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Long-term Extremes of South African Financial and Economic Variables

Daniel Shapiro

University of the Witwatersrand

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Background

- Uncertain outcomes of financial and economic variables affect assets and liabilities
- Extreme outcomes unlikely but can have large adverse impacts
- Aim of investigation:
  - What does historical data suggest?
  - What commonly used models are suitable for long-term extremes?

Long term extremes in Applications

- Capital modelling
- Options and guarantees Asset allocation
- Pension funding levels
- Corporate risk management
- Insurance regulations- Solvency II, SAM

Context of the research

- Extreme outcomes measured using VaR
- Annual time horizon used
- Context in integrated models of assets and liabilities

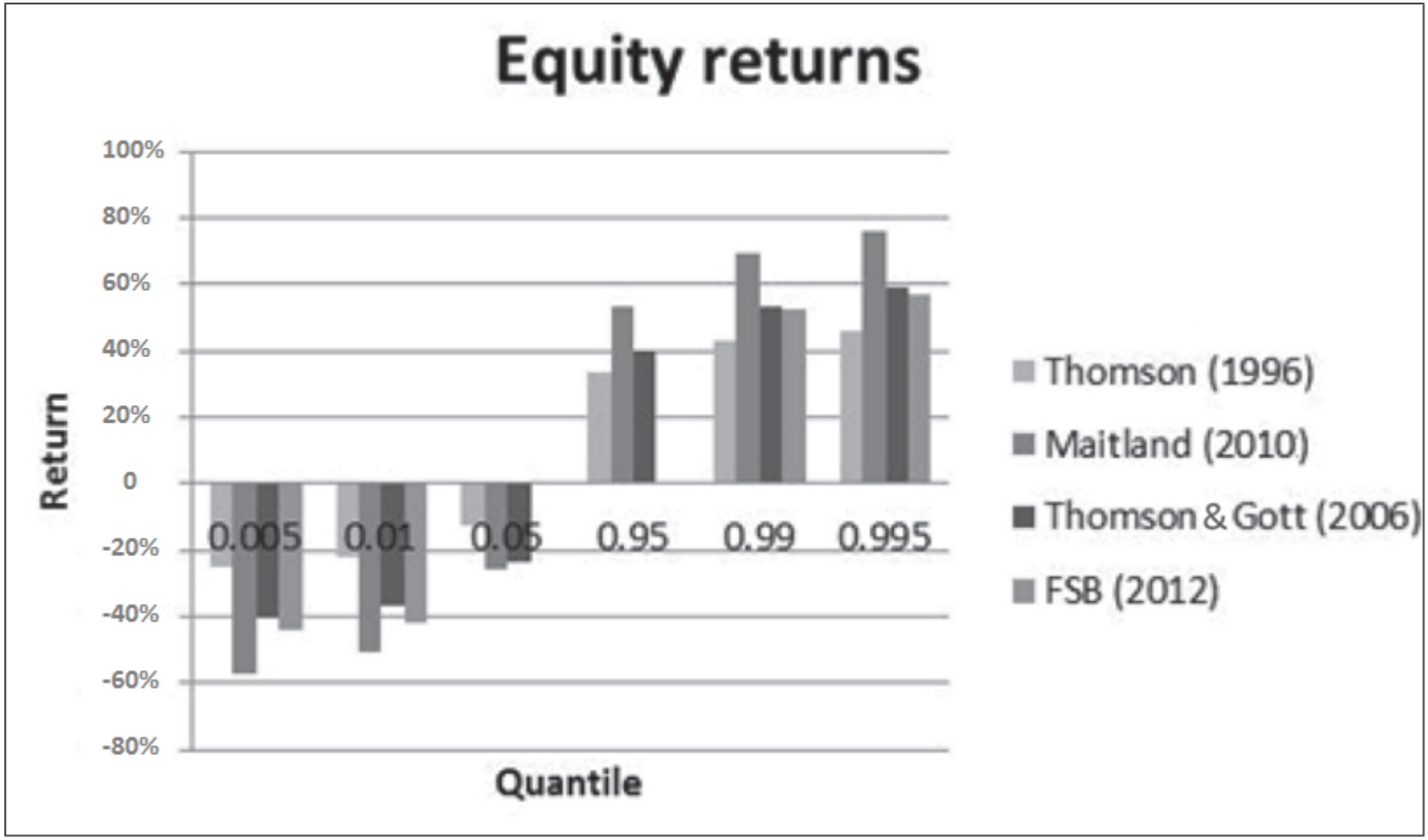
Literature of extremes

- Returns distributions exhibit high peaks and fat tails
- Much analysis of short-term extremes
- Analysis of long-term extremes much more scanty

