Modelling the Interactions Across International Stock,
Bond and Foreign Exchange Markets

Abdul Hakim, MEc. (UWA)

This thesis is presented for the degree of Doctor of
Philosophy of The University of Western Australia

UWA Business School
The University of Western Australia

2009

Abstract

Given the theoretical and historical evidence that support the benefit of investing internationally, there is little knowledge available of proper international portfolio construction in terms of how much should be invested in foreign countries, which countries should be targeted, and types of assets to be included in the portfolio. The prospects of these benefits depend on the market volatilities, cross-country correlations, and currency risks to change in the future. Another important issue in international portfolio diversification is the growth of newly emerging markets which have different characteristics from the developed ones. Addressing the issues, the thesis intends to investigate the nature of volatility, conditional correlations, and the impact of currency risks in international portfolio, both in developed and emerging markets.

Chapter 2 provides literature review on volatility spillovers, conditional correlations, and forecasting both VaR and conditional correlations using GARCH-type models. Attention is made on the estimated models, type of assets, regions of markets, and tests of forecasts.

Chapter 3 investigates the nature of volatility spillovers across international assets, which is important in determining the nature of portfolio's volatility when most assets are seems to be connected. The VARMA-AGARCH model of McAleer, Hoti and Chan (2008) is estimated since the model is parsimonious compared to the currently available models, yet also incorporates both possible volatility spillovers and asymmetric effect of negative and positive shocks on conditional variance.

Chapter 4 investigates the nature of conditional correlations to evaluate risk when the covariance matrix is decomposed into the conditional variance of each asset and their conditional correlations. This approach is important when interactions and time-varying conditional correlations across assets in the portfolio are evident.

Chapter 4 conducts conditional correlations forecast across financial assets using a rolling window approach based on various multivariate GARCH models assuming constant conditional correlations. This will provide information about the nature of dynamic conditional correlations across financial assets. The forecast is important in financial practices such as hedging activity and policy decision making by central bank that uses exchange rates mainly as an indicator for future inflationary risk, among others.

The impacts of incorporating volatility spillovers and asymmetric effect on the forecast performance of conditional correlation will also be examined in this thesis. The VARMA-AGARCH of McAleer, Hoti and Chan (2008) and the VARMA-GARCH model of Ling and McAleer (2003) will be estimated to accommodate volatility spillovers and asymmetric effect. The CCC model of Bollerslev (1990) will also be estimated as benchmark as the model does not incorporate both volatility spillovers and asymmetric effects.

Given the information about the nature of conditional correlations resulted from the forecasts using a rolling window technique, Section 2 of Chapter 4 investigates the nature of conditional correlations by estimating two multivariate GARCH models allowing for time-varying conditional correlations, namely the DCC model of Engle (2002) and the GARCC model of McAleer et al. (2008).

Chapter 5 conducts VaR forecast considering the important role of VaR as a standard tool for risk management. Especially, the chapter investigates whether volatility spillovers and time-varying conditional correlations discussed in the previous two chapters are of helps in providing better VaR forecasts. The BEKK model of Engle and Kroner (1995) and the DCC model of Engle (2002) will be estimated to incorporate volatility spillovers and conditional correlations, respectively. The DVEC model of Bollerslev et al. (1998) and the CCC model of Bollerslev (1990) will be estimated to

serve benchmarks, as both models do not incorporate both volatility spillovers and time-varying conditional correlations.

Chapter 6 concludes the thesis and lists some possible future research.

Table of Contents

Abstract	ii
Table of Contents	v
List of Tables	viii
List of Figures	xviii
Acknowledgments	xxix
Chapter 1: Introduction	1
 Chapter 2: Methodology and Literature Review	 16
2.1. Methodology and Review of GARCH Family Models	16
2.1.1. Univariate GARCH Models and Their Properties	16
2.1.2. Multivariate GARCH Models with Constant Conditional Correlations and Their Properties	18
2.1.3. Multivariate GARCH Models with Dynamic Conditional Correlations and Their Properties	22
2.1.4. Tests for Value-at-Risk Forecasts Evaluation	25
 2.2. Literature Review on Interactions Across Stock, Bond and Foreign Exchange in the Empirical Finance Literature	 27
2.2.1. Literature Review on Returns and Volatility Spillovers Across Stock, Bond and Foreign Exchange	27
2.2.2. Literature Review on Forecasting Conditional Correlations in Stock, Bond and Foreign Exchange	33
2.2.3. Literature Review on Dynamic Conditional Correlations Across Stock, Bond and Foreign Exchange	38
2.2.4. Forecasting Portfolio Value-at-Risk Consists of Stock, Bond and Foreign Exchange	45
 Chapter 3: Interactions Across International Stock, Bond and Foreign Exchange Markets	 58
3.1. Interactions Across Developed Markets	58
3.2. Interactions Across Emerging and Developed Markets	72

3.3. Economic Significance	87
Appendix 3-1 Tables 3-21-A to 3-30-B	91
Appendix 3-2 Tables 3-31-A to 3-45-B	102
Appendix 3-3 Figures 3-1 to 3-20	118
Appendix 3-4 Figures 3-21 to 3-47	121

Chapter 4: Dynamic Conditional Correlations Across International

Stock, Bond and Foreign Exchange Markets:

Estimation and Forecasts	125
4.1. Forecasting Conditional Correlations in	
Stock, Bond and Foreign Exchange Markets	126
4.1.1. Conditional Correlations Forecast in Developed Countries	126
4.1.2. Conditional Correlations Forecast	
in Emerging-Developed Countries	135
4.1.2.1. Analysis on Emerging-Emerging Countries	139
4.1.2.2. Analysis on Emerging-Developed Countries	145
4.2. Conditional Correlations Across International Stock,	
Bond and Foreign Exchange Markets	151
4.2.1. Conditional Correlations Across Developed Countries	151
4.2.2. Conditional Correlations in Emerging and	
Emerging-Developed Countries	160
4.3. Concluding Remarks	170
Appendix 4-1 Table 4-29-A to 4-30-F	171
Appendix 4-2 Table 4-31-A 4-32-F	180
Appendix 4-3 Figures 4-1 to 4-91	190
Appendix 4-4 Figures 4-92 to 4-217	202

Chapter 5: Forecasting Portfolio Value-at-Risk

for International Stocks, Bonds and Foreign Exchange	219
5.1. VaR Forecasts for Developed Markets	220
5.2. VaR Forecasts for Emerging-Developed Markets	227
5.3. VaR Forecasts and Dynamic Conditional Correlations	
of Spot and Futures Returns on Stocks and Bonds	238
Appendix 5-1 Tables 5-15-A to 5-19	248
Appendix 5-2 Tables 5-20-A to 5-24	274

Appendix 5-3 Tables 5-25-A to 5-28	314
Appendix 5-4 Graphs of VaR Forecasts for Developed Markets	321
Appendix 5-5: Graphs of VaR Forecasts for Emerging and Emerging and Emerging-Developed Markets	327
 Chapter 6: Conclusion	336
6.1. Summary and Conclusion	336
6.2. Future Research	342
 References	344

List of Tables

Table 3-1	: Summary of Variable Names, Developed Markets	59
Table 3-2	: Descriptive Statistic, Jarque-Bera and Its Probability for the Returns, Developed Markets	61
Table 3-3	: ADF Test of a Unit Root in the Returns, Developed Markets	62
Table 3-4	: Phillips-Perron Test of a Unit Root, Developed Markets	63
Table 3-5	: Univariate AR(1)-GARCH(1,1) Estimates, Developed Markets	65
Table 3-6	: Univariate AR(1)-GJR(1,1) Estimates, Developed Markets	66
Table 3-7	: Second Moment and Log Moment Conditions for the AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) Models, Developed Markets	67
Table 3-8	: Summary of Mean Spillovers and Their Signs, Developed Markets	69
Table 3-9	: Summary of Volatility Spillovers and Their Signs, Developed Markets	70
Table 3-10	: Summary of Variable Names, Emerging-Developed Markets	73
Table 3-11	: Descriptive Statistic, Jarque-Bera and Its Probability for the Returns, Emerging-Developed Markets	74
Table 3-12	: Unit Root Test, ADF, Emerging-Developed Markets	76
Table 3-13	: Unit Root Test, PP, Emerging-Developed Markets	77
Table 3-14	: Univariate AR(1)-GARCH(1,1) for the Returns, Emerging-Developed Markets	79
Table 3-15	: Univariate AR(1)-GJR(1,1) for the Returns, Emerging-Developed Markets	81
Table 3-16	: Second Moment and Log Moment Conditions for the AR(1)-GARCH(1,1) and AR(1)-GJR(1,1), Emerging-Developed Markets	82
Table 3-17	: Summary of Mean Spillovers Evidence and Their Signs, VARMA-AGARCH, Emerging-Developed Markets	83
Table 3-18	: Summary of Volatility Spillovers Evidence and Their Signs, VARMA-AGARCH, Emerging-Developed Markets	84
Table 3-19	: Volatility Spillovers, Analysis with Respect to Group of Markets, Developed Markets	87

Table 3-20	: Volatility Spillovers, Analysis with Respect to Group of Markets, Emerging-Developed Markets	88
Table 3-21-A	: VARMA-AGARCH, Cond. Mean for Australia-Japan	92
Table 3-21-B	: VARMA-AGARCH, Cond. Variance for Australia-Japan	92
Table 3-22-A	: VARMA-AGARCH, Cond. Mean for Australia-New Zealand	93
Table 3-22-B	: VARMA-AGARCH, Cond. Variance for Australia-New Zealand	93
Table 3-23-A	: VARMA-AGARCH, Cond. Mean for Australia-Singapore	94
Table 3-23-B	: VARMA-AGARCH, Cond. Variance for Australia-Singapore	94
Table 3-24-A	: VARMA-AGARCH, Cond. Mean for Australia-USA	95
Table 3-24-B	: VARMA-AGARCH, Cond. Variance for Australia-USA	95
Table 3-25-A	: VARMA-AGARCH, Cond. Mean for Japan-New Zealand	96
Table 3-25-B	: VARMA-AGARCH, Cond. Variance for Japan-New Zealand	96
Table 3-26-A	: VARMA-AGARCH, Cond. Mean for Japan-Singapore	97
Table 3-26-B	: VARMA-AGARCH, Cond. Variance for Japan-Singapore	97
Table 3-27-A	: VARMA-AGARCH, Cond. Mean for Japan-USA	98
Table 3-27-B	: VARMA-AGARCH, Cond. Variance for Japan-USA	98
Table 3-28-A	: VARMA-AGARCH, Cond. Mean for New Zealand-Singapore	99
Table 3-28-B	: VARMA-AGARCH, Cond. Variance for New Zealand-Singapore	99
Table 3-29-A	: VARMA-AGARCH, Cond. Mean for New Zealand-USA	100
Table 3-29-B	: VARMA-AGARCH, Cond. Variance for New Zealand-USA	100
Table 3-30-A	: VARMA-AGARCH, Cond. Mean for Singapore-USA	101
Table 3-30-B	: VARMA-AGARCH, Cond. Variance for Singapore-USA	101
Table 3-31-A	: VARMA-AGARCH, Cond. Mean for Indonesia-Japan	103
Table 3-31-B	: VARMA-AGARCH, Cond. Variance for Indonesia-Japan	103
Table 3-32-A	: VARMA-AGARCH, Cond. Mean for Indonesia-Malaysia	104
Table 3-32-B	: VARMA-AGARCH, Cond. Variance for Indonesia-Malaysia	104
Table 3-33-A	: VARMA-AGARCH, Cond. Mean for Indonesia-Philippines	105
Table 3-33-B	: VARMA-AGARCH, Cond. Variance for Indonesia-Philippines	105
Table 3-34-A	: VARMA-AGARCH, Cond. Mean for Indonesia-Thailand	106
Table 3-34-B	: VARMA-AGARCH, Cond. Variance for Indonesia-Thailand	106
Table 3-35-A	: VARMA-AGARCH, Cond. Mean for Indonesia-USA	107

Table 3-35-B	: VARMA-AGARCH, Cond. Variance for Indonesia-USA	107
Table 3-36-A	: VARMA-AGARCH, Cond. Mean for Japan-Malaysia	108
Table 3-36-B	: VARMA-AGARCH, Cond. Variance for Japan-Malaysia	108
Table 3-37-A	: VARMA-AGARCH, Cond. Mean for Japan-Philippines	109
Table 3-37-B	: VARMA-AGARCH, Cond. Variance for Japan-Philippines	109
Table 3-38-A	: VARMA-AGARCH, Cond. Mean for Japan-Thailand	110
Table 3-38-B	: VARMA-AGARCH, Cond. Variance for Japan-Thailand	110
Table 3-39-A	: VARMA-AGARCH, Cond. Mean for Japan-USA	111
Table 3-39-B	: VARMA-AGARCH, Cond. Variance for Japan-USA	111
Table 3-40-A	: VARMA-AGARCH, Cond. Mean for Malaysia-Philippines	112
Table 3-40-B	: VARMA-AGARCH, Cond. Variance for Malaysia-Philippines	112
Table 3-41-A	: VARMA-AGARCH, Cond. Mean for Malaysia-Thailand	113
Table 3-41-B	: VARMA-AGARCH, Cond. Variance for Malaysia-Thailand	113
Table 3-42-A	: VARMA-AGARCH, Cond. Mean for Malaysia-USA	114
Table 3-42-B	: VARMA-AGARCH, Cond. Variance for Malaysia-USA	114
Table 3-43-A	: VARMA-AGARCH, Cond. Mean for Philippines-Thailand	115
Table 3-43-B	: VARMA-AGARCH, Cond. Variance for Philippines-Thailand	115
Table 3-44-A	: VARMA-AGARCH, Cond. Mean for Philippines-USA	116
Table 3-44-B	: VARMA-AGARCH, Cond. Variance for Philippines-USA	116
Table 3-45-A	: VARMA-AGARCH, Cond. Mean for Thailand-USA	117
Table 3-45-B	: VARMA-AGARCH, Cond. Variance for Thailand-USA	117
Table 4-1	: Summary of Variable Names, Longer Data for Forecasting, Developed Markets	127
Table 4-2	: ADF Test of a Unit Root in the Returns, Longer Data for Forecasting, Developed Markets	128
Table 4-3	: Phillips-Perron Test of a Unit Root in Returns, Longer Data for Forecasting, Developed Markets	128
Table 4-4	: Summary of Trend in Correlations Forecasts, Developed Markets	130
Table 4-5	: Summary of Average Correlation Coefficient between Pairs of Assets, Developed Markets	130
Table 4-6-A	: Analysis of the Impact of Volatility Spillovers Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-AGARCH, Developed Markets	131
Table 4-6-B	: Analysis of the Impact of Volatility Spillovers Effect on the	

	Correlations between the Conditional Correlations forecast from CCC and VARMA-GARCH, Developed Markets	132
Table 4-6-C	: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA-AGARCH and VARMA-GARCH, Developed Markets	133
Table 4-6-D	: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA-AGARCH and CCC, Developed Markets	134
Table 4-7	: Summary of Variable Names, Longer Data for Forecasting, Emerging-Developed Markets	136
Table 4-8	: ADF Test of a Unit Root in the Returns, Longer Data for Forecasting, Emerging-Developed Markets	136
Table 4-9	: Phillips-Perron Test of a Unit Root in the Returns, Longer Data for Forecasting, Emerging-Developed Markets	137
Table 4-10	: Summary of Trend in Correlations Forecasts, Emerging-Emerging Markets	139
Table 4-11	: Summary of Average Correlation Coefficient between Pairs of Assets, Emerging-Emerging Markets	139
Table 4-12-A	: Analysis of the Impact of Volatility Spillovers Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-AGARCH, Emerging-Emerging Markets	141
Table 4-12-B	: Analysis of the Impact of Volatility Spillovers Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-GARCH, Emerging-Emerging Markets	142
Table 4-12-C	: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA-AGARCH and VARMA-GARCH, Emerging-Emerging Markets	143
Table 4-12-D	: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA-AGARCH and CCC, Emerging-Emerging Markets	144

Table 4-13	: Summary of Trend in Correlations Forecasts, Emerging-Developed Countries	145
Table 4-14	: Summary of Average Correlation Coefficient between Pairs of Assets, Emerging-Developed Markets	145
Table 4-15-A	: Analysis of the Impact of Volatility Spillovers Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-AGARCH, Emerging-Developed Markets	147
Table 4-15-B	: Analysis of the Impact of Volatility Spillover Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-GARCH, Emerging-Developed Markets	148
Table 4-15-C	: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA- AGARCH and VARMA-GARCH, Emerging-Developed Markets	149
Table 4-15-D	: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA- AGARCH and CCC, Emerging-Developed Markets	150
Table 4-16	: Summary of Variables Names, Developed Markets	152
Table 4-17	: DCC and GARCC, Conditional Means and Variances, Developed Markets	153
Table 4-18	: DCC and GARCC, Moment Conditions, Developed Markets	155
Table 4-19	: DCC Estimates of the Q_t Model, Developed Markets	155
Table 4-20	: GARCC Estimates of the Q_t Model, Developed Markets	157
Table 4-21	: Rank of Pairs of Varying Conditional Correlations, Developed Markets	159
Table 4-22	: Summary of Variable Names, Emerging-Developed Markets	161
Table 4-23	: DCC and GARCC, Conditional Means and Variances, Emerging-Developed Markets	163
Table 4-24	: DCC and GARCC, Moment Conditions, Emerging-Developed Markets	164
Table 4-25	: DCC Estimates of the Q_t Model, Emerging-Developed Markets	164
Table 4-26	: GARCC Estimates of the Q_t Model, Emerging-Developed Markets	165
Table 4-27	: Rank of Pairs of Varying Conditional Correlations, Emerging-Emerging Markets	168

Table 4-28	: Rank of Pairs of Varying Conditional Correlations, Emerging-Developed Markets	168
Table 4-29-A	: Correlation between Forecasts of Cond. Correlation Resulted from Each Model, Bond-Bond, Developed Markets	171
Table 4-29-B	: Correlation between Forecasts of Cond. Correlation Resulted from Each Model, Stock-Stock, Developed Markets	171
Table 4-29-C	: Correlation between Forecasts of Cond. Correlation Resulted from Each Model, ER-ER, Developed Markets	172
Table 4-29-D	: Correlation between Forecasts of Cond. Correlation Resulted from Each Model, Bond-Stock, Developed Markets	173
Table 4-29-E	: Correlation between Forecasts of Cond. Correlation Resulted from Each Model, Bond-ER, Developed Markets	174
Table 4-29-F	: Correlation between Forecasts of Cond. Correlation Resulted from Each Model, Stock-ER, Developed Markets	175
Table 4-30-A	: Summary of Volatility Spillovers and Asymmetric Effect, Bond-Bond, Developed Markets	176
Table 4-30-B	: Summary of Volatility Spillovers and Asymmetric Effect, Stock-Stock, Developed Markets	176
Table 4-30-C	: Summary of Volatility Spillovers and Asymmetric Effect, ER-ER, Developed Markets	177
Table 4-30-D	: Summary of Volatility Spillovers and Asymmetric Effect, Bond-Stock, Developed Markets	177
Table 4-30-E	: Summary of Volatility Spillovers and Asymmetric Effect, Bond-ER, Developed Markets	178
Table 4-30-F	: Summary of Volatility Spillovers and Asymmetric Effect, Stock-ER, Developed Markets	179
Table 4-31-A	: Correlation between Forecasts of Cond. Correlations, Bond-Bond, Emerging-Developed Markets	180
Table 4-31-B	: Correlation between Forecasts of Cond. Correlations, Stock-Stock, Emerging-Developed Markets	180
Table 4-31-C	: Correlation between Forecasts of Cond. Correlations, ER-ER, Emerging-Developed Markets	181
Table 4-31-D	: Correlation between Forecasts of Cond. Correlations, Bond-Stock, Emerging-Developed Markets	182

Table 4-31-E	: Correlation between Forecasts of Cond. Correlations, Bond-ER, Emerging-Developed Markets	183
Table 4-31-F	: Correlation between Forecasts of Cond. Correlations, Stock-ER, Emerging-Developed Markets	184
Table 4-32-A	: Summary of Volatility Spillovers and Asymmetric Effect, Bond-Bond, Emerging-Developed Markets	185
Table 4-32-B	: Summary of Volatility Spillovers and Asymmetric Effect, Stock-Stock, Emerging-Developed Markets	185
Table 4-32-C	: Summary of Volatility Spillovers and Asymmetric Effect, ER-ER, Emerging-Developed Markets	186
Table 4-32-D	: Summary of Volatility Spillovers and Asymmetric Effect, Bond-Stock, Emerging-Developed Markets	187
Table 4-32-E	: Summary of Volatility Spillovers and Asymmetric Effect, Bond-ER, Emerging-Developed Markets	188
Table 4-32-F	: Summary of Volatility Spillovers and Asymmetric Effect, Stock-ER, Emerging-Developed Markets	189
Table 5-1	: Code number of Assets in each Portfolio, Developed Markets	221
Table 5-2	: Tests of VaR Thresholds, Normal Distribution, Developed Markets	223
Table 5-3	: Tests of VaR Thresholds, t Distribution, Developed Markets	224
Table 5-4-A	: Test Summary, 5% level of Significance, Developed Markets	225
Table 5-4-B	: Test Summary, 1% level of Significance, Developed Markets	225
Table 5-5	: Code number of Assets in each Portfolio, Emerging-Developed Markets	228
Table 5-6	: Tests of VaR Thresholds, Normal Distribution, Emerging-Developed Markets	230
Table 5-7	: Tests of VaR Thresholds, t Distribution, Emerging-Developed Markets	232
Table 5-8-A	: Test Summary, 5% level of significance, Emerging-Emerging Markets	234
Table 5-8-B	: Test Summary, 1% level of significance, Emerging-Emerging Markets	234
Table 5-9-A	: Test Summary, 5% level of significance, Emerging-Developed Markets	235

Table 5-9-B	: Test Summary, 1% level of significance, Emerging-Developed Markets	235
Table 5-10	: Univariate AR (1)-GARCH(1,1) and Moment Conditions, Spot and Futures	239
Table 5-11	: Univariate AR (1)-GJR(1,1) and Moment Conditions, Spot and Futures	240
Table 5-12	: Test of VaR forecast, Normal Distribution, Spot and Futures	243
Table 5-13	: Test of VaR Forecasts, t Distribution, Spot and Futures	244
Table 5-14-A	: Test Summary, 5% level of significance, Spot and Futures	245
Table 5-14-B	: Test Summary, 1% level of significance, Spot and Futures	245
Table 5-15-A	: BEKK: Australia-Japan_Normal Distribution	249
Table 5-15-B	: BEKK: Australia-New Zealand_Normal Distribution	250
Table 5-15-C	: BEKK: Australia-Singapore_Normal Distribution	251
Table 5-15-D	: BEKK: Australia-USA_Normal Distribution	252
Table 5-15-E	: BEKK: Japan-NZ_Normal Distribution	253
Table 5-15-F	: BEKK: Japan-Singapore_Normal Distribution	254
Table 5-15-G	: BEKK: Japan-USA_Normal Distribution	255
Table 5-15-H	: BEKK: NZ-Singapore_Normal Distribution	256
Table 5-15-I	: BEKK: NZ-USA_Normal Distribution	257
Table 5-15-J	: BEKK: Sing-USA_Normal Distribution	258
Table 5-16-A	: BEKK: Australia-Japan_t Distribution	259
Table 5-16-B	: BEKK: Australia-New Zealand_t Distribution	260
Table 5-16-C	: BEKK: Australia-Singapore_t Distribution	261
Table 5-16-D	: BEKK: Australia-USA_t Distribution	262
Table 5-16-E	: BEKK: Japan-NZ_t Distribution	263
Table 5-16-F	: BEKK: Japan-Singapore_t Distribution	264
Table 5-16-G	: BEKK: Japan-USA_t Distribution	265
Table 5-16-H	: BEKK: NZ-Singapore_t Distribution	266
Table 5-16-I	: BEKK: NZ-USA_t Distribution	267
Table 5-16-J	: BEKK: Sing-USA_t Distribution	268
Table 5-17-A	: DVEC Estimation_Normal Distribution	269
Table 5-17-B	: DVEC Estimation_t Distribution	270
Table 5-18-A	: CCC Estimation_Normal Distribution	271
Table 5-18-B	: CCC Estimation_t Distribution	272
Table 5-19	: DCC Model: Coefficients of Cond. Correlation Equation	273

Table 5-20-A : BEKK: Indonesia-Japan_Normal Distribution	275
Table 5-20-B : BEKK: Indonesia-Malaysia_Normal Distribution	276
Table 5-20-C : BEKK: Indonesia-Philippine_Normal Distribution	277
Table 5-20-D : BEKK: Indonesia-Thailand_Normal Distribution	278
Table 5-20-E : BEKK: Indonesia-USA_Normal Distribution	279
Table 5-20-F : BEKK: Japan-Malaysia_Normal Distribution	280
Table 5-20-G : BEKK: Japan-Philippine_Normal Distribution	281
Table 5-20-H : BEKK: Japan-Thailand_Normal Distribution	282
Table 5-20-I : BEKK: Japan-USA_Normal Distribution	283
Table 5-20-J : BEKK: Malaysia-Philippine_Normal Distribution	284
Table 5-20-K : BEKK: Malaysia-Thailand_Normal Distribution	285
Table 5-20-L : BEKK: Malaysia-USA_Normal Distribution	286
Table 5-20-M : BEKK: Philippine-Thailand_Normal Distribution	287
Table 5-20-N : BEKK: Philippine-USA_Normal Distribution	288
Table 5-20-O : BEKK, thailand-USA_Normal Distribution	289
Table 5-21-A : BEKK: Indonesia-Japan_t Distribution	290
Table 5-21-B : BEKK: Indonesia-Malaysia_t Distribution	291
Table 5-21-C : BEKK: Indonesia-Philippine_t Distribution	292
Table 5-21-D : BEKK: Indonesia-Thailand_t Distribution	293
Table 5-21-E : BEKK: Indonesia-USA_t Distribution	294
Table 5-21-F : BEKK: Japan-Malaysia_t Distribution	295
Table 5-21-G : BEKK: Japan-Philippine_t Distribution	296
Table 5-21-H : BEKK: Japan-Thailand_t Distribution	297
Table 5-21-I : BEKK: Japan-USA_t Distribution	298
Table 5-21-J : BEKK: Malaysia-Philippine_t Distribution	299
Table 5-21-K : BEKK: Malaysia-Thailand_t Distribution	300
Table 5-21-L : BEKK: Malaysia-USA_t Distribution	301
Table 5-21-M : BEKK: Philippine-Thailand_t Distribution	302
Table 5-21-N : BEKK: Philippine-USA_t Distribution	303
Table 5-21-O : BEKK, thailand-USA_t Distribution	304
Table 5-22-A : DVEC Estimation_Normal Distribution (part 1)	305
Table 5-22-A : DVEC Estimation_Normal Distribution (part 2)	306
Table 5-22-B : DVEC Estimation_t Distribution (part 1)	307
Table 5-22-B : DVEC Estimation_t Distribution (part 2)	308
Table 5-23-A : CCC Estimation_Normal Distribution (part 1)	309

Table 5-23-A : CCC Estimation_Normal Distribution (part 2)	310
Table 5-23-B : CCC Estimation_t Distribution (part 1)	311
Table 5-23-B : CCC Estimation_t Distribution (part 2)	312
Table 5-24 : DCC Model: Coefficients of Cond. Correlation Equation	313
Table 5-25-A : BEKK: Spot and Futures, Normal Distribution	314
Table 5-25-B : BEKK: Spot and Futures, t Distribution	315
Table 5-26-A : DVEC: Spot and Futures, Normal Distribution	316
Table 5-26-B : DVEC: Spot and Futures, t Distribution	317
Table 5-27-A : CCC: Spot and Futures, Normal Distribution	318
Table 5-27-B : CCC: Spot and Futures, t Distribution	319
Table 5-28 : DCC, Spot and Futures	320

List of Figures

Figure 3-1	: Daily Returns for Ausbond	118
Figure 3-2	: Daily Returns for Japbond	118
Figure 3-3	: Daily Returns for NZbond	118
Figure 3-4	: Daily Returns for Sgbond	118
Figure 3-5	: Daily Returns for Usbond	118
Figure 3-6	: Daily Returns for Ausstock	118
Figure 3-7	: Daily Returns for Japstock	118
Figure 3-8	: Daily Returns for Nzstock	118
Figure 3-9	: Daily Returns for Sgstock	119
Figure 3-10	: Daily Returns for Usstock	119
Figure 3-11	: Daily Returns for Audjpy	119
Figure 3-12	: Daily Returns for Audnzd	119
Figure 3-13	: Daily Returns for Audsgd	119
Figure 3-14	: Daily Returns for Nzdjpy	119
Figure 3-15	: Daily Returns for Sgdjpy	119
Figure 3-16	: Daily Returns for Sgdnzd	119
Figure 3-17	: Daily Returns for Usdaud	120
Figure 3-18	: Daily Returns for Usdjpy	120
Figure 3-19	: Daily Returns for Usdnzd	120
Figure 3-20	: Daily Returns for Usdsgd	120
Figure 3-21	: Daily Returns for Indbond	121
Figure 3-22	: Daily Returns for Japbond	121
Figure 3-23	: Daily Returns for Malbond	121
Figure 3-24	: Daily Returns for Phibond	121
Figure 3-25	: Daily Returns for Thabond	121
Figure 3-26	: Daily Returns for Usbond	121
Figure 3-27	: Daily Returns for Indstock	121
Figure 3-28	: Daily Returns for Japstock	121
Figure 3-29	: Daily Returns for Malstock	122
Figure 3-30	: Daily Returns for Phistock	122
Figure 3-31	: Daily Returns for Thastock	122
Figure 3-32	: Daily Returns for Usstock	122
Figure 3-33	: Daily Returns for Jpyidr	122

Figure 3-34	: Daily Returns for Myridr	122
Figure 3-35	: Daily Returns for Myrjpy	122
Figure 3-36	: Daily Returns for Myrphp	122
Figure 3-37	: Daily Returns for Myrthb	123
Figure 3-38	: Daily Returns for Phpidr	123
Figure 3-39	: Daily Returns for Phpjpy	123
Figure 3-40	: Daily Returns for Thbidr	123
Figure 3-41	: Daily Returns for Thbjpy	123
Figure 3-42	: Daily Returns for Thbphp	123
Figure 3-43	: Daily Returns for Usdidr	123
Figure 3-44	: Daily Returns for Usdjpy	123
Figure 3-45	: Daily Returns for Usdmyr	124
Figure 3-46	: Daily Returns for Usdphp	124
Figure 3-47	: Daily Returns for Usdthb	124

Figures 4-1 to 4-91 are the forecasts of conditional correlations between pair of assets resulted from the CCC, VARMA-AGARCH and VARMA-GARCH models for Developed Markets.

Figure 4-1	: Forecasts of conditional correlations, Ausbond-Japbond	190
Figure 4-2	: Forecasts of conditional correlations, Ausbond-Nzbond	190
Figure 4-3	: Forecasts of conditional correlations, Ausbond-Sgbond	190
Figure 4-4	: Forecasts of conditional correlations, Ausbond-Usbond	190
Figure 4-5	: Forecasts of conditional correlations, Japbond-Nzbond	190
Figure 4-6	: Forecasts of conditional correlations, Japbond-Sgbond	190
Figure 4-7	: Forecasts of conditional correlations, Japbond-Usbond	191
Figure 4-8	: Forecasts of conditional correlations, Nzbond-Sgbond	191
Figure 4-9	: Forecasts of conditional correlations, Nzbond-Usbond	191
Figure 4-10	: Forecasts of conditional correlations, Sgbond-Usbond	191
Figure 4-11	: Forecasts of conditional correlations, Ausstock-Japstock	191
Figure 4-12	: Forecasts of conditional correlations, Ausstock-Nzstock	191
Figure 4-13	: Forecasts of conditional correlations, Ausstock-Sgstock	191
Figure 4-14	: Forecasts of conditional correlations, Ausstock-Usstock	191
Figure 4-15	: Forecasts of conditional correlations, Japstock-Nzstock	192
Figure 4-16	: Forecasts of conditional correlations, Japstock-Sgstock	192
Figure 4-17	: Forecasts of conditional correlations, Japstock-Usstock	192

Figure 4-18	: Forecasts of conditional correlations, Nzstock-Sgstock	192
Figure 4-19	: Forecasts of conditional correlations, Nzstock-Usstock	192
Figure 4-20	: Forecasts of conditional correlations, Sgstock-Usstock	192
Figure 4-21	: Forecasts of conditional correlations, Usdaud-Usdjpy	192
Figure 4-22	: Forecasts of conditional correlations, Usdaud-Usdnzd	192
Figure 4-23	: Forecasts of conditional correlations, Usdaud-Usdsgd	193
Figure 4-24	: Forecasts of conditional correlations, Usdjpy-Usdnzd	193
Figure 4-25	: Forecasts of conditional correlations, Usdjpy-Usdsgd	193
Figure 4-26	: Forecasts of conditional correlations, Usdnzd-Usdsgd	193
Figure 4-27	: Forecasts of conditional correlations, Ausbond-Ausstock	193
Figure 4-28	: Forecasts of conditional correlations, Ausbond-Japstock	193
Figure 4-29	: Forecasts of conditional correlations, Ausbond-Nzstock	193
Figure 4-30	: Forecasts of conditional correlations, Ausbond-Sgstock	193
Figure 4-31	: Forecasts of conditional correlations, Ausbond-Usstock	194
Figure 4-32	: Forecasts of conditional correlations, Japbond-Ausstock	194
Figure 4-33	: Forecasts of conditional correlations, Japbond-Japstock	194
Figure 4-34	: Forecasts of conditional correlations, Japbond-Nzstock	194
Figure 4-35	: Forecasts of conditional correlations, Japbond-Sgstock	194
Figure 4-36	: Forecasts of conditional correlations, Japbond-Usstock	194
Figure 4-37	: Forecasts of conditional correlations, Nzbond-Ausstock	194
Figure 4-38	: Forecasts of conditional correlations, Nzbond-Japstock	194
Figure 4-39	: Forecasts of conditional correlations, Nzbond-Nzstock	195
Figure 4-40	: Forecasts of conditional correlations, Nzbond-Sgstock	195
Figure 4-41	: Forecasts of conditional correlations, Nzbond-Usstock	195
Figure 4-42	: Forecasts of conditional correlations, Sgbond-Ausstock	195
Figure 4-43	: Forecasts of conditional correlations, Sgbond-Japstock	195
Figure 4-44	: Forecasts of conditional correlations, Sgbond-Nzstock	195
Figure 4-45	: Forecasts of conditional correlations, Sgbond-Sgstock	195
Figure 4-46	: Forecasts of conditional correlations, Sgbond-Usstock	195
Figure 4-47	: Forecasts of conditional correlations, Usbond-Ausstock	196
Figure 4-48	: Forecasts of conditional correlations, Usbond-Japstock	196
Figure 4-49	: Forecasts of conditional correlations, Usbond-Nzstock	196
Figure 4-50	: Forecasts of conditional correlations, Usbond-Sgstock	196
Figure 4-51	: Forecasts of conditional correlations, Usbond-Usstock	196
Figure 4-52	: Forecasts of conditional correlations, Ausbond-Usdaud	196

Figure 4-53	: Forecasts of conditional correlations, Ausbond-Usdjpy	196
Figure 4-54	: Forecasts of conditional correlations, Ausbond-Usdnzd	196
Figure 4-55	: Forecasts of conditional correlations, Ausbond-Usdsgd	197
Figure 4-56	: Forecasts of conditional correlations, Japbond-Usdaud	197
Figure 4-57	: Forecasts of conditional correlations, Japbond-Usdjpy	197
Figure 4-58	: Forecasts of conditional correlations, Japbond-Usdnzd	197
Figure 4-59	: Forecasts of conditional correlations, Japbond-Usdsgd	197
Figure 4-60	: Forecasts of conditional correlations, Nzbond-Usdaud	197
Figure 4-61	: Forecasts of conditional correlations, Nzbond-Usdjpy	197
Figure 4-62	: Forecasts of conditional correlations, Nzbond-Usdnzd	197
Figure 4-63	: Forecasts of conditional correlations, Nzbond-Usdsgd	198
Figure 4-64	: Forecasts of conditional correlations, Sgbond-Usdaud	198
Figure 4-65	: Forecasts of conditional correlations, Sgbond-Usdjpy	198
Figure 4-66	: Forecasts of conditional correlations, Sgbond-Usdnzd	198
Figure 4-67	: Forecasts of conditional correlations, Sgbond-Usdsgd	198
Figure 4-68	: Forecasts of conditional correlations, Usbond-Usdaud	198
Figure 4-69	: Forecasts of conditional correlations, Usbond-Usdjpy	198
Figure 4-70	: Forecasts of conditional correlations, Usbond-Usdnzd	198
Figure 4-71	: Forecasts of conditional correlations, Usbond-Usdsgd	199
Figure 4-72	: Forecasts of conditional correlations, Ausstock-Usdaud	199
Figure 4-73	: Forecasts of conditional correlations, Ausstock-Usdjpy	199
Figure 4-74	: Forecasts of conditional correlations, Ausstock-Usdnzd	199
Figure 4-75	: Forecasts of conditional correlations, Ausstock-Usdsgd	199
Figure 4-76	: Forecasts of conditional correlations, Japstock-Usdaud	199
Figure 4-77	: Forecasts of conditional correlations, Japstock-Usdjpy	199
Figure 4-78	: Forecasts of conditional correlations, Japstock-Usdnzd	199
Figure 4-79	: Forecasts of conditional correlations, Japstock-Usdsgd	200
Figure 4-80	: Forecasts of conditional correlations, Nzstock-Usdaud	200
Figure 4-81	: Forecasts of conditional correlations, Nzstock-Usdjpy	200
Figure 4-82	: Forecasts of conditional correlations, Nzstock-Usdnzd	200
Figure 4-83	: Forecasts of conditional correlations, Nzstock-Usdsgd	200
Figure 4-84	: Forecasts of conditional correlations, Sgstock-Usdaud	200
Figure 4-85	: Forecasts of conditional correlations, Sgstock-Usdjpy	200
Figure 4-86	: Forecasts of conditional correlations, Sgstock-Usdnzd	200
Figure 4-87	: Forecasts of conditional correlations, Sgstock-Usdsgd	201

Figure 4-88	: Forecasts of conditional correlations, Usstock-Usdaud	201
Figure 4-89	: Forecasts of conditional correlations, Usstock-Usdjpy	201
Figure 4-90	: Forecasts of conditional correlations, Usstock-Usdnzd	201
Figure 4-91	: Forecasts of conditional correlations, Usstock-Usdsgd	201

Figures 4-92 to 4-217 are the forecasts of conditional correlations between pair of assets resulted from the CCC, VARMA-AGARCH and VARMA-GARCH models for Emerging and Emerging-Developed Markets.

