Jumps, Realized volatility and Value-at-Risk

Shuai Yang

Submitted by Shuai Yang to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Finance in May 2012.

This thesis is available for library use on the understanding that it is copyright material and that no quotation from this thesis may be published without proper acknowledgement.

I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature: .................. ........................
Acknowledgements

I would like to express my deepest appreciation to my supervisor, Professor Richard D. F. Harris, who is my role model for being a good scholar. Without his solid support, precious advice, and untiring patience, this thesis could not have been completed.

I dedicate this thesis to my wife, Zimo Zhou, and my parents. Without their continuous encouragement and strong beliefs, I could not have dreamed of pursuing the PhD in UK.
Abstract

This thesis consists of three research topics, which together study the related topics of volatility jumps, modeling volatility and forecasting Value-at-Risk (VaR).

The first topic focuses on volatility jumps based on two recently developed jumps detection methods and empirically studied six markets and the distributional features, size and intensity of jumps and cojumps. The results indicate that foreign exchange markets have higher jump intensities, while equity markets have a larger jump size. I find that index and stock markets have more interdependent cojumps across markets. I also find two recently proposed jump detection methods deliver contradictory results of jump and cojump properties. The jump detection technique based on realized outlyingness weighted variation (ROWV) delivers higher jump intensities in foreign exchange markets, whereas the bi-power variation (BV) method produces higher jump intensities in equity markets. Moreover, jumps under the ROWV method display more serial correlations than the BV method. The ROWV method detects more cojumps and higher cojumps intensities than the BV method does, particularly in foreign exchange markets.

In the second topic, the Model Confidence Set test (MCS) is used. MCS selects superior models by power in forecasting ability. The candidate models set included 9 GARCH type models and 8 realized volatility models. The dataset is based on six markets spanning more than 10 years, avoiding the so-called data snooping problem. The dataset is extended by including recent financial crisis periods. The advantage of the MCS test is that it can compare models in a group,
not only in a pair. Two loss functions that are robust to noise in volatility proxy were also implemented and the empirical results indicated that the traditional GARCH models were outperformed by realized volatility models when using intraday data. The MCS test based on MSE selected asymmetric ARFIMA models and the HAR mode as the most predictive, while the asymmetric QLike loss function revealed the leveraged HAR and leveraged HAR-CJ model based on bi-power variation as the highest performers. Moreover, results from the subsamples indicate that the asymmetric ARFIMA model performs best over turbulent periods.

The third topic focuses on evaluating a broad band of VaR forecasts. Different VaR models were compared across six markets, five volatility models, four distributions and 8 quantiles, resulting in 960 specifications. The MCS test based on regulatory favored asymmetric loss function was applied and the empirical results indicate that the proposed asymmetric ARFIMA and leveraged HAR models, coupled with generalized extreme value distribution (GEV) or generalized Pareto distribution (GPD), have the superior predictive ability on both long and short positions. The filtered extreme value methods were found to handle not only extreme quantiles but also regular ones.

The analysis conducted in this thesis is intended to aid risk management, and subsequently reduce the probability of financial distress in the sector.
# Table of Contents

Chapter 1: Introduction ........................................................................................................... 17

1.1 Thesis overview and relations of research topics ......................................................... 17

1.2 Jumps and Cojumps in realized volatility ..................................................................... 18

1.2.1 Development of jumps detection techniques ......................................................... 18

1.2.2 Motivations and contributions ................................................................................. 20

1.3 Evaluating the forecasting ability of volatility models .................................................. 22

1.3.1 Development of volatility models ........................................................................... 22

1.3.2 Motivations and contributions ................................................................................. 25

1.4 Evaluating Value-at-Risk models .................................................................................. 27

1.4.1 Development of VaR models .................................................................................. 27

1.4.2 Motivations and contributions ................................................................................. 30

1.5 Synopsis of thesis .......................................................................................................... 32

Chapter 2: Data descriptions .............................................................................................. 35

2.1 Introduction .................................................................................................................... 35

2.2 Daily returns computed from intraday data ................................................................. 37

2.3 Realized volatility and its stylized facts ........................................................................ 40

2.4 Summary of data description ....................................................................................... 43

Chapter 3: Jumps And Cojumps In Realized Volatility ...................................................... 60

3.1 Introduction .................................................................................................................... 60

3.2 Literature review .......................................................................................................... 63

3.2.1 Basic bi-power variations ....................................................................................... 64

3.2.2 Modified bi-power variations .................................................................................. 66

3.2.3 Other integrated volatility variations ....................................................................... 67

3.3 Methodology ................................................................................................................ 69

3.3.1 Brownian Semi-Martingale with Jumps model ....................................................... 70
3.3.2 Bi-Power Variation.................................................................71
3.3.3 Realized outlyingness weighted variation..............................73
3.3.4 Daily jump tests......................................................................77
3.4 Empirical Results......................................................................80
  3.4.1 Realized jumps.......................................................................80
  3.4.2 Jumps dynamics.....................................................................82
  3.4.3 Cojumps................................................................................83
3.5 Summary...................................................................................85

Chapter 4: Evaluating The Forecast Ability Of Volatility Models........ 99
  4.1 Introduction..............................................................................99
  4.2 Literature Reviews...................................................................102
    4.2.1 Short memory models..............................................................102
    4.2.2 Long memory models..............................................................103
    4.2.3 Realized volatility models....................................................104
    4.2.4 Summary of literature review................................................106
  4.3 Methodology.............................................................................106
    4.3.1 GARCH family models...........................................................107
    4.3.2 ARFIMA models....................................................................113
    4.3.3 HAR family models.................................................................115
    4.3.4 Loss functions.......................................................................117
    4.3.5 Test of superior predictive ability..........................................118
    4.3.6 Model confidence set..............................................................120
  4.4 Empirical Results.....................................................................123
    4.4.1 In-sample Estimation results....................................................123
    4.4.2 Full sample comparisons.......................................................128
    4.4.3 Dot-com bubble burst and aftermath....................................133
    4.4.4 Calm markets.......................................................................136
Chapter 5: Evaluating Value-at-Risk models .............................................. 183

5.1 Introduction ....................................................................................... 183
  5.1.1 Concepts of Value-at-Risk (VaR) ................................................. 183
  5.1.2 History of VaR .............................................................................. 184
  5.1.3 Early VaR models ......................................................................... 184
  5.1.4 Filtered VaR models ..................................................................... 187
  5.1.5 Extreme Value models ................................................................. 188
  5.1.6 Realized volatility models ............................................................. 189
  5.1.7 Contributions and chapter organization ....................................... 190

5.2 Literature review ............................................................................. 192
  5.2.1 Elementary VaR models ................................................................. 192
  5.2.2 Filtered VaR models ..................................................................... 194
  5.2.3 Extreme value models (EVT) ........................................................ 197
  5.2.4 Realized volatility models ............................................................. 201

5.3 Methodology .................................................................................. 203
  5.3.1 Value-at-Risk .............................................................................. 203
  5.3.2 Conventional Distributions of innovations ................................... 205
  5.3.3 Generalized Pareto distribution ..................................................... 207
  5.3.4 Generalized Extreme Value distribution ....................................... 211
  5.3.5 Kupiec LR test .............................................................................. 214
  5.3.6 Dynamic Quantile test ................................................................. 216
  5.3.7 Evaluating VaR forecasts .............................................................. 217

5.4 Empirical results ........................................................................... 218
  5.4.1 In-sample estimation of GPD and GEV ....................................... 218