Long-term extremes

- Work of the Benchmarking Stochastic Models Working Party
  - Moments of historical data
  - Quantiles of historical data
  - Confidence intervals by bootstrapping
  - Parametric distributions (prior distributions assumed)
  - Limitations due to data
- Embrechts, Kaufmann and Patie (2005)
  - Used aggregation rules and backtesting
- Limited consideration in stochastic invesment models

South African equity returns



Data series used

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Monthly data sources

	1960–2011	1925–1960
Equities	1995–2011: JSE Total return index	Firer and McLeod (1999)
	1960–1995: JSE All share index with dividends allocated evenly over the year	
Inflation	CPI	1940–1960: Firer and McLeod (1999)
Short-term interest rates	1960–1986: 0-year bond yield	–
	1986–2011: Alexander Forbes Money-Market Index	
Long-term interest rates	1970–2011: 20-year bond yield	–

Annual data sources

	1960–2011	1900–1960
Equities	1995–2011: JSE Total return index	Firer and Staunton (2002)
	1960–1995: JSE All share index with dividends allocated evenly over the year	
Inflation	CPI	Firer and Staunton (2002)
Short-term interest rates	1960–1986: 0-year bond yield	Firer and Staunton (2002)
	1986–2011: Alexander Forbes Money-Market Index	
Long-term interest rates	20-year bond yield	1925–1960: Firer and McLeod (1999), derived from monthly yields

Data series modelled

- Equities modelled as annual returns
- Interest and inflation rates modelled as annual changes
- Moments of data
  - Mean , variance
  - Skewness
  - Kurtosis

Empirical estimates of extremes

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	0.005		0.01		0.05	
	1900–2011	1960–2011	1900–2011	1960–2011	1900–2011	1960–2011
Equities	–42.1%	–46.0%	–34.8%	–41.5%	–24.9%	–28.1%
Short-term interest rates	–7.4%	–9.0%	–5.0%	–7.7%	–3.2%	–3.8%
Long-term interest rates	–2.3%	2.5%	–2.0%	2.5%	–1.7%	2.5%
Inflation	–22.0%	–11.1%	–12.4%	–11.1%	–6.8%	–11.1%

	0.995		0.99		0.95	
	1900–2011	1960–2011	1900–2011	1960–2011	1900–2011	1960–2011
Equities	63.7%	53.0%	54.8%	50.2%	39.1%	40.7%
Short-term interest rates	6.7%	7.0%	6.1%	6.8%	2.9%	4.2%
Long-term interest rates	3.8%	3.9%	5.4%	3.7%	1.3%	2.5%
Inflation	13.6%	6.4%	13.0%	6.1%	5.6%	6.1%

Uncertainty

- Wide confidence intervals for equities, especially for high quantiles
- Negative changes in interest rates wider than positive
- Considerably less uncertainty for changes in long-term rates than short
- Wide confidence intervals for inflation
- Some variation in results over different periods

Parametric modelling

- Backtesting employed to evaluate modelling of extremes
- Range of models considered
  - Random Walk
  - AR(p)
  - GARCH
  - Extreme Value Theory
- Lack of data overcome using scaling rules

Results

- GARCH model parameters violate stationarity condition
- Best fitting models:
  - Equities: Random Walk
  - Short-term rates: Random Walk and AR
  - Long-term rates: Same as short-term rates
  - Inflation: Random Walk
- Significance tests
  - Few significant results for equities and negative short-term interest rates and inflation
- Results robust to periods and quantiles

Limitations and further work

- Stationary assumption
- Use of expected shortfall
- Measuring uncertainty of parametric models
- Dependence between extremes

Implications

- Non-parametric results can be used as ex-post estimates
- Mixed success of parametric modelling suggests further research needed…
- …but lack of data
- Implications for validation of ALM models
- Given the materiality of extremes caution needed
- Other methods such as expert judgement and deterministic scenarios may be useful

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THANK YOU EXTREMELY