Figure 4-92	: Forecasts of conditional correlations, Indbond_Japbond	203
Figure 4-93	: Forecasts of conditional correlations, Indbond_Malbond	203
Figure 4-94	: Forecasts of conditional correlations, Indbond_Phibond	203
Figure 4-95	: Forecasts of conditional correlations, Indbond_Thabond	203
Figure 4-96	: Forecasts of conditional correlations, Indbond_Usbond	203
Figure 4-97	: Forecasts of conditional correlations, Japbond_Malbond	203
Figure 4-98	: Forecasts of conditional correlations, Japbond_Phibond	203
Figure 4-99	: Forecasts of conditional correlations, Japbond_Thabond	203
Figure 4-100	: Forecasts of conditional correlations, Malbond_Phibond	204
Figure 4-101	: Forecasts of conditional correlations, Malbond_Thabond	204
Figure 4-102	: Forecasts of conditional correlations, Malbond_Usbond	204
Figure 4-103	: Forecasts of conditional correlations, Phibond_Thabond	204
Figure 4-104	: Forecasts of conditional correlations, Phibond_Usbond	204
Figure 4-105	: Forecasts of conditional correlations, Thabond_Usbond	204
Figure 4-106	: Forecasts of conditional correlations, Indstock_Japstock	204
Figure 4-107	: Forecasts of conditional correlations, Indstock_Malstock	204
Figure 4-108	: Forecasts of conditional correlations, Indstock_Phistock	205
Figure 4-109	: Forecasts of conditional correlations, Indstock_Thastock	205
Figure 4-110	: Forecasts of conditional correlations, Indstock_Usstock	205
Figure 4-111	: Forecasts of conditional correlations, Japstock_Malstock	205
Figure 4-112	: Forecasts of conditional correlations, Japstock_Phistock	205
Figure 4-113	: Forecasts of conditional correlations, Japstock_Thastock	205
Figure 4-114	: Forecasts of conditional correlations, Malstock_Phistock	205
Figure 4-115	: Forecasts of conditional correlations, Malstock_Thastock	205
Figure 4-116	: Forecasts of conditional correlations, Malstock_Usstock	206
Figure 4-117	: Forecasts of conditional correlations, Phistock_Thastock	206
Figure 4-118	: Forecasts of conditional correlations, Phistock_Usstock	206

Figure 4-119	: Forecasts of conditional correlations, Thastock_Usstock	206
Figure 4-120	: Forecasts of conditional correlations, Usdldr_Usdipy	206
Figure 4-121	: Forecasts of conditional correlations, Usdldr_Usdmyr	206
Figure 4-122	: Forecasts of conditional correlations, Usdldr_Usdphp	206
Figure 4-123	: Forecasts of conditional correlations, Usdldr_Usdthb	206
Figure 4-124	: Forecasts of conditional correlations, Usdipy_Usdmyr	207
Figure 4-125	: Forecasts of conditional correlations, Usdipy_Usdphp	207
Figure 4-126	: Forecasts of conditional correlations, Usdipy_Usdthb	207
Figure 4-127	: Forecasts of conditional correlations, Usdmyr_Usdphp	207
Figure 4-128	: Forecasts of conditional correlations, Usdmyr_Usdthb	207
Figure 4-129	: Forecasts of conditional correlations, Usdphp_Usdthb	207
Figure 4-130	: Forecasts of conditional correlations, Indbond_Indstock	207
Figure 4-131	: Forecasts of conditional correlations, Indbond_Japstock	207
Figure 4-132	: Forecasts of conditional correlations, Indbond_Malstock	208
Figure 4-133	: Forecasts of conditional correlations, Indbond_Phistock	208
Figure 4-134	: Forecasts of conditional correlations, Indbond_Thastock	208
Figure 4-135	: Forecasts of conditional correlations, Indbond_Usstock	208
Figure 4-136	: Forecasts of conditional correlations, Japbond_Indstock	208
Figure 4-137	: Forecasts of conditional correlations, Japbond_Malstock	208
Figure 4-138	: Forecasts of conditional correlations, Japbond_Phistock	208
Figure 4-139	: Forecasts of conditional correlations, Japbond_Thastock	208
Figure 4-140	: Forecasts of conditional correlations, Malbond_Indstock	209
Figure 4-141	: Forecasts of conditional correlations, Malbond_Japstock	209
Figure 4-142	: Forecasts of conditional correlations, Malbond_Malstock	209
Figure 4-143	: Forecasts of conditional correlations, Malbond_Phistock	209
Figure 4-144	: Forecasts of conditional correlations, Malbond_Thastock	209
Figure 4-145	: Forecasts of conditional correlations, Malbond_Usstock	209
Figure 4-146	: Forecasts of conditional correlations, Phibond_Indstock	209
Figure 4-147	: Forecasts of conditional correlations, Phibond_Japstock	209
Figure 4-148	: Forecasts of conditional correlations, Phibond_Malstock	210
Figure 4-149	: Forecasts of conditional correlations, Phibond_Phistock	210
Figure 4-150	: Forecasts of conditional correlations, Phibond_Thastock	210
Figure 4-151	: Forecasts of conditional correlations, Phibond_Usstock	210
Figure 4-152	: Forecasts of conditional correlations, Thabond_Indstock	210
Figure 4-153	: Forecasts of conditional correlations, Thabond_Japstock	210

Figure 4-154	: Forecasts of conditional correlations, Thabond_Malstock	210
Figure 4-155	: Forecasts of conditional correlations, Thabond_Phistock	210
Figure 4-156	: Forecasts of conditional correlations, Thabond_Thastock	211
Figure 4-157	: Forecasts of conditional correlations, Thabond_Usstock	211
Figure 4-158	: Forecasts of conditional correlations, Usbond_Indstock	211
Figure 4-159	: Forecasts of conditional correlations, Usbond_Malstock	211
Figure 4-160	: Forecasts of conditional correlations, Usbond_Phistock	211
Figure 4-161	: Forecasts of conditional correlations, Usbond_Thastock	211
Figure 4-162	: Forecasts of conditional correlations, Indbond_Usdldr	211
Figure 4-163	: Forecasts of conditional correlations, Indbond_Usdjpy	211
Figure 4-164	: Forecasts of conditional correlations, Indbond_Usdmyr	212
Figure 4-165	: Forecasts of conditional correlations, Indbond_Usdphp	212
Figure 4-166	: Forecasts of conditional correlations, Indbond_Usdthb	212
Figure 4-167	: Forecasts of conditional correlations, Japbond_Usdldr	212
Figure 4-168	: Forecasts of conditional correlations, Japbond_Usdmyr	212
Figure 4-169	: Forecasts of conditional correlations, Japbond_Usdphp	212
Figure 4-170	: Forecasts of conditional correlations, Japbond_Usdthb	212
Figure 4-171	: Forecasts of conditional correlations, Malbond_Usdldr	212
Figure 4-172	: Forecasts of conditional correlations, Malbond_Usdjpy	213
Figure 4-173	: Forecasts of conditional correlations, Malbond_Usdmyr	213
Figure 4-174	: Forecasts of conditional correlations, Malbond_Usdphp	213
Figure 4-175	: Forecasts of conditional correlations, Malbond_Usdthb	213
Figure 4-176	: Forecasts of conditional correlations, Phibond_Usdldr	213
Figure 4-177	: Forecasts of conditional correlations, Phibond_Usdjpy	213
Figure 4-178	: Forecasts of conditional correlations, Phibond_Usdmyr	213
Figure 4-179	: Forecasts of conditional correlations, Phibond_Usdphp	213
Figure 4-180	: Forecasts of conditional correlations, Phibond_Usdthb	214
Figure 4-181	: Forecasts of conditional correlations, Thabond_Usdldr	214
Figure 4-182	: Forecasts of conditional correlations, Thabond_Usdjpy	214
Figure 4-183	: Forecasts of conditional correlations, Thabond_Usdmyr	214
Figure 4-184	: Forecasts of conditional correlations, Thabond_Usdphp	214
Figure 4-185	: Forecasts of conditional correlations, Thabond_Usdthb	214
Figure 4-186	: Forecasts of conditional correlations, Usbond_Usdldr	214
Figure 4-187	: Forecasts of conditional correlations, Usbond_Usdmyr	214
Figure 4-188	: Forecasts of conditional correlations, Usbond_Usdphp	215

Figure 4-189 : Forecasts of conditional correlations, Usbond_Usdthb	215
Figure 4-190 : Forecasts of conditional correlations, Indstock_Usdidr	215
Figure 4-191 : Forecasts of conditional correlations, Indstock_Usdjpy	215
Figure 4-192 : Forecasts of conditional correlations, Indstock_Usdmyr	215
Figure 4-193 : Forecasts of conditional correlations, Indstock_Usdphp	215
Figure 4-194 : Forecasts of conditional correlations, Indstock_Usdthb	215
Figure 4-195 : Forecasts of conditional correlations, Japstock_Usdidr	215
Figure 4-196 : Forecasts of conditional correlations, Japstock_Usdmyr	216
Figure 4-197 : Forecasts of conditional correlations, Japstock_Usdphp	216
Figure 4-198 : Forecasts of conditional correlations, Japstock_Usdthb	216
Figure 4-199 : Forecasts of conditional correlations, Malstock_Usdidr	216
Figure 4-200 : Forecasts of conditional correlations, Malstock_Usdjpy	216
Figure 4-201 : Forecasts of conditional correlations, Malstock_Usdmyr	216
Figure 4-202 : Forecasts of conditional correlations, Malstock_Usdphp	216
Figure 4-203 : Forecasts of conditional correlations, Malstock_Usdthb	216
Figure 4-204 : Forecasts of conditional correlations, Phistock_Usdidr	217
Figure 4-205 : Forecasts of conditional correlations, Phistock_Usdjpy	217
Figure 4-206 : Forecasts of conditional correlations, Phistock_Usdmyr	217
Figure 4-207 : Forecasts of conditional correlations, Phistock_Usdphp	217
Figure 4-208 : Forecasts of conditional correlations, Phistock_Usdthb	217
Figure 4-209 : Forecasts of conditional correlations, Thastock_Usdidr	217
Figure 4-210 : Forecasts of conditional correlations, Thastock_Usdjpy	217
Figure 4-211 : Forecasts of conditional correlations, Thastock_Usdmyr	217
Figure 4-212 : Forecasts of conditional correlations, Thastock_Usdphp	218
Figure 4-213 : Forecasts of conditional correlations, Thastock_Usdthb	218
Figure 4-214 : Forecasts of conditional correlations, Usstock_Usdidr	218
Figure 4-215 : Forecasts of conditional correlations, Usstock_Usdmyr	218
Figure 4-216 : Forecasts of conditional correlations, Usstock_Usdphp	218
Figure 4-217 : Forecasts of conditional correlations, Usstock_Usdthb	218
Figure 5-1-A : VaR_Aus-Jap_BEKK	322
Figure 5-1-B : VaR_Aus-Jap_DVEC	322
Figure 5-1-C : VaR_Aus-Jap_CCC	322
Figure 5-1-D : VaR_Aus-Jap_DCC	322
Figure 5-2-A : VaR_Aus-NZ_BEKK	322
Figure 5-2-B : VaR_Aus-NZ_DVEC	322

Figure 5-2-C : VaR_Aus-NZ_CCC	322
Figure 5-2-D : VaR_Aus-NZ_DCC	322
Figure 5-3-A : VaR_Aus-Sing_BEKK	323
Figure 5-3-B : VaR_Aus-Sing_DVEC	323
Figure 5-3-C : VaR_Aus-Sing_CCC	323
Figure 5-3-D : VaR_Aus-Sing_DCC	323
Figure 5-4-A : VaR_Aus-USA_BEKK	323
Figure 5-4-B : VaR_Aus-USA_DVEC	323
Figure 5-4-C : VaR_Aus-USA_CCC	323
Figure 5-4-D : VaR_Aus-USA_DCC	323
Figure 5-5-A : VaR_Jap-NZ_BEKK	324
Figure 5-5-B : VaR_Jap-NZ_DVEC	324
Figure 5-5-C : VaR_Jap-NZ_CCC	324
Figure 5-5-D : VaR_Jap-NZ_DCC	324
Figure 5-6-A : VaR_Jap-Sing_BEKK	324
Figure 5-6-B : VaR_Jap-Sing_DVEC	324
Figure 5-6-C : VaR_Jap-Sing_CCC	324
Figure 5-6-D : VaR_Jap-Sing_DCC	324
Figure 5-7-A : VaR_Jap-USA_BEKK	325
Figure 5-7-B : VaR_Jap-USA_DVEC	325
Figure 5-7-C : VaR_Jap-USA_CCC	325
Figure 5-7-D : VaR_Jap-USA_DCC	325
Figure 5-8-A : VaR_NZ-Sing_BEKK	325
Figure 5-8-B : VaR_NZ-Sing_DVEC	325
Figure 5-8-C : VaR_NZ-Sing_CCC	325
Figure 5-8-D : VaR_NZ-Sing_DCC	325
Figure 5-9-A : VaR_NZ-USA_BEKK	326
Figure 5-9-B : VaR_NZ-USA_DVEC	326
Figure 5-9-C : VaR_NZ-USA_CCC	326
Figure 5-9-D : VaR_NZ-USA_DCC	326
Figure 5-10-A : VaR_Sing-USA_BEKK	326
Figure 5-10-B : VaR_Sing-USA_DVEC	326
Figure 5-10-C : VaR_Sing-USA_CCC	326
Figure 5-10-D : VaR_Sing-USA_DCC	326
Figure 5-11-A : VaR_Ind-Jap_BEKK	328

Figure 5-11-B : VaR_Ind-Jap_DVEC	328
Figure 5-11-C : VaR_Ind-Jap_CCC	328
Figure 5-11-D : VaR_Ind-Jap_DCC	328
Figure 5-12-A : VaR_Ind-Mal_BEKK	328
Figure 5-12-B : VaR_Ind-Mal_DVEC	328
Figure 5-12-C : VaR_Ind-Mal_CCC	328
Figure 5-12-D : VaR_Ind-Mal_DCC	328
Figure 5-13-A : VaR_Ind-Phi_BEKK	329
Figure 5-13-B : VaR_Ind-Phi_DVEC	329
Figure 5-13-C : VaR_Ind-Phi_CCC	329
Figure 5-13-D : VaR_Ind-Phi_DCC	329
Figure 5-14-A : VaR_Ind-Tha_BEKK	329
Figure 5-14-B : VaR_Ind-Tha_DVEC	329
Figure 5-14-C : VaR_Ind-Tha_CCC	329
Figure 5-14-D : VaR_Ind-Tha_DCC	329
Figure 5-15-A : VaR_Ind-Usa_BEKK	330
Figure 5-15-B : VaR_Ind-Usa_DVEC	330
Figure 5-15-C : VaR_Ind-Usa_CCC	330
Figure 5-15-D : VaR_Ind-Usa_DCC	330
Figure 5-16-A : VaR_Jap-Mal_BEKK	330
Figure 5-16-B : VaR_Jap-Mal_DVEC	330
Figure 5-16-C : VaR_Jap-Mal_CCC	330
Figure 5-16-D : VaR_Jap-Mal_DCC	330
Figure 5-17-A : VaR_Jap-Phi_BEKK	331
Figure 5-17-B : VaR_Jap-Phi_DVEC	331
Figure 5-17-C : VaR_Jap-Phi_CCC	331
Figure 5-17-D : VaR_Jap-Phi_DCC	331
Figure 5-18-A : VaR_Jap-Tha_BEKK	331
Figure 5-18-B : VaR_Jap-Tha_DVEC	331
Figure 5-18-C : VaR_Jap-Tha_CCC	331
Figure 5-18-D : VaR_Jap-Tha_DCC	331
Figure 5-19-A : VaR_Jap-Usa_BEKK	332
Figure 5-19-B : VaR_Jap-Usa_DVEC	332
Figure 5-19-C : VaR_Jap-Usa_CCC	332
Figure 5-19-D : VaR_Jap-Usa_DCC	332

Figure 5-20-A : VaR_Mal-Phi_BEKK	332
Figure 5-20-B : VaR_Mal-Phi_DVEC	332
Figure 5-20-C : VaR_Mal-Phi_CCC	332
Figure 5-20-D : VaR_Mal-Phi_DCC	332
Figure 5-21-A : VaR_Mal-Tha_BEKK	333
Figure 5-21-B : VaR_Mal-Tha_DVEC	333
Figure 5-21-C : VaR_Mal-Tha_CCC	333
Figure 5-21-D : VaR_Mal-Tha_DCC	333
Figure 5-22-A : VaR_Mal-Usa_BEKK	333
Figure 5-22-B : VaR_Mal-Usa_DVEC	333
Figure 5-22-C : VaR_Mal-Usa_CCC	333
Figure 5-22-D : VaR_Mal-Usa_DCC	333
Figure 5-23-A : VaR_Phi-Tha_BEKK	334
Figure 5-23-B : VaR_Phi-Tha_DVEC	334
Figure 5-23-C : VaR_Phi-Tha_CCC	334
Figure 5-23-D : VaR_Phi-Tha_DCC	334
Figure 5-24-A : VaR_Phi-Usa_BEKK	334
Figure 5-24-B : VaR_Phi-Usa_DVEC	334
Figure 5-24-C : VaR_Phi-Usa_CCC	334
Figure 5-24-D : VaR_Phi-Usa_DCC	334
Figure 5-25-A : VaR_Tha-Usa_BEKK	335
Figure 5-25-B : VaR_Tha-Usa_DVEC	335
Figure 5-25-C : VaR_Tha-Usa_CCC	335
Figure 5-25-D : VaR_Tha-Usa_DCC	335

Acknowledgements

I would like to express my utmost gratefulness to Prof. Michael McAleer for supervising most of the works in my thesis. His continuous supports and enthusiasm during the candidature have made the thesis completion possible. His positive outlook and confidence in my research inspired me and gave me confidence. His guidance in preparing international publication is of priceless experience to my research knowledge.

I would like to express my deepest gratitude to my supervisor Prof. Felix Chan for his guidance, advice, patience, support, enthusiasm, and ultimate helps in software and computation techniques. I have been benefited from hours of discussion which provided valuable insight about the future research might come.

I would like to express my sincere thanks to my supervisor Prof. Darrell Turkington for providing helps in most helpless situation that makes the thesis submission possible.

I would like to acknowledge Prof. Manabu Asai (Soka University), Prof. Marcello Medeiros (Pontificia Universidade Católica do Rio de Janeiro), and Dr. Bernardo da Veiga for helpful comments and suggestions.

I am indebted to the following individuals who have offered their friendship, advice and support during my thesis completion: Dr. Suhejla Hoti, Dr. Riaz Shareef, Dr. Duc Hong Vo, Alan, Grace, Mei, Heru, Ian, Lien, and Syaifullah. Special thanks to Ghialy Choy Lee Yap, MEd., for continuous supports and motivation, and for advices to deal with the hardest situation in my candidature time.

I wish to express my sincere thanks to Suwarsono Muhammad, MBA (UII), Dr. Achmad Sobirin (UII), Dr. Asmai Ishak (UII), Prof. Edy Suandi Hamid (UII), Prof. Luthfi Hasan (UII), Dr. Anas Hidayat (UII), Arif Hartono, MBA (UII), and Dekar

Urumsyah, MBA (UII), and Roman Fitra (UII), Mila (UII), for supports and advice during the candidature time.

I would like to thank seminars participants in ACE 2007 at Curtin University of Technology, Australia; ASIMMOD 2007 at Chiang Mai, Thailand; ESAM07 in Brisbane, Australia; FEMES07 in Taipei, Taiwan; International Workshop on Quantitative Finance and Risk, National Chung Hsing University, Taichung, Taiwan, 2007, MODSIM07 at University of Canterbury, New Zealand; and FEMES 2008 at Singapore Management University, Singapore, for helpful comments.

I would like to acknowledge the editors and referees of *Applied Economics* and *Mathematics and Computers in Simulations* for their constructive comments and suggestions.

I wish to acknowledge Universitas Islam Indonesia, Yogyakarta, for providing scholarship and other supports that make the thesis completion possible. I would like to thank GRS, FIRN, and ARC for travel award and grant to attend conferences, which give valuable insight for the thesis completion.

My heartfelt gratitude is especially to my mother and late father for providing unfinished love, supports and prayer.

Most of the thesis is drawn from several papers from joint research during my PhD candidature, for which I am the first-named author. Some of these papers have already been accepted for publication in international journal. Permission from my co-authors, namely Professor Michael McAleer and Dr. Felix Chan to include material from our joint research is greatly appreciated.

Chapter 3 is based on two papers. The first is a joint paper that is to appear in *Applied Economics*, DOI: 10.1080/00036840701720994. Earlier version of this paper has appeared in Hakim, A. and M. McAleer, "Modelling the Interactions Across International Stock, Bond and Foreign Exchange Markets," in G. McDonald (eds.), *The*

35th *Australian Conference of Economists, ACE*, Perth, Australia, September 2006 (ISBN: 1740675010). Furthermore, this paper has been presented in International Workshop on Quantitative Finance and Risk, National Chung Hsing University, Taichung, Taiwan, 2007. The second paper has appeared in Hakim, A. and M. McAleer, "Modelling the Interactions Across International Stock, Bond and Foreign Exchange Markets: Emerging Markets Evidence," in B. Ekasingh, A. Jintrawet and A. Pratummintra (eds.), *The Second International Conference on Asian Simulation and Modelling, ASIMMOD*, Chiang Mai, Thailand, 2007 (ISBN: 974-672-145-3).

Part of Chapter 4 comprises 3 joint papers. The first paper has appeared in Hakim, A., M. McAleer, and F. Chan, "Modelling Conditional Correlations Across International Stock, Bond and Foreign Exchange Markets," in B. Ekasingh, A. Jintrawet and A. Pratummintra (eds.), *The Second International Conference on Asian Simulation and Modelling, ASIMMOD*, Chiang Mai, Thailand, 2007 (ISBN: 974-672-145-3). The second joint paper is: Hakim, A. and M. McAleer, "Modelling Conditional Correlations in International Stock, Bond and Foreign Exchange Markets: Emerging Markets Evidence," presented in Econometric Society Australasian Meeting, ESAM07, Brisbane, Australia, 2007, and the Far Eastern Meeting of the Econometric Society, FEMES, 2007, Taipei, Taiwan. The third paper is a joint paper that is to appear in *Mathematics and Computers in Simulations*, DOI:10.1016/j.matcom.2008.07.013. Earlier version of this paper has appeared in Hakim, A. and M. McAleer, "Forecasting Conditional Correlations in Stock, Bond and Foreign Exchange Markets," In Oxley, L. and D. Kulasiri (eds.), *MODSIM 2007 International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand*, December 2007, ISBN: 978-0-9758400-4-7.

Part of Chapter 5 comprises two joint papers. The first paper has appeared in Hakim, A., M. McAleer, and F. Chan, "Forecasting Portfolio Value-at-Risk for

International Stocks, Bonds and Foreign Exchange,” in Oxley, L. and D. Kulasiri (eds.), *MODSIM 2007 International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand*, December 2007, ISBN: 978-0-9758400-4-7. The second paper, Hakim, A. and M. McAleer, “VaR Forecasts and Dynamic Conditional Correlations of Spot and Futures Returns on Stocks and Bonds,” has been presented in Far Eastern and South Asian Meeting of the Econometric Society 2008 (FEMES 2008), Singapore Management University, Singapore.

Chapter 1

Introduction

"The historical evidence indicates that investing internationally offers benefits in terms of portfolio risk reduction and return enhancement..... Whether or not we can expect these benefits to continue in the future depends in part upon whether we expect cross-country correlations, market volatilities and currency risks to change."

Odier and Solnik (1993)

Optimal portfolio selection has been widely discussed, especially since the inception of modern portfolio selection theory by Markowitz (1952). He shows that an efficient portfolio, namely one that maximizes expected returns for a given degree of risk can be obtained by diversifying assets across several markets with given correlation. However, Markowitz (1952) approach assumes correlations between assets remain constant over time which can be unrealistic because there is a tendency for the asset returns to respond to the influence of domestic and international activities. This changes the correlation between assets returns and therefore violate the fundamental assumption of Markowitz's (1952) theory.

Markowitz (1952) and Tobin (1958) associated risk with the portfolio's variance. Since the assumption of constant conditional variance is often violated in financial time series, optimal portfolio selection should also consider time-varying volatility. This has motivated the birth of ARCH and GARCH family models (see Engle (2004)).

Diversification of portfolios across indexes from different countries offer greater benefits resulted from the imperfect correlation of expected returns which stems from

two reasons; (1) the countries' economy and politics evolve differently, and (2) the countries have different industries in their stock-market indices (see Heston and Rouwenhost (1994)).

An indication of the size of the gains from including foreign stocks in a portfolio has been provided by Solnik (1974). He finds that volatility of a portfolio declines as stocks are added to the portfolio, and also that the gains from international diversification were much larger when diversifying to countries having smaller stock markets. This holds because, in smaller countries, there are fewer opportunities to diversify within the country than in larger countries.

In order to further optimize the portfolio, diversification should also consider investing in different classes of assets, both within and across countries. Such assets to be considered are domestic and foreign bonds. Adding bonds into a portfolio can stabilize the overall return, provide an element of safety, and generate steady income.¹ In addition, Odier and Solnik (1993) find evidence that combining bond and stock in a portfolio provides more efficient portfolio compare to a portfolio consists of stock or bond only.

Diversifying portfolios across countries should also consider the possibility of added risk from unanticipated changes in exchange rates. Evidence on exchange rate risk from investing in foreign stocks has been provided by Eun and Resnick (1988). The exchange rate contributes a fraction of the volatility of home currency rate of returns of unhedged foreign asset via the direct effect of the exchange rate volatility itself, and via the indirect effect of the covariance between exchange rates and local stock returns.

The issue of the currency risk associated with foreign bonds is addressed in Odier and Solnik (1993). They show that the contribution of exchange rates to the riskiness of bonds is much larger than for stocks. This result arises from the negative

¹ Royal Bank of Canada Investment, 2001-2007. The information are available from: <http://www.rbcfinancialplanning.com/RBC:SNPXgo71A8UA19DKBpM/IP-bonds-provide-stability-safety-income.html>

correlation between the stock price and currency value, and the positive correlation between bond price and currency value. In spite of the high contribution of exchange rates to the volatility in bonds, Odier and Solnik (1993) provide empirical evidence that diversifying assets on international bonds is still important in reducing risk on the international portfolio.

Given the theoretical and historical evidence that support the benefit of investing internationally, there is little knowledge available of proper international portfolio construction in terms of how much should be invested in foreign countries, which countries should be targeted, and in what types of assets. The prospects of these benefits depend on the market volatilities, cross-country correlations, and currency risks to change in the future (Odier and Solnik (1993)). Following the liberalization of capital markets and the development of technology information in most countries, international financial market tends to become more integrated. If assets are priced in an internationally integrated capital market, diversifying portfolios on international assets will merely compensate for their systematic risk. On the other hand, if assets are priced in segmented or non-integrated capital markets, diversifying portfolios among international asset provides special benefits compared with diversifying portfolios only among domestic assets. Therefore, the question that remains to be answered is whether international diversification still provides benefits given more integrated financial markets.

Integrated regional stock and bond markets will lead to a more efficient allocation of capital within the region, with lower transaction costs and more liquid market. This will attract investors from outside the region. However, the correlation between the markets in the region will lead to less benefit from portfolio diversification across countries in the region. Previous studies have different findings regarding the importance of international diversification. Levy and Sarnat (1970), Solnik (1974),

Lassard (1976), and Biger (1979) have shown that international diversification provides US investors a lower risk for a given level of expected return. However, Kalra et al. (2004), investigate both developed and emerging markets, suggests that the benefits of international diversification are much smaller than previously understood. In addition, French and Poterba (1991) find that given the potential benefit of portfolio diversification by investing internationally, individuals and institutions in most countries hold modest amount of foreign equity, known as home bias puzzle. Campbell and Krauss (2007) explain that this is caused by the downside risk model, whereby the investor maximizes his return given a downside risk constraint.

Motivated by the aforementioned problems, this thesis investigates the nature of volatility, conditional correlations, and currency risk in international financial markets from developed countries to construct efficient international portfolios. Four chosen countries to be examined are Australia, Japan, New Zealand, Singapore and the USA.

Another important issue in international portfolio diversification is the growth of new markets in several parts of the world, namely Latin America, Eastern Europe, Russia, the Middle East, Africa and Asia. These markets have different characteristics from the developed ones. Bekaert and Harvey (1997) list four distinguishing characteristics of emerging market returns, namely higher sample average returns, low correlations with developed market returns, more predictable returns, and higher volatility. The predictability of emerging markets is a signal that those markets are not efficient. The inefficiency of emerging markets has been found by Worthington and Higgs (2006) and Kim and Shamsuddin (2008), among others. Emerging market predictability is caused by the strong influence of local information, which means that emerging markets are segmented from the world markets (Harvey (1995)).

For investors from outside emerging markets, the first three characteristics offer potential higher profit, while the last characteristic offers potential higher risk.

Understanding the nature of the relationship within emerging markets and between emerging and developed markets opens the possibility of having more efficient portfolio.

Among the emerging markets, this thesis considers Asian markets. The aggregate local currency bonds outstanding in emerging East Asia grew by 10% in the first half of 2007, expanding faster than gross domestic product in most markets.² Along with their financial markets liberalization, this area becomes a promising investment venue.

Indonesia, Malaysia, the Philippines, Singapore and Thailand are the original members of the Association of South East Asia Nations (ASEAN), well known as ASEAN-5. Several other countries in the region are now joint the group, namely Brunei Darussalam, Cambodia, Laos, Myanmar, and Vietnam. ASEAN has made a remarkable progress in developing the ASEAN Free Trade Area (AFTA) in year 1992 and the ASEAN Investment Area (AIA) in year 1998. The agenda in the near future are the capital market integration for national bond markets and stock markets and the prospect of a currency union to achieve more efficient regional market. These will reduce the traditional dependence of firms on bank loans, and attract capital from outside the region (see Click and Plummer (2005) for further discussion). ASEAN-5 is among the first who are ready for such integration scheme. However, this thesis considers Singapore as a developed market, as suggested by various studies such as Richards (1996), Worthington et al. (2003), Worthington and Higgs (2004) and Tse and Yip (2006).

Considering the importance of emerging markets, this thesis also investigates the conditional volatility, conditional correlations and foreign exchange risk in four countries from East Asia with rapid growth in bond, stock and foreign exchange

² The information is from Asia Bond Monitor Report, 2007, which can be downloaded from http://asianbondsonline.adb.org/documents/abm_nov2007.pdf

markets, in a separate analysis. Those countries are Indonesia, Malaysia, the Philippines, and Thailand. Two developed markets as benchmarks will be included in this analysis, namely the USA and Japan. This will enable testing of the hypothesis that diversifying assets on emerging markets provides low-risk portfolios.

The fact that the uncertainty of speculative prices, as measured by the variance and covariance, are changing through time has been recognized for some time (see, for example, Mandelbrot (1963) and Fama (1970)). However, it is only recently that applied researchers in financial and monetary economics have explicitly modelled the time variation in second or higher-order moments. One of the most prominent tools that have emerged for characterizing such changing variances is the Autoregressive Conditional Heteroscedasticity (ARCH) model of Engle (1982) and the Generalized ARCH (GARCH) of Bollerslev (1986), as well as their various univariate and multivariate extensions. For a comprehensive discussion about multivariate GARCH models, see McAleer (2005), Bauwens et al. (2006), and Silvennoinen and Terasvirta (2008).

The ARCH model and its generalizations are best to interpret as models that assist in forecasting volatility. Some papers have tried to find the causes of volatility. Anderson and Bollerslev (1998) examine the effects of macroeconomic announcements on exchange rate volatility. Another approach is to use the volatility measured in other markets. Engle et al. (1990) find evidence that stock market volatility causes bond market volatility in the future by modelling the influence of volatility in markets with earlier closing times on markets with later closing times. Ross (1989) argues that market volatility can be regarded as a measure of information flow, while Conrad et al. (1991) find evidence that information flows are from large to small firms. Hamao et al. (1990) find evidence of volatility spillovers from the US stock market to both the UK and the Japanese stock markets. Therefore, volatility spillovers are important in measuring the

volatility of stock market returns. This motivates this thesis to investigate the nature of volatility spillovers (or interactions) not only in stock markets, but also across stock, bond and foreign exchange rates. By including foreign exchange rates in the analysis, this will provide the nature of currency risk from international investment as well.

There are two classes of models to incorporate returns and volatility spillovers, namely multi-step and multivariate procedures. Multi-step procedures use univariate models to estimate the unconditional residuals and the conditional volatilities of each return series. Univariate GARCH models for each market are then modified by including the lagged squared unconditional residuals of other markets arising from the first step to capture the volatility surprises from the other markets. On the other hand, multivariate procedures use models that explicitly accommodate inter-market dependencies in the conditional mean and/or the conditional variance equations. The extension from a univariate GARCH model to an n -variate model requires allowing the conditional covariance matrix of the n -dimensional zero mean residuals to depend on elements of the information set (Engle and Kroner (1995)). This thesis will focus on multivariate models.

Chapter 3, motivated by the aforementioned problems, considers two models in modeling returns and volatility spillovers across stock, bond and foreign exchange markets, namely the VARMA(p,q)-AGARCH(r,s) model of McAleer, Hoti and Chan (2008) and VARMA(p,q)-GARCH(r,s) model of Ling and McAleer (2003). Consistency and asymptotic normality of the QML estimator of VARMA-AGARCH are demonstrated in McAleer, Hoti and Chan (2008), which facilitates statistical inference. Estimations will be carried out for both developed and emerging countries.

Chapter 4 investigates the nature of conditional correlations between international financial assets both for developed and emerging countries. In obtaining an efficient portfolio, at least three strategies are available; including investment in

different classes of assets within a country, investment in the same classes of assets across countries, and investment in different classes of assets across countries. In each case, the primary objective is to construct a portfolio that has the largest expected return with minimum risk. Thus, the evaluation of risk plays a central role in modern portfolio theory and risk management.

One way of evaluating risk is to examine the conditional covariance matrix of the portfolio. This can be done by modelling the conditional covariance matrix directly, or by decomposing the covariance matrix into the conditional variance of each asset and their conditional correlations. Although the latter approach is more popular, the restriction of constant conditional correlations is typically imposed for the second approach.

However, recent research has found that the correlations are not constant over time. Longin and Solnik (2001) find that equity correlations increase (decrease) during bear (bull) markets. Hunter and Simon (2005) find that the correlations among US and other major bond market returns are not constant, but are influenced by fundamentals and market conditions. Cappiello et al. (2006) find evidence that conditional correlations between equity and bond returns typically decline when stock markets suffer from financial turmoil.

Some studies find the importance of incorporating conditional correlation in financial model. Gibson and Boyer (1998) suggest that the model assumes constant conditional correlation performs worse than the models that incorporate time-variation in correlation, based on the ability to price option. Chib et al. (2006) suggest that the model assumes constant conditional correlation performs the worst in forecasting Value-at-Risk (VaR). Giamouridis and Vrontos (2007) suggest that dynamic covariance/correlation models are successful in constructing portfolios with minimum tail-risk. These motivate this thesis to investigate the nature of dynamic conditional

correlations across financial assets. This will help in deciding to what asset and in what country should the portfolio be diversified.

Section 1 of Chapter 4 conducts forecast of conditional correlations between financial stock, bond and foreign exchange using a rolling window technique based on three multivariate GARCH models assuming constant conditional correlations. This will provide the dynamic nature of conditional correlation, and allows an evaluation of the impact of various multivariate GARCH models characteristics, namely volatility spillovers and asymmetric effect of negative and positive unconditional shocks, on conditional correlations forecasts.

Given information about the nature of conditional correlations in Section 4.1, Section 2 of Chapter 4 investigates the nature of conditional correlations by estimating two multivariate GARCH models that incorporate conditional correlations, namely the DCC model of Engle (2002) and the GARCC model of McAleer et al. (2008).

Confirming a theory through empirical testing is a crucial in the development of science. Economists can be divided into three classes or approaches in terms of their view of model building (see Dharmapala and McAleer (1996)). The first approach, usually called traditionalist, tends to build empirical model to conduct empirical test to support theory. The second class, called instrumentalist, build empirical models to conduct forecasting. This approach also considers the accuracy of forecasting as the main tool in justifying a theory. The third approach builds models to test whether the theory is valid. This approach enables to falsify a theory based on empirical tests. Like most papers in financial empirical research, this thesis belongs to the second approach.

Three key elements in portfolio construction are estimates of returns, risks and correlations of assets in the portfolio. Researchers have, for so long, focused mainly on estimating returns and risk, and have assumed that correlations are constant and have therefore paid less attention on them. However, recent studies uncover that the

correlations among financial assets vary over time (see Solnik et al. (1996), De Santis and Gerard (1997), Longin and Solnik (2001), Cappiello et al. (2006), and Hunter and Simon (2005), among others). Therefore, modelling and forecasting future conditional correlation between assets becomes important in portfolio selection. Moreover, a forecast of correlation between two financial asset prices is required to price or hedge an option whose payoff depends on both asset prices or to measure the risk of a portfolio whose return depends on both asset prices (Gibson and Boyer (1998)). Forecast of correlations between exchange rates is also important for a central bank that uses exchange rates mainly as an indicator for future inflationary risk (Castren and Mazzotta (2005)).

A crucial issue is selecting the best model for forecasting conditional correlations. However, empirical studies revealed that the forecast performance of various models tend to change depending on the assets of interests, the availability of higher frequency data to calculate realized correlations, and the criteria used to compare the forecasts. The development of GARCH family models open new ways to forecast conditional correlations. Some multivariate GARCH models directly incorporate time varying conditional correlations such as the DCC model of Engle (2002), the VCC model of Tse and Tsui (2002), and the GARCC model of McAleer et al. (2008). For GARCH models that do not directly incorporate time varying correlation, correlations forecasts can be conducted using rolling window technique. Some papers have shown that GARCH models are useful in providing correlations forecasts (see Gibson and Boyer (1998), Cheng and Ryan (2002), Chong (2005), and Castren and Mazzotta (2005), among others).

Another growing issue in finance literature is the investigation of the relationship between correlation and volatility. King and Wadhwani (1990) and Bertero and Mayer (1989) find that international correlations tend to increase during periods of market

crises. Ramchand and Susmel (1998) document that the correlations between stock markets are higher in a high variance state as compared to a low variance regime. Longin and Solnik (1995) and Karolyi and Stulz (1995) find that correlations across major stock markets are higher when market are more volatile. On the other hand, the development in GARCH family model uncovers the importance of volatility spillovers and asymmetric effect of negative and positive unconditional shock on the conditional variance in explaining the volatility in financial assets (see Fleming et al. (1998) and Scruggs and Glabanidis (2003), among others). These motivate this thesis to investigate whether multivariate GARCH models which capture volatility spillovers and asymmetric effect provide different conditional correlations forecasts.

In section 1 of Chapter 4, three multivariate GARCH models, namely the CCC model of Bollerslev (1990), the VARMA-GARCH model of Ling and McAleer (2003), and the VARMA-AGARCH model of McAleer, Hoti and Chan (2008) will be estimated for the purposes. The VARMA-GARCH model incorporates volatility spillovers, the VARMA-AGARCH model incorporates both volatility spillovers and asymmetric effect, while the CCC model serves as the benchmark since the model does not incorporate volatility spillovers or asymmetric effects. Three classes of assets are included in the models, namely stock, bond and foreign exchange, considering the importance of those assets in portfolio construction (see Chen, Roll, and Ross (1986) and Odier and Solnik (1993), among others).

Since the estimated models do not directly incorporate time varying conditional correlations, a rolling window technique is used to forecast one-day ahead conditional correlations. Rolling windows are a recursive estimation procedure whereby the model is estimated for a restricted sample, then re-estimated by adding one observation to the end of the sample and deleting one observation from the beginning of the sample (see Da Veiga, Chan and McAleer (2008b)). To evaluate the impact of model specification

on the forecast of conditional correlations, the chapter calculates and compares the correlations between the conditional correlations forecasts.

In Section 2 of Chapter 4, two models will be estimated to obtain the coefficient correlations for pairs of assets, namely the DCC model of Engle (2002) and the GARCC model of McAleer et al. (2008). The DCC model has been widely applied in modelling conditional correlations because of its simplicity while allowing the correlation to be dynamic. However, the model does not provide motivation of the conditional correlation specification. The advantage of the GARCC model is that it motivates the dynamic structure of the conditional correlations explicitly through serial correlation in the vector of standardized shocks (see McAleer et al. (2008) for further discussion)). Two-step estimation will be employed for the job. This is possible as the two-step estimation method models the conditional mean and conditional variance, on the one hand, and the conditional correlations on another, as different processes. Using two-step estimation, the DCC is estimated to provide the coefficient of correlation of all assets in general. Using the same estimation, the GARCC model is estimated to provide the coefficient of all pair-wise assets in the analysis.

Chapter 5 considers the importance of forecasting in portfolio construction by conducting Value-at-Risk (VaR) forecast for portfolio containing stock, bond and foreign exchange rates for both developed and emerging countries. After investigating the nature of volatility spillovers and time-varying conditional correlations, this thesis will further investigate the usefulness of both characteristics in finance literature. Specifically, this thesis aims to investigate the impact of incorporating volatility spillovers and dynamic conditional correlations in multivariate GARCH models on VaR forecast.

VaR can be viewed as one of the latest steps in the evolution of risk-management tools. It can summarize the worst portfolio loss related to the trading of financial assets

over a given time period with a given level of confidence. Even though VaR should be viewed as a necessary but not sufficient condition procedure for risk management, it has been used as a standard tool for risk managers (see Jorion (2001) for further discussion about VaR).

However, VaR contains some disadvantages that should be noted. First, it does not reward diversification. It is possible that aggregating two portfolios together into one portfolio results in a higher VaR than the sum of the two single portfolios. Second, VaR ignores how large the losses are beyond the quantile (see Overbeck (2004)).

The development of univariate, and especially multivariate, GARCH-family models has contributed to the development of VaR forecasts methods. Three advantages of estimating multivariate GARCH models are the possibility of estimating the conditional covariances between assets, incorporating the interaction across those assets, and considering the conditional correlations across those assets. These might improve the VaR forecasts accuracy of a portfolio comprising these components, since the calculation of VaR of a portfolio requires the estimation of standard deviation and correlations across assets (see Skintzi et al. (2005)). Important issues in choosing models for VaR forecast are discussed in McAleer (2008).

Chapter 5 estimates four multivariate GARCH-type models, namely the DVEC model of Bollerslev et al. (1988), the BEKK model of Engle and Kroner (1995), the CCC model of Bollerslev (1990), and the DCC model of Engle (2002). The BEKK model is estimated as it incorporates the volatility spillovers across assets. This will check the results provided by the VARMA-AGARCH model of McAleer, Hoti and Chan (2008) estimated in Chapters 3 and 4. The DCC model will be estimated to incorporate time-varying conditional correlations across assets. The DVEC and CCC models serve the benchmarks as both models do not incorporate both volatility spillovers and time-varying conditional correlations.

There are two types of approach for evaluating the VaR accuracy, namely the statistical based procedure and loss function approaches (see Caporin (2008)). The thesis applies the first approach because it provides the possibility of inference analysis. This thesis considers various tests of Unconditional Coverage (CC) of Kupiec (1995) and Christoffersen (1998), the Conditional Coverage (CC) of Christoffersen (1998) and Lopez (1999), and Time Until First Failure (TUFF) of Kupiec (1995) regarding the violation of VaR resulted by the models. The UC test is uniformly most powerful for a given sample size (see Lopez (1999)). However, in the presence of time dependent heteroscedasticity, what is more important is the conditional accuracy of interval forecasts (see Lopez (1999)). This leads to the application of the CC test. Another type of test, the TUFF test, will also be applied. This test is important from the performance-based scheme (see Kupiec (1995)).

