best in periods of high excess cross-sectional dispersion as they are like being long an option.
- Strongin, Petsch, Segal and Sharenow (2002) find value strategies work best when confined within sector (small cross-sectional dispersion), while growth strategies work best with no sector constraints (high dispersion)
- Solnik and Roulet (2000) examine the dispersion of country returns as a way of estimating correlations between markets

Hybrid Factor Structure
Dealing with Omitted Factors

- When we select which factors to include in a risk model, we choose in order to best describe security behaviors over a particular sample period.
  - As time passes conditions change. Our specified factor structure will fit the new conditions well in some periods, and less well in others.
  - The loss of efficiency in the model as conditions change is called “omitted variable bias”
- The solution to omitted variable bias to is add temporary factors to the model to measure new pervasive forces in the market
  - Compute the principal components of the residual return covariance matrix
  - Keep principal components with statistically significant eigenvalues as temporary factors

Hybrid Factor Structure

- Temporary factors allow the model to adjust automatically to new forces in the market
  - Internet effect in the US
  - Allows the model to capture risks that would otherwise be hard to measure, such as the current corporate restructuring process in Japan. Hard to get reliable statistics on layoffs and plant closings

- Model can now make a correct discrimination between common factor risks and asset specific risks. The model is “complete” by construction.
  - Asset specific risks are presumed to be uncorrelated. They diversify away as the number of portfolio assets increases.
  - But owning 20, 200, or 2000 low P/E stocks doesn’t diversify away a value bet
  - Critical to understanding where portfolio “bets” really are

Other Current Changes

- We've put back "dead" currencies (e.g. the Deutsche Mark) into the Global model to allow for attribution runs and back-testing into the past periods when those currencies existed
- Twenty additional emerging markets have been added to the Global model
- We've refined our industry classifications
  - Particularly in the US
  - FTSE/Dow Jones Global Sector Classifications will be included soon for all models
- Low liquidity, small-cap stocks are excluded from estimation universes, improving model accuracy
  - All stocks are still covered, even those not used for estimation

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How Do We Know the New Models are Better?

- We created over 10,000 sample portfolios going back to 1989
  - Randomly picked stocks, random numbers of stocks
  - Cap weighted, Equal Weighted, Halfway
- Forecast tracking error and absolute volatility over the upcoming year
  - Observe the portfolios out of sample for the next year, rebalancing monthly back to original weights
- Analyze results
  - Cross-sectional discriminating power at a moment in time. Are the high risk (forecast) portfolios really coming out to be the high risk portfolios?
  - Bias. On average, are we too high or too low in estimating risk
  - Consistency over time. Do results bounce around?

Some Test Results for Our Global Model

Global									
Existing					Enhanced				
	Correlation		Bias			Correlation		Bias	
	13 yr	5yr	13 yr	5yr		13 yr	5yr	13 yr	5yr
Tracking Error	0.65	0.68	1.05	1.02	Tracking Error	0.73	0.73	1.11	1.03
Portfolio	0.49	0.44	1.2	0.9	Portfolio	0.55	0.45	1.15	0.96

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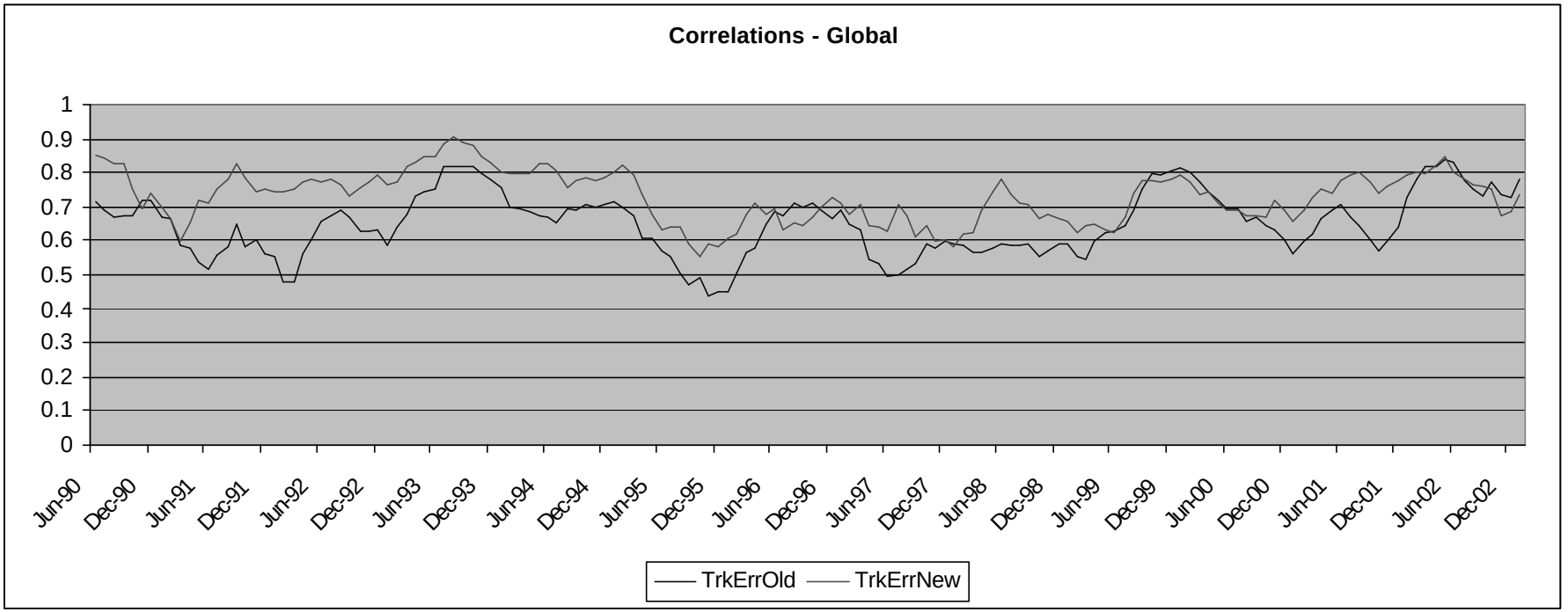
Global Model Test

