Risk Management and Extreme Scenario Development using Multiple Regime Switching Approaches

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Business Studies
in
Finance

at Massey University, Palmerston North
New Zealand

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2004

ACKNOWLEDGEMENTS

First and most importantly, I wish to express my deepest and most sincere gratitude to my supervisor, Dr. John Dalle Molle for his generous help, constant encouragement, patience and guidance throughout this thesis. I wish to thank him for introducing me to the world of Extreme Value Theory and Regime Switching Models. He shared with his extensive knowledge on risk management but also in areas like mathematical finance, simulations and programming and without him this thesis would not been possible.

I wish to thank Massey University for using the computing, printing facilities, and also providing access to DATASTREAM for retrieving financial data maintained by them.

Lastly, I would like to thank my family and friends for their constant support and encouragement in completing this report.

Abstract

Over the last twenty-five years, there have been an increasingly large number of extreme events in the financial markets. This includes market crashes and natural disasters that have led to extremely large losses and claims. Extreme event risk affects all aspects of risk assessment modeling and management. Traditional risk measurement methods focus on probability of laws governing average of sums, and do not focus on the tails of distribution. The investigation concerns the characterization and development of extreme markets scenarios for use in risk measurement and capital adequacy determination frameworks. The first part of the investigation concerns the development of event timelines that can be used for characterizing whether a period of time should be considered normal or extreme market conditions or regimes. The time lines have allowed the identification of the different times when the markets were calm and when the markets were turbulent. They assist in building scenarios, and also to identify the scenarios for decomposition of data to model the different regions, either the tail or the center of the distribution using the mentioned regime switching models. The information from the event time line can be used to define scenarios in a stress testing context.

In this investigation, extreme value analysis, which is an extension of the standard VaR techniques, useful in measuring extreme events has been used, which fits density functions by placing more weights in the tails than the normal Gaussian distribution and model the upper and lower tail of an underlying distribution. Extreme value distribution functions including "*fat tailed*" will be fitted to the tails of critical market factors to model the extreme market events that are not given appropriate probability of occurrence under normal conditions. The Hill estimator, which is recognized as the consistent estimator for empirical analysis is used for calculating the tail index parameter for EVT modeling, However, it has to be noted that the Hill estimator is efficient when the underlying distribution is fat-tailed as compared to the gaussian, where the tail index estimates tend to go to infinity. The

performance of Extreme value theory estimation technique with multiple regimes on real and simulated financial time series for efficient results, compared to the standard VaR techniques has been studied.

In this investigation, multiple regime switching approach has been used to identify regimes and measure risk accordingly. It is assumed that the center of the returns distribution is normally distributed with 90 percent of the data in the in the center region and each tail contains 5 percent of the data. Three regime switching models have been used in this analysis which includes, the Unconditional LT-C-RT (Left tail – Center – Right Tail) transfers, the 3 State Regime Markov Transition Model and the Geometric Time in Trail Model. The regime switching models are modeled using the following procedures:

1) The Unconditional LT-C-RT (Left Tail – Center – Right Tail) model is an IID model (Independent and Identically Distributed) model and has a simple Bernoulli approach where the market is in a normal state with probability P or an abnormal state with probability $1-p$. The transition between states is independent of the last state.

2) A Markov chain approach where the next state of the market is a function of the current state. That there are the following transitions possible:

2.1) Normal to normal
2.2) Normal to abnormal
2.3) Abnormal to abnormal
2.4) Abnormal to normal

3). The Geometric Time in Tail model is a hybrid Bernoulli approach where the markets stays in a given state based on a duration model and when the duration in a given states has expired, the sampling of the next state using a independent Bernoulli approach similar to approach one. This implies that the after the market has stayed in a given regime for the sample duration time, it can stay in the current regime with probability p or leave the regime with probability $1-p$. The sample

duration can be based on the exponential distribution for continuous time and the geometric distribution for discrete time such as daily movements.

Tail index estimation results using EVT indicate the presence of fat tails in equity data and the results of Value-at-Risk (VaR) and Expected Shortfall (ES) are considerably similar for the three regime switching models. The comparison of results from the multiple regime switching models to the one region distribution results, which serve as the base case prove the efficiency of using this approach for a better risk measure.

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