VaR forecasting will be conducted for portfolios containing stock, bond and foreign exchange, for both developed and emerging countries. Chapter 5 also conducts the VaR forecast for portfolios which consists of futures and their underlying spot price. Another topic that is of importance in finance is the role of derivatives markets in constructing efficient portfolio. There are generally three motivations for trading futures contracts, namely for speculation, hedging, and arbitrage. A crucial measure in deciding whether to use futures for speculate or hedge purposes is the covariance between futures contracts and their underlying assets. The covariance is determined by the variance of each market and the correlation between both markets. A key issue in modelling variance is the nature of volatility spillovers, resulted from the comovement in financial volatilities across assets and markets. The nature of conditional correlations is useful in determining whether the spot and futures returns are substitutes or complements, which can be used to hedge against contingencies. Balasubramanyan (2004) shows that

portfolio which considers time varying correlation with volatility comovement and spillover outperforms the constant correlation model without comovement and spillover.

Considering the importance of the interdependence and the correlation between futures contracts and the underlying spot price, it is surprising that the literature in this topic is thin. Most papers in the literature investigate stock, currency and commodity markets. This motivates this thesis to investigate bond and stock futures and their underlying spot price regarding their interdependence and conditional correlations. For these purposes, four government bond indices from Australia, Japan, New Zealand and USA, and seven stock indices from Australia, Indonesia, Japan, Malaysia, New Zealand, Singapore and USA, namely 11 assets in total, are investigated. The futures of bond and stock in some emerging markets are not yet available or difficult to access at the moment. From the 11 assets, 11 portfolios are constructed where each portfolio contains futures and the underlying asset. The same models will be estimated, namely the BEKK, DCC, DVEC and CCC models. The estimate of the model will also be used to forecast VaR, considering the role of VaR as an extension of valuation methods for derivative instruments (see Jorion (2001)).

The rest of this thesis is organized as follows. Chapter 2 discusses the literature review, including methods that are estimated in this thesis. Chapter 3 investigates the nature of interactions across asset markets. Chapter 4 investigates the nature of conditional correlations across asset markets and conducts forecasts on the conditional correlations. Chapter 5 conducts VaR forecasts for financial asset markets, including futures and the underlying spot markets, and Chapter 6 concludes.

Chapter 2

Methodology and Literature Review

This chapter provides a concise literature reviews on volatility models and their empirical applications in analyzing conditional variances and correlations for financial assets.

2.1. Methodology and Review of GARCH Family Models

Since the introduction of Engle's (1982) Autoregressive Conditional Heteroscedasticity (ARCH) and Bollerslev's (1986) Generalised ARCH (GARCH) models, a plethora of models have been proposed to investigate conditional variance (or volatility). The area of volatility modelling is of fundamental importance, especially in finance and financial modelling, where volatility is often used as a proxy of risk.

This section provides a survey on the theoretical development of some of the well known univariate and multivariate GARCH type models.

2.1.1. Univariate GARCH Models and Their Properties

Among the bulk varieties of univariate GARCH models, this thesis considers two of the most basic ones, namely the GARCH model of Bollerslev (1986) and the GJR model of Glosten et al. (1993). The univariate GARCH model of Bollerslev (1986) can be expressed as follows:

$$y_t = E(y_t|F_{t-1}) + \varepsilon_t, \quad (2.1)$$

$$\varepsilon_t = \eta_t \sqrt{h_t}, \quad (2.2)$$

$$h_t = \omega + \sum_{j=1}^r \alpha_j \varepsilon_{t-j}^2 + \sum_{j=1}^s \beta_j h_{t-j}, \quad (2.3)$$

where $\eta_t \sim iid(0,1)$, F_t is the past information available at time t . $\omega > 0$, $\alpha_i \geq 0 \forall i=1, \dots, r$ and $\beta_i \geq 0 \forall i=1, \dots, g$ are sufficient conditions to ensure a strictly positive conditional variance, $h_t > 0$. In case of $r=s=1$, α_1 represents the ARCH effect, or the short-run persistence of shocks, and β_1 represents the GARCH effects, or the contribution of shocks to long-run persistence, namely $\alpha_1 + \beta_1$.

Glosten et al. (1993) extend the model by incorporating the asymmetric effect of unconditional shock on conditional variance. The conditional variance of the model can be expressed as follows:

$$h_t = \omega + \sum_{j=1}^r (\alpha_j \varepsilon_{t-j}^2 + \gamma_j I_{t-j} \varepsilon_{t-j}^2) + \sum_{j=1}^s \beta_j h_{t-j}, \quad (2.4)$$

where $I_t = \begin{cases} 0, & \varepsilon_t \geq 0 \\ 1, & \varepsilon_t < 0 \end{cases}$. If $r=s=1$, $\omega > 0$, $\alpha_1 \geq 0$, $\alpha_1 + \gamma_1 \geq 0$, and $\beta_1 \geq 0$ are sufficient condition to ensure that the conditional variance $h_t \geq 0$. The short-persistence of positive (negative) shocks are given by α_1 ($\alpha_1 + \gamma_1$). When the conditional shocks, η_t , follow a symmetric distribution, the expected short-run persistence is $\alpha_1 + \gamma_1 / 2$, and the contribution of shocks to expected long-run persistence is $\alpha_1 + \gamma_1 / 2 + \beta_1$ (see McAleer (2005)).

Ling and McAleer (2002a) and (2002b) established the necessary and sufficient conditions for strict stationarity and ergodicity, as well as for the existence of all moments, for the univariate GARCH(r,s) model. Ling and McAleer (2003) showed that

the QMLE for GARCH(r,s) is consistent if the second moment regularity condition is satisfied. The necessary and sufficient condition for the existence of the second moment of ε_t is $\alpha + \beta < 1$ in the case of GARCH(1,1). Jeantheau (1998) showed that the weaker log-moment regularity condition, given by $E(\log(\alpha_1 \eta_t^2 + \beta_1)) < 0$, is sufficient for the QMLE to be consistent for the GARCH(1,1) model.

The second moment condition, namely $\alpha_1 + \frac{\gamma_1}{2} + \beta_1 < 1$, is sufficient for consistency and asymptotic normality of the QMLE for GJR(1,1) (see Ling and McAleer (2002b)). Moreover, McAleer, Chan and Marinova (2007) established the log-moment regularity condition for the GJR(1,1) model, namely $E(\log((\alpha_1 + \gamma_1 I(\eta_t))\eta_t^2 + \beta_1)) < 0$, and showed that it is sufficient for the consistency and asymptotic normality of the QMLE for GJR(1,1).

2.1.2. Multivariate GARCH Models with Constant Conditional Correlations and Their Properties

While the development in univariate GARCH family models have been remarkable, those models are of little help in analysing the interactions of both returns and volatility across markets. This motivates the birth of multivariate GARCH models, by which such interactions can be easily incorporated. Among the first of such models are the VEC model of Bollerslev et al. (1988), the CCC model of Bollerslev (1990), and the BEKK model of Engle and Kroner (1995). However, neither VEC nor BEKK imposes the assumption of constant conditional correlation.

The three multivariate GARCH models with the assumption of constant conditional correlations considered in this thesis are the VARMA-AGARCH of

McAleer et al. (2008), the VARMA-GARCH model of Ling and McAleer (2003) and the CCC model of Bollerslev (1990).

The VARMA-AGARCH model of McAleer, Hoti and Chan (2008) is a parsimonious model that incorporates mean and volatility spillovers. In addition, it also allows the asymmetric effect of negative and positive unconditional shock. This model nests other multivariate GARCH models with constant conditional correlations such as the VARMA-GARCH of Ling and McAleer (2003) and the CCC model of Bollerslev (1990). For further details regarding the structural and statistical properties of various time-varying univariate and multivariate conditional volatility models, see Li et al. (2002), Ling and McAleer (2002a, 2002b), and McAleer (2005).

The VARMA-AGARCH model can be formulated as follows:

$$Y_t = E(Y_t | F_{t-1}) + \varepsilon_t, \quad (2.5)$$

$$\Phi(L)(Y_t - \mu) = \Psi(L)\varepsilon_t, \quad (2.6)$$

$$\varepsilon_t = D_t \eta_t, \quad (2.7)$$

$$H_t = W + \sum_{i=1}^r A_i \bar{\varepsilon}_{t-i} + \sum_{i=1}^r C_i I(\eta_{t-i}) \bar{\varepsilon}_{t-i} + \sum_{j=1}^s B_j H_{t-j}, \quad (2.8)$$

where $D_t = \text{diag}(h_{1t}^{1/2}, \dots, h_{kt}^{1/2})$, k is the number of returns, $\eta_t = (\eta_{1t}, \dots, \eta_{kt})'$ is a sequence of identically and independently (i.i.d) random vectors, $H_t = (h_{1t}, \dots, h_{kt})'$, $W = (\omega_1, \dots, \omega_k)'$, $\bar{\varepsilon}_t = (\varepsilon_{1t}^2, \dots, \varepsilon_{kt}^2)'$, A_i, C_i and B_j are $k \times k$ matrices with typical elements α_i, γ_i and β_j , respectively, for $i, j = 1, \dots, k$. $\Phi(L) = I_k - \Phi_1 L - \dots - \Phi_p L^p$ and $\Psi(L) = I_k - \Psi_1 L - \dots - \Psi_q L^q$ are polynomials in L , the lag operator. $I(\eta_t) = \text{diag}(I(\eta_{it}))$ is a $k \times k$ matrix, and $I(\eta_{it})$ is an indicator function, given as:

$$I(\eta_{i,t}) = \begin{cases} 1, & \varepsilon_{i,t} \leq 0 \\ 0, & \varepsilon_{i,t} > 0 \end{cases} \quad (2.9)$$

The VARMA-AGARCH model is able to capture the possible multivariate asymmetries concerning the impact of positive and negative unconditional shocks to market i on the conditional variance of market i through the coefficient γ_i .

Restricting equation (2.8) by setting C_i to the null matrix yields the VARMA-GARCH model of Ling and McAleer (2003), where the conditional variance equation is as follows:

$$H_t = W + \sum_{i=1}^r A_i \bar{\varepsilon}_{t-i} + \sum_{j=1}^s B_j H_{t-j} \quad (2.10)$$

Furthermore, restricting equation (2.8) by setting $C_i = 0$, with A_i and B_i being diagonal matrices for all i, j , then VARMA-AGARCH reduces to the CCC model of Bollerslev (1990). Therefore, both VARMA-GARCH and CCC nested to VARMA-AGARCH.

The structural and statistical properties of the VARMA-GARCH model were established in Ling and McAleer (2003). This includes the necessary and sufficient conditions for stationary and ergodicity, sufficient conditions for the existence of moments of ε_i , and sufficient conditions for consistency and asymptotic normality of the Quasi-Maximum Likelihood Estimator (QMLE) in the absence of normality of η_i . As CCC is nested within VARMA-GARCH, the structural and statistical properties established in Ling and McAleer (2003) also apply to the CCC model.

The structural and statistical properties of the VARMA-AGARCH model were established in McAleer, Hoti and Chan (2008). As an extension of the VARMA-

GARCH model, it follows that the conditions established for the VARMA-AGARCH model are equivalent to those for VARMA-GARCH when $C_i = 0$ for all i .

The conditional correlation is assumed to be constant for the three multivariate GARCH models. From (2.7), it is obvious that

$$\varepsilon_t \varepsilon_t' = D_t \eta_t \eta_t' D_t'. \quad (2.11)$$

The conditional covariance matrix is

$$E(\varepsilon_t \varepsilon_t' | F_{t-1}) = \Omega_t = D_t \Gamma D_t', \quad (2.12)$$

where $\Gamma = E(\varepsilon_t \varepsilon_t' | F_{t-1}) = E(\eta_t \eta_t')$, which is a constant matrix for all t . The conditional correlation matrix is then defined as

$$\Gamma = D_t^{-1} \Omega_t D_t^{-1}, \quad (2.13)$$

which is assumed to be constant over time. Furthermore, the conditional correlation of ε_t is, by definition, equal to the covariance matrix of the standardized shocks, η_t .

The CCC model reduces the parameters to be estimated, but it assumes that the conditional variance for each return follows a univariate GARCH process, which means that it does not incorporate volatility spillovers.

2.1.3. Multivariate GARCH Models with Dynamic Conditional Correlations and Their Properties

The assumption of constant conditional correlation implies that the standardized shocks are independent of their past values. This is a valid assumption if the standardized shocks are a sequence of independently and identically distributed (iid) random vectors, or alternatively a martingale difference process. Since the shocks are not likely to be independent in practice, there is no guarantee that such models will be valid (see McAleer (2005) for further details). In response, several papers incorporate time-varying conditional correlations such as the Dynamic Conditional Correlation (DCC) model of Engle (2002), the Varying Conditional Correlation (VCC) model of Tse and Tsui (2002), and the Generalized Autoregressive Conditional Correlation (GARCC) model of McAleer et al. (2008).

Interestingly, some of the multivariate GARCH models proposed in the literature earlier, such as VEC and BEKK, also allow the possibility of time varying conditional correlations as these models focus on modelling dynamic in the conditional covariance matrix instead of the conditional correlation matrix. As such, both VEC and BEKK allow the possibility of both dynamic and constant conditional correlations between assets.

However, the VEC model suffers from a common problem associated with multivariate GARCH models, namely the curse of dimensionality. The model also requires further parametric restrictions to ensure the positive definiteness of the estimated covariance matrix. To reduce the number of parameters, Bollerslev et al. (1988) suggest the DVEC model. However, the model does not incorporate the spillovers across assets. The BEKK model of Engle and Kroner (1995) resolves the

positive definiteness issue and incorporates spillover effects; it did not resolve the problem associated with the curse of dimensionality.

The specification of the VEC model is as follows:

$$y_t = E(y_t | F_{t-1}) + \varepsilon_t \quad (2.14)$$

$$\varepsilon_t = D_t \eta_t \quad (2.15)$$

$$vech(\Omega_t) = C + \sum_{i=1}^r A_i vech(\varepsilon_{t-1} \varepsilon_{t-1}') + \sum_{j=1}^s B_j vech(\Omega_{t-j}) \quad (2.16)$$

where Ω_t is the conditional covariance matrix, $vech(.)$ denotes the column stacking operator of the lower portion of a symmetric matrix, C is a $\frac{1}{2}k(k+1) \times 1$ vector, $A_i, i = 1, \dots, r$, and $B_j, j = 1, \dots, s$, are $\frac{1}{2}k(k+1) \times \frac{1}{2}k(k+1)$ matrices. The DVEC model is obtain by taking the main diagonal of matrices A and B in (2.16).

The conditional covariance of BEKK model can be written as follows:

$$\Omega_t = \Omega \Omega' + A \varepsilon_{t-1} \varepsilon_{t-1}' A' + B \Omega_{t-1} B' \quad (2.17)$$

with the (implied) conditional correlation $\Gamma_t = \text{diag}(\Omega_t)^{-1/2} \Omega_t \text{diag}(\Omega_t)^{-1/2}$ where $\text{diag}\{A\}$ denotes the diagonal matrix consisting of the diagonal elements of a matrix A . Obviously, the conditional correlation matrix, Γ_t , as implied by BEKK is typically not a constant matrix.

The DCC model provides estimates of overall coefficients correlations for all assets in the portfolio. The DCC model is given as follows:

$$Q_t = (1 - \phi_1 - \phi_2)S + \phi_1 \eta_{t-1} \eta_{t-1}' + \phi_2 Q_{t-1} \quad (2.18)$$

$$\Gamma_t = \{diag(Q_t)^{-1/2}\} Q_t \{diag(Q_t)^{-1/2}\} \quad (2.19)$$

where ϕ_1 and ϕ_2 are scalar parameters, and Γ_t is the conditional correlation matrix after it is standardized by (2.19).

The GARCC model provides estimates of a unique process for each pair of dynamic conditional correlations. The GARCC model of McAleer et al. (2008) motivates the dynamic structure of the conditional correlations explicitly through serial correlation in the vector of standardized shocks.

$$\eta_t = v_t (\eta_{1t}, \dots, \eta_{kt})' \quad v_t \sim iid(0,1) \quad (2.20)$$

$$\eta_{it} = \sum_{l=1}^L \phi_{il} \eta_{it-l} + \xi_{it} \quad \forall i=1, \dots, k \quad (2.21)$$

$$\xi_{it} \sim iid(0, \sigma_{\xi_{it}}^2) \quad \xi_t \sim iid(0, \Omega) \quad (2.22)$$

$$E_{t-1}(\eta_t \eta_t') = Q_t \quad (2.23)$$

$$\Gamma_t = diag\{Q_t\}^{-1/2} Q_t diag\{Q_t\}^{-1/2} \quad (2.24)$$

The dynamics of the conditional correlations depend on the specification of ϕ_{it} and L . McAleer et al. (2008) consider four specific cases of the GARCC model. This thesis considers only Case 4 of the GARCC model as it allows modelling of the dynamic conditional correlation across pairs of assets. For Case 4, the conditional correlation matrix is described by the following process:

$$Q_t = \Omega + \Phi_1 \circ \eta_{t-1} \eta_{t-1}' + \Phi_2 \circ Q_{t-1} \quad (2.25)$$

where Φ_1 and Φ_2 are two $k \times k$ matrices of coefficients, and $\circ$ denotes the Hadamard element-by-element product.

2.1.4. Tests for Value-at-Risk Forecasts Evaluation

Since Chapter 5 of this thesis conducts forecasts of Value-at-Risk (VaR), this section reviews some famous tests to evaluate the forecasts. Several back tests are widely used in the literature, namely the tests of unconditional coverage (UC), independence (IND), conditional coverage (CC), and time until first failure (TUFF). The UC test was first proposed by Kupiec (1995). The test examines whether the failure rate of a model is statistically different from expectation. Later Christoffersen (1998) derived likelihood ratio (LR) of UC, IND and CC.

In UC test, the probability of observing x violations in a sample of size T , is given by:

$$\Pr(x) = C_x^T (f)^x (1-f)^{T-x} \quad (2.26)$$

where f is the desired proportion of observations. $C_x^T = \frac{T!}{x!(T-x)!}$ where ! denotes the

factorial operator such that $T! = \prod_{i=0}^{T-1} T-i$. The null hypothesis is that the empirical

failure rate, $\hat{f}$, is equal to the confidence level of the VaR, α . The LR statistic of UC is:

$$LR_{UC} = 2 \log \left[\frac{(1-\alpha)^{n_0} \alpha^{n_1}}{(1-\hat{f})^{n_0} \hat{f}^{n_1}} \right], \quad (2.27)$$

where $\hat{f} = x/T$, n_0 is the number of failures and n_1 is the number of success. The statistic is distributed as χ^2 with 1 degree of freedom.

The weakness of UC test is that it tests only the equality between the VaR violations and the confidence level. However, simply testing for the correct unconditional coverage is insufficient when dynamics are present in the higher-order moments. Therefore it is also important that the VaR violations are not correlated in time. The LR statistic of Christoffersen (1998) and Lopez (1999) for testing whether the series are independent is:

$$LR_{IND} = -2 \log \left[\frac{(1-\hat{f})^{n_{00}+n_{10}} \hat{f}^{n_{01}+n_{11}}}{(1-\hat{f}_{01})^{n_{00}} \hat{f}_{01}^{n_{01}} (1-\hat{f}_{11})^{n_{10}} \hat{f}_{11}^{n_{11}}} \right], \quad (2.28)$$

where n_{ij} is the number of observation with value i followed by j . The statistic is distributed as χ^2 with 1 degree of freedom.

The joint of unconditional coverage and independence tests are the conditional coverage test, with the following LR statistic:

$$LR_{CC} = LR_{UC} + LR_{IND}. \quad (2.29)$$

The statistic is distributed as χ^2 with 2 degree of freedom.

The TUFF test of Kupiec (1995) is based on the number of observations until a failure is recorded, which is important in a performance-based verification scheme. The null hypothesis is the same as the UC test, namely the empirical failure rate, $\hat{f}$, is equal to the confidence level of the VaR, α . Given v , the number of days until the first failure occurs, it tests whether the underlying potential loss estimates are consistent with the null. Therefore, the null can be further set to $H_0 = \alpha = \hat{f} = 1/v$. The LR statistic, which follows χ^2 with 1 degree of freedom, is as follows:

$$LR_{TUFF} = -2 \log \left[\frac{\hat{f}(1 - \hat{f})^{v-1}}{\frac{1}{v} \left(1 - \frac{1}{v}\right)^{v-1}} \right]. \quad (2.30)$$

2.2. Literature Review on Interactions Across Stock, Bond and Foreign Exchange in the Empirical Finance Literature

This section provides a literature review on the interactions between stock, bond and foreign exchange in both the conditional mean and the conditional variance. A brief overview on the computation of Value-at-Risk based on various parametric models is also provided.

2.2.1. Literature Review on Returns and Volatility Spillovers Across Stock, Bond and Foreign Exchange

Papers study domestic market linkages tend to suggest that the volatility spillovers in individual asset in isolation are strong, and the influence of bond to stock markets is stronger than the other way around. Papers investigate international market linkages also suggest that the volatility spillovers in individual asset in isolation are strong, while the influence of bond to stock markets is evidence in both directions. In addition, most papers find volatility spillovers from stocks to foreign exchange rates.

Significant research has been undertaken in the domestic transmission of asset price shocks. The studies on stock market have been done by Kroner and Ng (1998)

using a novel Generalized Dynamic Covariance model who find evidence of volatility spillovers from large to small firms. The studies on stock and bond markets, mostly focus on the US market, have been conducted by Fleming et al. (1998) using a Stochastic Volatility model, Bollerslev et al. (1988) using a VEC model, Stivers and Sun (2002) using a univariate GARCH model, and Scruggs and Glabadanidis (2003) using the Asymmetric Dynamic Covariance model of Kroner and Ng (1998). These authors tend to support volatility spillovers from bond to stock markets, but not in the other direction. Ehrmann et al. (2005), using the GARCH and Regime Switching models, find that, in the US market, bond yields and equity markets are much more strongly affected by changes in short-term interest rates than in the case of the Euro area. By contrast, Euro area short rates and equity markets are relatively more affected by bond yields and exchange rates as compared with the US market.

International interactions in a single market in isolation have been done by various papers. The volatility spillovers across international stock markets has been conducted using various univariate and multivariate GARCH models (see, for example, Hamao et al. (1990), Koutmos and Booth (1995), Koutmos (1996), Bala and Premaratne (2004), and da Veiga and McAleer (2005)). These authors find evidence of volatility spillovers across most countries in the analysis. Skintzi and Refenes (2006) examine US and European bond linkages and have found significant volatility spillovers from both the aggregate Euro area and US bond markets to the individual European bond markets. Volatility spillovers within exchange rate markets have been investigated by Engle et al. (1990) and Hurley and Santos (2003) using various GARCH models, and evidence of spillovers has been found. Cappiello et al. (2006) using a novel Asymmetric Dynamic Conditional Correlation model, find strong evidence of market volatility correlations for European, EMU, and US equities, but the evidence is less clear for bond market volatilities.

Volatility spillovers between stock and bond markets for the US market, aggregate European market, and individual European markets have been investigated by Christiansen (2004). Using the DCC model, he finds that national bond (stock) volatilities are mainly influenced by bond (stock) effects. Overall, global, regional and local volatility effects are all found to be important. Regarding the linkages between stock and foreign exchange, most papers have tended to suggest that the volatility spillovers are from stocks to foreign exchange rates (see, for example, Kanas (2000), Yang (2003), and Chiang and Yang (2003)).

Within emerging markets, evidence of volatility spillovers in individual asset is found in stock and foreign exchange. So far, there is no studies investigate volatility spillovers in individual bond market in isolation. Volatility spillovers across markets are found to be strong from bond to stock, but weak from bond to stock markets. Evidence of bidirectional volatility spillovers are also found across stock and foreign exchange markets.

Interactions in individual asset across emerging and developed countries are evident in stock, bond and foreign exchange markets, mostly from developed to emerging countries. There are not many studies investigate volatility spillovers across emerging-developed countries both across bond and stock markets and across bond and foreign exchange markets. However, abundant studies investigate those of across stock and exchange rates, and evidence of volatility spillovers are found in both directions.

The volatility spillovers in Asian stock markets have been investigated by So et al. (1997) using an Autoregressive Random Variance model and In et al. (2001) using a VAR-EGARCH model. The middle-east markets have been investigated by Al-Deehani and Moosa (2006) by applying stochastic volatility and structural time series models. Those papers find evidence of volatility spillovers across most markets.

The interactions between emerging bond markets have been analysed by Cifarelli and Paladino (2004). Using orthogonal GARCH procedure, they find the signs of contagion in Latin America. Cifarelli and Paladino (2007), using Principal Component Analysis (PCA) and GARCH models, find the evidence of comovements between spread changes, more within than across geographical areas (Latin America and Asia). Johansson (2008), applying a VECM-DCC-MVGARCH model, finds the evidence of mean spillovers across some Asian bond markets. He also finds that the volatility spikes seem to be fairly correlated with each other, indicating that the correlations among the four markets should be significant. So far, there is no author investigates the volatility spillovers across emerging bond markets.

Auyong et al. (2004), applying cointegration and Granger causality tests, find causality relationship from Brazilian real to other emerging markets during the Mexican crises. Ito and Hashimoto (2005), estimating a regression on high-frequency exchange rates, suggest that Indonesia is the main origin country which affects exchange rates of other countries. Baharumshah and Wooi (2007), using the EGARCH model of Nelson (1991), find evidence of volatility spillover effects for the currencies in Asian markets.

Fang and Miller (2002), applying a bivariate GARCH-M model, find evidence that domestic currency depreciation adversely affects stock market returns across Thailand and four Asian Tigers. They also find that stock market returns volatility depends on the conditional variance of exchange rate depreciation. Abid et al. (2003), applying the BEKK model of Engle and Kroner (1995) find evidence of volatility spillover across Asian stock markets and Asian foreign exchange markets. Mishra et al. (2007), applying univariate GARCH and EGARCH models, find the evidence of a bi-directional spillovers between the Indian stock market and Rupee/USD.

Han et al. (2003) investigate the effect of Mexican peso devaluation in 1994 on some emerging bond markets. Estimating a regression method to measure the return

spillovers, they find that Latin America as a region was more exposed to the Mexican crisis than emerging markets from other regions of the world. Jahjah and Yue (2004) investigate the linkage between exchange rates policy to sovereign bond spreads using a regression method in developing countries. The main finding is that real exchange rate overvaluation significantly raises bond spreads.

Hurditt (2004), using the BEKK model, finds volatility spillovers evidence across bond, stock and foreign exchange markets, but the strongest volatility transmission is from bond to stock markets. He also notes that the volatility spillover from stock to bond market is weak.

Abundant literature investigates the nature of volatility spillovers across developed and emerging stock markets. Most papers investigate Asian market with their connection to major countries such as the USA, Japan, and the UK. Various univariate and multivariate GARCH family models are applied such as MA-GARCH-M, EGARCH, Asymmetric Dynamic Covariance (ADC), bivariate GJR-GARCH, MA-EGARCH, bivariate EGARCH, ARMA-GARCH-M, and BEKK models. Most papers suggest the influence of both USA and Japan to emerging countries (Pacific-Basin and Asian countries), with a greater effect from USA, but not vice versa. However, mean spillovers from the developed to emerging markets are not homogenous across the emerging markets, and own-volatility spillovers are generally higher than cross-volatility spillovers for all markets, but specifically for the emerging markets (see Tay and Zhu (2000), Ng (2000), Kim (2003), Wei et al. (1995), Worthington et al. (2003), Nam et al. (2008), Ng (2000), and Chou et al. (1999), among others). However, some papers find the volatility spillovers from emerging to developed markets, namely from Korea to US, but not from US to Korea, (see Miyakoshi (2003)) and Hahm (2004)). Miyakoshi (2003) also finds that the volatility of the Asian market is influenced more by the Japanese market than by the US market. Li (2007), applying the BEKK model,

provides evidence of weak volatility spillovers from Hong Kong to China, but not from US stock markets.

Bogdan and Warzynski (2004) investigate return and volatility spillovers across US and emerging bond markets. Using a univariate GARCH model, they find evidence of volatility spillovers from US to all emerging markets. Inoguchi (2007), applying a univariate EGARCH model, find evidence of volatility transmission from both US and ADB bond markets to several Asian markets.

Volatility transmission across emerging and developed foreign exchange has been investigated by Wang and Wang (1999). Using the BEKK model they find that volatility transmission evidence across Japan, Malaysia, Hong Kong, and Singapore. The volatility spillovers across Korea and Singapore to Indonesia, Malaysia, Philippines, and Thailand is provided by Baharumshah and Wooi (2007) by applying EGARCH and Volatility Spillover Models.

Interactions across stock and foreign exchange rates between emerging and developed markets have been investigated by several papers such as Caporale et al. (2002). Applying the BEKK model on Japan, South Korea, Indonesia and Thailand, they find that in the pre-crisis sample stock prices lead exchange rates negatively in Japan and South Korea and positively in Indonesia and Thailand. Assoe (2001), using a multivariate EGARCH model, finds that in contrast to developed markets, where exchange rate innovations have no significant impact on the volatility of stock markets, shocks in foreign exchange markets significantly increase volatility in emerging stock markets.

So far, there is no study investigates returns and volatility spillovers across stock and bond markets and across bond and foreign exchange markets for the case of emerging-developed markets.

From the aforementioned literature review, it can be inferred that there is a lack of studies investigate the interactions in individual bond market in emerging markets, a limited studies investigate the interactions across bond and foreign exchange in emerging, developed, and emerging-bond markets, and also a lack of studies investigate the interactions across emerging-developed markets both across bond and stock markets and across bond and foreign exchange markets. Chapter 3 of this thesis fills the gap by estimating the VARMA-AGARCH model of McAleer, Hoti and Chan (2008) and the VARMA-GARCH of Ling and McAleer (2003) on bond, stock, and foreign exchange markets for developed and emerging markets. This is the first application to such models in those markets, especially in emerging markets.

2.2.2. Literature Review on Forecasting Conditional Correlations in Stock, Bond and Foreign Exchange

To study the earliest work on forecasting correlations on financial assets, we must go back to, at least, Elton and Gruber (1973), who forecast correlation in stock markets using full historical model, univariate and multivariate index model, and constant correlation model. They use statistical and economic significance to test the accuracy of the forecasts. Since then, even though is not as generous as in forecasting volatility, forecasting correlations have been enjoying a lot of attention in the literature. Literature on correlations forecasts can be classified from the methods and tests that they use. Following Campa and Chang (1998), the methods to forecast correlations can be categorized into four groups, namely historical, RiskMetricsTM, implied, and GARCH-based correlations.

Most paper which use historical correlation technique suggest that it performs worse compared to the other models (see Elton and Gruber (1973), Waincott (1990), Bodurtha and shen (1995), Campa and Chang (1998), Gibson and Boyer (1998), Walter and Lopez (2000), Cheng and Ryan (2002), Chong (2004), Chong (2005), and Castren and Mazzotta (2005)). However, Skintzi and Sisini (2007) suggest that historical model is better suited for the currency portfolio. An interesting modification made by Eun and Resnik (1984), namely the Mean model, in which the historical correlation matrix contains the future mean correlation, shown to have better forecast accuracy than the full historical correlation model.

Regarding the EWMA (RiskMetricsTM) model, some papers suggest that the model is not useful in forecasting correlations (Gibson and Boyer (1998), and Chong (2004, 2005)), while some other papers suggest that EMWA is useful (Bodurtha and shen (1995), Campa and Chang (1998), and Castren and Mazzotta (2005)).

The option-implied correlation model is found to be a good model to forecast correlations (see Bodurtha and shen (1995), Campa and Chang (1998), and Castren and Mazzotta (2005)). However, Chong (2005) suggests that the implied correlation model can not outperform econometric GARCH models, while Walter and Lopez (2000) suggest that the performance of the implied correlation forecasts varies significantly across currencies and across time periods, therefore it may not be worth calculating in all instances.

The rapid development in the GARCH family models open new ways to forecast correlations. In comparison to the other models, with the exception of Campa and Chang (1998) and Bodurtha and shen (1995), most papers suggest that the GARCH models are either good or the best models (see Gibson and Boyer (1998), Cheng and Ryan (2002), Chong (2005), and Castren and Mazzotta (2005)). An interesting finding is provided by Skintzi and Sisini (2007), which suggest that GARCH models can better

account for the correlation's dynamic structure in the stock and bond portfolios, but not for the currency portfolio. Comparison among different specification within GARCH models suggests that asymmetric effect is important when they are evident ((Chong (2004) for univariate model and Vargas (2006) for multivariate model). However, McAleer and da Veiga (2008a) suggest that incorporating spillovers does not make any different in correlations forecasts.

Various evaluation techniques of correlations forecasts have been applied in the literature, which can be can be classified into three methods. First, using realized correlation as the evaluators. The test can be conducted by analysis of loss functions: MFE (mean forecast error), RMSFE (root mean squared forecast error), AMSFE (average mean squared forecast error), Diebold and Mariano (1995) test, or encompassing regressions. Second, using financial evaluation measures such as reduction of hedged portfolio volatility, evaluation on the profitable trading strategy, minimum future variance of the selected portfolios, risk management-based loss functions which is measured by the accuracy of the VaR, or analysis of quantitative asset allocation. Third, evaluating the correlation of the forecasts of correlations to test whether alternative forecast models provide different forecasts.

The mixed results regarding the goodness of the aforementioned models in providing correlations forecasts might be due to the type of financial assets that they investigate and the evaluation techniques that they use to evaluate the forecasts.

A plausible way to measure forecast performance for conditional correlations is to compute the correlations between the measured conditional correlations and the conditional correlation forecasts. This method was used by Wainscott (1990) and McAleer and da Veiga (2008a). Wainscott (1990) uses historical rolling correlations to forecast future correlations between stock and bond. To test the accuracy of the forecasts, he calculates the correlation between the conditional correlation forecasts and

the following period non-overlapping correlation. He suggests that historical correlation is an unsatisfactory predictor of future correlation. McAleer and da Veiga (2008a) estimate the CCC and VARMA-GARCH models, and a novel Portfolio Spillover (PS)-GARCH model to conduct correlations forecast. A rolling window approach is used to forecast 1-day ahead conditional correlations. To compare the forecast accuracy, they calculate the correlation between conditional correlation forecasts. They find that all three models yield very similar results. This thesis extends the technique applied in McAleer and da Veiga (2008a) by incorporating the asymmetric effect and the application to international stock, bond and foreign exchange.

While there is abundance of studies investigate forecasting correlations in developed markets, there are only a limited number of studies investigate forecasting correlations in emerging markets. Most studies in this area focus on exchange rates and stock markets. Some of those studies aim to find the best model for forecasting (Vargas (2006) and Bekiros and Georgoutsos (2007)), and some others forecast the correlations for other purposes such as testing the difference of correlation before and after crises (Huang and Yang (2003)), forecasting optimal hedge ratio (Lee and Yoder (2007)), or testing contagion effect (Wang and Thi (2007)).

Huang and Yang (2003) calculate the forecast k -period-forward of dynamic conditional correlation based on forecast errors of the VAR model developed by Den Haan (2000). The method is applied to exchange rates in China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, and Taiwan. In order to explore significant changes before and after the crisis, they calculate standard deviations of the correlation coefficients via the bootstrap method before applying the conventional t -test. They test the difference of correlation coefficients before and after the crisis. The results indicate increased interactions between exchange rates markets.

Vargas (2006) investigates the forecast of correlations between exchange rates markets in China, Hong Kong, Malaysia, Philippines, Singapore and Thailand, using various types of DCC models, namely DCC, Block DCC (BDCC), Asymmetric DCC (ADCC), and Asymmetric Block DCC (ABDCC). Applying the DM test of Diebold and Mariano (1995) and the Modified DM test of Harvey, Leybourne and Newbold (1997), he finds that ABDCC model is competitive in in-sample forecasting and performs better than alternative DCC models in out-of-sample forecasting in the presence of asymmetric effect between blocks and asset returns.

Lee and Yoder (2007) develop a Markov regime-switching time-varying correlation generalized autoregressive conditional heteroscedasticity (RS-TVC GARCH) model for estimating optimal hedge ratios. They do not directly forecast correlation, but the model is used to forecast optimal hedge ratio. For testing purpose, they use White's reality check (Sullivan et al. (1999) and White (2000)), which tests the hypothesis that the best-performing dynamic hedging model has no predictive superiority over the poorest performer. Using the Nikkei 225 and the Hang Seng index futures data, they find that RS-TVC outperforms the constant conditional correlation (CCC) and TVC models both in- and out-of-sample in terms of variance reduction.

Bekiros and Georgoutsos (2007) derive estimates of the correlation index of extreme observations based on de Oliveira (1973) formula to obtain the correlation forecasts. For comparison purpose, they estimate the corresponding correlation index by fitting a bivariate GARCH model where the variance and covariance equations are modeled as GARCH(1,1). Estimating US dollar/Cyprus pound and Cyprus Stock Exchange General Index (SGI), they find substantial difference from the competing model.

Wang and Thi (2007) apply the forward forecasting test on the DCC model of Engle (2002) in an attempt to test for contagion between Taiwan and US stock under

asymmetry. They use N-step forecast test that uses the recursive calculations to perform Chow forecast test. They find that the dynamic correlation coefficient mean of recursive sample period and forecasting sample period, between Taiwan and US stock, are not the same. This proves that contagion is significant.

So far, there is no study compares the correlations forecast of multivariate models incorporating various criteria such as volatility spillovers and asymmetric effect of negative and positive shocks on conditional covariance in emerging markets. This is another main contribution of this thesis.

2.2.3. Literature Review on Dynamic Conditional Correlations Across Stock, Bond and Foreign Exchange

A number of papers have attempted to investigate the nature of conditional correlations across financial assets. This, partly, follows the development in multivariate GARCH models. Among the earliest multivariate GARCH model is the VEC model of Bollerslev et al. (1988) which model the conditional variance. De Goeij and Marquering (2004) formulate the conditional correlations from the covariance and variances in the model, and apply it on stock and bond markets. Beine (2004) uses the same technique and applies it on foreign exchange markets. Both papers provide the evidence of time-varying conditional correlations.

As mentioned in previous section, the VEC model suffers from a common problem associated with multivariate GARCH models, namely the curse of dimensionality, and also requires further restrictions to ensure the positive definiteness of the estimated covariance matrix. The BEKK model of Engle and Kroner (1995) resolves the positive definiteness issue but did not resolve the problem associated with the curse of dimensionality. Some papers derive the conditional correlations from the

BEKK model such as Dungey et al. (2003) and Yang and Sun (2006) on stocks, Kukharchuk and Babetskii (2008) on exchange rates, and Tastan (2006) on stock-exchange rates. Some other papers propose new models based on the BEKK framework such as Qiao et al. (2007) with the Fractionally Integrated Vector Error Correction Model BEKK (FIVECM-BEKK) model, and Serban et al. (2007) with the VAR-EGARCH-Multiple Degree of Freedom- t model. Both papers provide estimate on stock markets, and they find the evidence of time-varying conditional correlations. Kroner and Ng (1998) propose the General Dynamic Covariance (GDC) model that encompasses the VEC and BEKK models, and is capable of capturing time-varying conditional correlations. These models have been used by Scruggs and Glabadanidis (2003) which find evidence of time-varying conditional correlations between bond and stock markets.

The VEC and BEKK models do not directly incorporate conditional correlations, even though one can derive it from the BEKK model. The first multivariate GARCH model to incorporate conditional correlation is the constant conditional correlation (CCC) model of Bollerslev (1990). As the name suggests, the CCC model restricts the conditional covariance to be proportional to the product of the conditional standard deviations, where the conditional correlation coefficient of the asset returns is time invariant. Bollerslev (1990) provides an application to foreign exchange markets, and suggests that the estimates for all the conditional correlations are highly significant. Several papers apply the CCC model, and most of them do not support the assumption of constant conditional correlations. Those papers are Longin and Solnik (1995), Audrino and Adesi (2006) on exchange rates, Chib et al. (2006) and Yang and Sun (2006) on stocks, and Scruggs and Glabadanidis (2003) on bond and stock markets. A few papers support the assumption of constant conditional correlations such as

Theodossiou and Lee (1993) on stocks, and Lien et al. (2002) on spot and futures of currency markets.

Some other papers assume constant conditional correlations in building their models. The VAR-CORR model of Christiansen (2002) allows for various differences between announcement days and non-announcement days, and has been applied on the correlation between bonds. The VARMA-GARCH model of Ling and McAleer (2003) and the VARMA-AGARCH model of McAleer, Hoti and Chan (2008) allow for mean and volatility spillovers with the VARMA-AGARCH model also incorporate the possibility of asymmetric effect between negative and positive shock on the conditional variance. These models have been applied by McAleer and Da Veiga (2008a) and Da Veiga et al. (2008b) on stocks markets. The estimated models suggest that the correlations are time-varying.

Engle (2002) uses the DCC model to investigate the conditional correlations across stock, bond, and foreign exchange markets in the USA and France. The model has been applied to examine the correlations across stock markets by Suleiman (2004), Maghyreh and Al-Zuobi (2005), Chib et al. (2006), Chiang et al. (2007), Wang and Thi (2007), Barari et al. (2008), Chen et al. (2008), Diamandis (2008), and Da Veiga et al. (2008a). The application on foreign exchange markets is provided by Audrino and Adesi (2006), and Rodriguez (2006). The application on bond markets is provided by Johansson (2008). Some other papers apply the models including different classes of assets such as between bond and stock markets by Wong and Vlaar (2003), Christiansen (2004), Baur and Lucey (2006), and between stock, money and foreign exchange markets by Kuper and Lestano (2007). All papers provide evidence of time-varying conditional correlations.