Time Series Display



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Bias in Test Results

- Upward bias in the test results is desirable
  - If conditions were constant, one would expect that volatility realizations in the future will be comparable to the volatility realizations seen during the sample period. In the real world conditions are not constant. The total uncertainty of future portfolio performance has to include both our expectation of portfolio risk, plus a (positive) cushion to reflect our uncertainty about the future.
  - Underestimating risk is more problematic for the asset management business than if we overestimate risk. Remember Pascal's conjecture?
  - Our tests are formed by picking stocks randomly. Managers do not pick securities randomly, but rather with specific strategies in mind. Portfolios will have much more specifically concentrated risks
  - Different amounts of bias are desirable in different countries. Countries with the most transparent markets have the most asset specific risk and ought have the most concentrated portfolios. Morck, Yeung and Yu (2000), Li and Myers (2004)

Benchmark Tuned Models

- In a few months, Northfield has introduced new versions of many of its models that are specifically “tuned” for use with FTSE benchmark indices
- Estimation universes are based on FTSE index constituents
- Sector classification based on the new FTSE/Dow Jones Global sector classifications
- Using FactSet you can already report risk decomposition based on the FTSE/DJ sector classifications

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Upcoming Further Enhancements

- A kurtosis adjustment will be added to the factor variances
  - Based on “extreme value” theory for a mixture of normal distributions
- Volatility change information derived from option implied volatility will be incorporated in a short-term version of the Global model
  - These techniques already used in the US Short Term model
  - Allows for the short-horizon risk estimates needed to forecast the market impact portion of transaction costs
  - See diBartolomeo and Warrick (2002)

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Conclusions

- The specification and estimation of equity risk models has evolved
- Mechanisms have now been put in place to deal with major imperfections in classical assumptions
  - Omitted variable bias
  - Higher moments such as skew and kurtosis in return distributions
  - Serial correlation in factor and security returns
- Risk models are very effective, and getting better

References

- Parkinson, Michael. “The Extreme Value Method For Estimating the Variance of The Rate of Return.” *Journal of Business*; 1980; v 53(1); 61-66.

- diBartolomeo, Dan. “Getting an Early Jump on Market Anomalies: Lessons From the Internet Stock Phenomena”, Northfield Working Paper, 1999, http://www.northinfo.com/documents/65.pdf

- Wilcox, Jarrod. “Better Risk Management”, Journal of Portfolio Management, Summer 2000

- Knez, Peter J. and Mark J. Ready. "On The Robustness Of Size And Book-To-Market In Cross-Sectional Regressions," Journal of Finance, 1997, v52(4,Sep), 1355-1382.

- Jin, Li and Stewart Myers. "R-Squared Around the World: New Theory and New Tests", Harvard/MIT Working Paper, February 2004.

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References

- Black, Fischer and Andre F. Perold. "Theory Of Constant Proportion Portfolio Insurance," Journal of Economic Dynamics and Control, 1992, v16(3/4), 403-426.

- Solnik, Bruno and Jacques Roulet. "Dispersion As Cross-Sectional Correlation," Financial Analyst Journal, 2000, v56(1,Jan/Feb), 54-61

- Petsch, Melanie, Steve Strongin, Lewis Segal and Greg Sharenow. “A Stockpicker’s Reality Part III: Sector Strategies for Maximizing Returns to Stockpicking”, Goldman Sachs Research, January 2002

- Derman, Emanuel, “The perception of time, risk and return during periods of speculation,” Quantitative Finance 2(4), August 2002, pp. 282-296

References

- Morck, Randall, Bernard Yeung and Wayne Yu. "The Information Content Of Stock Markets: Why Do Emerging Markets Have Synchronous Stock Price Movements?," Journal of Financial Economics, 2000, v58(1-2,Jan), 215-260.

- diBartolomeo,Dan. “Recent Variation in the Risk Level of US Equity Securities”. Northfield Working Paper 2000. http://www.northinfo.com/documents/67.pdf

- Lilo, Fabrizio, Rosario Mantegna, Jean-Philippe Bouchard and Marc Potters. “Introducing Variety in Risk Management”, WILMOTT December 2002

- diBartolomeo, Dan and Sandy Warrick. “Making Covariance-Based Portfolio Risk Models Responsive to the Rate at which Markets Reflect New Information”, *Linear Factor Models in Finance* (Editors J. Knight and S. Satchell), Chapter 12, Butterworth-Heineman, Oxford, 2005