Some other papers extend the DCC model by incorporating various specifications. Billio et al. (2003) and Billio et al. (2006) extend the DCC model by

introducing the Block DCC (BDCC) model, where the dynamic is constrained to be equal only among group of variables. Estimating the model on Italian sectoral stock index, they find the dynamic of conditional correlations and the dissimilarities of the correlations resulted from the BDCC and DCC models. Cappiello et al. (2006) develop the Asymmetric Generalized DCC (AG-DCC) model, and provide evidence of time-varying conditional correlations in bond and stock markets, and also document the asymmetric evidence both in stock and bond correlations. Vargas (2006) develops the Asymmetric Block DCC (ABDCC) model, and applies the model to ER markets. He finds the evidence of time-varying conditional correlations in the markets, and also documents the evidence of better forecasts compare to the DCC model of Engle (2002), the AG-DCC model of Cappiello et al. (2006), and the BDCC model of Billio et al. (2003).

Li and Zou (2008) develop the Mixed Asymmetric DCC (MADCC) model which is capable of capturing concurrent responses of the conditional covariance of standardized return residuals to positive and negative information shocks. Applying the model to Chinese bond and stock markets, they find that the bond–stock correlations respond more strongly to joint negative than joint positive shocks. However, the stock–stock correlation is found to increase for joint positive shocks. Osborn et al. (2008) develop the Periodic DCC (PDCC) model which allows periodic (day-specific) conditional correlations of shocks across markets. Applying the model on the international stock markets, they find strong evidence of periodic conditional correlations for the shock.

Recent paper by Caporin and McAleer (2008) derive the scalar special case of the BEKK model using a multivariate extension of the random autoregressive (RCA) model of Tsay (1987). They also obtain an indirect DCC model that is consistent with the scalar BEKK representation. They suggest time-varying conditional correlations

across Germany, French and the UK stock markets, and that the scalar BEKK and indirect DCC provide smoother conditional correlation as compared with the direct DCC.

Closely related to the DCC model is the Varying Conditional Correlation (VCC) model of Tse and Tsui (2002). Tse and Tsui (2002) investigate the correlations between stock and foreign exchange markets, and find the evidence of time varying correlations. The model has been applied by Srikanthakumar and Silvapulle (2008) on the stock markets of some Asian countries, and the evidence of varying correlations is provided. The GARCC model of McAleer et al. (2008) analyses the dynamic conditional stock markets across Hong Kong, Japan and the USA. These models provide empirical evidence to support time-varying conditional correlations between pairs of assets.

Some other papers extend the univariate ARCH model of Engle (1982), the univariate GARCH model of Bollerslev (1986), or the univariate EGARCH of Nelson (1991) and construct the multivariate counterparts to model varying conditional correlations. The ARCH and GARCH models have been extended to incorporate conditional correlations by some papers. Those papers which investigate stock markets are Christodoulakis and Satchell (2002) who propose the CorARCH and CorGARCH models, Storti (2007) with a proposed multivariate bilinear GARCH model, and Diamandis (2008) with the Markov Switching ARCH-L model.

Some other papers study exchange rates are Chang and Kim (2001) who extend multivariate latent factor ARCH model of Diebold and Nerlov (1989), Audrino and Adesi (2006) with a proposed RW-ACC and RW-TCC, Fong et al. (2006) with a multivariate ARCH model with random coefficients, Kearney and Muckley (2007) with the principal component analysis and the O-GARCH model. Meanwhile, Hunter and Simon (2005) propose a bivariate GARCH model and apply it on bonds markets, and Christodoulakis (2007) develops the CorARCH model and estimates the model on bond

and stock markets, and Most papers provide evidence of time-varying conditional correlations. The EGARCH model of Nelson (1991) has been extended to a bivariate EGARCH model incorporating dynamic conditional correlations by Kim et al. (2005) on stocks, Kim et al. (2006b) and Skintzi and Refenes (2006) on bonds, Kim et al. (2006a) on bond-stock, and Mun (2007) on foreign exchange and stock markets. They tend to suggest that the conditional correlations are time-varying.

There are also papers in the literature that use non-GARCH family frameworks to model conditional correlations such as Huang and Yang (2003) using VaR forecast error model of Den Haan (2000), Leong and Felmingham (2003) using simple correlation analysis of pre- and post-crisis, Chib et al. (2006) with a proposed Multivariate Stochastic Volatility (MSV) model, Pelletier (2006) with Regime switching DCC model, and Smith and Swanson (2008) with a moving average correlations model.

Many papers have investigated conditional correlations between financial assets both within emerging markets and between emerging-developed markets. Various models have been estimated for the purposes.

The correlations between emerging bond markets have been found to be time varying by Johansson (2008) on the study of correlations between China, South Korea, Malaysia, and Thailand. However, the correlation between emerging-developed bond markets are found to be inconclusive by Kim et al. (2006b); they provide evidence for strong dynamic linkages between existing EU member country bond markets with that of Germany, but weak and relatively less dynamic linkages for the UK and the three accession countries of Czech Republic, Poland and Hungary.

The correlations between emerging-emerging stock markets have been investigated by Leong and Felmingham (2003), Chiang et al. (2007), Qiao et al. (2007), Serban et al. (2007), Diamandis (2008) and, Srianthakumar and Silvapulle (2008).

These papers suggest time-varying conditional correlations. Some of them provide the pictures of increasing conditional correlations such as Chiang et al. (2007), and Qiao et al. (2007). Some other papers find the evidence of increasing correlations in domestic Chinese stock markets following the opening B-share market, namely Chen et al. (2008) and Da Veiga, Chan and McAleer (2008a,b).

The correlations between emerging foreign exchange markets have been investigated by Huang and Yang (2003), Vargas (2006), Kearney and Muckley (2007) and Kukharchuk and Babetskii (2008). They find evidence of time-varying correlations. In addition, Huang and Yang (2003) find the increased interactions in the markets. The first three papers also provide the evidence of time-varying correlations between emerging-developed markets. These papers study Asian markets except Kukharchuk and Babetskii (2008) who studies East European markets.

The correlations between bond-stock within emerging markets have been investigated by Capiello et al. (2006). They find evidence of time-varying correlations in most pairs of assets. The countries investigated include Euroepan, Australasia and Americas. Li and Zou (2008) investigate the Chinese domestic bond and stock markets. They find evidence that the bond-stock correlations tend to increase only in the presence of bad news, but the stock-stock correlations tend to increase in the presence of good news.

Kuper and Lestano (2007) investigate the correlation between stock, money market and exchange rates in Indonesia and Thailand. Using the DCC model, their relationship among financial markets changed over time and intensified during the Asian financial crises in 1997.

The DCC model has been widely applied in modelling conditional correlations because of its simplicity while allowing the correlation to be dynamic. However, the model does not provide motivation of the conditional correlation specification. Some

papers have modelled some pairs of these countries using the DCC model, but none has done so for all of these markets. Moreover, it is the first time that the GARCC model is used to estimate the conditional correlations between any pairs of these countries.

2.2.4. Forecasting Portfolio Value-at-Risk Consists of Stock, Bond and Foreign Exchange

Research on modelling and forecasting VaR can be viewed from, at least, three points of views, namely the method to forecast, the test to evaluate the forecast, and the assets that construct the portfolio.

Regarding the method to calculate and forecast VaR thresholds, the J.P. Morgan (1996) develops the RiskMetricsTM. While it is simple, it does not incorporate some characteristic in financial assets, such as heavy tail and interactions across assets. A plethora of papers offer methods incorporating such characteristics. Following Manganelli and Engle (2004) and Taylor (2008), VaR methods can be classified into three categories: parametric, semiparametric, and nonparametric. Parametric approaches involve parameterization of the time-varying stochastic behavior of financial prices. Conditional quantile forecasts are constructed from a conditional volatility forecast and a distributional assumption. Typically, exponential smoothing, GARCH and SV models are used to forecast the volatility, assuming normal or t distributions. Semiparametric VaR approaches include those based on extreme value analysis, such as the method of McNeil and Frey (2000) and those based on the use of quantile regression, such as the conditional autoregressive value at risk (CaViaR) model of Engle and Manganelli (2004). Belongs the group of nonparametric VaR is historical simulation (HS), which estimate VaR as the quantile of the empirical distribution of the returns in a moving

window of the most recent periods. To overcome the drawback in RiskMetricsTM, J.P. Morgan (2006) develops the new version of RiskMetricsTM, called RM2006. However, all papers cited in this thesis apply the 1996 version of RiskMetricsTM.

Despite the shortcoming, abundant of papers estimates the 1996 version of RiskMetricsTM - EWMA to calculate VaR thresholds. Many papers apply the methods on stock markets, namely Billio and Pelizzon (2000), Guermat and Harris (2002), Brooks and Persaud (2003a), Gonzales-Rivera et al. (2004), Allen et al. (2006), Bao et al. (2006), Chiu et al. (2006), Lin et al. (2006), Wu et al. (2006), Yao et al. (2006), Chen, Liu and So (2008), McAleer and Da Veiga (2008b), and Taniai and Taniguchi (2008). The application on foreign exchange markets has been done by Christoffersen (1998), Chong (2005), Chen et al. (2007), and Ku and Wang (2008). The application on the mixture of assets has been conducted by various papers such as Berkowitz and O'Brien (2002) on stocks, interest rates, and foreign exchange rates, by Brooks and Persaud (2002 and 2003b) on bonds, stocks and commodities, and Skintzi and Sisinis (2007) on bond, stock and currency.

Those papers find that the RiskMetricsTM is outperformed by other methods in most application, mostly by parametric and semiparametric methods. However, the method passes some tests in Christoffersen (1998), performs better in some assets in Chong (2005), and performs well in Bao et al. (2006). Guermat and Harris (2002) develop Exponentially Weighted Moving Likelihood that nests RiskMetricsTM - EWMA, and find that the propose model outperforms both the RiskMetricsTM - EWMA and GARCH models in providing VaR forecasts. Assuming generalized error distribution (GED) on RiskMetricsTM - EWMA model, Lin et al. (2006) report that the approach offers substantial improvements on the accuracy of VaR forecasts. The evaluation is carried out using Kupiec (1995) tests and failure ratios.

So far, the most popular parametric methods to forecast VaR have been GARCH and Stochastic Volatility (SV) family models. Univariate GARCH family models have been applied by several authors to model and forecast VaR. Most papers support the usefulness of the models in forecasting VaR, except Wong et al. (2003). The application on stock markets has been done by Billio and Pelizzon (2000), Brooks and Persaud (2003a), Wong et al. (2003), Angelidis et al. (2004), Gonzales-Rivera et al. (2004), Li and Lin (2004), Chiu et al. (2006), Yao et al. (2006), Zhang and Huang (2006), Bali and Theodossiou (2007), Tag (2007), Bhattacharyya et al. (2008), Chen, Liu and So (2008), and McAleer and Da Veiga (2008b). The application on foreign exchange rates has been done by Cheong (2008), Chong (2005), Chen et al. (2007), and Ku and Wang (2008). Other papers apply the models to the mixture of assets such as bond and stock markets (see Brooks and Persaud (2002, 2003b), and Brooks et al. (2005)), stock and foreign exchange (see Hartz et al. (2006)), and bond, stock and foreign exchange markets (see Berkowitz and O'Brien (2002)).

Some papers suggest that the EGARCH model of Nelson (1991) performs the best among univariate GARCH family models, such as Angelidis and Benos (2004), Bali and Theodossiou (2007). It is also found that assuming other than normal distributions offers better VaR forecast (see Angelidis et al. (2004), Bali and Theodossiou (2007), and Bhattacharyya et al. (2008), among others). Hartz et al. (2006), using a resampling method based on the bootstrap bias-correction step for GARCH model, provides better forecast than normal GARCH. Gao and Song (2008) find better results by deriving the limiting distributions of the GARCH model by the filtered historical simulation (FHS) method.

Comparing univariate GARCH family methods with other models provides mixture results. They generally outperform the RiskMetricsTM models (see Berkowitz and O'Brien (2002), Gonzales-Rivera et al. (2004), Yao et al. (2006), Ku and Wang

(2008), and Taniai and Taniguchi (2008)). However, they are outperformed by SV family models (Billio and Pelizzon (2000), Gonzales-Rivera et al. (2004)), and Chen, Liu and So (2008), the EVT model (Brooks and Persaud (2002) and Brooks et al. (2005)), semi variance model (Brooks and Persaud (2003a)), the long-term mean and the linear regression in volatility (Brooks and Persaud (2003b)), the Independent Component Analysis VaR (Chen et al. (2007)), and the more general Markov Switching (SWARCH) models (Li and Lin (2004)). Some authors suggest that univariate GARCH family models can not outperform their multivariate counterparts such as Brooks and Persaud (2003a and 2003b), and Ku and Wang (2008). However, a few papers can not conclude which one of the two family models performs the best, such as Chong (2005) and McAleer and Da Veiga (2008b).

Among the well known multivariate GARCH family models in the literature are the VEC model of Bollerslev et al. (1988), the CCC model of Bollerslev (1990), the BEKK model of Engle and Kroner (1995), the VARMA-GARCH of Ling and McAleer (2003), the VARMA-AGARCH model of McAleer, Hoti and Chan (2008), the DCC model of Engle (2002), the VCC model of Tse and Tsui (2002), and the GARCC model of McAleer et al. (2008).

In forecasting VaR thresholds, the VEC model has been applied by Ferreira (2005), and the CCC model has been applied by Ferreira (2005), Ku and Wang (2008), McAleer and da Veiga (2008a), and Da Veiga, Chan and McAleer (2008a). The BEKK model has been applied by Ferreira (2005) and Ku and Wang (2008). Skintzi and Sisinis (2007) apply Diagonal BEKK while Caporin and McAleer (2008) develop the scalar BEKK model. The VARMA-GARCH model has been applied by McAleer and Da Veiga (2008a,b). The VARMA-AGARCH model has been applied by Allen et al. (2006) and Da Veiga, Chan and McAleer (2008b). The DCC model has been applied by

Wu et al. (2006), Skintzi and Sisinis (2007), Caporin and McAleer (2008), Ku and Wang (2008), and Da Veiga, Chan and McAleer (2008a).

Some new multivariate GARCH models have recently been developed, and have been applied to forecast VaR thresholds. McAleer and Da Veiga (2008a) propose a portfolio spillover (PS)-GARCH model. The model has been used to forecast VaR by Allen et al. (2006) and McAleer and da Veiga (2008b). McAleer and Da Veiga (2008b) propose Single-Index and Portfolio methods. Applying on various univariate and multivariate GARCH family models, they find that single-index type models led to lower capital charges based on the Basel Capital Accord penalties, as compared to their portfolio type counterparts. Asai and McAleer (2008) propose a new Portfolio Index (PI) GARCH model and the asymmetric counterpart. An empirical example showed the benefits of the asymmetric PI-GARCH model for the purpose of forecasting VaR thresholds. Asai, McAleer and Da Veiga (2008) propose Portfolio Single Index (PSI) Multivariate Conditional and stochastic volatility models (PSI-MSV), an approach that incorporates volatility spillover effects parsimoniously. This model can be used for more accurate portfolio risk management, to enable efficient forecasting of VaR. Brooks and Persaud (2003a) apply the multivariate versions of GARCH, GJR and EGARCH models. Ferreira (2005) proposes the generalized version of asymmetric dynamic covariance of Kroner and Ng (1998). Wu et al. (2006) propose independent component analysis (ICA) to decompose multivariate time series into statistically independent time series.

Comparing performance across multivariate GARCH models in forecasting VaR is not easy, as there are quite number of models, types of testing criteria, distributions, and assets to be investigated. However, several papers made some suggestions. Allen et al. (2006) suggest that the PS-GARCH outperforms VARMA-AGARCH and Portfolio-GARCH models. Brooks and Persaud (2003a) suggest that multivariate version of

EGARCH model outperforms multivariate GJR and multivariate GARCH models. Caporin and McAleer (2008) find that the Scalar BEKK and the DCC models have similar performance. Ferreira (2005) suggests that GDC-type models (generalized version of asymmetric dynamic covariance of Kroner and Ng (1998)) outperform the CCC model, while the VEC and BEKK models provide similar forecast. Ku and Wang (2008) find that the DCC model outperforms the GARCH, CCC, EWMA, and BEKK models. McAleer and da Veiga (2008a) find that the VARMA-GARCH, PS-GARCH, and CCC models provide similar VaR forecasts. McAleer and da Veiga (2008b) find that single-index type models perform better as compared to their portfolio-type counterparts. Da Veiga, Chan and McAleer (2008a) find that the DCC model dominates the CCC model according to the UC tests. Wu et al. (2006) find that the independent component analysis (ICA)-GARCH models are more effective than the DCC, PCA-GARCH and EWMA models.

Another famous parametric approach to VaR is the Stochastic Volatility (SV) family model. The models describe the volatility evolution of a financial time series by introducing innovation to the conditional variance equation (see Tsay (2000)). The models have been used to forecast VaR by several authors.

Berkowitz (2001) apply the SV model to compare a new approach to test VaR with other backtest tests. Sadorsky (2005) uses range-based SV model to forecast VaR in stock, bond and foreign exchange markets. The model fails the UC and CC tests. Raggi and Bordignon (2006) apply various types of SV models on stock markets and the APARCH model of Ding et al. (1993). The models are the SV of Hull and White (1987), SV of Heston (1993), SV with jump component of Bates (1996), and contemporaneous Jump SV (DPS) of Duffie et al. (2000). The out of sample results show that DPS- t and the APARCH models work properly with a coverage level of 99%. Asai, McAleer and Da Veiga (2008) propose a portfolio single index multivariate

conditional and stochastic volatility (PSI-MSV) model and state that the model can be used for more accurate portfolio risk management, to enable efficient forecasting of VaR. Chen, Liu and So (2008) generalize the thresholds stochastic volatility (THSV) model and incorporate heavy-tailed distribution. Applying on stock markets, they find the the proposed model generate more accurate VaR forecasts than RiskMetricsTM, AR-GARCH- n and AR-GARCH- t models.

Among the semiparametric application of VaR methods, the EVT and Quantile Regression approaches are the most popular. The application of the EVT model in VaR forecast is motivated by the fact that assets with the same volatility may exhibit different behavior in terms of their extremes. Volatility refers to the variance of a random variable, while extremes are a characteristic of the tails only (Nefci (2000)). As VaR is value in the tail area, it might be more appropriate to model the extreme value to estimate the VaR thresholds. The EVT model has been used to calculate and forecast VaR by several authors. The application on stock markets has been done by Longin (2000), Bao et al. (2006), Lin and Shen (2006), and Angelidis et al. (2007), while the application on bond has been done by Bali (2003). The application on the mixture of assets has been done by Bali (2007) on bond, stock and foreign exchange rates, Brooks and Persaud (2002) on bond, stock and commodities, Brooks et al. (2005) on futures of stocks, bonds and interest rates, and Nefci (2000) on foreign exchange rates, bond and interest rates.

In most cases, the EVT outperforms any other models in the comparisons, except in Brooks and Persaud (2002) where the EVT is outperformed by the quantile method, and in Lin and Shen (2006) where the EVT performs well but does not outperform the other models in the investigation.

Another famous semiparametric VaR method, those based on the quantile regressions (QR), has been applied by Cheong (2008) on stock markets. Comparing

with parametric long-memory ARCH assuming Gaussian and student- t distributions and a Power-law Pareto distribution, he finds that the quantile estimation provides relatively large losses. Engle and Manganelli (2004) propose a CaViaR model that estimate VaR by modeling the quantile directly. Applying the model to stock markets, they illustrate the ability of the model to adapt to new risk environments. The model has been applied by Bao et al. (2006) who apply the model to forecast VaR to stock markets. They find that the model showed some success in predicting the VaR risk measure for various periods, generally more stable than those that invert a distribution function.

Belong to the nonparametric VaR method is the historical simulation (HS) models. Application on stock markets has been done by several papers. Longin (2000) finds that in most cases, the EVT gives similar results to the historical method and always perform better than the variance-covariance method. Chong (2005) applies the model to foreign exchange rates. The results are inconclusive in that a group of models perform the best in a portfolio, but not on the others. Zhang and Huang (2006) find that the HS model can not outperform the proposed model, namely the combination of max-stable, GARCH and Markov processes, while Angelidis et al. (2007) find that the HS model cannot outperform semiparametric model (Filtered Historical Simulation and Extreme Value Theory),

Regarding the test for VaR evaluation, the earlier test version is the backtesting approach under the Basel Accord, where the regulators verify the performances of the internal model in the last 250 days (see Basel Committee on Banking Supervision (1996)). The test has been applied in empirical works by various papers such as Brooks and Persaud (2002), Brooks and Persaud (2003a), Wong et al. (2003), Brooks et al. (2005), Allen et al. (2006), and McAleer and Da Veiga (2008a,b).

As the test may lead to the application of a model that fulfills the requirement of Basel Accord but translates into a bigger cost, various new tests have been developed. Following Caporin (2008), VaR evaluation can be categorized into two approaches, (1) the statistical hypothesis testing and (2) comparison of loss function. Belong to the first approach are the proportion failure test (or unconditional coverage (UC) test) of Kupiec and Christoffersen (1998), Time Until the First Failure (TUFF) test of Kupiec (1995), conditional coverage (CC) test of Christoffersen (1998), CC test of Lopez (1999), GMM based approach of Christoffersen et al. (2001), and density forecast test of Berkowitz test (2001). Belongs to the second approach is the loss function test criteria of Lopez (1999). Lopez (1999) stated that statistical hypothesis tests have low power against the alternatives. Loss functions could be used to make an alternative comparison approach. In fact, despite loss functions should be preferred, the UC, ID, CC and TUFF tests are becoming a benchmark in any case.

The proportion failure test (or UC test) of Kupiec (1995) has been applied by various papers such as Billio and Pelizzon (2000), Berkowitz and O'Brien (2002), Guermat and Harris (2002), Brooks and Persaud (2003b), Angelidis et al. (2004), Li and Lin (2004), Chiu et al. (2006), Hartz et al. (2006), Li and Shen (2006), Lin et al. (2006), Bali (2007), Angelidis et al. (2007), Bali and Theodossiou (2007), Tag (2007), Asai and McAleer (2008), Bhattacharyya et al. (2008), Brownless and Gallo (2008), Chen, Liu and So (2008), Ku and Wang (2008), Kozaki and Sato (2008), McAleer and Da Veiga (2008b), Da Veiga, Chan and McAleer (2008a), and Yao et al. (2006).

The time until the first failure (TUFF) test of Kupiec (1995) has been applied by several papers such as Billio and Pelizzon (2000), Brooks and Persaud (2003b), and Da Veiga, Chan and McAleer (2008a).

Conditional coverage (CC) test of Christoffersen (1998) and Lopez (1999) have been applied by various paper such as Berkowitz and O'Brien (2002), Guermat and

Harris (2002), Angelidis et al. (2004), Chiu et al. (2006), Hartz et al. (2006), Raggi and Bordignon (2006), Yao et al. (2006), Bali (2007), Tag (2007), Brownless and Gallo (2008), McAleer and Da Veiga (2008b), and Da Veiga, Chan and McAleer (2008a).

The GMM based approach of Christoffersen et al. (2001) has been applied by Christoffersen et al. (2001) and Yao et al. (2006).

Various new statistical test have been developed in the literature. The Duration-based-test, density test and density tail backtesting by Christoffersen and Pelletier (2004) have been applied by Raggi and Bordignon (2006). Hansen's (2005) superior predictive ability (SPA) hypothesis testing, allows to conduct multiple comparison of the forecasting performance of a benchmark model against its competitors, has been applied by Angelidis et al. (2007). The Dynamic Quantile (DC) test of Engle and Manganelli (2004) has been applied by Ferreira (2005), and the novel Logit-based test for predictability of violations of Da Veiga et al. (2005).

The loss function of Lopez (1999) has been applied by Angelidis et al. (2004), Yao et al. (2006), and Angelidis et al. (2007). Several papers use various types of loss function such as Chong (2005) which uses asymmetric loss function, Ferreira (2005) and Gonzales-Rivera et al. (2004) which uses economic loss function, Caporin and McAleer (2008) which use regulator's loss function,.

The literature on VaR forecast in emerging markets is currently limited. Most of the available papers focus on stock markets. As in the previous section, the literature on VaR forecast in emerging markets will be classified regarding the estimated models.

The RiskMetricsTM - EWMA for calculating VaR thresholds has been applied by Bao et al. (2006), Chiu et al. (2006), Lin et al. (2006), and Yao et al. (2006). They suggest that the EWMA model cannot outperform GARCH family models. However, Bao et al finds that EWMA performs reasonably well in tranquil periods. In addition, Lin et al. (1995), assuming generalized error distribution, show that EWMA offers

substantial improvements on capturing returns distributions, and can significantly enhance the estimation accuracy of portfolio VaR.

The most popular parametric methods to forecast VaR, namely GARCH family models, have been used by some papers. Univariate GARCH family models have been applied by Chiu et al. (2006), Yao et al. (2006), Bhattacharyya et al. (2008) and Cheong (2008). As in the previous paragraph, the univariate GARCH models outperform EWMA. In addition, Bhattacharyya et al. (2008) find that assuming Pearson's Type IV distribution is a much better fit as compared to normal distribution on the standardized residuals obtained from the GARCH models of log returns. However, Cheong (2008) find that The predicted VaR under the Pareto distribution and long-memory ARCH are the same.

Multivariate GARCH models have been used to forecast VaR in emerging markets by Da Veiga, Chan and McAleer (2008a,b). Using VARMA-AGARCH model of McAleer, Hoti and Chan (2008), Da Veiga, Chan and McAleer (2008b) find that adjusting for the structural change may not be overly important. Da Veiga, Chan and McAleer (2008a) find that the DCC models perform better than the CCC model. So far, there is no papers estimate Stochastic Volatility family models to forecast VaR in emerging markets.

Among the semiparametric application of VaR methods, the EVT and Quantile Regression approaches are the most popular. Engle and Manganelli (2004) propose a CaViaR model that estimate VaR by modeling the quantile directly. Bao et al. (2006) apply the EVT and CaViaR model on Asian stock markets, namely Indonesia, Korea, Malaysia, Taiwan, and Thailand. They find that the EVT-based models do better in the crisis period. They also find that the CaViaR quantile regression models of Engle and Manganelli (2004) have shown some success in predicting the VaR risk measure for various periods, generally more stable than those that invert a distribution function.

Belongs to the nonparametric models for calculating VaR is the historical simulation (HS) model. Bao et al. apply the model to forecast VaR in Asian stock markets. They find that the HS model can not outperform the other parametric models, namely the EVT-based models and the CaViaR models. Cheong (2008) applies nonparametric quantile estimation to forecast VaR of Malaysian stock markets. He finds that the nonparametric method cannot outperform ARCH type models.

Regarding the test to evaluate the VaR forecasts, most papers use unconditional and conditional coverage, and also the TUFF tests. Unconditional coverage has been used by Chiu et al. (2006), Lin et al. (2006), Yao et al. (2006) and Da Veiga, Chan and McAleer (2008a). Conditional coverage has been used by Chiu et al. (2006), Yao et al. (2006) and Da Veiga, Chan and McAleer (2008a). The TUFF test has been used by Da Veiga, Chan and McAleer (2008a).

Spot, forwards and futures prices of financial assets have been investigated over an extended period. The investigation ranges from the impact of the futures trading on the volatility of the underlying assets (such as Antoniou and Holmes (1995), Hung et al. (2003)), alternative pricing models (Sequeira et al. (1999), Zhong et al. (2004)), and the effectiveness of hedging spot markets using the corresponding futures markets (Baillie and Myers (1991), Lien et al. (2002)).

Another important topic is the interdependence between futures contract and their underlying spot assets, which has been investigated using various GARCH family models. Most papers in the literature investigate stock, currency and commodity markets. They find evidence of volatility spillovers from futures to spot markets (Koutmos and Tucker (1996), Gannon and Choi (1998)), and from spot(futures) to futures(spot) (Gannon and Yeung (2004), Manera et al. (2006)). The results of the investigations on conditional correlations are inconclusive; Koutmos and Tucker (1996) find that the conditional correlations between futures and their underlying spot assets

are constant, while Lien and Yang (2006) and Manera et al. (2006) find that the conditional correlations are time-varying.

There are several issues in forecasting VaR regarding futures markets, such as the impact of hedging on VaR and the impact of futures trading on VaR. Harris and Shen (2006) investigate the impact of minimizing variance of hedging on Conditional VaR and VaR. They find that although minimum-variance hedging unambiguously reduces the standard deviation of portfolio returns, it can increase both left skewness and kurtosis. As the result, the effectiveness of hedging in terms of VaR and CVaR is uncertain. Illueca and Lafuente (2007) investigate the impact of futures trading on the underlying stock index in Spain. They find that the unexpected futures trading increases the Conditional VaR of spot returns. Lee and Locke (2006) investigate the speculative trader's strategies. Using futures floor trader's proprietary trading data, they find that floor trader VaR can be predicted somewhat, using simple market variables such as volume and volatility.

Chapter 3

Interactions Across International Stock, Bond and Foreign Exchange Markets

This chapter investigates the interactions between international stock, bond and foreign exchange rates for both developed and emerging markets using various multivariate GARCH models. As stated in the introduction, this chapter estimates the VARMA-AGARCH model to analyse the volatility spillovers across financial markets. Sections 3.1 and 3.2 consider developed and emerging markets, respectively.

3.1. Interactions Across Developed Markets

This section considers developed markets, namely Australia, Japan, New Zealand, Singapore and the USA. The data used in this chapter are the daily closing price index of bond, stock, and foreign exchange rates from those countries. The bond, stock and foreign exchange returns and their variable names are summarized in Table 3-1. All the data are obtained from DataStream database services. The sample ranges from 30/9/1998 to 12/5/2006, with 1,986 observations for each index and foreign exchange rates. The starting date was chosen to be 30/9/1998 to exclude the effects of the 1997 Asian economic and financial crises, and because the Singaporean bond data are relatively constant before the starting date.

The returns of market i at time t are calculated as follows:

$$R_{i,t} = \log(P_{i,t} / P_{i,t-1}), \quad (3.1)$$

where $P_{i,t}$ and $P_{i,t-1}$ are the closing prices of stock i at days t and $t-1$, respectively. In terms of foreign exchange returns, $P_{i,t}$ and $P_{i,t-1}$ are the exchange rates of country i at days t and $t-1$, respectively. Each stock and bond price index is denominated in the local currency. The volatility of returns is calculated as $Vol_{i,t} = [R_{i,t} - E(R_{i,t})]^2$, where $E(R_{i,t})$ is the expected return at time t .

The plots of the daily returns for the 20 series are given in Figures 3-1 to 3-20 in Appendix 3-3. The figures show that the mean returns are constant but the variances change over time, with large (small) changes tending to be followed by large (small) changes of either sign. This 'stylized fact' seems appropriate to be modelled using Engle's (1982) ARCH and Bollerslev's (1986) GARCH models.

Table 3-1: Summary of Variable Names, Developed Markets

No	Variable	Index Names	Variable Names
1	Australian Bond	AU Benchmark 10 Year Govt. Index	AUSBOND
2	Japanese Bond	JP Benchmark 10 Year Govt. Index	JAPBOND
3	New Zealand Bond	NZ Benchmark 10 Year Govt. Index	NZBOND
4	Singaporean Bond	Sg Gov. Bond Long Term Index	SGBOND
5	US Bond	US Benchmark 10 Year Govt. Index	USBOND
6	Australian Stock	S&P ASX 200 Price Index	AUSSTOCK
7	Japanese Stock	Nikkei 225 Stock Average Price Index	JAPSTOCK
8	New Zealand stock	NZX ALL Price Index	NZSTOCK
9	Singaporean Stock	Singapore Straits Time Price Index	SGSTOCK
10	US Stock	S&P 500 Composite Price Index	USSTOCK
11	Exchange Rates	AUD/JPY	AUDJPY
12	Exchange Rates	AUD/NZD	AUDNZD
13	Exchange Rates	AUD/SGD	AUDSGD
14	Exchange Rates	NZD/JPY	NZDJPY
15	Exchange Rates	SGD/JPY	SGDJPY
16	Exchange Rates	SGD/NZD	SGDNZD
17	Exchange Rates	USD/AUD	USDAUD
18	Exchange Rates	USD/JPY	USDJPY
19	Exchange Rates	USD/NZD	USDNZD
20	Exchange Rates	USD/SGD	USDSGD

Note: ER = Exchange Rates.

Table 3-2 displays some descriptive statistics for the daily returns for all assets. All markets are restricted to have five trading days per week. Among the 20 series, the highest and the lowest average returns are Sgstock and Usdaud, respectively, while the highest and the lowest standard deviation are Japstock and Sgbond, respectively.

The statistics for skewness reveal that the underlying distributions for returns seem to be negatively skewed in most cases. This implies that the number of negative outliers is greater than the number of positive outliers in most cases. This is consistent with the return figures in Figure 3-1 to 3-20. In addition, the statistics for kurtosis are greater than 3 in all cases, indicating that the probability of observing outliers and extreme observations in returns is greater than any random variable that follows a standard normal distribution.

Given the statistics for skewness and kurtosis, it is perhaps not surprising to find that the Jarque-Bera (J-B) Lagrange multiplier test statistics strongly reject the assumption of normality for the distributions of returns in all cases.

Table 3-2: Descriptive Statistic, Jarque-Bera and Its Probability for the Returns, Developed Markets

No	Series	Mean	Std. Dev.	Skewness	Kurtosis	Jarque Bera	Probability
1	AUSBOND	-0.004	0.458	-0.178	4.470	189.429	0
2	JAPBOND	-0.002	0.317	-0.892	10.332	4716.438	0
3	NZBOND	-0.001	0.378	-0.243	4.262	151.497	0
4	SGBOND	0.020	0.257	-0.835	22.007	30154.97	0
5	USBOND	-0.005	0.455	-0.321	4.189	151.335	0
6	AUSSTOCK	0.037	0.710	-0.534	7.026	1437.349	0
7	JAPSTOCK	0.009	1.390	-0.073	4.981	326.956	0
8	NZSTOCK	0.030	0.731	-0.376	7.109	1445.332	0
9	SGSTOCK	0.047	1.171	-0.115	6.994	1325.532	0
10	USSTOCK	0.010	1.147	0.098	5.199	403.668	0
11	AUDJPY	0.003	0.796	-0.382	5.948	768.319	0
12	AUDNZD	0.002	0.420	0.246	5.319	465.702	0
13	AUSGD	0.010	0.649	-0.168	4.995	339.145	0
14	NZDJPY	0.001	0.827	-0.417	4.774	318.150	0
15	SGDJPY	-0.007	0.535	-0.760	10.130	4402.535	0
16	SGDNZD	0.008	0.878	0.088	64.273	310994.8	0
17	USDAUD	-0.013	0.696	0.221	4.672	247.621	0
18	USDJPY	-0.010	0.665	-0.847	13.801	9902.047	0
19	USDNZD	-0.011	0.744	0.232	4.623	236.154	0
20	USDSGD	-0.003	0.291	-0.321	8.514	2552.310	0

Stationarity is an important characteristic for time series data. If a time series is nonstationary, the underlying processes will be explosive so that the cointegration method should be used. Moreover, the conditional mean model may be inadequate for forecasting purposes. This section presents both the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests to examine the stationarity of the return series. Both tests include a drift and a trend.

The motivation for using the PP test is to accommodate the possible presence of ARCH or GARCH errors. While the ADF test accommodates serial correlation by specifying explicitly the structure of serial correlation in the errors, the PP test does not assume the specific type of serial correlation or heteroscedasticity in the disturbances, and can have higher power than the ADF test under a wide range of circumstances (for further details, see Phillips and Perron (1988)).

Table 3-3: ADF Test of a Unit Root in the Returns, Developed Markets

No	Variable Names	Delta	t-statistic	Critical Value(1%)	Probability
1	AUSBOND	-1.0276	-45.8023	-3.96	0
2	JAPBOND	-0.9893	-44.0918	-3.96	0
3	NZBOND	-1.0354	-46.1477	-3.96	0
4	SGBOND	-0.9735	-43.8456	-3.96	0
5	USBOND	-0.9510	-42.4695	-3.96	0
6	AUSSTOCK	-1.0193	-45.4151	-3.96	0
7	JAPSTOCK	-1.0333	-46.0874	-3.96	0
8	NZSTOCK	-0.9503	-42.3883	-3.96	0
9	SGSTOCK	-0.9611	-42.8456	-3.96	0
10	USSTOCK	-1.0183	-45.4378	-3.96	0
11	AUDJPY	-1.0171	-45.3085	-3.96	0
12	AUDNZD	-1.0016	-44.5813	-3.96	0
13	AUDSGD	-1.0796	-48.2386	-3.96	0
14	NZDJPY	-0.9815	-43.7179	-3.96	0
15	SGDJPY	-0.9229	-41.2164	-3.96	0
16	SGDNZD	-1.3534	-41.4816	-3.96	0
17	USDAUD	-1.0308	-45.9233	-3.96	0
18	USDJPY	-0.9818	-43.7941	-3.96	0
19	USDNZD	-0.9955	-44.3424	-3.96	0
20	USDSGD	-1.0393	-46.3969	-3.96	0

Note: All estimates of δ are significantly less than 0 at the 1% level.

This thesis applies Schwarz Information Criteria, automatic selection menu in EViews, to select the lag length parameter in ADF test. This automatic selection resulted in zero lag length for all series, except for Sgdnzd which has 1 lag length. This indicates that the serial correlation in return is not high. The PP test applies automatic bandwidth selection, resulted various bandwidth from 1 to 21.

As shown in Tables 3-3 and 3-4, both ADF and PP test for non-stationarity strongly reject the null of unit root. Therefore, all returns series are stationary.

Table 3-4: Phillips-Perron Test of a Unit Root, Developed Markets

No	Variable	Delta	t-statistik	Critical Value(1%)	Probability
1	AUSBOND	-1.028	-45.867	-3.96	0
2	JAPBOND	-0.989	-44.108	-3.96	0
3	NZBOND	-1.035	-46.304	-3.96	0
4	SGBOND	-0.973	-43.846	-3.96	0
5	USBOND	-0.951	-42.456	-3.96	0
6	AUSSTOCK	-1.019	-45.425	-3.96	0
7	JAPSTOCK	-1.033	-46.089	-3.96	0
8	NZSTOCK	-0.950	-42.391	-3.96	0
9	SGSTOCK	-0.961	-42.943	-3.96	0
10	USSTOCK	-1.018	-45.746	-3.96	0
11	AUDJPY	-1.017	-45.305	-3.96	0
12	AUDNZD	-1.002	-44.586	-3.96	0
13	AUDSGD	-1.080	-48.317	-3.96	0
14	NZDJPY	-0.982	-43.710	-3.96	0
15	SGDNZD	-1.109	-51.302	-3.96	0
16	SGDJPY	-0.923	-41.189	-3.96	0
17	USDAUD	-1.031	-45.930	-3.96	0
18	USDJPY	-0.982	-43.839	-3.96	0
19	USDNZD	-0.995	-44.362	-3.96	0
20	USDSGD	-1.039	-46.357	-3.96	0

To see whether the conditional variances of the stock and foreign exchange returns follow the GARCH process, univariate AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) models will be estimated. If the properties of the univariate models are satisfied, then it would be sensible to extend the models to their multivariate counterparts. The lag length of 1 in autoregressive for both AR-GARCH and AR-GJR models are justified using Schwarz Information Criterion. This criterion suggests increasing SIC statistic on investigations up to lag 5, except in AR-GJR model for Sgdznd.

The estimated parameters for the AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) models are given in Tables 3-5 and 3-6, respectively. From both tables, it is clear that not all returns follow an AR(1) process. This may be interpreted as the returns possibly being determined by other variables, such as spillovers from other markets, while displaying GARCH volatility behaviour. From Table 3-5, the ARCH(1) term is

significant for all returns, with SGBOND returns significant in 10% level. From Table 3-6, the SGBOND, AUSSTOCK and SGD NZD show only weak evidence of ARCH effect, but all show GARCH effect. It can be concluded that all series exhibit time-varying conditional volatility, which can be successfully modelled using the GARCH(1,1) or GJR(1,1) models. Asymmetric behaviour is found to be significant for NZBOND, AUSSTOCK, JAPSTOCK, USSTOCK and USD NZD. This provides the motivation to use models that incorporate asymmetric effect of negative and positive shocks on conditional variance.

In order to check the structural properties of the univariate models, the second moment and log-moment conditions are evaluated for both the AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) models (see chapter 2). Table 3-7 provides the results of the second moment and log-moment conditions for the GARCH(1,1) and GJR(1,1) models for all returns series.

Regarding the regularity conditions of the AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) models, both the second moment and log-moment conditions are satisfied for all returns, which suggest that the empirical estimates are statistically valid for these series. Thus, the AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) models successfully model the conditional volatility in each of the series.

Table 3-5: Univariate AR(1)-GARCH(1,1) Estimates, Developed Markets

No	Series	C	AR(1)	ω	α	β
1	AUSBOND	0.000	-0.015	0.000	0.014	0.984
		-0.296	-0.683	0.367	3.209	193.508
2	JAPBOND	0.000	0.009	0.000	0.107	0.884
		1.676	0.375	1.630	4.608	47.389
3	NZBOND	0.000	-0.010	0.000	0.030	0.965
		0.414	-0.421	0.854	4.810	143.104
4	SGBOND	2.5E-04	0.126	0.000	0.154	0.801
		4.863	4.430	2.069	1.673	13.263
5	USBOND	0.000	0.043	0.000	0.036	0.952
		-0.662	1.854	1.551	4.464	96.602
6	AUSSTOCK	0.001	0.000	1.0E-06	0.071	0.910
		4.128	0.013	3.667	3.895	52.108
7	JAPSTOCK	0.000	-0.001	2.9E-06	0.070	0.916
		1.644	-0.037	2.694	4.805	56.328
8	NZSTOCK	3.5E-04	0.071	7.0E-07	0.071	0.916
		2.430	2.738	3.115	3.677	47.600
9	SGSTOCK	0.001	0.032	7.4E-07	0.074	0.923
		3.485	1.271	2.511	4.510	62.112
10	USSTOCK	0.000	-0.031	6.0E-07	0.055	0.941
		1.424	-1.356	2.445	5.186	91.507
11	AUDJPY	0.000	0.013	5.0E-07	0.044	0.948
		1.174	0.546	3.385	4.571	99.048
12	AUDNZD	0.000	0.020	3.9E-07	0.040	0.937
		-0.340	0.768	2.108	4.092	74.252
13	AUDSGD	0.000	-0.047	2.9E-07	0.038	0.955
		0.963	-2.136	1.967	5.427	123.189
14	NZDJPY	0.000	0.031	6.6E-07	0.047	0.943
		1.154	1.248	2.350	3.332	58.768
15	SGDJPY	0.000	0.010	4.2E-07	0.045	0.937
		0.417	0.420	3.590	4.732	96.244
16	SGDNZD	0.000	-0.035	1.1E-05	0.099	0.719
		0.822	-1.426	2.579	3.224	12.936
17	USDAUD	0.000	-0.023	5.9E-07	0.037	0.950
		-1.303	-1.062	2.967	4.684	94.868
18	USDJPY	0.000	-0.023	7.0E-07	0.017	0.963
		-0.256	-0.997	4.200	3.028	131.298
19	USDNZD	0.000	0.008	2.3E-06	0.034	0.923
		-1.132	0.313	2.203	2.976	35.000
20	USDSGD	0.000	-0.024	0.000	0.032	0.947
		-1.007	-0.972	1.359	4.158	69.660

Notes:

1. Two entries for each parameter are their respective estimate and the Bollerslev-Wooldridge (1992) robust *t*-ratio.
2. C and AR(1) denote the constant and the own one-period lagged returns.
3. Entries in **bold** are significant at the 5% level.

Table 3-6: Univariate AR(1)-GJR(1,1) Estimates, Developed Markets

No	Series	C	AR(1)	ω	α	γ	β
1	AUSBOND	0.000	-0.015	0.000	0.016	-0.003	0.984
		-0.267	-0.688	0.331	2.256	-0.371	182.144
2	JAPBOND	0.000	0.018	1.7E-07	0.067	0.073	0.879
		0.974	0.712	2.252	2.036	1.782	44.696
3	NZBOND	0.000	-0.008	0.000	0.043	-0.026	0.968
		0.814	-0.334	0.510	4.160	-2.143	160.083
4	SGBOND	2.4E-04	0.128	0.000	0.149	0.011	0.800
		5.454	4.104	0.759	1.213	0.090	5.579
5	USBOND	0.000	0.041	0.000	0.043	-0.015	0.955
		-0.479	1.793	1.588	3.277	-0.940	102.816
6	AUSSTOCK	3.7E-04	0.001	1.1E-06	0.002	0.116	0.916
		2.660	0.029	4.793	0.100	4.508	61.792
7	JAPSTOCK	0.000	0.002	3.7E-06	0.040	0.064	0.909
		0.937	0.071	3.211	2.097	2.591	52.600
8	NZSTOCK	3.1E-04	0.071	6.8E-07	0.055	0.025	0.919
		2.122	2.758	3.331	3.426	0.982	54.308
9	SGSTOCK	0.001	0.035	7.7E-07	0.055	0.036	0.924
		2.852	1.338	2.511	3.040	1.501	67.431
10	USSTOCK	0.000	-0.022	7.5E-07	-0.017	0.118	0.953
		-0.509	-1.027	4.248	-1.723	6.145	118.355
11	AUDJPY	0.000	0.013	5.0E-07	0.044	-0.001	0.948
		1.181	0.533	2.728	2.785	-0.073	91.490
12	AUDNZD	0.000	0.023	0.000	0.047	-0.023	0.940
		-0.092	0.892	2.223	3.520	-1.203	69.244
13	AUDSGD	0.000	-0.046	3.0E-07	0.031	0.012	0.955
		0.822	-2.060	2.226	3.017	1.004	134.115
14	NZDJPY	0.000	0.030	6.3E-07	0.049	-0.004	0.944
		1.175	1.240	2.237	2.742	-0.194	60.469
15	SGDJPY	0.000	0.011	4.7E-07	0.041	0.010	0.934
		0.338	0.458	3.840	3.250	0.560	82.183
16	SGDNZD	0.000	-0.028	0.000	0.037	0.192	0.583
		0.413	-0.959	1.682	0.883	1.568	3.527
17	USDAUD	0.000	-0.023	6.3E-07	0.040	-0.007	0.950
		-1.214	-1.037	2.861	4.209	-0.532	85.451
18	USDJPY	0.000	-0.023	6.9E-07	0.018	-0.003	0.964
		-0.232	-1.000	3.879	2.253	-0.288	123.136
19	USDNZD	0.000	0.006	2.8E-06	0.051	-0.041	0.917
		-0.717	0.254	2.488	3.224	-2.060	33.552
20	USDSGD	0.000	-0.023	0.000	0.038	-0.010	0.944
		-0.929	-0.922	1.382	3.310	-0.616	73.073

Notes:

1. Two entries for each parameter are their respective estimate and the Bollerslev-Wooldridge (1992) robust *t*-ratio.
2. C and AR(1) denote the constant and the own one-period lagged returns.
3. Entries in **bold** are significant at the 5% level.

Table 3-7: Second Moment and Log Moment Conditions for the AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) Models, Developed Markets

No	Variable	GARCH(1,1)		GJR(1,1)	
		Second Moment	Log Moment	Second Moment	Log Moment
1	AUSBOND	0.998	-0.002	0.998	-0.002
2	JAPBOND	0.991	-0.024	0.982	-0.032
3	NZBOND	0.995	-0.006	0.998	-0.004
4	SGBOND	0.955	-0.101	0.955	-0.101
5	USBOND	0.988	-0.013	0.991	-0.011
6	AUSSTOCK	0.981	-0.026	0.976	-0.031
7	JAPSTOCK	0.986	-0.020	0.981	-0.026
8	NZSTOCK	0.987	-0.019	0.987	-0.019
9	SGSTOCK	0.997	-0.010	0.996	-0.011
10	USSTOCK	0.995	-0.008	0.995	-0.011
11	AUDJPY	0.991	-0.012	0.991	-0.011
12	AUDNZD	0.977	-0.025	0.976	-0.026
13	AUDSGD	0.993	-0.009	0.992	-0.010
14	NZDJPY	0.991	-0.012	0.991	-0.012
15	SGDJPY	0.982	-0.021	0.980	-0.023
16	SGDNZD	0.818	-0.228	0.715	-0.393
17	USDAUD	0.987	-0.015	0.986	-0.016
18	USDJPY	0.980	-0.021	0.981	-0.020
19	USDNZD	0.957	-0.046	0.947	-0.055
20	USDSGD	0.979	-0.023	0.978	-0.025

After demonstrating the statistical adequacy of the AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) models, we can extend them to their multivariate counterparts, namely the VARMA(1,1)-GARCH(1,1) and VARMA(1,1)-AGARCH(1,1) models, respectively. These models are diagonal in MA parts, which mean that they do not incorporate spillovers of MA terms from one return to the others. As some returns exhibit asymmetric patterns in the conditional variances, and the VARMA(1,1)-GARCH(1,1) estimates are similar to those of the VARMA(1,1)-AGARCH(1,1) estimates, despite the significance of the asymmetric terms, only the VARMA(1,1)-AGARCH(1,1) estimates will be presented.

Data analysis using the VARMA(1,1)-AGARCH(1,1) model is conducted for five countries, as described above. Groupings of models will be examined, where each

group of models contains two countries, namely two stock and bond indices and the exchange rates between a country pair. As five countries are investigated, there are ten models to be estimated in total.

It should be noted that there are different trading time in Australasian markets, with overlapping trading time. This nonsynchronous trading can cause short-run correlation in stock and index returns. The problem is solved by adding a first-order moving average term to extract serial autocorrelation from the conditional mean returns (see French et al. (1987) and Wang and Firth (2004)). It should be noted as well that the US market opens after the closing of the Australasian ones. Therefore, there are possibilities of contemporaneous causality effect from Australasia to the USA, but not the opposite. However, the main focus of this thesis is to investigate the overall impact of the markets, which can be done using daily data.

The estimates of the conditional means and conditional variances of the VARMA(1,1)-AGARCH(1,1) model are given in Tables 3-21-A to 3-30-B in Appendix 3-1. A summary of the mean and volatility spillovers, together with their signs, are given in Tables 3-8 and 3-9, respectively. From the analysis of the mean spillovers, there is evidence of international spillovers from every market to all other markets. Thus, international mean spillovers are evident for bond to bond, bond to exchange rates, bond to stock, exchange rates to bond, exchange rates to stock, stock to bond, stock to exchange rates, and stock to stock markets. The signs of the spillovers within individual markets, namely from one bond market to another and from one stock market to another, are all positive, while the rest are a mixture of positive and negative effects. Spillovers from bond to bond markets, and from stock to stock markets, which are evident in 19 cases, are dominated by the USA, followed by Singapore.

Table 3-8: Summary of Mean Spillovers and Their Signs, Developed Markets

Exchange Rates to Bond	Sign	Bond to Stock	Sign
AUDJPY to JAPBOND	+	AUSBOND to NZSTOCK	-
NZJPY to JAPBOND	-	SGBOND to AUSSTOCK	+
USDJPY to JAPBOND	+	USBOND to AUSSTOCK	+
USDJPY to USBOND	+		
USDNZD to USBOND	+	Stock to Bond	
USDSGD to SGBOND	-	AUSSTOCK to AUSBOND *	+
USDSGD to USBOND	+	USSTOCK to AUSBOND	-
		USSTOCK to NZBOND	-
Exchange Rates to Stock			
NZDJPY to JAPSTOCK	+	Stock to Exchange Rates	
SGDJPY to JAPSTOCK	+	AUSSTOCK to AUDJPY	+
USDJPY to JAPSTOCK	-	USSTOCK to USDAUD	-
SGDNZD to NZSTOCK	-	NZSTOCK to NZDJPY	+
USDNZD to NZSTOCK	+	JAPSTOCK to SGDJPY	-
USDSGD to USSTOCK	-	SGSTOCK to SGDJPY	+
		USSTOCK to USDJPY	-
Bond to Bond		NZSTOCK to SGDNZD	+
AUSBOND to JAPBOND	+	NZSTOCK to USDNZD	-
AUSBOND to NZBOND	+	USSTOCK to USDNZD	-
USBOND to AUSBOND	+	USSTOCK to USDSGD	-
NZBOND to JAPBOND	+		
SGBOND to JAPBOND	+	Stock to Stock	
SUBOND to JAPBOND	+	AUSSTOCK to JAPSTOCK	+
SGBOND to NZBOND	+	AUSSTOCK to NZSTOCK	+
USBOND to NZBOND	+	SGSTOCK to AUSSTOCK	+
USBOND to SGBOND	+	USSTOCK to AUSSTOCK	+
		JAPSTOCK to NZSTOCK	+
Bond to Exchange Rates	+	SGSTOCK to JAPSTOCK	+
AUSBOND to AUDJPY	-	USSTOCK to JAPSTOCK	+
AUSBOND to AUDSGD	-	SGSTOCK to NZSTOCK	+
JAPBOND to AUDJPY	+	USSTOCK to NZSTOCK	+
SGBOND to AUDSGD	+	USSTOCK to SGSTOCK	+
USBOND to USDAUD	+		
JAPBOND to NZDJPY	+		
NZBOND to NZDJPY	-		
JAPBOND to SGDJPY	+		
SGBOND to SGDJPY	-		
JAPBOND to USDJPY	+		
USBOND to USDJPY	-		
USBOND to USDSGD	-		
USBOND to USDAUD	-		

Note: * = domestic spillovers.

Table 3-9: Summary of Volatility Spillovers and Their Signs, Developed Markets

Exchange Rates to Bond	Sign	Bond to Stock	Sign
AUDJPY to AUSBOND (S,L)	- , +	SGBOND to SGSTOCK (L)	-
AUDSGD to SGBOND (S,L)	- , -	AUSBOND to SGSTOCK (L)	+
USDAUD to AUSBOND (S)	-	USBOND to AUSSTOCK (S)	+
USDNZD to NZBONDS, (S,L)	+ , -	AUSBOND to USSTOCK (L)	+
USDSGD to USBOND (L)	+	NZBOND to NZSTOCK* (S,L)	+ , -
		NZBOND to SGSTOCK (L)	+
		USBOND to NZSTOCK (L)	-
Exchange Rates to Stock		USBOND to USSTOCK* (S,L)	- , +
AUDNZD to NZSTOCK (L)	+		
AUDSGD to SGSTOCK (L)	+		
USDAUD to AUSSTOCK (S)	-	Stock to Bond	
SGDJPY to SGSTOCK (S,L)	- , +	JAPSTOCK to JAPBOND* (S)	-
SGDNZD to NZSTOCK (S)	-	AUSSTOCK to AUSBOND* (S,L)	+ , +
		USSTOCK to AUSBOND (L)	+
		JAPSTOCK to NZBOND (S)	+
Bond to Bond		JAPSTOCK to JAPBOND* (L)	-
NZBOND to AUSBOND (S)	+	USSTOCK to USBOND* (S,L)	+ , +
AUSBOND to NZBOND (L)	-	SGSTOCK to SGBOND* (L)	-
AUSBOND to SGBOND (S)	+	NZSTOCK to USBOND (L)	-
USBOND to AUSBOND (S,L)	+ , +	USSTOCK to SGBOND (S)	-
JAPBOND to SGBOND (S)	-	USSTOCK to USBOND* (S)	-
NZBOND to SGBOND (L)	+		
USBOND to NZBOND (S,L)	+ , +		
SGBOND to USBOND (S,L)	+ , -	Stock to Exchange Rates	
		SGSTOCK to AUDSGD (S)	+
Bond to Exchange Rates		JAPSTOCK to SGDJPY (L)	-
USBOND to USDAUD (L)	-	JAPSTOCK to USDJPY (L)	-
SGBOND to SGDJPY (L)	-	NZSTOCK to USDNZD (S,L)	- , +
USBOND to USDJPY (S)	-	USSTOCK to USDNZD (L)	+
USBOND to USDSGD (L)	+	USSTOCK to USDSGD (S,L)	+ , -
		Stock to Stock	
		AUSSTOCK to NZSTOCK (S)	+
		SGSTOCK to AUSSTOCK (S)	+
		USSTOCK to JAPSTOCK (S)	+
		SGSTOCK to NZSTOCK (S)	+
		NZSTOCK to SGSTOCK (L)	+
		USSTOCK to SGSTOCK (L)	+

Note: S = short persistence, L = long persistence, and * = domestic spillovers.

International mean spillovers across markets, namely from bond to stock markets and from stock to bond markets, are evident in only 5 cases and is dominated by the USA. Therefore, international mean spillovers in individual markets are more common than across markets, and are dominated by the USA. In addition, domestic mean spillovers are evident only in one case, namely from AUSSTOCK to AUSBOND.

There is also strong evidence of mean spillovers from exchange rates to both stock and bond markets, and from both stock and bond markets to exchange rates. The spillovers are generally of the same magnitude, and the signs are mixed.

Volatility spillovers consist of short and long run persistence. The short run persistence of shocks to index i in the same market is given by $\hat{\alpha}_i + \frac{1}{2}\hat{\gamma}_i$, where $\hat{\alpha}_i$ is the estimated short run persistence of positive shocks and $\hat{\alpha}_i + \hat{\gamma}_i$ is the estimated short run persistence of negative shocks. The estimated long run persistence of shocks to index i in the same market is given by $\hat{\alpha}_i + \frac{1}{2}\hat{\gamma}_i + \hat{\beta}_i$. Tables 3-21-B to 3-30-B in Appendix 3-1 show that all markets are influenced by their own long run persistence, but some are not influenced by their own short run persistence.

There is also evidence of international volatility spillovers from every market to all other markets. This means that volatility spillovers are evident from bond to bond, bond to exchange rates, bond to stock, exchange rates to bond, exchange rates to stock, stock to bond, stock to exchange rates, and stock to stock markets. The signs of spillovers from one stock to another stock market are all positive, while the remaining spillover effects are of mixed signs. As distinct from the case of mean spillovers discussed above, bond-to-bond and stock-to-stock market spillovers are not dominated by a single country.

International volatility spillovers across markets (from bond to stock markets and from stock to bond markets) are also evident. The spillovers across markets are as

strong as those within an individual market, namely from bond to bond markets and from stock to stock markets.

Domestic volatility spillovers are also evident in several cases, namely from NZBOND to NZSTOCK, USBOND to USSTOCK, USSTOCK to USBOND, JAPSTOCK to JAPBOND, and SGSTOCK to SGBOND.

There is also strong evidence of volatility spillovers from exchange rates to both stock and bond markets, and from both stock and bond markets to exchange rates. The spillovers are of similar magnitude, and the signs are mixed.

Asymmetry, as indicated by the significance of $\hat{\gamma}$, is evident in the cases of JAPBOND, JAPSTOCK, AUSSTOCK, NZBOND, SGSTOCK, SGDZD, USDZD, and USSTOCK. In total, 8 of 20 variables show significant asymmetric effects, which supports the use of the VARMA(1,1)-AGARCH(1,1) model.

3.2. Interactions Across Emerging and Developed Markets

"As markets become more global, players are increasingly active at emerging market desks."

Jay Smith, president of Leading Market Technologies, in Louis (1997)

This section investigates the interactions across financial assets in emerging markets, namely Indonesia, Malaysia, the Philippine, and Thailand. Two developed markets as benchmarks also included in the analysis, namely Japan and the USA.

Table 3-10: Summary of Variable Names, Emerging-Developed Markets

No	Variable	Index Names	Variable Names
1	Indonesian Bond	Indonesian Govt. Bond (INDOGB 14.5 10)	Indbond
2	Japanese Bond	JP Benchmark 10 Year Govt. Index	Japbond
3	Malaysian Bond	Malaysian Govt. Bond (MGS 6.844 10)	Malbond
4	Philippines Bond	Philippine Govt. Bond (RPGGB 14.75 10)	Phibond
5	Thailand Bond	Thailand Govt. Bond (THAIGB 17.5 11)	Thabond
6	US Bond	US Benchmark 10 Year Govt. Index	Usbond
7	Indonesian Stock	Jakarta SE Composite – Price Index	Indstock
8	Japanese Stock	Nikkei 225 Stock Average Price Index	Japstock
9	Malaysian stock	Kuala Lumpur Comp. DS-CALC-Price Index	Malstock
10	Philippines Stock	Philippine SE I(PSEi) – Price Index	Sgstock
11	Thailand Stock	DJSI World Thailand Subset - Price Index	Thastock
12	US Stock	S&P 500 Composite Price Index	Usstock
13	Exchange Rates	Indonesian Rupiah – Japanese Yen ER	Jpyidr
14	Exchange Rates	Indonesian Rupiah – Malaysia Ringgit ER	Myridr
15	Exchange Rates	Japanese Yen – Malaysian Ringgit ER	Myrjpy
16	Exchange Rates	Philippine Peso – Malaysian Ringgit ER	Myrphp
17	Exchange Rates	Thailand Baht – Malaysian Ringgit ER	Myrthb
18	Exchange Rates	Indonesian Rupiah – Philippine Peso ER	Phpidr
19	Exchange Rates	Japanese Yen Philippine Peso	Phpjpy
20	Exchange Rates	Indonesian Rupiah – Thailand Baht ER	Thbidr
21	Exchange Rates	Japanese Yen – Thailand Baht ER	Thbjpy
22	Exchange Rates	Philippine Peso Thailand Baht ER	Thbphp
23	Exchange Rates	Indonesian Rupiah – US Dollar ER	Usdidr
24	Exchange Rates	Japanese Yen – US Dollar ER	Usdjpy
25	Exchange Rates	Malaysian Ringgit – US Dollar ER	Usdmyr
26	Exchange Rates	Philippine Peso – US Dollar ER	Usdphp
27	Exchange Rates	Thailand Baht – US Dollar ER	Usdthb

Note: ER = Exchange Rates.

The data used in this chapter are the daily closing price index of bond, stock, and foreign exchange rates from the aforementioned countries. The detail of the data is in Table 3-10. The data are obtained from the DataStream and Bloomberg database services. The sample ranges from 28/3/2003 to 8/9/2006, with 901 observations for each index and foreign exchange rates.

Table 3-11: Descriptive Statistic, Jarque-Bera and Its Probability for the Returns, Emerging-Developed Markets

No	Series	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
1	Indbond	-0.001	0.410	-0.979	18.000	8590.692	0
2	Japbond	-0.005	0.265	-0.511	6.377	467.328	0
3	Malbond	-0.012	0.127	-0.711	15.694	6125.010	0
4	Phibond	0.002	0.217	0.176	10.112	1903.289	0
5	Thabond	-0.021	0.303	-1.740	45.625	68662.590	0
6	Usbond	-0.008	0.421	-0.207	4.627	105.846	0
7	Indstock	0.144	1.248	-0.602	7.431	791.427	0
8	Japstock	0.072	1.177	-0.428	4.378	98.785	0
9	Malstock	0.045	0.594	0.137	5.279	197.762	0
10	Phistock	0.092	1.150	0.069	4.645	102.324	0
11	Thastock	0.022	1.404	0.662	8.824	1339.064	0
12	Usstock	0.045	0.720	0.069	3.418	7.275	0.026
13	Jpyidr	0.005	0.631	-0.751	12.817	3703.064	0
14	Myridr	0.007	0.507	-1.177	23.994	16755.110	0
15	Myrjpy	-0.001	0.654	-0.370	59.185	118531.300	0
16	Myrphp	0.002	1.712	-0.156	434.455	6988503.000	0
17	Myrthb	0.011	0.291	-0.009	6.018	342.035	0
18	Phpidr	0.008	0.505	-1.201	22.428	14386.720	0
19	Phpjpy	0.004	0.584	0.075	4.361	70.378	0
20	Thbidr	0.017	0.506	-1.232	20.411	11609.100	0
21	Thbjpy	0.012	0.544	-0.452	8.499	1165.665	0
22	Thbphp	0.008	0.333	-0.427	8.166	1029.321	0
23	Usdidr	0.002	0.530	-0.832	21.288	12660.250	0
24	Usdjpy	-0.003	0.548	-0.132	3.902	33.164	0
25	Usdmyr	-0.004	0.211	-0.571	34.408	37082.640	0
26	Usdphp	-0.006	0.305	-0.105	5.642	263.661	0
27	Usdthb	-0.015	0.304	-0.142	7.218	670.873	0

The plots of the daily returns for the 27 series are given in Figures 3-21 to 3-47 in the Appendix 3-4. The figures show that the mean returns are constant but the variances change over time, with large (small) changes tending to be followed by large (small) changes of either sign. As in the previous section, this 'stylized fact' seems appropriate to be modelled using Engle's (1982) ARCH and Bollerslev's (1986) GARCH models.

There are several spikes in Tables 3-35 and 3-36. The spikes in Table 3-35, namely myrjpy, are possibly related to the large intervention operation in 2003 by Bank of Japan in an effort to reduce the value of Yen. The spike in Table 3-36, namely myrphp, might be caused by the anticipation of the shift from the dollar peg to managed float exchange rate system in Malaysia in 2005.

Table 3-11 displays some descriptive statistics for the daily returns for all assets. All markets are restricted to have five trading days per week. Among the 27 series, the highest and the lowest average returns are Indstock and Thabond, respectively, while the highest and the lowest standard deviation are Myrphp and Malbond, respectively.

The statistics for skewness reveal that the underlying distributions for returns seem to be negatively skewed in most cases. This implies that the number of negative outliers is greater than the number of positive outliers in most cases. This is consistent with the return figures in Figure 3-21 to 3-47. In addition, the statistics for kurtosis are greater than 3 in all cases, indicating that the probability of observing outliers and extreme observations in returns is greater than any random variable that follows a standard normal distribution.

Given the statistics for skewness and kurtosis, it is perhaps not surprising to find that the Jarque-Bera (J-B) Lagrange multiplier test statistics strongly reject the assumption of normality for the distributions of returns in all cases.

As in Section 3.1, this section uses both ADF and Phillips-Perron tests to test the stationarity of the return series. This section also applies Schwarz Information Criteria, automatic selection menu in EViews, to select the lag length parameter in ADF test. This automatic selection resulted in zero lag length for all series, except for Thabond, Indstock and Thbidr which have 1 lag length, and Usdmyr which has 9 lag length. Tables 3-12 and 3-13 show that those returns are stationary based on the ADF and Phillips-Perron tests, respectively.

Table 3-12: Unit Root Test, ADF, Emerging-Developed Markets

No	Series	δ	t -statistic	Critical Value (1%)	Probability
1	Indbond	-1.078	-32.392	-3.968	0
2	Japbond	-0.944	-28.317	-3.968	0
3	Malbond	-0.832	-25.264	-3.968	0
4	Phibond	-0.903	-27.417	-3.968	0
5	Thabond	-0.859	-18.351	-3.968	0
6	Usbond	-0.996	-29.822	-3.968	0
7	Indstock	-0.958	-21.649	-3.968	0
8	Japstock	-0.991	-29.696	-3.968	0
9	Malstock	-0.853	-25.827	-3.968	0
10	Phistock	-0.840	-25.469	-3.968	0
11	Thastock	-0.971	-29.081	-3.968	0
12	Usstock	-1.064	-31.939	-3.968	0
13	Jpyidr	-1.036	-31.070	-3.968	0
14	Myridr	-1.097	-33.000	-3.968	0
15	Myrjpy	-1.176	-35.785	-3.968	0
16	Myrphp	-3.424	-18.959	-3.968	0
17	Myrthb	-0.994	-29.758	-3.968	0
18	Phpidr	-1.084	-32.617	-3.968	0
19	Phpjpy	-1.112	-33.584	-3.968	0
20	Thbidr	-1.129	-34.107	-3.968	0
21	Thbjpy	-1.219	-24.534	-3.968	0
22	Thbphp	-1.031	-31.064	-3.968	0
23	Usdidr	-1.076	-32.336	-3.968	0
24	Usdjpy	-1.016	-30.430	-3.968	0
25	Usdmyr	-1.889	-10.738	-3.968	0
26	Usdphp	-1.193	-36.428	-3.968	0
27	Usdthb	-1.000	-29.967	-3.968	0

The 6 countries in the analysis construct 15 models to be estimated, which each model contains a pair of countries, with 2 stocks, 2 bonds and 1 exchange rate from the corresponding countries. As data on Myrphp contains 2 outliers, namely observations 10/6/2005 and 13/6/2005 (see Figure 3-36), two dummy variables are included in the estimation for the group. Both dummy variables are found to be significant.

Table 3-13: Unit Root Test, PP, Emerging-Developed Markets

No	Series	δ	<i>t</i> -statistic	Critical Value (1%)	Probability
1	Indbond	-1.078	-33.146	-3.968	0
2	Japbond	-0.944	-28.314	-3.968	0
3	Malbond	-0.832	-25.947	-3.968	0
4	Phibond	-0.903	-28.143	-3.968	0
5	Thabond	-1.000	-30.571	-3.968	0
6	Usbond	-0.996	-29.827	-3.968	0
7	Indstock	-0.885	-26.662	-3.968	0
8	Japstock	-0.991	-29.702	-3.968	0
9	Malstock	-0.853	-25.873	-3.968	0
10	Phistock	-0.840	-25.289	-3.968	0
11	Thastock	-0.971	-29.811	-3.968	0
12	Usstock	-1.064	-32.436	-3.968	0
13	Jpyidr	-1.036	-31.093	-3.968	0
14	Myridr	-1.097	-32.858	-3.968	0
15	Myrjpy	-1.176	-36.079	-3.968	0
16	Myrphp	-1.489	-116.999	-3.968	0
17	Myrthb	-0.994	-29.794	-3.968	0
18	Phpidr	-1.084	-32.512	-3.968	0
19	Phpjpy	-1.112	-33.398	-3.968	0
20	Thbidr	-1.129	-34.033	-3.968	0
21	Thbjpy	-1.115	-33.792	-3.968	0
22	Thbphp	-1.031	-31.040	-3.968	0
23	Usdidr	-1.076	-32.245	-3.968	0
24	Usdjpy	-1.016	-30.431	-3.968	0
25	Usdmyr	-1.414	-53.705	-3.968	0
26	Usdphp	-1.193	-36.432	-3.968	0
27	Usdthb	-1.000	-29.972	-3.968	0

To see whether the conditional variances of the stock and foreign exchange returns follow the GARCH process, univariate AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) models will be estimated. If the properties of the univariate models are satisfied, then it would be sensible to extend the models to their multivariate counterparts. As in Section 3.1, the lag length of 1 in autoregressive for both AR-GARCH and AR-GJR models are justified using Schwarz Information Criterion. This criterion suggests increasing SIC statistic on investigations up to lag 5 in most series. The results of the estimation on univariate AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) are provided in Tables 3-14 and 3-15. It can be seen that not all the series are explained by

it's own AR(1) effect. This means that there is a possibility of mean spillovers from other asset. Tables 3-14 and 3-15 also show that some of the series show weak evidence of ARCH effect, but all show GARCH effects. In addition, Table 3-15 also provides evidence of asymmetry in 4 of the 27 returns series.

In order to check the structural properties of the univariate models, as in Section 3.1, the second moment and log-moment conditions are evaluated for both the AR(1)-GARCH(1,1) and AR(1)-GJR(1,1) models. Table 3-16 shows that for AR(1)-GARCH(1,1) model, not all the second moment conditions are fulfilled, however their corresponding log moment conditions are met. It also shows that for AR(1)-GJR(1,1) model, not all the second moment conditions are fulfilled, however their corresponding log moment conditions are met, except in Usdmyr where both second moment and log moment condition are not met. However, estimating ARMA(1,1)-GJR(1,1) to the series provides the second moment of 0.788 (which is less than 1) and log moment of -0.386 (which is less than 0). The estimation shows evidence of GARCH effect, but the evidence of asymmetric effect is not found. This suggests the importance of correctly specifying the conditional mean.

Since some series exhibit the asymmetric effect of negative and positive shocks on conditional volatility, this chapter will estimate the VARMA(1,1)-AGARCH(1,1) alone. As in previous section, these models are diagonal in MA parts, which mean that it does not incorporate spillovers of MA terms from one return to the others. The parameter estimates for the VARMA-AGARCH model and their asymptotic t -ratios are in Tables 3-31 to 3-45 in Appendix 3-2. The summary of mean and volatility spillovers is provided in Tables 3-17 and 3-18, respectively.

Table 3-14: Univariate AR(1)-GARCH(1,1) for the Returns, Emerging-Developed Markets

No	Series	C	AR(1)	ω	α	β
1	Indbond	2.15E-04	0.046	3.58E-07	0.244	0.801
		2.651	0.754	2.462	2.917	18.742
2	Japbond	0.000	0.044	0.000	0.098	0.886
		1.032	1.218	0.987	3.008	23.970
3	Malbond	-1.12E-04	0.248	0.000	0.062	0.940
		-2.639	4.744	0.572	2.406	38.722
4	Phibond	0.000	0.067	0.000	0.152	0.812
		-0.953	1.617	0.951	4.014	16.095
5	Thabond	0.000	0.262	0.000	0.259	0.404
		-0.745	5.866	2.257	1.614	2.391
6	Usbond	0.000	0.000	0.000	0.007	0.992
		-0.714	-0.001	-0.206	1.715	223.434
7	Indstock	0.002	0.169	1.40E-05	0.134	0.772
		5.069	4.298	2.568	3.151	13.023
8	Japstock	0.001	0.025	0.000	0.076	0.912
		2.764	0.760	1.846	3.778	41.226
9	Malstock	0.000	0.152	0.000	0.022	0.971
		1.692	4.273	0.663	2.810	116.522
10	Phistock	0.001	0.182	0.000	0.092	0.850
		2.166	4.979	1.832	3.319	15.963
11	Thastock	0.000	0.015	0.000	0.070	0.932
		-0.661	0.441	1.388	4.823	68.039
12	Usstock	0.000	-0.059	1.47E-06	0.029	0.939
		1.897	-1.841	2.064	2.027	40.265
13	Jpyidr	0.000	-0.005	0.000	0.218	0.544
		-0.113	-0.136	3.436	2.825	5.478
14	Myridr	0.000	-0.050	2.70E-06	0.317	0.621
		0.962	-0.904	2.949	2.770	7.015
15	Myrjpy	0.000	-0.035	0.00	0.223	0.607
		-0.642	-0.820	2.127	1.333	7.891
16	Myrphp	0.000	0.052	0.000	0.065	0.932
		0.027	1.385	0.510	4.409	50.852
17	Myrthb	0.000	0.065	6.05E-07	0.149	0.783
		1.262	1.641	2.691	4.614	20.291
18	Phpidr	0.000	-0.038	3.17E-06	0.281	0.618
		0.846	-0.729	2.802	2.926	7.246
19	Phpjpy	0.000	-0.107	0.000	0.030	0.698
		0.188	-3.181	1.061	0.854	2.552
20	Thbidr	0.000	-0.075	3.47E-06	0.279	0.604
		1.763	-1.441	3.433	2.540	6.309
21	Thbjpy	0.000	-0.087	0.000	0.102	0.623
		1.111	-2.170	1.490	1.342	2.636
22	Thbphp	0.000	-0.027	0.000	0.046	0.917
		0.520	-0.836	1.569	3.493	42.632
23	Usdidr	0.000	-0.002	2.24E-06	0.348	0.634
		0.714	-0.033	3.234	2.977	8.146
24	Usdjpy	0.000	-0.014	0.000	0.048	0.643

		-0.195	-0.400	1.393	1.326	2.714
25	Usdmyr	0.000	-0.475	0.000	0.697	0.517
		-0.920	-7.500	0.509	1.625	5.371
26	Usdphp	0.000	-0.129	0.000	0.107	0.890
		-0.109	-3.298	1.046	4.553	41.777
27	Usdthb	0.000	0.024	5.76E-07	0.096	0.845
		-0.834	0.598	2.247	2.509	17.471

Notes:

1. Two entries for each parameter are their respective estimate and the Bollerslev-Wooldridge (1992) robust *t*-ratio.
2. C and AR(1) denote the constant and the own one-period lagged returns.
3. Entries in **bold** are significant at the 5% level.

Table 3-15: Univariate AR(1)-GJR(1,1) for the Returns, Emerging-Developed Markets

		C	AR(1)	ω	α	γ	β
1	Indbond	2.20E-04	0.052	5.09E-07	0.186	0.102	0.786
		2.990	0.927	3.934	2.345	0.768	19.591
2	Japbond	0.000	0.062	0.000	0.005	0.131	0.906
		0.006	1.758	1.329	0.295	3.521	39.806
3	Malbond	-1.17E-04	0.248	0.000	0.045	0.022	0.944
		-2.837	4.544	0.553	1.354	0.670	38.477
4	Phibond	0.000	0.068	0.000	0.154	-0.006	0.812
		-1.010	1.654	1.374	3.051	-0.082	18.137
5	Thabond	0.000	0.279	2.93E-06	0.023	0.450	0.434
		-1.274	5.314	2.271	0.307	2.035	3.060
6	Usbond	0.000	0.000	0.000	-0.013	0.022	1.002
		-1.550	0.012	-0.418	-0.908	1.341	124.758
7	Indstock	0.002	0.182	2.57E-05	0.018	0.298	0.662
		3.483	4.903	3.294	0.597	2.940	7.987
8	Japstock	0.001	0.035	2.69E-06	0.047	0.063	0.902
		2.222	1.051	2.546	1.648	1.497	42.036
9	Malstock	0.000	0.153	0.000	0.021	0.004	0.971
		1.610	4.308	0.590	2.104	0.276	92.952
10	Phistock	0.001	0.179	0.000	0.096	-0.032	0.874
		2.359	4.910	1.802	2.570	-0.744	19.894
11	Thastock	0.000	0.015	0.000	0.070	-0.010	0.936
		-0.546	0.424	1.438	3.662	-0.369	70.355
12	Usstock	0.000	-0.054	6.19E-07	-0.026	0.062	0.980
		1.291	-1.689	3.055	-2.918	3.599	157.632
13	Jpyidr	0.000	-0.004	0.000	0.271	-0.139	0.587
		0.522	-0.106	3.623	2.678	-0.944	6.731
14	Myridr	0.000	-0.046	2.69E-06	0.360	-0.106	0.630
		1.560	-0.846	2.811	2.350	-0.493	6.910
15	Myrjpy	0.000	0.018	7.30E-06	0.007	0.286	0.676
		-1.098	0.488	3.951	0.273	0.883	13.642
16	Myrphp	0.000	0.051	0.000	0.073	-0.024	0.936
		0.247	1.377	0.566	4.159	-0.918	51.973
17	Myrthb	0.000	0.065	5.65E-07	0.163	-0.048	0.798
		1.394	1.633	2.452	3.829	-0.926	16.692
18	Phpidr	0.000	-0.031	3.19E-06	0.327	-0.134	0.632
		1.561	-0.631	2.475	2.487	-0.767	6.953
19	Phpjpy	0.000	-0.106	0.000	0.040	-0.021	0.704
		0.163	-3.143	1.142	0.859	-0.416	2.813
20	Thbidr	2.95E-04	-0.065	3.30E-06	0.319	-0.112	0.625
		2.383	-1.302	3.021	2.491	-0.615	6.034
21	Thbjpy	0.000	-0.082	0.000	0.122	-0.045	0.606
		1.245	-2.044	1.355	1.083	-0.407	2.289
22	Thbphp	0.000	-0.033	0.000	0.053	-0.035	0.932
		0.587	-1.047	1.528	2.095	-1.063	42.245
23	Usdidr	0.000	0.001	2.25E-06	0.384	-0.087	0.639
		1.270	0.025	3.089	2.458	-0.390	8.070
24	Usdjpy	0.000	-0.011	0.000	0.070	-0.042	0.649
		-0.144	-0.318	1.393	1.267	-0.783	2.767

25	Usdmyr	-1.14E-04	-0.192	0.000	-0.010	0.023	1.009
		-5.828	-3.424	0.021	-0.562	0.528	88.062
26	Usdphp	0.000	-0.126	0.000	0.090	0.023	0.896
		-0.326	-3.238	0.888	2.934	0.625	40.272
27	Usdthb	0.000	0.024	0.000	0.086	0.015	0.848
		-0.955	0.586	1.277	1.388	0.262	10.008

Notes:

Notes:

1. Two entries for each parameter are their respective estimate and the Bollerslev-Wooldridge (1992) robust *t*-ratio.
2. C and AR(1) denote the constant and the own one-period lagged returns.
3. Entries in **bold** are significant at the 5% level.

Table 3-16: Second Moment and Log Moment Conditions for the AR(1)-GARCH(1,1) and AR(1)-GJR(1,1), Emerging-Developed Markets

		AR(1)-GARCH(1,1)		AR(1)-GJR(1,1)	
		Second Moment	log Moment	Second Moment	log Moment
1	Indbond	1.046	-0.061	1.023	-0.082
2	Japbond	0.985	-0.028	0.977	-0.031
3	Malbond	1.002	-0.011	1.000	-0.011
4	Phibond	0.963	-0.088	0.963	-0.089
5	Thabond	0.663	-0.687	0.682	-0.658
6	Usbond	0.999	-0.001	1.000	-0.001
7	Indstock	0.906	-0.122	0.829	-0.250
8	Japstock	0.988	-0.019	0.981	-0.027
9	Malstock	0.994	-0.007	0.994	-0.007
10	Phistock	0.942	-0.070	0.954	-0.055
11	Thastock	1.002	-0.006	1.001	-0.006
12	Usstock	0.968	-0.034	0.985	-0.016
13	Jpyidr	0.762	-0.356	0.789	-0.309
14	Myridr	0.939	-0.203	0.937	-0.200
15	Myrjpy	0.830	-0.286	0.826	-0.273
16	Myrphp	0.997	-0.004	0.914	-0.004
17	Myrthb	0.933	-0.099	0.936	-0.092
18	Phpidr	0.899	-0.219	0.892	-0.218
19	Phpjpy	0.728	-0.320	0.734	-0.312
20	Thbidr	0.884	-0.245	0.888	-0.230
21	Thbjpy	0.725	-0.344	0.705	-0.372
22	Thbphp	0.964	-0.042	0.968	-0.036
23	Usdidr	0.982	-0.167	0.980	-0.166
24	Usdjpy	0.692	-0.374	0.698	-0.367
25	Usdmyr	1.214	-0.456	1.010	0.007
26	Usdphp	0.997	-0.017	0.998	-0.015
27	Usdthb	0.942	-0.077	0.942	-0.076

Table 3-17: Summary of Mean Spillovers Evidence and Their Signs, VARMA-AGARCH, Emerging-Developed Markets

No	Exchange Rates to Bond	Sign	No	Bond to Stock	Sign
1	Jpyidr to Japbond	+	1	Indbond to Phistock	+
2	Myridr to Malbond	-	2	Thabond to Thastock	-
3	Myrjpy to Malbond	+	3	Japbond to Thastock	-
4	Myrjpy to Malbond	+			
5	Usdjpy to Usbond	+	No	Stock to Bond	Sign
6	Myrthb to Malbond	+	1	Indstock to Indbond	+
7	Usdmyr to Usbond	+	2	Japstock to Japbond	-
8	Usdthb to Usbond	+	3	Japstock to Malbond	+
9	Myrphp to Phibond (new)	+	4	Phistock to Japbond	-
			5	Thastock to Japbond	+
No	Exchange Rates to Stock	Sign	6	Malstock to Thabond	-
1	Jpyidr to Indstock	+	7	Phistock to Thabond	-
2	Phpidr to Phistock	-	8	Thastock to Phibond	+
3	Myrjpy to Japstock	-	9	Phistock to Phibond (new)	-
4	Myrjpy to Malstock	+			
5	Phpjpy to Japstock	+	No	Stock to Exchange Rates	Sing
6	Usdjpy to Japstock	+	1	Indstock to Jpyidr	-
7	Usdjpy to Usstock	-	2	Indstock to Myridr	-
8	Myrphp to Malstock	+	3	Indstock to Phpidr	-
9	Myrphp to Phistock	+	4	Indstock to Thbidr	-
10	Usdmyr to Usstock	-	5	Indstock to Usdldr	-
11	Usdthb to Thastock	-	6	Japstock to Myrjpy	-
12	Usdthb to Usstock	-	7	Malstock to Murjpy	+
			8	Malstock to Myrthb	+
No	Bond to Bond	Sign	9	Usstock to Usdmyr	-
1	Usbond to Japbond	+	10	Usstock to Usdphp	-
2	Malbond to Thabond	+	11	Usstock to Usdthb	-
3	Thabond to Malbond	+			
4	Usbond to Malbond	+	No	Stock to Stock	Sign
5	Thabond to Usbond	+	1	Indstock to Thastock	+
6	Usbond to Thabond	+	2	Indstock to Phistock	+
			3	Usstock to Indstock	+
No	Bond to Exchange Rates	Sign	4	Japstock to Phistock	+
1	Japbond to Myrjpy	-	5	Phistock to Japstock	+
2	Japbond to Usdjpy	+	6	Usstock to Japstock	+
3	Usbond to Usdjpy	-	7	Malstock to Thastock	+
4	Malbond to Usdmyr	+	8	Usstock to Malstock	+
5	Usbond to Usdmyr	-	9	Phistock to Thastock	+
6	Thabond to Usdthb	+	10	Usstock to Phistock	+
7	Usbond to Usdthb	-	11	Usstock to Thastock	+

Table 3-18: Summary of Volatility Spillovers Evidence and Their Signs, VARMA-AGARCH, Emerging-Developed Markets

No	Exchange Rates to Bond	Sign	No	Bond to Stock	Sign
1	Jpyidr to Japbond (S)	-	1	Indbond to Indstock(S)	-
2	Myridr to Indbond (S,L)	+, -	2	Japbond to Japstock (S,L)	-, +
3	Phpidr to Indbond (S)	-	3	Malbond to Indstock (S)	-
4	Usdidr to Indbond (S,L)	+, -	4	Japbond to Phistock (S,L)	-, +
5	Myrjpy to Japbond (S,L)	-, +	5	Thabond to Thastock (S,L)	-, +
6	Phpjpy to Phibond (S)	-	6	Thabond to Phistock (S,L)	+, -
7	Myrphp to Phibond (L)	+	7	Thabond to Usstock (S)	-
8	Thbphp to Phibond (S)	-	8	Usbond to Thastock (S)	+
9	Thbjpy to Japbond (L)	+	9	Usbond to Usstock (L)	+
10	Usdjpy to Usbond (L)	-	10	Malbond to Japstock (L)	-
11	Myrthb to Malbond (L)	-	11	Malbond to Malstock (L)	+
12	Thbphp to Thabond (L)	-			
13	Usdphp to Phibond (L)	-	No	Stock to Bond	Sign
14	Usdthb to Thabond (L)	-	1	Japstock to Japbond (S,L)	+, -
15	Myrphp to Malbond (S,L)	+, +	2	Malstock to Indbond (S,L)	+, -
			3	Malstock to Malbond (S)	+
No	Exchange Rates to Stock	Sign	4	Indstock to Thabond (S,L)	-, -
1	Jpyidr to Japstock (S,L)	+, -	5	Thastock to Indbond (S)	-
2	Usdidr to Usstock (S,L)	-, +	6	Usstock to Indbond (S,L)	+, -
3	Myrjpy to Japstock (S,L)	-, +	7	Phistock to Phibond (S,L)	-, -
4	Myrjpy to Malstock (S,L)	+, -	8	Malstock to Thabond (S)	-
5	Usdjpy to Japstock (S,L)	+, -	9	Thastock to Malbond (S,L)	-, +
6	Usdjpy to Usstock (S,L)	-, +	10	Phistock to Thabond (S)	-
7	Myrphp to Malstock (S)	+	11	Thastock to Phibond (S)	+
8	Myrphp to Phistock (S)	-	12	Thastock to Thabond (S,L)	-, +
9	Usdmyr to Malstock (S,L)	+, -	13	Phistock to Usbond (S,L)	-, -
10	Usdmyr to Usstock (S,L)	-, +	14	Usstock to Phibond (S,L)	-, +
11	Usdphp to Phistock (S,L)	+, -	15	Indstock to Malbond (L)	+
12	Usdthb to Usstock (S,L)	-, +	16	Indstock to Indbond (L)	+
13	Myridr to Malstock (L)	-	17	Japstock to Malbond (L)	-
14	Thbjpy to Japstock (L)	+	18	Malstock to Japbond (L)	-
			19	Usstock to Japbond (L)	-
No	Bond to Bond	Sign	20	Phistock to Malbond (S)	-
1	Malbond to Indbond (S,L)	+, -	21	Usstock to Malbond (L)	-
2	Indbond to Phibond (S,L)	-, -	22	Thastock to Usbond (L)	+
3	Phibond to Indbond (S)	-			
4	Malbond to Japbond (S,L)	-, +			
5	Usbond to Phibond (S)	+	No	Stock to Exchange Rates	Sign
6	Japbond to Usbond (L)	+	1	Indstock to Usdidr (S)	+
7	Phibond to Thabond (L)	-	2	Japstock to Usdjpy (S)	-
8	Thabond to Phibond (L)	-	3	Thastock to Thbphp (S,L)	+, -
			4	Thastock to Thbidr (L)	-
			5	Japstock to Myrjpy (L)	+
No	Bond to Exchange Rates	Sign	6	Japstock to Phpjpy (L)	-
1	Indbond to Myridr (S)	-	7	Usstock to Usdjpy (L)	-
2	Phibond to Phpidr (S)	-	8	Thastock to Myrthb (L)	-
3	Indbond to Usdidr (S)	-	9	Malstock to Usdmyr (L)	-

4	Japbond to Myrjpy (S)	-	10	Malstock to Myrphp (S,L)	+,-
5	Malbond to Myrjpy (S)	-	No	Stock to Stock	Sign
6	Thabond to Myrthb (S)	-	1	Indstock to Thastock (S)	-
7	Thabond to Thbphp (S)	-	2	Usstock to Malstock (S,L)	+,-
8	Thabond to Usdthb (S)	-	3	Phistock to Usstock (S,L)	+,-
9	Thabond to Thbidr (L)	-	4	Malstock to Indstock (L)	+
10	Usabonnd to Usdidr (L)	-	5	Usstock to Thastock (L)	+
11	Japbond to Usdjpy (L)	-			
12	Usbond to Usdjpy (L)	+			
13	Usbond to Usdmyr (L)	-			
14	Usbond to Usdphp (L)	-			

Note: S = short persistence, L = long persistence

The analysis of mean spillovers finds that the signs of spillovers from stock to stock markets and bond to bond markets are all positive, while the rest are a mixture of positive and negative signs. The return spillovers within individual asset markets (bond to bond and stock to stock) are evident in 17 of 60 possible cases (28%), and the return spillovers across asset markets (bond to stock and stock to bond) are evident in 12 of 72 possible cases (17%). This means that the spillovers within individual class of assets are stronger than that of across assets. It should be noted as well that the highest return spillovers is from stock to stock (11 of 30 cases, or 37%), followed by the spillovers from stock to bond (9 of 36 cases, or 25%). This means stock has stronger influences than bond does.

The analysis of volatility spillovers finds that the volatility spillovers within individual asset markets (stock to stock and bond to bond markets) are evident in 13 of 60 possible cases (22%), while the volatility spillovers across markets (bond to stock and stock to bond), are evident in 33 of 72 possible cases (46%). This means that, different from the case of returns spillovers, the spillovers across assets are stronger than that of within individual assets. As in the case of returns spillovers, the influence from stock markets to bond markets is stronger than the influence from bond to stock market.

It is also found that emerging bond markets are influenced by Usbond, but not by Japbond. Usbond is influenced by Thabond. Emerging stock markets are influenced by both Japstock and Usstock, but Usstock dominates the influences. Japstock is influenced by Phistock, while Usstock is independent of emerging markets influence.

Investigation on cross-asset markets finds that emerging stock (bond) markets are influenced only by Japanese bond (stock) markets. This means that emerging stock (bond) markets are independent of US bond (stock) markets. It is also found that Japbond is influenced by emerging stock markets.

Analysis within emerging countries finds that there is evidence of mean spillovers in all classes from assets to any other classes of assets. Foreign exchange markets are found to be important in determining the behaviour of stock and bond markets. In addition, foreign exchange markets are not independent of both stock and bond markets.

The analysis regarding developed and emerging markets find that developed bond markets influence emerging bond markets, and vice-versa. However, only Japbond that is influenced by emerging bond markets, while Usbond is independent of emerging bond markets. Emerging stock markets are influenced by Usstock, and vice versa, but emerging stocks and Japstock are independent.

Emerging stocks markets are influenced by Usbond, but independent of Japbond, while both Usstock and Japstock are influenced by emerging bond markets. Emerging bond markets are influenced by developed stock markets, and developed bond markets are influenced by emerging stock markets.

Analysis within emerging-emerging markets finds that there is evidence of volatility spillovers from all classes of assets to any other classes of assets. Foreign exchange markets are found to be important in determining the volatility behaviour of

stock and bond markets. In addition, foreign exchange rates are not independent of both stock and bond markets.

Asymmetric effects are evident in several cases, namely Japbond, Japstock, Usbond, Usstock, Indbond, Indstock and Myrphp. This provides the motivation of estimating the VARMA-AGARCH model rather than the VARMA-GARCH model.

3.3. Economic Significance

The evidence of volatility spillovers in bond and stock markets in all directions may serve important information to gain profitable trade by changing the allocation of funds in both assets. Chulia and Torro (2008) suggests a trading rule that consists of taking positions in one asset according to the signals given by the volatility of a related asset. Specifically, if a volatility increment (decline) is forecasted in asset j in $t-1$ and spilled to asset i , then a trader should sell (buy) asset i .

Table 3-19: Volatility Spillovers, Analysis with Respect to Group of Markets, Developed Markets

No	Spillovers Direction	Evidence, out of possible cases*	%
1	From Bond to Bond	8 of 20	$(8/20) \times 100 = 40$
2	From Stock to Stock	6 of 20	$(6/20) \times 100 = 30$
3	From Stock to Bond	10 of 25	$(10/25) \times 100 = 40$
4	From Bond to Stock	8 of 25	$(8/25) \times 100 = 32$
5	From ER to Bond	5 of 20	$(5/20) \times 100 = 25$
6	From ER to Stock	5 of 20	$(5/20) \times 100 = 25$

Note: * denotes the number of volatility spillovers evidence in a specific direction, out of the total number of possible spillovers in that direction.

Table 3-20: Volatility Spillovers, Analysis with Respect to Group of Markets, Emerging-Developed Markets

No	Spillovers Direction	Evidence, out of possible cases*	%
1	From Bond to Bond	8 of 30	$(8/30) \times 100 = 27$
	- Emerging to Emerging	5 of 12	$(5/12) \times 100 = 42$
	- Emerging to Developed	1 of 8	$(1/8) \times 100 = 12.5$
	- Developed to Emerging	1 of 8 (from Japan)	$(1/8) \times 100 = 12.5$
	- Developed to Developed	1 of 2	$(1/2) \times 100 = 50$
2	From Stock to Stock	5 of 30	$(5/30) \times 100 = 17$
	- Emerging to Emerging	2 of 12	$(2/12) \times 100 = 17$
	- Emerging to Developed	1 of 8	$(1/8) \times 100 = 12.5$
	- Developed to Emerging	2 of 8 (from the USA)	$(2/8) \times 100 = 25$
	- Developed to Developed	0 of 2	$(0/2) \times 100 = 0$
3	From Stock to Bond	22 of 36	$(22/36) \times 100 = 61$
	- Emerging to Emerging	13 of 16	$(13/16) \times 100 = 81$
	- Emerging to Developed	3 of 8	$(3/8) \times 100 = 37.5$
	- Developed to Emerging	5 of 8 (from Japan and the USA)	$(5/8) \times 100 = 62.5$
	- Developed to Develop	1 of 2	$(1/2) \times 100 = 50$
4	From Bond to Stock	11 of 36	$(11/36) \times 100 = 31$
	- Emerging to Emerging	5 of 16	$(5/16) \times 100 = 32$
	- Emerging to Developed	2 of 8	$(2/8) \times 100 = 25$
	- Developed to Emerging	2 of 8 (from Japan and the USA)	$(2/8) \times 100 = 25$
	- Developed to Develop	2 of 2	$(2/2) \times 100 = 100$
5	From ER to Bond	15 of 90	$(15/90) \times 100 = 17$
	- ER to Emerging Bond	11 of 60	$(11/60) \times 100 = 18$
	- ER to Developed Bond	4 of 30	$(4/30) \times 100 = 13$
6	From ER to Stock	14 of 90	$(14/90) \times 100 = 16$
	- ER to Emerging Stock	6 of 60	$(6/60) \times 100 = 10$
	- ER to Developed Stock	8 of 30	$(8/30) \times 100 = 27$

Note: * denotes the number of volatility spillovers evidence in a specific direction, out of the total number of possible spillovers in that direction.

To construct an efficient portfolio when investing in developed markets, it is important to consider the volatility spillovers across assets, considering the group of countries where the assets are located, which is summarized in Table 3-19. Based on Table 3-19, regarding the trading strategy by Chulia and Torro (2008), investing in bond markets should pay attention on the volatility spillovers from both stock and other bond markets (40% each). The volatility spillovers from exchange rates are also important, which account for 25%. In addition, investing in stock markets should pay attention on the volatility spillovers from both bond and stock markets, with the spillovers from bond markets are slightly stronger than those of other stock markets (32% and 30%, respectively). The volatility spillovers from exchange rates are also important, which is account for 25%.

To construct an efficient portfolio when investing in emerging markets, it is important to consider the volatility spillovers across assets, considering the group of countries where the assets are located, which is summarized in Table 3-20. Based on Table 3-20, regarding the trading strategy by Chulia and Torro (2008), investing in emerging bond markets should consider more on the volatility spillovers from emerging and developed stock markets (81% and 62%, respectively). The volatility spillovers from other emerging bond markets are also important (42%), while those from developed markets are of the least important (12.5%). The volatility spillovers from exchange rates are also important, which account for 18%. In addition, investing in emerging stock markets should pay attention more on the volatility spillovers from emerging bond markets (32%), followed by volatility spillovers from developed bond and stock markets (25% each). Surprisingly, the volatility spillovers from other emerging stock markets are not quite strong (17%). The volatility spillovers from exchange rates are account for 10%.

A question remains is that whether those spillovers are economically significant, in terms of providing positive returns after considering transaction cost, using the aforementioned trading strategies. The answer to this question is beyond the scope of this thesis and shall be left for future research. A note for using the trading strategies is that one needs to consider the sign of volatility spillovers from one asset to another. As the spillovers are a mixture of positive and negative signs, there will be no general rule for such trading.

Appendix 3-1

Tables 3-21-A to 3-30-B, The Estimates of Developed Markets Case

Notes on Tables 3-21-A to 3-30-B:

- (1) Two entries for each parameter are their respective estimate and the Bollerslev-Wooldridge (1992) robust *t*-ratio.
- (2) C and MA(1) denote constant and Moving Average of degree 1, respectively.
- (3) Entries in **bold** are significant at the 5% level.

Table 3-21-A: VARMA-AGARCH, Conditional Mean for Australia-Japan

Return	C	MA(1)	AUDJPY(-1)	AUSBOND(-1)	AUSSTOCK(-1)	JAPBOND(-1)	JAPSTOCK(-1)
AUDJPY	0.000	-0.769	0.747	-0.154	0.049	0.145	-0.001
	0.746	-14.106	13.525	-5.228	2.716	3.680	-0.115
AUSBOND	0.000	-0.488	0.002	0.454	-0.006	0.009	-0.003
	-0.399	-1.473	0.220	1.347	-0.400	0.304	-0.412
AUSSTOCK	0.000	0.002	0.011	-0.011	-0.024	0.022	0.025
	1.659	0.004	0.517	-0.319	-0.049	1.479	1.852
JAPBOND(-1)	0.000	-0.306	0.014	0.032	-0.002	0.292	-0.007
	0.847	-1.339	2.120	2.600	-0.234	1.258	-1.507
JAPSTOCK	0.000	0.248	0.001	-0.086	0.124	-0.067	-0.277
	0.902	0.911	0.025	-1.367	2.555	-0.780	-1.029

Table 3-21-B: VARMA-AGARCH, Conditional Variance for Australia-Japan

Variance	ω	α_{AUDJPY}	$\alpha_{AUSBOND}$	$\alpha_{AUSSTOCK}$	$\alpha_{AUDJPY(-1)}$	$\alpha_{AUSBOND(-1)}$	$\alpha_{AUSSTOCK(-1)}$	γ	β_{AUDJPY}	$\beta_{AUSBOND}$	$\beta_{AUSSTOCK}$	$\beta_{JAPBOND}$	$\beta_{JAPSTOCK}$
AUDJPY	0.000	0.047	0.009	-0.009	0.002	0.002	0.004	-0.007	0.937	0.011	0.012	0.008	-0.002
	0.322	2.560	0.370	-0.790	0.059	0.059	0.983	-0.351	59.795	0.337	0.730	0.183	-0.328
AUSBOND	0.000	-0.002	-0.008	-0.002	0.000	0.000	0.001	0.008	0.002	1.001	0.004	-0.002	-0.001
	-0.593	-2.222	-1.072	-1.520	-0.009	-0.009	1.920	1.045	1.972	250.064	1.858	-0.211	-1.186
AUSSTOCK	2.3E-05	0.008	-0.003	0.111	-0.053	-0.053	-0.001	0.129	-0.002	-0.037	0.450	-0.043	-0.007
	99.267	0.375	-0.074	2.188	-1.407	-1.407	-0.131	1.599	-0.038	-0.259	6.909	-0.587	-0.451
JAPBOND	2.0E-07	0.001	0.000	0.000	0.047	0.047	-0.002	0.078	0.002	0.000	0.000	0.889	0.001
	5.383	0.609	0.061	-0.379	1.540	1.540	-2.500	2.298	1.745	0.142	0.036	34.347	1.620
JAPSTOCK	0.000	-0.028	0.017	0.055	-0.175	-0.175	0.036	0.060	0.057	0.193	-0.056	0.269	0.895
	0.104	-1.406	0.244	1.070	-1.291	-1.291	1.876	2.322	1.563	1.418	-0.967	1.442	41.617

Table 3-22-A: VARMA-AGARCH, Conditional Mean for Australia-New Zealand

Return	C	MA(1)	AUDNZD(-1)	AUSBOND(-1)	AUSSTOCK(-1)	NZBOND(-1)	NZSTOCK(-1)
AUDNZD	0.000	0.011	0.002	-0.066	0.000	0.022	0.010
	-0.143	0.027	0.005	-1.794	0.028	0.467	0.742
AUSBOND	0.000	-0.141	0.023	0.107	-0.021	0.015	0.012
	-0.528	-0.446	1.089	0.337	-1.494	0.327	0.857
AUSSTOCK	0.000	-0.679	0.011	-0.039	0.685	0.050	-0.023
	1.145	-2.524	0.436	-0.928	2.565	0.937	-1.303
NZBOND	0.000	-0.835	0.010	0.116	0.002	0.686	-0.003
	0.735	-20.003	1.040	4.912	0.336	11.923	-0.409
NZSTOCK	0.000	-0.153	-0.008	-0.116	0.082	0.099	0.208
	1.654	-0.873	-0.210	-2.238	3.174	1.541	1.213

Table 3-22-B: VARMA-AGARCH, Conditional Variance for Australia-New Zealand

Variance	ω	α_{AUDNZD}	$\alpha_{AUSBOND}$	$\alpha_{AUSSTOCK}$	α_{NZBOND}	$\alpha_{NZSTOCK}$	γ	β_{AUDNZD}	$\beta_{AUSBOND}$	$\beta_{AUSSTOCK}$	β_{NZBOND}	$\beta_{NZSTOCK}$
AUDNZD	7.4E-06	0.142	-0.003	-0.002	0.007	-0.002	0.035	0.544	-0.036	-0.004	-0.013	-0.007
	3.704	3.058	-0.096	-0.108	0.161	-0.190	0.542	5.660	-0.289	-0.166	-0.089	-0.381
AUSBOND	0.000	-0.003	-0.010	-0.005	0.022	0.003	-0.011	-0.004	0.999	0.008	-0.002	-0.003
	0.282	-1.141	-1.036	-2.229	3.684	1.008	-1.494	-1.148	191.421	2.684	-0.419	-0.846
AUSSTOCK	0.000	0.000	0.010	-0.017	-0.018	-0.001	0.144	0.046	0.040	0.888	-0.056	0.032
	0.457	-0.003	0.403	-0.895	-0.558	-0.090	5.022	0.860	0.778	33.447	-0.859	1.349
NZBOND	0.000	-0.001	0.005	0.000	0.015	0.003	-0.019	-0.001	-0.008	-0.001	0.998	-0.002
	1.358	-0.318	1.045	0.124	2.314	1.122	-2.407	-0.343	-3.337	-0.613	238.455	-0.595
NZSTOCK	0.000	0.007	0.059	0.045	-0.004	0.074	0.016	0.184	-0.054	-0.026	0.033	0.849
	-0.848	0.244	1.747	2.158	-0.085	3.480	0.458	1.977	-0.617	-1.306	0.251	24.492

Table 3-23-A: VARMA-AGARCH, Conditional Mean for Australia-Singapore

Return	C	MA(1)	AUDSGD(-1)	AUSBOND(-1)	AUSSTOCK(-1)	SGBOND(-1)	SGSTOCK(-1)
AUDSGD	0.000	-0.545	0.485	-0.170	0.034	0.165	0.025
	-0.140	-5.969	5.189	-5.338	1.823	3.594	2.095
AUSBOND	0.000	-0.180	-0.023	0.118	-0.003	0.145	-0.013
	-0.630	-0.857	-1.522	0.561	-0.209	3.013	-1.176
AUSSTOCK	0.001	0.628	-0.011	-0.011	-0.633	0.109	0.036
	2.418	4.163	-0.734	-0.414	-4.178	2.312	2.571
SGBOND	2.7E-04	0.106	-0.002	0.002	0.012	0.033	-0.004
	3.588	0.463	-0.563	0.186	1.409	0.149	-0.784
SGSTOCK	0.000	-0.636	0.050	0.004	0.036	-0.056	0.658
	1.608	-3.853	1.630	0.081	1.203	-0.699	4.103

Table 3-23-B: VARMA-AGARCH, Conditional Variance for Australia-Singapore

Variance	ω	α_{AUDSGD}	$\alpha_{AUSBOND}$	$\alpha_{AUSSTOCK}$	α_{SGBOND}	$\alpha_{SGSTOCK}$	γ	β_{AUDSGD}	$\beta_{AUSBOND}$	$\beta_{AUSSTOCK}$	β_{SGBOND}	$\beta_{SGSTOCK}$
AUDSGD	6.9E-07	0.025	-0.007	-0.004	0.009	0.005	0.016	0.948	0.002	-0.004	-0.010	-0.001
	2.119	2.075	-0.517	-0.564	0.587	1.930	1.117	65.072	0.140	-0.451	-0.515	-0.240
AUSBOND	0.000	-0.001	0.004	-0.004	0.013	0.001	0.007	0.003	0.990	0.006	-0.015	-0.002
	-1.526	-0.821	0.415	-1.526	0.985	1.110	0.682	1.485	160.511	2.132	-0.797	-1.426
AUSSTOCK	1.7E-06	-0.003	-0.008	-0.015	0.030	0.008	0.119	0.000	0.004	0.918	-0.068	-0.004
	2.167	-0.421	-0.385	-0.997	0.377	2.333	4.800	-0.035	0.164	46.981	-0.705	-0.638
SGBOND	4.7E-07	-0.001	0.010	-0.001	0.170	0.000	0.007	-0.009	0.007	0.000	0.780	0.001
	40.339	-2.717	1.990	-1.206	2.138	-0.184	0.061	-3.241	0.682	0.398	18.889	1.081
SGSTOCK	-3.8E-06	-0.031	0.006	0.017	0.409	0.042	0.065	0.073	0.385	0.028	-0.435	0.862
	-4.396	-1.788	0.094	0.538	1.638	1.768	2.166	2.135	3.067	0.738	-1.789	31.182

Table 3-24-A: VARMA-AGARCH, Conditional Mean for Australia-USA

Return	C	MA(1)	USDAUD	AUSBOND(-1)	AUSSTOCK(-1)	USBOND(-1)	USSTOCK(-1)
USDAUD	0.000	-0.730	0.704	0.195	-0.021	-0.181	-0.051
	-1.060	-12.190	11.914	6.655	-1.101	-6.069	-4.153
AUSBOND	0.000	-0.123	0.005	-0.048	0.020	0.683	-0.032
	0.050	-3.549	0.577	-1.919	1.970	35.536	-4.225
AUSSTOCK	3.9E-04	-0.176	-0.006	0.018	0.081	0.111	0.321
	3.893	-4.039	-0.366	0.674	2.121	4.297	24.935
USBOND	0.000	0.044	0.004	-0.017	-0.011	0.000	0.006
	-0.467	0.112	0.302	-0.655	-0.711	0.000	0.625
USSTOCK	0.000	0.731	-0.034	0.006	0.004	0.074	-0.738
	-0.547	6.822	-1.663	0.161	0.176	2.149	-6.923

Table 3-24-B: VARMA-AGARCH, Conditional Variance for Australia-USA

Variance	ω	α_{USDAUD}	$\alpha_{AUSBOND}$	$\alpha_{AUSSTOCK}$	$\alpha_{USSTOCK}$	γ	β_{USDAUD}	$\beta_{AUSBOND}$	$\beta_{AUSSTOCK}$	$\beta_{USSTOCK}$
USDAUD	1.2E-06	0.029	-0.005	0.000	0.024	-0.001	0.954	0.023	-0.005	-0.004
	5.757	3.388	-0.340	0.007	1.413	-0.069	92.573	1.197	-0.436	-1.271
AUSBOND	1.3E-06	-0.005	0.147	-0.003	0.069	-0.046	-0.002	0.231	-0.019	0.018
	6.705	-1.963	3.200	-1.079	3.196	-0.736	-0.116	2.083	-2.170	3.383
AUSSTOCK	1.8E-06	-0.011	0.009	0.030	-0.021	0.046	0.013	0.006	0.888	-0.003
	3.525	-2.678	0.418	1.544	-2.023	1.492	1.445	0.236	37.610	-0.802
USBOND	2.6E-07	-0.002	0.006	-0.002	0.028	-0.002	0.003	0.002	-0.002	-0.001
	2.140	-0.308	0.619	-0.442	1.703	-0.137	0.440	0.220	-0.341	-0.459
USSTOCK	0.000	-0.004	0.001	0.011	-0.056	0.132	-0.001	0.144	0.000	0.949
	-1.224	-0.322	0.018	0.417	-1.650	6.613	-0.038	1.994	-0.011	88.897

Table 3-25-A: VARMA-AGARCH, Conditional Mean for Japan-New Zealand

Return	C	MA(1)	NZDJPY(-1)	JAPBOND(-1)	JAPSTOCK(-1)	NZBOND(-1)	NZSTOCK(-1)
NZDJPY	0.000	-0.752	0.741	0.079	0.001	-0.110	0.076
	0.724	-10.510	10.298	1.967	0.088	-3.013	4.076
JAPBOND	0.000	-0.558	0.016	0.536	-0.008	0.029	0.001
	0.543	-3.468	2.839	3.265	-1.895	2.196	0.160
JAPSTOCK	0.000	0.413	0.071	-0.082	-0.420	-0.119	0.065
	1.037	2.064	2.174	-1.051	-2.111	-1.639	1.657
NZBOND	0.000	0.227	0.006	0.051	-0.009	-0.247	0.001
	0.710	0.726	0.639	1.898	-1.367	-0.792	0.091
NZSTOCK	0.000	0.504	-0.007	0.014	0.027	0.025	-0.440
	1.917	3.023	-0.456	0.318	2.695	0.703	-2.550

Table 3-25-B: VARMA-AGARCH, Conditional Variance for Japan-New Zealand

Variance	ω	α_{NZDJPY}	$\alpha_{JAPBOND}$	$\alpha_{JAPSTOCK}$	α_{NZBOND}	$\alpha_{NZSTOCK}$	γ	β_{NZDJPY}	$\beta_{JAPBOND}$	$\beta_{JAPSTOCK}$	β_{NZBOND}	$\beta_{NZSTOCK}$
NZDJPY	0.000	0.042	0.034	-0.002	0.022	0.017	-0.004	0.940	-0.032	0.004	-0.011	-0.006
	0.869	1.962	0.949	-0.490	0.513	1.759	-0.204	38.158	-0.804	0.741	-0.159	-0.434
JAPBOND	0.000	0.000	0.043	0.001	0.005	-0.001	0.078	0.003	0.895	-0.001	0.000	0.001
	1.738	-0.067	1.334	1.354	1.341	-1.188	2.428	1.599	35.903	-2.054	-0.027	1.030
JAPSTOCK	0.000	-0.014	-0.209	0.037	-0.052	0.020	0.068	0.046	0.251	0.885	0.443	0.005
	-0.626	-0.579	-1.721	1.711	-0.445	0.592	2.394	1.089	1.461	33.012	1.847	0.097
NZBOND	0.000	0.000	-0.003	0.001	0.027	0.001	-0.024	-0.001	0.007	-0.001	0.980	-0.001
	0.944	-0.452	-0.460	2.838	2.961	0.870	-2.183	-0.680	0.831	-1.747	128.261	-0.576
NZSTOCK	9.4E-07	-0.005	0.020	-0.002	0.069	0.055	0.040	0.019	-0.025	0.001	-0.095	0.895
	1.953	-0.632	0.652	-0.550	2.045	2.807	1.508	1.734	-0.871	0.274	-2.064	45.291

Table 3-26-A: VARMA-AGARCH, Conditional Mean for Japan-Singapore

Return	C	MA(1)	SGDJPY(-1)	JAPBOND(-1)	JAPSTOCK(-1)	SGBOND(-1)	SGSTOCK(-1)
SGDJPY	0.000	-0.917	0.910	0.056	-0.011	-0.059	0.008
	1.257	-33.898	34.253	3.324	-2.453	-3.406	1.926
JAPBOND	0.000	-0.333	-0.012	0.313	-0.007	0.049	0.000
	0.704	-1.460	-1.129	1.363	-1.351	2.493	-0.054
JAPSTOCK	0.000	-0.161	0.106	-0.044	0.111	-0.108	0.120
	0.742	-0.778	2.032	-0.520	0.530	-0.960	4.339
SGBOND	0.000	0.006	-0.014	0.023	0.000	0.021	-0.006
	0.675	0.007	-0.249	0.554	-0.016	0.023	-0.515
SGSTOCK	0.000	-0.474	0.002	0.095	-0.021	-0.094	0.523
	1.757	-2.009	0.083	1.301	-1.146	-1.209	2.321

Table 3-26-B: VARMA-AGARCH, Conditional Variance for Japan-Singapore

Variance	ω	α_{SGDJPY}	$\alpha_{JAPBOND}$	$\alpha_{JAPSTOCK}$	α_{SGBOND}	$\alpha_{SGSTOCK}$	γ	β_{SGDJPY}	$\beta_{JAPBOND}$	$\beta_{JAPSTOCK}$	β_{SGBOND}	$\beta_{SGSTOCK}$
SGDJPY	8.4E-07	0.036	0.008	0.002	0.015	0.002	0.010	0.914	0.005	-0.004	-0.034	0.002
	6.569	2.387	0.461	1.411	1.676	0.846	0.519	46.162	0.232	-2.071	-3.105	0.931
JAPBOND	2.3E-07	0.001	0.060	0.001	0.001	0.000	0.065	0.003	0.884	-0.001	0.000	0.000
	6.349	0.264	1.587	1.709	0.486	-0.337	1.639	0.971	35.338	-3.052	-0.145	0.815
JAPSTOCK	3.1E-06	-0.009	-0.143	0.030	0.378	0.010	0.070	-0.028	0.286	0.906	-0.318	0.002
	2.594	-0.171	-1.278	1.596	0.993	0.579	2.726	-0.490	1.845	48.036	-0.793	0.088
SGBOND	3.5E-06	0.000	-0.009	-0.001	0.151	0.001	0.050	-0.003	-0.005	-0.002	0.600	0.000
	3.328	0.023	-2.309	-1.173	2.095	0.797	0.410	-0.606	-0.531	-1.221	4.958	0.161
SGSTOCK	-1.5E-06	-0.064	-0.128	0.000	0.039	0.054	0.095	0.181	0.261	0.001	0.091	0.870
	-9.802	-1.971	-1.465	-0.065	0.143	2.558	3.046	2.665	1.896	0.078	0.354	33.733

Table 3-27-A: VARMA-AGARCH, Conditional Mean for Japan-USA

Return	C	MA(1)	USDJPY(-1)	JAPBOND(-1)	JAPSTOCK(-1)	USBOND(-1)	USSTOCK(-1)
USDJPY	0.000	-0.636	0.607	0.088	-0.015	-0.131	-0.033
	-0.068	-7.824	7.425	2.392	-1.714	-5.289	-3.032
JAPBOND	0.000	-0.243	-0.021	0.231	-0.005	0.062	-0.006
	0.664	-1.824	-2.360	1.721	-1.119	5.338	-1.125
JAPSTOCK	0.000	-0.256	0.109	-0.017	0.178	-0.062	0.442
	1.064	-4.370	2.648	-0.210	3.325	-1.136	16.792
USBOND	0.000	-0.265	0.040	-0.048	0.000	0.306	-0.002
	-0.992	-1.096	2.776	-1.570	-0.026	1.290	-0.263
USSTOCK	0.000	0.684	-0.050	0.002	0.004	0.062	-0.692
	-0.627	4.933	-1.945	0.041	0.286	1.793	-5.073

Table 3-27-B: VARMA-AGARCH, Conditional Variance for Japan-USA

Variance	ω	α_{USDJPY}	$\alpha_{JAPBOND}$	$\alpha_{JAPSTOCK}$	α_{USBOND}	$\alpha_{USSTOCK}$	γ	β_{USDJPY}	$\beta_{JAPBOND}$	$\beta_{JAPSTOCK}$	β_{USBOND}	$\beta_{USSTOCK}$
USDJPY	1.8E-06	0.012	0.023	0.002	-0.026	0.005	0.009	0.921	0.018	-0.006	0.030	0.000
	4.838	1.161	0.569	0.949	-2.069	1.681	0.611	69.098	0.508	-1.976	1.266	-0.090
JAPBOND	1.5E-07	0.000	0.040	0.000	0.003	0.000	0.084	0.002	0.895	-0.001	-0.003	0.001
	4.135	0.083	1.804	1.080	1.277	-0.465	3.023	1.615	42.039	-1.753	-0.818	0.747
JAPSTOCK	0.000	-0.008	-0.069	0.032	-0.034	0.040	0.051	-0.025	0.192	0.911	0.164	-0.024
	0.444	-0.317	-0.630	2.151	-0.548	2.548	2.409	-1.169	1.470	47.224	1.265	-1.449
USBOND	9.3E-08	-0.002	0.008	0.000	-0.010	0.003	0.014	0.000	-0.005	0.000	0.999	-0.003
	2.599	-1.736	0.983	0.592	-1.447	4.363	1.609	-0.090	-0.531	-0.324	288.258	-3.930
USSTOCK	0.000	-0.003	-0.019	0.001	-0.038	-0.026	0.125	0.014	0.040	-0.003	0.057	0.959
	0.287	-0.320	-0.387	0.129	-1.381	-2.743	6.482	1.586	0.721	-0.363	1.419	103.818

Table 3-28-A: VARMA-AGARCH, Conditional Mean for New Zealand-Singapore

Return	C	MA(1)	SGDNZD(-1)	NZBOND(-1)	NZSTOCK(-1)	SGBOND(-1)	SGSTOCK(-1)
SGDNZD	0.000	-0.811	0.777	-0.020	0.049	0.054	-0.007
	-0.250	-10.553	9.345	-0.659	2.999	1.238	-0.830
NZBOND	0.000	-0.623	0.014	0.564	0.002	0.094	-0.010
	0.286	-4.798	1.594	4.162	0.235	3.013	-1.556
NZSTOCK	0.001	0.473	-0.023	0.028	-0.401	0.037	0.046
	2.621	3.449	-3.708	0.735	-2.822	0.665	3.183
SGBOND	2.1E-04	0.062	0.009	0.020	0.010	0.073	-0.003
	3.108	0.272	1.492	1.457	1.783	0.329	-0.780
SGSTOCK	0.000	-0.629	0.045	0.079	0.047	-0.110	0.659
	1.743	-4.226	1.864	1.339	1.899	-1.446	4.621

Table 3-28-B: VARMA-AGARCH, Conditional Variance for New Zealand-Singapore

Variance	ω	α_{SGDNZD}	α_{NZBOND}	$\alpha_{NZSTOCK}$	α_{SGBOND}	$\alpha_{SGSTOCK}$	γ	α_{SGDNZD}	α_{NZBOND}	$\alpha_{NZSTOCK}$	α_{SGBOND}	$\alpha_{SGSTOCK}$
SGDNZD	4.4E-06	0.004	0.269	-0.003	0.052	-0.004	0.089	0.845	-0.242	0.005	0.013	0.011
	4.783	0.159	1.021	-0.266	0.749	-0.786	2.943	26.186	-1.119	0.226	0.209	1.519
NZBOND	0.000	0.001	0.032	0.001	0.008	0.001	-0.020	-0.001	0.974	-0.001	-0.009	-0.001
	1.128	1.387	3.076	0.337	0.959	1.228	-1.697	-1.113	99.598	-0.295	-0.805	-0.697
NZSTOCK	1.8E-06	-0.002	0.036	0.068	0.041	0.014	0.025	0.003	-0.106	0.866	-0.074	0.003
	10.062	-3.270	1.027	3.255	1.159	3.170	0.755	1.226	-2.622	35.767	-1.741	0.381
SGBOND	1.5E-07	0.000	-0.005	0.005	0.214	0.000	0.010	-0.002	0.023	0.001	0.760	-0.001
	4.183	0.497	-1.173	1.808	2.071	-0.780	0.076	-1.453	3.712	0.445	15.737	-2.273
SGSTOCK	-3.5E-06	-0.016	-0.087	0.018	0.362	0.033	0.102	0.006	0.699	0.095	-0.305	0.835
	-3.270	-0.870	-0.833	0.561	1.605	1.339	3.134	0.686	3.993	1.993	-1.361	23.981

Table 3-29-A: VARMA-AGARCH, Conditional Mean for New Zealand-USA

Return	C	MA(1)	USDNZD(-1)	NZBOND(-1)	NZSTOCK(-1)	USBOND(-1)	USSTOCK(-1)
USDNZD	0.000	-0.855	0.836	0.003	-0.031	-0.038	-0.025
	-0.661	-13.925	13.093	0.087	-2.028	-1.330	-2.569
NZBOND	0.000	-0.081	-0.010	-0.047	0.005	0.552	-0.028
	1.702	-2.285	-1.116	-1.806	0.606	37.043	-4.577
NZSTOCK	3.2E-04	0.053	0.048	-0.021	0.035	0.018	0.192
	2.374	0.733	2.580	-0.534	0.506	0.592	13.862
USBOND	0.000	-0.217	0.034	-0.044	-0.005	0.267	0.005
	-0.439	-0.789	2.825	-1.504	-0.394	0.972	0.507
USSTOCK	0.000	0.117	-0.002	-0.042	-0.054	0.068	-0.139
	-0.392	0.418	-0.096	-0.685	-1.789	1.478	-0.499

Table 3-29-B: VARMA-AGARCH, Conditional Variance for New Zealand-USA

Variance	ω	α_{USDNZD}	α_{NZBOND}	$\alpha_{NZSTOCK}$	$\alpha_{USDSTOCK}$	γ	α_{USDNZD}	α_{NZBOND}	$\alpha_{NZSTOCK}$	$\alpha_{USDSTOCK}$
USDNZD	3.5E-05	0.154	-0.065	-0.018	0.023	-0.188	0.154	0.125	0.175	-0.041
	3.586	3.202	-1.055	-2.979	0.364	-3.793	0.906	0.294	2.496	0.263
NZBOND	1.3E-06	0.010	0.150	0.002	0.023	-0.064	-0.026	0.390	0.002	0.113
	1.931	3.368	3.194	0.852	2.186	-1.103	-2.284	3.187	0.369	2.945
NZSTOCK	0.000	0.002	0.019	0.066	0.007	0.015	-0.005	0.059	0.891	-0.075
	1.366	0.272	0.499	2.852	0.329	0.494	-0.217	1.028	32.959	-1.705
USBOND	8.9E-07	0.000	0.007	0.004	0.018	0.018	-0.003	0.045	-0.016	0.895
	2.053	0.123	0.362	1.195	0.910	0.894	-0.317	1.359	-2.327	21.504
USSTOCK	0.000	-0.015	-0.016	0.028	-0.044	0.125	0.011	0.182	-0.027	-0.012
	1.245	-1.633	-0.232	1.333	-1.206	6.219	0.509	1.587	-1.183	-0.153
										92.286

Table 3-30-A: VARMA-AGARCH, Conditional Mean for Singapore-USA

Return	C	MA(1)	USDSGD(-1)	SGBOND(-1)	SGSTOCK(-1)	USBOND(-1)	USSTOCK(-1)
USDSGD	0.000	-0.311	0.269	0.025	-0.011	-0.050	-0.018
	-0.966	-1.867	1.599	1.092	-1.870	-3.754	-3.367
SGBOND	1.8E-04	0.006	-0.043	-0.035	0.002	0.190	-0.002
	3.749	0.081	-3.195	-0.522	0.595	11.717	-0.568
SGSTOCK	0.001	-0.138	-0.043	-0.050	0.111	-0.084	0.305
	3.292	-1.826	-0.601	-0.552	1.579	-1.769	13.086
USBOND	0.000	-0.514	0.086	-0.025	-0.005	0.534	0.002
	-0.491	-2.306	2.844	-0.654	-0.618	2.439	0.263
USSTOCK	0.000	0.773	-0.189	-0.093	0.020	0.049	-0.771
	-0.480	11.737	-3.684	-1.404	1.309	1.674	-11.856

Table 3-30-B: VARMA-AGARCH, Conditional Variance for Singapore-USA

Variance	ω	α_{USDSGD}	α_{SGBOND}	$\alpha_{SGSTOCK}$	$\alpha_{USSTOCK}$	γ	α_{USDSGD}	α_{SGBOND}	$\alpha_{SGSTOCK}$	$\alpha_{USSTOCK}$
USDSGD	0.000	0.016	0.001	0.001	-0.003	-0.009	0.973	-0.004	-0.001	0.007
	1.574	1.948	0.243	0.840	-1.310	-0.624	120.788	-0.575	-1.271	2.007
SGBOND	3.1E-06	0.000	0.150	-0.001	0.004	0.050	-0.002	0.597	-0.001	-0.001
	16.610	0.068	2.794	-1.221	0.198	0.471	-0.046	8.209	-0.787	-0.039
SGSTOCK	0.000	-0.050	0.248	0.064	0.030	0.037	0.225	-0.387	0.868	0.127
	-0.664	-1.751	1.880	2.661	0.501	1.051	1.224	-3.045	25.538	1.074
USBOND	3.0E-07	0.008	0.082	0.001	0.002	0.000	-0.019	-0.111	-0.001	0.999
	4.145	1.133	5.974	1.379	0.326	0.047	-2.060	-6.309	-1.463	208.968
USSTOCK	8.0E-07	0.040	0.181	0.016	-0.081	0.128	-0.074	-0.220	-0.006	0.103
	8.148	1.201	1.875	1.380	-2.609	6.435	-1.370	-1.883	-0.526	2.646
										98.349

Appendix 3-2

Tables 3-31-A to 3-45-B, The Estimates of Emerging-Developed Markets Case

Notes on Tables 3-27-A to 3-41-B:

(1) Two entries for each parameter are their respective estimate and the Bollerslev-

Wooldridge (1992) robust *t*-ratio.

(2) C and MA(1) denote constant and Moving Average of degree 1, respectively.

(3) Entries in **bold** are significant at the 5% level.

Table 3-31-A: VARMA-AGARCH, Conditional Mean for Indonesia-Japan

Return	C	MA(1)	Indbond(-1)	Indstock(-1)	Japbond(-1)	Japstock(-1)	Jpyidr(-1)
Indbond	0.000	0.039	-0.030	0.009	-0.018	0.015	-0.016
	1.473	0.134	-0.105	1.126	-0.659	1.485	-0.893
Indstock	0.002	0.193	-0.055	0.007	-0.103	-0.021	0.080
	3.069	1.195	-1.300	0.039	-0.777	-0.584	2.519
Japbond	0.000	0.046	0.011	-0.003	-0.015	-0.010	0.015
	0.892	0.172	0.514	-0.494	-0.056	-1.376	2.483
Japstock	0.001	0.467	-0.142	0.059	0.126	-0.418	-0.038
	2.352	2.487	-1.787	1.908	1.566	-2.241	-0.704
Jpyidr	0.000	0.189	-0.021	-0.060	0.023	-0.024	-0.173
	0.560	0.917	-0.372	-3.274	0.282	-1.368	-0.836

Table 3-31-B: VARMA-AGARCH, Conditional Variance for Indonesia-Japan

Variance	Omega	ARCH Effects (-1)						GARCH Effects (-1)					
		Indbond	Indstock	Japbond	Japstock	Jpyidr	Treshold	Indbond	Indstock	Japbond	Japstock	Jpyidr	
Indbond	8.77E-07	0.198	-0.002	-0.021	0.000	0.022	0.143	0.741	0.002	0.029	0.002	-0.039	
	26.219	1.831	-1.806	-1.586	-0.096	1.566	1.080	10.925	0.422	1.273	0.548	-1.808	
Indstock	1.84E-05	-0.119	-0.002	0.135	-0.021	-0.053	0.353	0.051	0.634	0.440	0.046	0.133	
	21.761	-7.060	-0.083	0.502	-0.771	-0.693	3.792	0.872	10.925	0.776	0.809	0.782	
Japbond	3.41E-07	0.005	0.000	0.001	0.001	-0.002	0.169	-0.002	0.000	0.863	-0.001	0.000	
	14.671	1.580	0.858	0.070	2.582	-1.968	3.962	-0.819	-0.432	36.423	-2.350	-0.179	
Japstock	1.07E-05	-0.025	-0.002	-0.517	-0.051	0.157	0.278	0.037	0.067	2.904	0.693	-0.354	
	14.823	-0.396	-0.080	-2.326	-2.548	2.648	5.268	0.497	1.917	3.378	12.659	-4.014	
Jpyidr	8.88E-06	0.051	0.020	0.052	0.001	0.166	-0.035	-0.013	-0.017	0.072	0.032	0.419	
	2.687	1.522	1.760	0.365	0.047	1.669	-0.231	-0.426	-1.229	0.248	1.348	2.627	

Table 3-32-A: VARMA-AGARCH, Conditional Mean for Indonesia-Malaysia

Return	C	MA(1)	Indbond(-1)	Indstock(-1)	Malbond(-1)	Malstock(-1)	Myridr(-1)
Indbond	0.000	-0.819	0.883	0.009	-0.008	0.013	-0.001
	-0.101	-12.694	18.837	2.208	-0.267	1.621	-0.050
Indstock	0.002	0.338	-0.058	-0.158	-0.106	-0.024	-0.055
	2.973	2.065	-0.921	-0.911	-0.435	-0.408	-0.714
Malbond	0.000	0.005	0.000	0.001	0.167	0.005	-0.015
	-1.761	0.023	-0.024	0.183	0.746	0.689	-2.197
Malstock	0.000	-0.029	0.002	0.029	0.091	0.175	-0.028
	1.754	-0.184	0.047	1.655	0.627	1.109	-0.888
Myridr	0.000	0.119	-0.010	-0.047	-0.025	-0.029	-0.163
	1.157	0.591	-0.510	-3.579	-0.179	-1.321	-0.820

Table 3-32-B: VARMA-AGARCH, Conditional Variance for Indonesia-Malaysia

Variance	ARCH Effects (-1)							GARCH Effects (-1)				
	Omega	Indbond	Indstock	Malbond	Malstock	Myridr	Treshold	Indbond	Indstock	Malbond	Malstock	Myridr
Indbond	1.08E-06	0.137	0.000	0.154	0.005	0.013	0.206	0.781	0.001	-0.089	-0.015	-0.028
	9.070	7.491	0.057	4.500	2.693	4.949	5.155	71.292	0.544	-2.693	-4.595	-8.004
Indstock	1.73E-05	-0.115	0.022	-1.097	-0.047	-0.017	0.284	0.053	0.634	-0.145	0.423	0.022
	3.042	-6.117	0.707	-4.361	-0.818	-0.208	4.385	0.847	11.863	-0.921	2.678	0.198
Malbond	2.15E-07	0.000	0.000	0.150	0.002	0.000	0.050	-0.001	0.000	0.598	0.002	0.000
	6.294	0.022	0.474	4.090	3.918	0.497	0.972	-1.518	-4.233	14.061	1.567	0.074
Malstock	1.05E-05	-0.023	0.007	0.003	0.142	-0.004	0.022	0.042	0.017	0.034	0.423	-0.038
	85.834	-1.706	0.892	0.011	1.911	-0.440	0.246	1.072	0.713	0.045	3.550	-2.091
Myridr	2.64E-06	-0.007	0.010	0.117	0.024	0.235	-0.023	0.004	0.004	-0.401	-0.028	0.597
	123.698	-2.277	1.548	0.898	1.371	2.537	-0.159	0.603	0.383	-1.463	-0.948	5.990

Table 3-33-A: VARMA-AGARCH, Conditional Mean for Indonesia-Philippines

Return	C	MA(1)	Indbond(-1)	Indstock(-1)	Phibond(-1)	Phistock(-1)	Phpidr(-1)
Indbond	0.000	0.039	-0.051	0.014	-0.033	0.012	-0.014
	1.717	0.123	-0.166	1.593	-1.374	1.252	-1.450
Indstock	0.002	0.297	-0.048	-0.145	0.239	0.006	-0.028
	3.076	1.633	-0.721	-0.757	1.382	0.184	-0.388
Phibond	0.000	-0.002	0.003	0.001	0.096	-0.005	-0.010
	-0.822	-0.004	0.230	0.224	0.216	-0.738	-1.289
Phistock	0.001	0.033	0.183	0.131	0.115	0.096	-0.059
	1.971	0.225	2.397	3.960	0.654	0.651	-1.944
Phpidr	0.000	0.144	0.005	-0.058	0.011	0.004	-0.159
	1.732	0.735	0.147	-4.217	0.227	0.325	-0.801

Table 3-33-B: VARMA-AGARCH, Conditional Variance for Indonesia-Philippines

Variance	ARCH Effects (-1)						GARCH Effects (-1)					
	Omega	Indbond	Indstock	Phibond	Phistock	Phpidr	Treshold	Indbond	Indstock	Phibond	Phistock	Phpidr
Indbond	1.16E-06	0.161	-0.001	-0.027	0.003	-0.011	0.117	0.741	0.003	-0.008	-0.006	0.009
	30.825	2.237	-0.452	-3.391	1.479	-3.609	0.939	14.587	0.967	-0.455	-1.867	0.990
Indstock	2.53E-05	-0.100	0.025	0.519	-0.003	-0.071	0.258	0.042	0.609	-0.384	0.041	0.131
	2.989	-2.330	0.724	1.089	-0.180	-1.119	3.651	0.526	9.020	-0.477	0.774	1.060
Phibond	1.28E-06	-0.001	0.000	0.171	0.000	0.000	0.049	-0.003	-0.001	0.629	-0.002	0.000
	6.584	-3.379	0.009	5.262	0.652	-1.147	1.297	-5.175	-1.048	15.132	-1.590	0.498
Phistock	7.15E-06	0.016	0.009	0.051	0.094	-0.031	-0.029	-0.044	-0.025	-0.026	0.882	0.062
	12.955	0.311	0.722	0.173	2.801	-1.131	-0.662	-1.008	-1.123	-0.057	35.814	2.077
Phpidr	3.80E-06	-0.004	0.011	-0.110	-0.002	0.225	-0.085	-0.003	-0.006	0.179	-0.004	0.631
	4.740	-0.878	1.776	-2.600	-0.592	2.226	-0.668	-0.768	-0.562	1.871	-0.412	7.960

Table 3-34-A: VARMA-AGARCH, Conditional Mean for Indonesia-Thailand

Return	C	MA(1)	Indbond(-1)	Indstock(-1)	Thabond(-1)	Thastock(-1)	Thbidr(-1)
Indbond	0.000	0.025	-0.058	0.028	-0.007	-0.001	-0.035
	3.185	0.099	-0.243	3.090	-0.140	-0.442	-1.374
Indstock	0.002	0.247	-0.048	-0.057	-0.027	0.001	0.051
	3.027	1.477	-1.298	-0.327	-0.228	0.044	0.701
Thabond	-0.001	0.012	0.040	-0.002	0.004	0.001	0.023
	-1.872	0.023	1.889	-0.404	0.009	0.085	1.650
Thastock	6.20E-05	-0.101	0.083	0.076	-0.414	0.125	-0.042
	0.170	-0.381	1.267	2.368	-2.899	0.478	-0.995
Thbidr	0.000	0.287	-0.010	-0.061	-0.080	0.001	-0.295
	2.215	1.928	-0.460	-5.243	-0.935	0.077	-1.970

Table 3-34-B: VARMA-AGARCH, Conditional Variance for Indonesia-Thailand

Variance	Omega	ARCH Effects (-1)						GARCH Effects (-1)					
		Indbond	Indstock	Thabond	Thastock	Thbidr	Threshold	Indbond	Indstock	Thabond	Thastock	Thbidr	
Indbond	2.13E-06	0.192	-0.001	0.021	-0.002	0.022	0.113	0.610	0.006	-0.032	0.002	-0.029	
	28.056	2.433	-0.512	1.278	-2.808	0.869	0.906	10.356	1.198	-1.739	0.974	-1.194	
Indstock	2.64E-05	-0.119	0.014	0.099	-0.005	0.014	0.298	0.060	0.662	-0.128	0.008	-0.036	
	157.372	-5.333	0.483	1.033	-0.344	0.183	3.464	0.895	15.071	-0.722	0.515	-0.321	
Thabond	4.43E-06	0.000	-0.002	0.139	0.002	0.003	0.048	-0.012	-0.003	0.565	-0.001	0.008	
	47.689	0.000	-5.461	1.669	0.630	0.597	0.272	-1.105	-1.991	8.586	-0.264	0.624	
Thastock	0.000	-0.004	-0.040	-0.029	0.264	-0.028	-0.046	0.023	-0.061	0.046	0.343	-0.065	
	353.616	-0.028	-4.427	-0.551	3.510	-1.173	-0.388	0.060	-0.931	0.108	5.080	-0.561	
Thbidr	5.29E-06	-0.006	0.005	0.159	0.000	0.369	-0.121	0.003	-0.001	-0.173	-0.004	0.515	
	31.613	-1.743	0.898	1.703	-0.180	2.628	-0.677	0.267	-0.127	-2.495	-3.136	7.369	

Table 3-35-A: VARMA-AGARCH, Conditional Mean for Indonesia-USA

Return	C	MA(1)	Indbond(-1)	Indstock(-1)	Usbond(-1)	Usstock(-1)	Usdldr(-1)
Indbond	0.000	0.020	-0.034	0.010	0.030	0.014	-0.039
	1.477	0.081	-0.131	1.426	1.573	1.324	-1.369
Indstock	0.002	0.225	-0.035	-0.056	-0.068	0.401	-0.051
	3.356	2.253	-0.575	-0.574	-0.795	8.028	-1.218
Usbond	0.000	0.014	-0.008	-0.005	0.001	-0.008	0.005
	-0.651	0.037	-0.322	-0.407	0.004	-0.380	0.461
Usstock	0.000	-0.387	-0.030	0.024	0.002	0.326	-0.025
	0.749	-1.063	-0.791	1.419	0.034	0.872	-0.768
Usdldr	0.000	0.053	-0.002	-0.052	-0.039	-0.033	-0.054
	1.176	0.233	-0.127	-3.658	-1.267	-1.390	-0.234

Table 3-35-B: VARMA-AGARCH, Conditional Variance for Indonesia-USA

	ARCH Effects (-1)						GARCH Effects (-1)					
Variance	Omega	Indbond	Indstock	Usbond	Usstock	Usdldr	Threshold	Indbond	Indstock	Usbond	Usstock	Usdldr
Indbond	1.01E-06	0.138	0.000	0.005	0.006	0.030	0.139	0.753	0.007	-0.026	-0.012	-0.035
	58.417	2.288	0.306	0.556	2.642	1.945	1.112	18.772	2.772	-1.590	-3.003	-2.912
Indstock	1.36E-05	-0.100	0.020	0.194	0.075	-0.082	0.319	0.111	0.578	0.302	0.077	0.083
	21.214	-6.320	0.613	1.100	0.913	-1.356	3.095	1.809	7.249	0.725	0.435	0.789
Usbond	2.40E-06	-0.008	0.003	0.005	0.010	-0.004	0.133	0.016	-0.006	0.755	0.009	0.000
	5.258	-1.764	1.632	0.259	1.002	-0.728	2.879	1.839	-1.781	10.613	0.605	-0.119
Usstock	0.000	0.000	0.004	-0.025	-0.037	-0.015	0.117	-0.008	-0.003	0.098	0.936	0.020
	0.863	0.009	0.682	-1.098	-2.492	-2.013	3.973	-0.624	-0.243	2.583	38.909	2.806
Usdldr	1.99E-06	-0.006	0.014	0.005	0.021	0.260	0.005	0.007	0.001	-0.115	0.018	0.587
	80.982	-2.032	2.004	0.281	1.116	2.526	0.026	1.175	0.045	-2.295	0.489	6.342

Table 3-36-A: VARMA-AGARCH, Conditional Mean for Japan-Malaysia

Return	C	MA(1)	Japbond(-1)	Japstock(-1)	Malbond(-1)	Malstock(-1)	Myripy(-1)
Japbond	0.000	-0.016	0.051	-0.011	0.076	0.003	0.022
	0.855	-0.080	0.252	-1.980	1.499	0.263	3.937
Japstock	0.001	0.295	0.047	-0.245	-0.341	-0.027	-0.110
	2.101	1.657	0.329	-1.361	-1.314	-0.451	-4.724
Malbond	-6.03E-05	0.005	0.016	0.004	0.165	0.004	0.017
	-2.368	0.030	1.090	2.085	1.049	0.595	3.098
Malstock	0.000	-0.134	-0.079	0.016	0.056	0.243	0.072
	0.858	-0.668	-1.159	1.119	0.357	1.219	2.339
Myripy	0.000	-0.557	-0.185	-0.027	0.030	0.064	0.554
	-1.063	-3.353	-2.646	-1.968	0.264	2.106	3.462

Table 3-36-B: VARMA-AGARCH, Conditional Variance for Japan-Malaysia

Variance	ARCH Effects (-1)						GARCH Effects (-1)					
	Omega	Japbond	Japstock	Malbond	Malstock	Myripy	Threshold	Japbond	Japstock	Malbond	Malstock	Myripy
Japbond	2.26E-07	-0.005	0.001	-0.041	0.000	-0.001	0.162	0.873	-0.001	0.080	-0.005	0.006
	41.224	-0.264	3.546	-3.063	-0.054	-7.110	3.399	34.814	-2.649	3.008	-1.985	3.243
Japstock	0.000	-0.035	-0.019	0.823	0.037	-0.040	0.144	0.994	0.876	-1.553	0.030	0.127
	-1.210	-0.122	-0.786	1.046	0.958	-6.596	3.458	2.000	30.488	-1.927	0.360	3.687
Malbond	3.40E-08	0.004	0.000	0.150	0.003	0.000	0.050	0.006	-0.001	0.600	0.006	0.000
	8.629	0.995	0.641	2.241	1.845	0.136	0.513	0.335	-2.490	6.566	1.870	-0.147
Malstock	7.99E-07	0.035	0.000	-0.004	-0.027	0.022	0.021	-0.042	0.001	0.232	1.000	-0.036
	6.687	0.855	-0.160	-0.033	-2.304	5.576	1.530	-0.718	0.397	2.238	112.081	-4.846
Myripy	2.92E-06	-0.165	-0.011	-0.301	0.017	0.048	0.231	0.179	0.039	0.476	-0.009	0.643
	4.910	-5.676	-1.626	-1.982	0.758	1.492	1.057	1.465	2.113	0.976	-0.112	12.102

Table 3-37-A: VARMA-AGARCH, Conditional Mean for Japan-Philippines

Return	C	MA(1)	Japbond(-1)	Japstock(-1)	Phibond(-1)	Phistock(-1)	Phippy(-1)
Japbond	0.000	-0.142	0.178	-0.009	0.000	-0.014	-0.017
	1.018	-0.568	0.715	-1.200	-0.008	-2.098	-1.378
Japstock	0.000	-0.157	-0.036	0.158	-0.081	0.071	0.124
	1.546	-0.873	-0.818	0.876	-0.535	2.689	2.201
Phibond	0.000	0.000	0.046	0.000	0.095	-0.002	-0.006
	-0.800	0.000	1.664	-0.046	0.319	-0.423	-0.654
Phistock	0.001	-0.136	-0.049	0.076	0.189	0.272	-0.006
	2.036	-0.820	-0.351	2.171	1.136	1.646	-0.088
Phippy	0.000	0.001	0.069	-0.021	0.108	0.008	-0.098
	-0.029	0.005	0.893	-1.009	1.110	0.503	-0.368

Table 3-37-B: VARMA-AGARCH, Conditional Variance for Japan- Philippines

Variance	ARCH Effects (-1)							GARCH Effects (-1)				
	Omega	Japbond	Japstock	Phibond	Phistock	Phippy	Threshold	Japbond	Japstock	Phibond	Phistock	Phippy
Japbond	4.23E-07	0.009	0.002	-0.008	0.000	0.003	0.172	0.837	-0.001	0.007	0.001	-0.010
	5.319	0.386	2.132	-1.904	-0.483	1.199	3.072	20.211	-1.539	0.844	0.758	-1.475
Japstock	0.000	-0.318	-0.060	0.450	-0.015	-0.042	0.269	2.362	0.768	-0.015	0.007	0.226
	0.311	-1.226	-3.400	1.125	-1.833	-0.752	5.517	3.136	16.509	-0.031	0.233	1.468
Phibond	1.10E-06	-0.011	0.000	0.163	0.001	-0.007	0.043	0.007	0.001	0.624	-0.002	0.004
	17.037	-0.942	0.449	2.604	0.899	-3.338	0.424	0.288	0.516	7.871	-1.327	0.400
Phistock	0.000	-0.568	-0.012	-0.115	0.077	0.016	-0.024	0.625	0.002	0.436	0.909	-0.085
	0.266	-3.047	-1.130	-0.536	2.842	0.289	-0.695	2.521	0.098	1.067	29.293	-0.140
Phippy	1.48E-05	-0.078	0.018	0.089	-0.007	0.058	-0.027	-0.130	-0.026	0.156	0.012	0.535
	2.615	-1.246	1.476	0.658	-1.175	1.078	-0.503	-0.882	-2.255	0.642	0.626	3.097

Table 3-38-A: VARMA-AGARCH, Conditional Mean for Japan-Thailand

Return	C	MA(1)	Japbond(-1)	Japstock(-1)	Thabond(-1)	Thastock(-1)	Thbjpy(-1)
Japbond	0.000	-0.025	0.068	-0.015	-0.014	0.013	-0.015
	1.031	-0.131	0.359	-2.602	-0.505	2.601	-1.098
Japstock	0.001	0.127	-0.035	-0.104	0.066	0.017	0.093
	2.057	0.911	-0.646	-0.760	0.522	0.614	1.390
Thabond	0.000	0.005	0.036	0.010	-0.003	-0.006	-0.006
	-0.812	0.005	0.814	1.276	-0.002	-0.774	-0.203
Thastock	0.000	-0.129	-0.391	0.010	-0.064	0.138	0.038
	-1.069	-0.476	-2.785	0.336	-1.251	0.519	0.732
Thbjpy	0.000	-0.456	0.104	0.001	-0.112	0.003	0.369
	0.999	-2.170	1.536	0.052	-1.872	0.275	1.669

Table 3-38-B: VARMA-AGARCH, Conditional Variance for Japan-Thailand

	ARCH Effects (-1)							GARCH Effects (-1)									
Variance	Omega	Japbond	Japstock	Thabond	Thastock	Thbjpy	Threshold	Japbond	Japstock	Thabond	Thastock	Thbjpy	Japbond	Japstock	Thabond	Thastock	Thbjpy
Japbond	-1.54E-07	0.003	0.001	0.002	0.000	0.000	0.148	0.886	-0.001	0.002	0.000	0.014	0.886	-0.001	0.002	0.000	0.014
	-8.961	0.153	2.103	0.884	-0.803	0.118	3.273	33.355	-3.735	0.194	1.041	2.845	33.355	-3.735	0.194	1.041	2.845
Japstock	-1.05E-05	-0.381	-0.061	0.126	0.010	0.054	0.272	2.019	0.748	-0.242	0.001	0.716	2.019	0.748	-0.242	0.001	0.716
	-17.820	-1.720	-2.696	1.675	0.886	0.393	4.764	2.886	13.726	-1.874	0.087	4.860	2.886	13.726	-1.874	0.087	4.860
Thabond	0.000	-0.001	-0.005	0.150	0.000	-0.001	0.050	0.000	-0.004	0.599	0.000	-0.002	0.000	-0.004	0.599	0.000	-0.002
	1.561	-0.006	-0.807	1.508	-0.175	-0.021	0.346	0.000	-0.730	5.215	0.006	-0.014	0.000	-0.730	5.215	0.006	-0.014
Thastock	-2.90E-06	0.237	-0.005	-0.050	0.103	-0.036	-0.003	-0.108	0.009	0.296	0.892	0.067	-0.108	0.009	0.296	0.892	0.067
	-12.635	1.112	-0.429	-1.526	3.850	-1.170	-0.082	-0.264	0.714	1.527	40.741	0.783	-0.264	0.714	1.527	40.741	0.783
Thbjpy	1.41E-05	0.038	0.010	0.088	0.000	0.158	-0.061	-0.064	0.021	-0.049	0.006	0.166	-0.064	0.021	-0.049	0.006	0.166
	2.980	0.314	1.165	1.160	-0.052	1.174	-0.465	-0.248	1.003	-0.872	0.619	0.679	-0.248	1.003	-0.872	0.619	0.679

Table 3-39-A: VARMA-AGARCH, Conditional Mean for Japan-USA

Return	C	MA(1)	Japbond(-1)	Japstock(-1)	Usbond(-1)	Usstock(-1)	Usdjpy(-1)
Japbond	0.000	-0.387	0.362	-0.012	0.114	-0.012	-0.012
	1.162	-3.545	3.326	-2.167	6.600	-1.211	-1.011
Japstock	0.000	-0.285	-0.037	0.204	-0.132	0.601	0.119
	1.909	-3.839	-0.285	3.060	-1.837	13.503	1.944
Usbond	0.000	-0.701	0.033	0.009	0.698	-0.007	0.045
	-0.692	-4.060	0.689	1.133	4.023	-0.456	2.282
Usstock	0.000	0.607	-0.081	-0.011	0.030	-0.621	-0.071
	0.411	3.057	-1.083	-0.614	0.742	-3.185	-2.232
Usdjpy	0.000	-0.153	0.164	0.011	-0.167	-0.048	0.093
	0.047	-1.250	4.114	0.754	-4.029	-1.906	0.804

Table 3-39-B: VARMA-AGARCH, Conditional Variance for Japan-USA

Variance	Omega	ARCH Effects (-1)			Threshold	GARCH Effects (-1)			Usbond	Usstock	Usdjpy
		Japbond	Japstock	Usbond		Japbond	Japstock	Usbond			
Japbond	2.02E-07	-0.008	0.001	0.007	0.132	0.882	0.001	-0.003	-0.005	0.001	0.001
	4.584	-0.491	1.311	1.208	3.071	25.063	0.751	-0.473	-1.978	0.155	0.155
Japstock	4.15E-05	0.034	0.007	-0.074	0.062	0.616	0.916	-0.073	0.039	-1.618	-1.618
	29.014	0.225	0.393	-1.376	2.316	2.205	34.870	-0.752	0.842	-15.832	-15.832
Usbond	8.10E-06	0.094	-0.005	-0.033	0.007	1.002	-0.007	0.180	0.140	-0.245	-0.245
	13.910	1.020	-1.609	-1.600	0.241	1.939	-0.648	0.576	1.918	-3.625	-3.625
Usstock	-5.70E-06	0.058	0.003	-0.029	0.088	-0.026	-0.002	0.032	1.004	0.253	0.253
	-52.285	0.893	0.774	-1.637	5.440	-0.396	-0.540	1.685	109.133	23.312	23.312
Usdjpy	1.74E-05	-0.083	-0.009	-0.046	-0.015	-0.342	0.015	0.381	-0.098	0.391	0.391
	29.725	-0.942	-4.544	-1.331	-0.292	-2.793	1.101	2.337	-2.652	4.906	4.906

Table 3-40-A: VARMA-AGARCH, Conditional Mean for Malaysia-Philippines

Return	C	MA(1)	Malbond(-1)	Malstock(-1)	Phibond(-1)	Phistock(-1)	Myrphp(-1)	d1	d2
Malbond	0.000	0.005	0.017	0.000	-0.002	0.001	0.000		
	-1.285	0.007	0.024	0.045	-0.113	0.155	-0.100		
Malstock	0.000	0.010	0.074	0.171	0.112	0.009	0.008		
	1.475	0.051	0.506	0.879	1.315	0.445	2.940		
Phibond	0.000	0.000	0.082	0.001	0.097	-0.005	-0.003		
	-1.306	0.001	1.423	0.096	0.438	-2.488	-1.971		
Phistock	0.001	-0.027	0.127	0.124	0.180	0.189	-0.023		
	1.792	-0.147	0.480	1.722	0.953	1.052	-8.313		
Myrphp	0.000	0.020	0.066	0.013	-0.039	0.005	0.018	0.359	-0.368
	-0.145	0.569	1.254	1.100	-1.173	0.833	47.333	1216.542	-1538.260

Table 3-40-B: VARMA-AGARCH, Conditional Variance for Malaysia-Philippines

Variance	omega	ARCH Effects						GARCH Effects					
		Malbond	Malstock	Phibond	Phistock	Myrphp	Treshold	Malbond	Malstock	Phibond	Phistock	Myrphp	
Malbond	1.4E-06	0.150	0.000	0.000	-0.001	0.000	0.050	0.600	0.000	0.000	-0.001	0.000	
	2.585	1.605	-0.045	-0.008	-2.075	-15.971	0.439	4.627	-0.051	-0.004	-0.646	-2.844	
Malstock	8.2E-06	-0.005	0.120	-0.031	0.018	0.000	0.038	0.013	0.502	-0.009	0.013	0.000	
	2.355	-0.022	1.715	-0.366	1.386	-6.457	0.425	0.020	3.435	-0.039	0.432	0.247	
Phibond	8.2E-07	0.020	0.004	0.156	-0.001	0.000	0.041	-0.013	0.017	0.605	-0.002	0.000	
	19.101	0.264	1.163	2.197	-3.659	-1.038	0.423	-0.064	0.787	5.639	-3.119	-25.474	
Phistock	5.0E-05	-0.078	0.177	0.105	0.150	-0.001	0.003	0.011	-0.227	-0.074	0.471	0.000	
	2.851	-0.133	1.486	0.152	2.239	-1.945	0.038	0.004	-0.694	-0.084	2.930	0.731	
Myrphp	0.000	0.011	0.002	0.011	-0.001	0.017	-0.040	0.005	-0.006	-0.006	0.001	0.992	
	1.556	0.581	2.385	1.391	-1.402	1.699	-3.340	0.213	-4.429	-0.568	1.853	156.885	

Table 3-41-A: VARMA-AGARCH, Conditional Mean for Malaysia-Thailand

Return	C	MA(1)	Malbond(-1)	Malstock(-1)	Thabond(-1)	Thastock(-1)	MyrThb(-1)
Malbond	-6.22E-05	0.006	0.157	0.004	0.039	0.000	0.024
	-2.480	0.033	0.960	0.676	2.665	0.159	2.719
Malstock	0.000	-0.126	0.044	0.270	0.112	0.008	0.118
	1.083	-0.654	0.266	1.456	1.536	0.498	1.914
Thabond	0.000	0.019	0.172	-0.024	0.008	0.008	0.001
	-0.642	0.066	2.648	-2.349	0.030	1.123	0.043
Thastock	0.000	-0.284	-0.166	0.156	-0.054	0.288	0.059
	-0.685	-1.056	-0.527	2.516	-1.812	1.069	0.646
Myrthb	0.000	0.007	0.028	0.045	-0.011	0.005	0.020
	1.306	0.025	0.556	2.979	-1.766	0.915	0.075

Table 3-41-B: VARMA-AGARCH, Conditional Variance for Malaysia-Thailand

		ARCH Effects (-1)					GARCH Effects (-1)					
Variance	Omega	Malbond	Malstock	Thabond	Thastock	MyrThb	Threshold	Malbond	Malstock	Thabond	Thastock	MyrThb
Malbond	1.35E-07	0.149	0.002	0.002	-3.23E-04	-0.001	0.052	0.600	-0.001	-0.003	0.002	-0.006
	3.256	2.222	1.076	0.801	-3.571	-0.889	0.456	6.850	-0.305	-1.337	2.372	-1.957
Malstock	0.000	-0.136	0.009	0.014	0.001	0.041	0.037	0.129	0.910	-0.049	0.005	-0.042
	1.821	-0.808	0.480	1.135	0.360	0.643	1.162	0.423	21.412	-1.575	0.926	-0.372
Thabond	3.34E-06	0.002	-0.017	0.140	-0.002	-0.023	0.056	0.005	0.012	0.589	0.006	-0.034
	19.056	0.035	-2.021	1.783	-1.859	-1.531	0.361	0.017	0.415	6.824	1.476	-0.661
Thastock	-3.69E-06	0.554	0.045	-0.070	0.088	0.050	-0.023	0.219	0.064	0.414	0.901	-0.078
	-58.216	0.909	0.957	-4.514	3.281	0.252	-0.661	0.164	0.898	4.311	30.714	-0.313
Myrthb	2.07E-06	-0.022	0.003	-0.003	0.000	0.175	0.011	0.010	-0.012	0.006	-0.002	0.635
	16.089	-0.618	0.618	-2.041	0.645	3.158	0.137	0.092	-0.841	0.653	-2.721	11.030

Table 3-42-A: VARMA-AGARCH, Conditional Mean for Malaysia-USA

Return	C	MA(1)	Malbond(-1)	Malstock(-1)	Usbond(-1)	Usstock(-1)	Usdmyr(-1)
Malbond	0.000	-0.465	0.634	0.007	0.033	-0.001	-0.014
	-1.727	-4.198	6.410	1.359	4.415	-0.416	-1.315
Malstock	0.000	-0.114	0.054	0.226	-0.077	0.211	-0.115
	1.086	-1.141	0.375	2.338	-1.719	8.889	-1.522
Usbond	0.000	0.011	-0.125	0.033	0.002	-0.021	0.114
	-1.528	0.045	-1.092	1.382	0.007	-1.219	2.239
Usstock	8.03E-05	-0.870	0.023	0.027	0.013	0.815	0.340
	2.588	-30.010	0.391	1.899	0.498	23.972	8.045
Usdmyr	0.000	0.004	0.061	0.001	-0.025	-0.023	-0.414
	1.217	0.032	2.090	0.201	-4.208	-4.783	-3.971

Table 3-42-B: VARMA-AGARCH, Conditional Variance for Malaysia-USA

Variance	ARCH Effects (-1)						GARCH Effects (-1)					
	Omega	Malbond	Malstock	Usbond	Usstock	Usdmyr	Threshold	Malbond	Malstock	Usbond	Usstock	Usdmyr
Malbond	-1.10E-07	0.104	0.003	0.006	0.000	0.000	0.170	0.543	0.009	0.016	-0.004	0.001
	-4.916	1.366	1.374	1.889	-1.433	0.357	1.252	5.033	1.852	1.895	-3.043	0.977
Malstock	0.000	-0.120	-0.023	0.011	0.013	0.217	0.010	0.195	1.000	0.015	-0.016	-0.149
	1.292	-1.053	-2.599	1.167	3.039	2.533	0.893	1.442	114.975	0.677	-2.840	-2.559
Usbond	0.000	0.004	0.002	-0.029	0.000	0.010	0.036	0.037	-0.003	1.001	0.004	-0.008
	-1.267	0.062	0.533	-1.583	0.167	0.596	2.036	0.470	-0.757	61.515	1.560	-0.739
Usstock	1.23E-06	-0.049	-0.027	0.003	-0.088	-0.062	0.264	-1.370	0.009	0.619	0.764	0.191
	3.136	-0.149	-1.613	0.075	-5.297	-2.053	6.371	-1.807	0.161	2.973	13.441	3.166
Usdmyr	1.47E-06	-0.005	0.000	0.000	-0.001	0.154	0.053	-0.006	-0.015	-0.016	0.001	0.598
	248.107	-0.813	-1.115	-0.206	-1.256	1.041	0.184	-0.428	-6.620	-2.209	1.507	5.879

Table 3-43-A: VARMA-AGARCH, Conditional Mean for Philippines-Thailand

Return	C	MA(1)	Phibond(-1)	Phistock(-1)	Thabond(-1)	Thastock(-1)	Thbphp(-1)
Phibond	0.000	-0.006	0.064	-0.001	0.020	0.015	-0.004
	0.174	-0.025	0.255	-0.149	1.058	2.896	-0.338
Phistock	0.001	0.088	0.131	0.083	-0.120	0.015	0.071
	1.979	0.459	0.752	0.421	-0.816	0.531	0.638
Thabond	0.000	0.064	0.002	-0.016	0.065	0.003	-0.006
	-1.409	0.296	0.046	-3.540	0.311	0.443	-0.245
Thastock	0.000	-0.074	0.224	0.104	-0.063	0.075	-0.103
	-0.820	-0.299	1.492	3.871	-3.983	0.309	-1.353
Thbphp	0.000	-0.118	-0.031	-0.003	0.010	0.010	0.098
	0.827	-0.191	-0.526	-0.317	0.427	1.329	0.158

Table 3-43-B: VARMA-AGARCH, Conditional Variance for Philippines-Thailand

Variance	Omega	ARCH Effects (-1)						GARCH Effects (-1)					
		Phibond	Phistock	Thabond	Thastock	Thbphp	Treshold	Phibond	Phistock	Thabond	Thastock	Thbphp	
Phibond	4.90E-07	0.121	0.002	0.001	0.001	-0.014	-0.004	0.824	-0.003	-0.005	0.000	0.004	
	15.517	3.492	2.850	0.949	3.689	-8.250	-0.070	26.478	-4.822	-3.610	-1.531	0.737	
Phistock	1.34E-05	0.041	0.093	0.317	0.003	0.142	-0.029	-0.059	0.875	-0.681	0.000	-0.525	
	2.823	0.159	2.322	2.089	0.299	0.907	-0.671	-0.138	19.262	-2.244	0.038	-1.508	
Thabond	5.10E-06	-0.023	-0.001	0.090	-0.001	-0.012	0.088	-0.079	-0.004	0.564	0.006	-0.136	
	84.472	-1.222	-2.000	1.209	-2.263	-0.563	0.563	-2.364	-1.570	3.890	1.987	-2.463	
Thastock	-1.47E-06	0.087	0.017	-0.045	0.093	-0.024	0.015	0.236	-0.014	0.299	0.880	0.011	
	-7.706	0.605	1.741	-1.404	2.988	-0.319	0.357	0.769	-0.770	1.567	31.238	0.079	
Thbphp	6.13E-07	0.030	0.002	-0.002	0.002	0.037	-0.034	-0.026	-0.002	-0.001	-0.002	0.937	
	6.588	1.068	0.976	-2.483	1.931	2.318	-1.600	-0.671	-0.602	-0.474	-3.287	29.315	

Table 3-44-A: VARMA-AGARCH, Conditional Mean for Philippines-USA

Return	C	MA(1)	Phibond(-1)	Phistock(-1)	Usbond(-1)	Usstock(-1)	Usdphp(-1)
Phibond	0.000	-0.022	0.081	-0.004	-0.010	0.001	-0.026
	-0.453	-0.040	0.150	-0.647	-0.564	0.113	-1.224
Phistock	0.000	-0.140	0.198	0.259	-0.038	0.464	-0.176
	1.630	-1.516	1.211	2.908	-0.431	9.639	-1.389
Usbond	0.000	0.005	-0.007	-0.005	0.003	-0.027	0.073
	-0.630	0.021	-0.099	-0.728	0.013	-1.298	1.602
Usstock	0.000	-0.548	-0.088	0.024	-0.009	0.472	0.033
	1.191	-3.225	-1.053	1.488	-0.203	2.602	0.501
Usdphp	0.000	-0.225	-0.016	-0.006	-0.011	-0.030	0.093
	-0.102	-1.066	-0.437	-0.892	-0.577	-2.764	0.424

Table 3-44-B: VARMA-AGARCH, Conditional Variance for Philippines-USA

Variance	Omega	ARCH Effects (-1)			Usbond	Usstock	Usdphp	GARCH Effects (-1)			Usbond	Usstock	Usdphp
		Phibond	Phistock	Phistock				Treshold	Phibond	Phistock			
Phibond	0.000	0.172	0.000	0.000	0.009	-0.005	-0.003	0.012	0.672	0.000	0.009	0.019	-0.021
	-0.158	5.233	-0.328	0.088	2.722	-5.911	-0.692	0.286	19.955	0.609	1.755	5.532	-3.042
Phistock	0.000	-0.046	0.088	0.109	0.109	0.047	0.625	-0.044	-0.514	0.857	0.075	0.083	-0.839
	1.689	-0.206	2.145	1.252	1.252	0.992	2.550	-0.879	-1.313	19.771	0.434	1.010	-3.513
Usbond	1.37E-05	-0.002	-0.008	0.144	0.144	-0.012	-0.004	0.047	-0.002	-0.014	0.586	-0.014	-0.004
	113.338	-0.021	-3.557	2.875	2.875	-1.086	-0.108	0.689	-0.010	-2.303	16.842	-0.727	-0.047
Usstock	4.56E-07	-0.009	0.007	0.007	-0.009	-0.053	0.055	0.066	-0.009	-0.008	0.026	1.002	-0.033
	3.793	-0.107	3.508	0.000	-0.644	-4.801	1.146	4.137	-0.087	-2.049	1.830	131.222	-0.699
Usdphp	8.91E-08	-0.003	0.000	0.000	0.009	-0.001	0.054	0.012	0.011	0.000	-0.020	0.004	0.927
	2.354	-0.306	-0.354	1.506	1.506	-0.324	2.331	0.440	0.561	0.296	-2.905	1.215	53.103

Table 3-45-A: VARMA-AGARCH, Conditional Mean for Thailand-USA

Return	C	MA(1)	Thabond(-1)	Thastock(-1)	Usbond(-1)	Usstock(-1)	Usdthb(-1)
Thabond	0.000	0.024	0.027	-0.001	0.186	-0.004	-0.024
	-1.538	0.236	0.280	-0.257	6.342	-0.675	-0.843
Thastock	0.000	-0.316	-0.134	0.335	-0.019	0.143	-0.242
	-0.514	-1.745	-2.589	1.893	-0.227	3.613	-2.464
Usbond	0.000	0.000	0.051	0.013	0.012	-0.024	0.082
	-0.719	-0.001	2.409	1.386	0.044	-1.325	1.994
Usstock	0.000	0.334	-0.008	0.001	0.008	-0.354	-0.180
	1.295	1.295	-0.145	0.043	0.173	-1.375	-3.959
Usdthb	0.000	-0.265	0.048	0.001	-0.063	-0.051	0.245
	-0.481	-1.656	4.098	0.170	-3.035	-4.475	1.540

Table 3-45-B: VARMA-AGARCH, Conditional Variance for Thailand-USA

Variance	Omega	ARCH Effects (-1)						GARCH Effects (-1)					
		Thabond	Thastock	Usbond	Usstock	Usdthb	Treshold	Thabond	Thastock	Usbond	Usstock	Usdthb	
Thabond	1.94E-06	0.132	-0.001	0.053	-0.006	-0.005	0.047	0.587	-0.001	0.072	-0.012	-0.058	
	31.693	2.002	-0.624	1.637	-1.908	-0.357	0.433	9.387	-0.238	0.726	-1.209	-4.027	
Thastock	-6.30E-06	-0.067	0.062	0.214	0.011	0.076	-0.030	0.294	0.917	0.195	0.061	-0.156	
	-51.779	-3.418	3.061	1.937	0.520	0.884	-1.183	1.710	34.985	1.116	2.401	-1.041	
Usbond	2.96E-06	-0.007	-0.003	-0.070	0.001	-0.004	0.056	0.006	0.023	0.549	0.028	-0.007	
	8.362	-1.053	-1.704	-4.042	0.179	-0.167	2.300	0.404	3.026	3.779	1.290	-0.107	
Usstock	-1.05E-06	-0.015	0.000	-0.039	-0.044	-0.076	0.161	0.025	-0.007	0.319	0.885	0.250	
	-2.632	-2.739	0.067	-1.289	-2.983	-1.982	4.882	0.895	-1.861	3.092	26.989	3.272	
Usdthb	1.39E-06	-0.002	0.000	0.032	-0.008	0.215	0.023	-0.002	-0.003	-0.006	0.019	0.585	
	12.074	-3.121	0.026	1.631	-1.422	1.992	0.197	-1.578	-1.747	-0.137	1.467	8.252	

Appendix 3-3: Figures 3-1 to 3-20

Figure 3-1: Daily Returns for Ausbond

Figure 3-5: Daily Returns for Usbond

Figure 3-2: Daily Returns for Japbond

Figure 3-6: Daily Returns for Ausstock

Figure 3-3: Daily Returns for NZbond

Figure 3-7: Daily Returns for Japstock

Figure 3-4: Daily Returns for Sgbond

Figure 3-8: Daily Returns for Nzstock

Figure 3-9: Daily Returns for Sgstock

Figure 3-13: Daily Returns for Audsgd

Figure 3-10: Daily Returns for Usstock

Figure 3-14: Daily Returns for Nzdjpy

Figure 3-11: Daily Returns for Audjpy

Figure 3-15: Daily Returns for Sgdjpy

Figure 3-12: Daily Returns for Audnzd

Figure 3-16: Daily Returns for Sgdnzd

Figure 3-17: Daily Returns for Usdaud

Figure 3-18: Daily Returns for Usdjpg

Figure 3-19: Daily Returns for Usdnzd

Figure 3-20: Daily Returns for Usdsgd

Appendix 3-4: Figures 3-21 to 3-47

Figure 3-21: Daily Returns for Indbond

Figure 3-25: Daily Returns for Thabond

Figure 3-22: Daily Returns for Japbond

Figure 3-26: Daily Returns for Usabond

Figure 3-23: Daily Returns for Malbond

Figure 3-27: Daily Returns for Indstock

Figure 3-24: Daily Returns for Phibond

Figure 3-28: Daily Returns for Japstock

Figure 3-29: Daily Returns for Malstock

Figure 3-33: Daily Returns for Jpyidr

Figure 3-30: Daily Returns for Phistock

Figure 3-34: Daily Returns for Myridr

Figure 3-31: Daily Returns for Thastock

Figure 3-35: Daily Returns for Myrjpy

Figure 3-32: Daily Returns for Usastock

Figure 3-36: Daily Returns for Myrphr

Figure 3-37: Daily Returns for Myrthb

Figure 3-41: Daily Returns for Thbjpy

Figure 3-38: Daily Returns for Phpidr

Figure 3-42: Daily Returns for Thbphp

Figure 3-39: Daily Returns for Phpjpy

Figure 3-43: Daily Returns for Usdldr

Figure 3-40: Daily Returns for Thbidr

Figure 3-44: Daily Returns for Usdjpy

Figure 3-45: Daily Returns for Usdmyr

Figure 3-46: Daily Returns for Usdphp

Figure 3-47: Daily Returns for Usdthb

Chapter 4

Dynamic Conditional Correlations Across International Stock, Bond and Foreign Exchange Markets: Estimation and Forecast

Chapter 4 investigates the nature of dynamic conditional correlations across international stock, bond and foreign exchange markets. Two investigations will be conducted. Firstly, it investigates the nature of conditional correlations using a rolling window approach to forecast conditional correlations, which will be conducted in Section 4.1. Three multivariate models assuming constant conditional correlations will be estimated as the based for the rolling windows forecasts, namely the VARMA-AGARCH model of McAleer, Hoti and Chan (2008), the VARMA-GARCH model of Ling and McAleer (2003), and the CCC model of Bollerslev (1990). Secondly, it investigates the nature of conditional correlations by estimating dynamic conditional correlation models, which will be conducted in Section 4.2. Two models will be estimated for this purpose, namely the DCC model of Engle (2002) and the GARCC model of McAleer et al. (2008).

4.1. Forecasting Conditional Correlations in Stock, Bond and Foreign Exchange Markets

“Everybody likes diversification. But how do you achieve it in a world that's increasingly correlated?”

J.C. Louis (1997)

This section forecasts conditional correlations between international stock, bond and foreign exchange rates for both developed and emerging countries. Sections 4.1.1 and 4.1.2 consider developed and emerging-developed countries, respectively.

4.1.1. Conditional Correlations Forecast in Developed Countries

The data investigated in this section are the same as those in Section 3.1, namely the daily closing price index of bond, stock, and foreign exchange rates from Australia, Japan, New Zealand, Singapore and the USA. However, this section considers only the exchange rates against USD. Therefore, there will be 14 series to be investigated, namely 5 bonds, 5 stocks and 4 exchange rates (compares to 20 series in Chapter 3, namely 5 bonds, 5 stocks and 10 exchange rates). In addition, as distinct from those of Section 3.1, this section collects longer data span, namely from 5/5/1997 to 1/5/2007, with 2,607 observations for each asset (compare to 30/9/1998 to 12/5/2006 with 1,986 observations for each asset in Section 3.1). This longer data observation is needed as some observations will be allocated to conduct forecasts. In addition, to achieve

convergence more possible, the returns of market i at time t are calculated as $R_{i,t} = 100 \times \log(P_{i,t} / P_{i,t-1})$, where $P_{i,t}$ and $P_{i,t-1}$ are the closing prices of asset i for days t and $t-1$, respectively. Table 4-1 lists the series.

All the data are obtained from the DataStream database services. As the data have more observations than those in Section 3.1, stationarity tests are re-conducted. All returns are found to be stationary, based on both ADF and Phillips-Perron tests, at the 1% level of significance. The test results are provided in Table 4-2 and 4-3 for the ADF and Phillips-Perron tests, respectively.

Table 4-1: Summary of Variable Names, Longer Data for Forecasting, Developed Markets

No	Variable	Variable Description	Names
1	Australian Bond	AU Benchmark 10 Year Govt. Index	Ausbond
2	Japanese Bond	JP Benchmark 10 Year Govt. Index	Japbond
3	New Zealand Bond	NZ Benchmark 10 Year Govt. Index	Nzbond
4	Singaporean Bond	Sg Gov. Bond Long Term Index	Sgbond
5	US Bond	US Benchmark 10 Year Govt. Index	Usbond
6	Australian Stock	S&P ASX 200 Price Index	Ausstock
7	Japanese Stock	Nikkei 225 Stock Average Price Index	Japstock
8	New Zealand stock	NZX ALL Price Index	Nzstock
9	Singaporean Stock	Singapore Straits Time Price Index	Sgstock
10	US Stock	S&P 500 Composite Price Index	Usstock
11	Exchange Rates	USD/AUD	Usdaud
12	Exchange Rates	USD/JPY	Usdjpy
13	Exchange Rates	YSD/NZD	Usdnzd
14	Exchange Rates	USD/SGD	Usdsgd

Table 4-2: ADF Test of a Unit Root in the Returns, Longer Data for Forecasting, Developed Markets

No	Variable	Delta	t-statistik	Critical Value(1%)	Probability
1	Ausbond	-0.998	-50.924	-3.96	0
2	Japbond	-0.975	-49.771	-3.96	0
3	Nzbond	-0.988	-50.424	-3.96	0
4	Sgbond	-1.008	-51.406	-3.96	0
5	Usbond	-0.948	-48.437	-3.96	0
6	Ausstock	-0.968	-49.396	-3.96	0
7	Japstock	-1.031	-52.638	-3.96	0
8	Nzstock	-0.976	-49.804	-3.96	0
9	Sgstock	-0.870	-44.779	-3.96	0
10	Usstock	-1.027	-52.440	-3.96	0
11	Usdaud	-1.024	-52.245	-3.96	0
12	Usdjpy	-0.999	-50.958	-3.96	0
13	Usdnzd	-1.022	-52.151	-3.96	0
14	Usdsgd	-1.082	-55.397	-3.96	0

Table 4-3: Phillips-Perron Test of a Unit Root in Returns, Longer Data for Forecasting, Developed Markets

No	Variable	Delta	t-statistik	Critical Value(1%)	Probability
1	Ausbond	-0.998	-50.958	-3.96	0
2	Japbond	-0.975	-49.756	-3.96	0
3	Nzbond	-0.988	-50.439	-3.96	0
4	Sgbond	-1.008	-51.406	-3.96	0
5	Usbond	-0.948	-48.371	-3.96	0
6	Ausstock	-0.968	-49.397	-3.96	0
7	Japstock	-1.031	-52.850	-3.96	0
8	Nzstock	-0.976	-49.842	-3.96	0
9	Sgstock	-0.870	-44.720	-3.96	0
10	Usstock	-1.027	-52.996	-3.96	0
11	Usdaud	-1.024	-52.271	-3.96	0
12	Usdjpy	-0.999	-50.958	-3.96	0
13	Usdnzd	-1.022	-52.185	-3.96	0
14	Usdsgd	-1.082	-55.331	-3.96	0

The purpose of this section is to compare the conditional correlations forecasts based on the CCC, VARMA-AGARCH and VARMA-GARCH models. A rolling window approach is used to forecast one-day ahead conditional correlations. The sample ranges from 5/5/1997 to 2/5/2007 (2,607 observations). In order to strike the balance between efficiency in estimation and a viable number of rolling regression, the rolling window

size is at 2000 for all data set, which leads to a forecasting period from 3/1/2005 – 2/5/2007 (607 observations). With stock, bond, and foreign exchange rates of the five countries, there are 14 series of assets to be analyzed. This constructs 91 bivariate models to be estimated. The estimates are conducted using EViews 6 software package. All estimations achieve convergence.

The conditional correlation forecasts are depicted in Figures 4-1 to 4-91 in Appendix 4-3. It is clear that the conditional correlations forecasts are not constant. Table 4-4 summarizes the trends in the correlations forecasts. The table shows that the pairs of bond-bond exhibit the most upward trends, followed by the pairs of stock-stock. The other pairs of assets exhibit the mixture of upward and downward trends. Even though there is no common pattern, but some figures show spikes in early 2006, possibly due to the collapse of Amaranth Advisors, which leads to the decrease in money collected by hedge funds worldwide.¹

Table 4-5 summarizes the average of correlations coefficients resulted from the three models and theirs signs. The table shows that the coefficient correlations between the same classes of assets are positive, while the rests have the mixture of positive and negative signs. It also shows that, overall, the correlations coefficients are low, namely 0.25. The highest and lowest correlations coefficients are bond-exchange rates (0.34) and stock-exchange rates (0.21), respectively.

The correlations between conditional correlations forecasts resulted from the three models are shown in Tables 4-29-A to 4-29-F in Appendix 4-1. The evidence of volatility spillovers and asymmetric effects are reported in Tables 4-30-A to 4-30-F in the Appendix 4-1. The parameter estimates for the three models and their asymptotic *t*-ratios, which are 99 pages long, are available upon request to the author.

¹ Visit http://www.metrics2.com/blog/2007/02/07/new_hedge_funds_raised_less_money_in_2006_89_large.html

Table 4-4: Summary of Trend in Correlations Forecasts, Developed Markets

	Trend resulted from CCC, VARMA-AGARCH, and VARMA-AGARCH models	
	Upward Trend	Downward Trend
Bond-bond	8 of 10	0
Stock-stock	3 of 10	0
ER-ER	1 of 10	3 of 10
Bond-stock	6 of 25	4 of 25
Bond-ER	2 of 20	5 of 20
Stock-ER	4 of 20	3 of 20
All pairs	24	15

Table 4-5: Summary of Average Correlation Coefficient between Pairs of Assets, Developed Markets

	CCC	VARMA-AGARCH	VARMA-GARCH	Average of the three models	Sign
Bond-bond	0.31	0.31	0.31	0.31	(+)
Stock-stock	0.27	0.28	0.28	0.28	(+)
ER-ER	0.29	0.30	0.30	0.30	(+)
Bond-stock	0.18	0.18	0.18	0.18	(+), (-)
Bond-ER	0.33	0.34	0.34	0.34	(-), in general
Stock-ER	0.21	0.21	0.21	0.21	(-), in general
All pairs	0.25	0.25	0.25	0.25	(+), (-)

Note: (+) means positive correlation, and (-) means negative correlation.

As volatility spillovers are evident not in all cases, it might be interesting to evaluate whether they have any impacts on the forecasts of conditional correlations. The analysis of the relationships between correlations of conditional correlations forecasts resulted from the three models and the evidence of volatility spillovers and asymmetric effects are shown in Tables 4-6-A to 4-6-D.

As the CCC model does not incorporate volatility spillovers, we can expect low correlation between the forecasts of conditional correlations resulted from the CCC and VARMA-AGARCH model, when volatility spillovers resulted from the VARMA-AGARCH model is evident, and vice versa.

Table 4-6-A: Analysis of the Impact of Volatility Spillovers Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-AGARCH, Developed Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	3	1	2	9	4	12	31
No Spillovers	7	6	2	11	13	6	45
Sum	10	7	4	20	17	18	76
Low Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	0	3	2	1	1	2	9
No Spillovers	0	0	0	4	2	0	6
Sum	0	3	2	5	3	2	15

As shown in Table 4-6-A, the last column, the correlations between the conditional correlations forecasts resulted from the CCC and VARMA-AGARCH models show that high and low correlations occur in 76 and 15 cases, respectively.² From the 76 high correlations cases, 31 cases occur even when volatility spillovers are evident, but 45 cases occur when volatility spillovers are not evident. This provides weak evidence that volatility spillovers might contribute to different correlations forecasts. From the 15 cases of low correlations, 9 cases occur when the volatility spillovers are evident. However, 6 of them occur when the volatility spillovers are not evident. Therefore, in general, there is weak evidence to suggest that volatility spillovers might contribute to different correlations forecasts.

² As Cohen et al. (1988) note, there is no formal interpretation of correlation size, it depends on the context and purposes. This thesis assumes correlation coefficient of less than |0.9| as low correlation since it expects that those models will yield similar correlation forecasts, since the CCC and VARMA-GARCH models nested to VARMA-AGARCH model.

Table 4-6-B: Analysis of the Impact of Volatility Spillovers Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-GARCH, Developed Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	5	4	2	9	4	12	36
No Spillovers	5	3	2	13	13	7	43
Sum	10	7	4	22	17	19	79
Low Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	0	3	2	0	1	1	7
No Spillovers	0	0	0	3	2	0	5
Sum	0	3	2	3	3	1	12

As shown in Table 4-6-B, the correlations between correlations forecasts resulted from the CCC and VARMA-GARCH models show that high and low correlations occur in 79 and 12 cases, respectively. From the 79 cases of high correlations, 36 cases occur when volatility spillovers are evident, while 43 cases of high correlations occur when volatility spillovers are not evident. From the 12 cases of the low correlations, 7 of them occur when the volatility spillovers are evident, while 5 of them occur when the volatility spillovers are not evident. This provides additional evidence that incorporating volatility spillovers in a multivariate GARCH model might contribute to different correlations forecasts.

Table 4-6-C: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA-AGARCH and VARMA-GARCH, Developed Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	3	9	2	17	6	16	53
No Asymmetric	7	0	4	5	13	4	33
Sum	10	9	6	22	19	20	86
High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	0	1	0	3	1	0	5
No Asymmetric	0	0	0	0	0	0	0
Sum	0	1	0	3	1	0	5

Since asymmetric effects are evident only in some cases, it is interesting to find out whether the occurrence of such asymmetric effect has any impacts on the correlations forecasts. As shown in Table 4-6-C, the correlations of correlations forecasts resulted from the VARMA-AGARCH and VARMA-GARCH models show that high and low correlations occur in 86 and 5 cases, respectively. From the 86 high correlations cases, 53 cases occur when the asymmetric effects are evident. This means that the occurrence of asymmetric effect does not influence, in general, the correlations forecasts. On the other hand, from the 5 cases where the correlations between VARMA-AGARCH and VARMA-GARCH are low, all of them occur when asymmetric effect occurs. This provides evidence that asymmetric effect influence the correlations forecasts. Therefore, it is unclear, from the analysis, whether incorporating asymmetric effects in multivariate GARCH models provide different correlations forecasts.

Table 4-6-D: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA-AGARCH and CCC, Developed Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	3	7	1	16	5	14	46
No Asymmetric	7	0	3	4	12	4	30
Sum	10	7	4	20	17	18	76
Low Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	0	3	1	4	2	2	12
No Asymmetric	0	0	1	1	1	0	3
Sum	0	3	2	5	3	2	15

Additional support for the above suggestion is provided from the evidence of correlations between the conditional correlations forecasts resulted from VARMA-AGARCH and CCC models. As shown in Table 4-6-D, the correlations between the correlations forecasts resulted from the VARMA-AGARCH and CCC models show that high and low correlations occur in 76 and 15 cases, respectively. From the 76 cases of high correlations, 46 cases occur even when asymmetric effects are evident. This suggests that asymmetric effects do not influence the forecasts of correlations. On the other hand, from the 15 cases where the correlations between VARMA-AGARCH and CCC are low, 12 of them occur when asymmetric effects are evident, which suggests that asymmetric effects seem to affect the forecasts of correlations. This supports the previous suggestion that it is unclear whether incorporating asymmetric effects in multivariate GARCH models provide different correlations forecasts.

4.1.2. Conditional Correlations Forecast in Emerging-Developed Countries

This section analyses the forecasts of conditional correlations in emerging-developed countries. The data investigated in this section are the same as those in Section 3.2, namely the daily closing price index of bond, stock, and foreign exchange rates from Indonesia, Japan, Malaysia, Philippine, Thailand, and the USA. However, as distinct from Section 3.2, this section considers only the exchange rates against USD. Therefore, there are 17 series to be considered, namely 6 bonds, 6 stocks and 5 exchange rates (compares to 27 series in Chapter 3, namely 6 bonds, 6 stocks and 15 exchange rates).

In addition, as distinct from those of Section 3.2, this section collects longer data span, namely from 7/1/2003 to 18/6/2007, with 1160 observations for each asset (compare to 28/3/2003 to 8/9/2006, with 901 observations in Section 3.2). This longer data observation is needed since some observations will be allocated to conduct forecasts. In addition, to achieve convergence more possible, the returns of market i at time t are calculated as $R_{i,t} = 100 \times \log(P_{i,t} / P_{i,t-1})$, where $P_{i,t}$ and $P_{i,t-1}$ are the closing prices of asset i for days t and $t-1$, respectively. Table 4-7 lists the series.

All the data are obtained from the Bloomberg and DataStream database services. As the data have more observations than those in Section 3.2, stationarity tests are re-conducted. All returns are found to be stationary, based on both ADF and Phillips-Perron tests at the 1% level of significance. The test results are in Table 4-8 and 4-9 for the ADF and Phillips-Perron tests, respectively.

Table 4-7: Summary of Variable Names, Longer Data for Forecasting, Emerging-Developed Markets

No	Variable	Index Names	Variable Names
1	Indonesian Bond	Indonesian Govt. Bond (INDOGB 14.5 10)	Indbond
2	Japan Bond	JP Benchmark 10 Year Govt. Index	Japbond
3	Malaysian Bond	Malaysian Govt. Bond (MGS 8.5 12)	Malbond
4	Philippines Bond	Philippine Govt. Bond (RPGB 14.75 10)	Phibond
5	Thailand Bond	Thailand Govt. Bond (THAIGB 4.125 8)	Thabond
6	US Bond	US Benchmark 10 Year Govt. Index	Usbond
7	Indonesian Stock	Jakarta SE Composite – Price Index	Indstock
8	Japan Stock	Nikkei 225 Stock Average Price Index	Japstock
9	Malaysian Stock	Kuala Lumpur Comp. DS-CALC-Price Index	Malstock
10	Philippines Stock	Philippine SE I(PSEi) – Price Index	Phistock
11	Thailand Stock	DJSI World Thailand Subset - Price Index	Thastock
12	US Stock	S&P 500 Composite Price Index	Usstock
13	Exchange Rates	USD/IDR	Usdldr
14	Exchange Rates	USD/JPY	Usdipy
15	Exchange Rates	USD/MUR	Usdmyr
16	Exchange Rates	USD/PHP	Usdphp
17	Exchange Rates	USD/THB	Usdthb

Table 4-8: ADF Test of a Unit Root in the Returns, Longer Data for Forecasting, Emerging-Developed Markets

No	Variable Names	Delta	t-statistic	Critical Value(1%)	Probability
1	Indbond	-1.046	-35.557	-3.966	0
2	Japbond	-0.968	-32.928	-3.966	0
3	Malbond	-1.037	-23.068	-3.966	0
4	Phibond	-1.056	-35.958	-3.966	0
5	Thabond	-0.996	-33.860	-3.966	0
6	Usbond	-0.996	-33.867	-3.966	0
7	Indstock	-0.956	-32.514	-3.966	0
8	Japstock	-1.020	-34.702	-3.966	0
9	Malstock	-0.829	-28.517	-3.966	0
10	Phistock	-0.879	-30.099	-3.966	0
11	Thastock	-1.038	-35.288	-3.966	0
12	Usstock	-1.083	-36.993	-3.966	0
13	Usdldr	-1.075	-36.577	-3.966	0
14	Usdipy	-1.022	-34.781	-3.966	0
15	Usdmyr	-1.339	-47.939	-3.966	0
16	Usdphp	-1.177	-40.631	-3.966	0
17	Usdthb	-1.035	-35.209	-3.966	0

Note: All estimates of δ are significantly less than 0 at the 1% level.

Table 4-9: Phillips-Perron Test of a Unit Root in the Returns, Longer Data for Forecasting, Emerging-Developed Markets

No	Variable Names	Delta	t-statistic	Critical Value(1%)	Probability
1	Indbond	-1.046	-35.647	-3.966	0
2	Japbond	-0.968	-32.912	-3.966	0
3	Malbond	-1.143	-38.833	-3.966	0
4	Phibond	-1.056	-35.932	-3.966	0
5	Thabond	-0.996	-33.870	-3.966	0
6	Usbond	-0.996	-33.868	-3.966	0
7	Indstock	-0.956	-32.558	-3.966	0
8	Japstock	-1.020	-34.702	-3.966	0
9	Malstock	-0.829	-28.636	-3.966	0
10	Phistock	-0.879	-29.908	-3.966	0
11	Thastock	-1.038	-35.297	-3.966	0
12	Usstock	-1.083	-37.335	-3.966	0
13	Usdldr	-1.075	-36.492	-3.966	0
14	Usdjpy	-1.022	-34.782	-3.966	0
15	Usdmyr	-1.339	-49.422	-3.966	0
16	Usdphp	-1.177	-40.956	-3.966	0
17	Usdthb	-1.035	-35.407	-3.966	0

Note: All estimates of δ are significantly less than 0 at the 1% level.

The sample for this section ranges from 7/1/2003 to 18/6/2007 (1160 observations). In order to strike a balance between efficiency in estimation and a viable number of rolling regression, the rolling window size is at 800 for all data set, which leads to a forecasting period from 31/1/2006 – 18/6/2007 (360 observations). With stock, bond, and foreign exchange rates of 6 countries, there are 17 series of assets to be analyzed, namely 6 bonds, 6 stocks and 5 exchange rates. This constructs 136 bivariate models to be estimated. There are 10 pairs of assets that have already been discussed in Section 4.1.1, as the result of including the USA and Japan in the analysis. Those pairs, which are not discussed in this section, are Japbond-Usbond, Japstock-Usstock, Japbond-Japstock, Japbond-Usstock, Usbond-Japstock, Usbond-Usstock, Japbond-Usdjpy, Usbond-Usdjpy, Japstock-Usdjpy, and Usstock-Usdjpy.

The estimates are conducted using EViews 6 software package. All estimations achieve convergence. The conditional correlation forecasts are depicted in Figures 4-92 to 4-217 in Appendix 4-4. It is clear that the conditional correlation forecasts are not constant. Most of the coefficient correlations are small, with the average of 0.15, and with higher of the maximum correlation is 0.45 (in Japbond-Thabond, resulted from the VARMA-AGARCH model).

The correlations between conditional correlations forecasts resulted from the three models, both for emerging-emerging and emerging-developed country cases, are shown in Tables 4-31-A to 4-31-F in Appendix 4-2. The evidence of volatility spillovers and asymmetric effects, both for emerging-emerging and emerging-developed country cases, are reported in Tables 4-32-A to 4-32-F in Appendix 4-2. The parameter estimates for the three models and their corresponding *t*-ratios, which are 138 pages long, are available upon request to the author.

Since there are two groups of markets, namely emerging and developed markets, the analysis will be divided into two groups, namely the group of emerging-emerging and emerging-developed countries.

4.1.2.1. Analysis on Emerging-Emerging Countries

Table 4-10 summarizes the trends in the correlations forecasts for emerging-emerging countries. The table shows that the pairs of stock-stock exhibit the most upward trends, followed by the pairs of bond-stock and bond-bond. The other pairs of assets exhibit the mixture of upward and downward trends.

Table 4-10: Summary of Trend in Correlations Forecasts, Emerging-Emerging Markets

Pairs of Assets	Trend Resulted from the CCC, VARMA-AGARCH, and VARMA-GARCH models	
	Upward Trend	Downward Trend
Bond-bond	2 of 6	0 of 6
Stock-stock	6 of 6	0 of 6
ER-ER	4 of 6	1 of 6
Bond-stock	10 of 16	0 of 16
Bond-ER	3 of 16	7 of 16
Stock-ER	0 of 16	8 of 16
All pairs	25 of 66	16 of 66

Table 4-11: Summary of Average Correlation Coefficient between Pairs of Assets, Emerging-Emerging Markets

Pairs of Assets	CCC	VARMA-AGARCH	VARMA-GARCH	Average of the Three Models	Sign
Bond-bond	0.14	0.14	0.14	0.14	(+)
Stock-stock	0.21	0.20	0.21	0.21	(+)
ER-ER	0.15	0.16	0.16	0.15	(+), in general
Bond-stock	0.13	0.13	0.13	0.13	(+), (-)
Bond-ER	0.28	0.29	0.29	0.28	(-), in general
Stock-ER	0.15	0.16	0.16	0.15	(+),(-)
All pairs	0.18	0.18	0.18	0.18	(+), (-)

Note: (+) and (-) represent positive and negative correlations, respectively.

Table 4-11 summarizes the average of correlations coefficients resulted from the three models and their signs for emerging-emerging countries. The table shows that the coefficient correlations between the same class of assets (bond-bond, stock-stock) are positive while the rests have the mixture of positive and negative signs. It also shows that, overall, the correlations coefficients are low, namely 0.18. The highest and lowest correlations coefficients are bond-ER (0.28) and bond-stock (0.21), respectively.

As volatility spillovers are evident not in all cases, it might be interesting to find out whether they have any connection to the forecasts of conditional correlations. The summary of relationships between correlations of conditional correlations forecasts resulted from the three models and the evidence of volatility spillovers and asymmetric effects for emerging-emerging markets are shown in Tables 4-12-A to 4-12-D.

Table 4-12-A: Analysis of the Impact of Volatility Spillovers Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-AGARCH, Emerging-Emerging Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	2	2	4	8	8	8	32
No Spillovers	1	2	1	4	3	4	15
Sum	3	4	5	12	11	12	47
Low Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	3	2	1	4	5	3	18
No Spillovers	0	0	0	0	0	1	1
Sum	3	2	1	4	5	4	19

From Table 4-12-A, the correlations between the conditional correlations forecasts resulted from the CCC and VARMA-AGARCH models for emerging-emerging markets show that high and low correlations occur in 47 and 19 cases, respectively. From the 47 cases of high correlations, 32 (15) cases occur when volatility spillovers are evident (not evident). It seems that both models do not provide different correlations forecast. However, from the 19 cases of low correlations, 18 cases occur when the volatility spillovers are evident, and only 1 of them occurs when the volatility spillovers are not evident. This suggests that incorporating volatility spillovers in a multivariate GARCH model might contribute to different correlations forecasts.

The analysis on the high and low correlations along with the evidence of volatility spillovers provides the mixture results in supporting the role of volatility spillovers in correlations forecasts. However, since the CCC model is nested in the VARMA-AGARCH model, we expect that both models provide the same correlations forecasts, which means that we expect high correlations of correlations forecasts from both models. Therefore, we should pay attention more on the low correlations cases,

which suggests that incorporating volatility spillovers in multivariate GARCH model might help providing different correlations forecasts.

The suggestions are further supported by the results provided by the correlation between conditional correlations forecasts resulted from the CCC and VARMA-GARCH models, which are summarized in Table 4-12-B. The table shows that high and low correlations between correlations forecasts resulted from the CCC and VARMA-GARCH occur in 50 and 16, respectively. From the 50 cases of high correlations, 37(13) cases occur when volatility spillovers are evident (not evident). From the 16 cases of low correlations evidence, 13 of them occur when the volatility spillovers are evident, while only 3 of them occur when the volatility spillovers are not evident. This provides additional evidence that incorporating volatility spillovers in a multivariate GARCH model might contributes to different correlations forecasts.

Table 4-12-B: Analysis of the Impact of Volatility Spillovers Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-GARCH, Emerging-Emerging Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	5	4	4	9	8	7	37
No Spillovers	0	1	1	3	3	5	13
Sum	5	5	5	12	11	12	50
Low Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	1	1	0	3	4	4	13
No Spillovers	0	0	1	1	1	0	3
Sum	1	1	1	4	5	4	16

Table 4-12-C: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA-AGARCH and VARMA-GARCH, Emerging-Emerging Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	0	2	0	4	0	3	9
No Asymmetric	3	4	5	8	11	10	41
Sum	3	6	5	12	11	13	50
High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	0	0	0	0	1	0	1
No Asymmetric	3	0	1	4	4	3	15
Sum	3	0	1	4	5	3	16

Since asymmetric effects are evident only in some cases, it is interesting to find out whether the occurrence of such asymmetric effect affects the correlations forecasts.

The high and low correlations of correlations forecasts resulted from the VARMA-AGARCH and VARMA-GARCH models occur in 50 and 16 cases, respectively (see Table 4-12-C). From the 50 cases of high correlation, only 9 cases occur when the asymmetric effects are evident. This means that 41 cases of high correlations occur when asymmetric are not evident. This seems to suggest that the occurrence of asymmetric effect influence the correlations forecasts. However, from the 16 cases where the correlations between the VARMA-AGARCH and VARMA-GARCH are low, 15 of them occur when asymmetric effect does not occur. Focusing on the low correlations evidence, we would like to suggest that incorporating asymmetric effect does not contribute to different correlations forecasts.

Table 4-12-D: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA-AGARCH and CCC, Emerging-Emerging Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	0	2	0	4	0	3	9
No Asymmetric	3	2	5	8	11	9	38
Sum	3	4	5	12	11	12	47
Low Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	0	0	0	0	1	0	1
No Asymmetric	3	2	1	4	4	4	18
Sum	3	2	1	4	5	4	19

From Table 4-12-D, the high and low correlations between the conditional correlations forecasts resulted from the VARMA-AGARCH and CCC are evident in 47 and 19 cases, respectively. From the 47 cases of high correlations, 9 (38) cases occur when asymmetric effects are evident (not evident). This suggests that asymmetric effects influence the forecasts of correlations. On the other hand, from the 19 cases where the correlations between the VARMA-AGARCH and VARMA-GARCH are low, only one case occurs when asymmetric effects are evident, and 18 of them occur when asymmetric effects are not evident. This suggests that the occurrence of asymmetric effect does not affect the correlations forecasts. Focusing on the low correlations evidence, we would like to suggest that asymmetric effects do not contribute to different correlations forecasts.

4.1.2.2. Analysis on Emerging-Developed Countries

The summary of trend analysis in the correlations forecast graphs between emerging-developed countries is provided in Table 4-13. The table shows that most pairs exhibit the mixture of upward trends and downward trends, with bond-bond exhibit only downward trend. The pairs of stock-stock exhibit the most upward trends.

Table 4-13: Summary of Trend in Correlations Forecasts, Emerging-Developed Countries

Pairs of Assets	Trend resulted from CCC, VARMA-AGARCH, and VARMA-AGARCH models	
	Upward Trend	Downward Trend
Bond-bond	0 of 8	2 of 8
Stock-stock	6 of 8	2 of 8
ER-ER	1 of 4	1 of 4
Bond-stock	5 of 16	1 of 16
Bond-ER	5 of 12	1 of 12
Stock-ER	4 of 12	4 of 12
All pairs	21 of 60	11 of 60

Table 4-14: Summary of Average Correlation Coefficient between Pairs of Assets, Emerging-Developed Markets

Pairs of Assets	CCC	VARMA-AGARCH	VARMA-GARCH	Average of the Three Models	Sign
Bond-bond	0.11	0.10	0.11	0.10	(+),(-)
Stock-stock	0.16	0.15	0.16	0.16	(+)
ER-ER	0.17	0.18	0.18	0.18	(+), in general
Bond-stock	0.07	0.07	0.07	0.07	(+), (-)
Bond-ER	0.13	0.13	0.13	0.13	(+),(-)
Stock-ER	0.08	0.08	0.09	0.08	(+),(-)
All pairs	0.11	0.11	0.11	0.11	(+), (-)

Note: (+) and (-) represent positive and negative correlations, respectively.

Table 4-14 summarizes the average of correlations coefficients resulted from the three models and their signs for emerging-developed markets. The table shows that the coefficient correlations between the stock-stock are positive, and the pairs of ER-ER are positive, in general. The rests have the mixture of positive and negative signs. It also shows that, overall, the correlations coefficients are low, namely 0.11. The highest and lowest correlations coefficients are ER-ER (0.18) and bond-stock (0.07), respectively. Overall, the correlations are lower compared to those of emerging-emerging markets.

The correlation between conditional correlations forecasts of the emerging-developed markets resulted from the three models are shown in Tables 4-31-A to 4-31-F in Appendix 4-2. The evidence of volatility spillovers and asymmetric effects are reported in Tables 4-32-A to 7-32-F in Appendix 4-2.

As volatility spillovers are evident not in all cases, it might be interesting to find out whether they have any connection to the forecasts of conditional correlations. The summary of relationships between correlations of forecasts correlations of the emerging-developed markets resulted from the three models and the evidence of volatility spillovers and asymmetric effects are shown in Tables 4-15-A to 4-15-D.

Table 4-15-A: Analysis of the Impact of Volatility Spillovers Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-AGARCH, Emerging-Developed Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	3	0	2	7	5	6	23
No Spillovers	0	4	0	2	1	2	9
Sum	3	4	2	9	6	8	32
Low Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	5	2	0	5	5	2	19
No Spillovers	0	2	2	2	1	2	9
Sum	5	4	2	7	6	4	28

The correlations between the conditional correlations forecasts on the emerging-developed markets resulted from the CCC and VARMA-AGARCH models show that high and low correlations occur in 32 and 28 cases, respectively (see Table 4-15-A). From the 32 high correlations cases, 23 cases occur when volatility spillovers are evident. This means that even though volatility spillovers are evident, the CCC and VARMA-AGARCH models provide, in general, the same forecasts of correlations. From the 28 cases of low correlations, 19 (9) cases occur when the volatility spillovers are evident (not evident). Focusing on the low correlations evidence, it tends to suggest that incorporating volatility spillovers in a multivariate GARCH model might contribute to different correlations forecasts.

Table 4-15-B: Analysis of the Impact of Volatility Spillover Effect on the Correlations between the Conditional Correlations forecast from CCC and VARMA-GARCH, Emerging-Developed Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	3	0	2	6	6	5	22
No Spillovers	0	4	0	5	1	4	14
Sum	3	4	2	11	7	9	36
High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Spillovers	4	2	1	5	4	2	18
No Spillovers	1	2	1	0	1	1	6
Sum	5	4	2	5	5	3	24

The suggestions are further supported by the evidence resulted from correlations forecasts generated by the CCC and VARMA-GARCH models. The high and low correlations between correlations forecasts resulted from the CCC and VARMA-GARCH occur in 36 and 24 cases, respectively (see Table 4-15-B). From the 36 cases of high correlations, 22 cases occur when volatility spillovers are evident. This suggests that the occurrence of volatility spillovers does not affect the forecast of correlations. From the 24 cases where the low correlations, 18 of them occur when the volatility spillovers are evident, while only 6 of them occur when the volatility spillovers are not evident. Focusing on low correlations evidence, we would like to suggest that incorporating volatility spillovers in a multivariate GARCH model contributes to different correlations forecasts.

Table 4-15-C: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA-AGARCH and VARMA-GARCH, Emerging-Developed Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	1	6	1	8	2	7	25
No Asymmetric	2	1	3	4	5	2	17
Sum	3	7	4	12	7	9	42
High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	1	1	0	1	1	2	6
No Asymmetric	4	0	0	3	4	1	12
Sum	5	1	0	4	5	3	18

The high and low correlations of conditional correlations forecasts on the emerging-developed markets resulted from the VARMA-AGARCH and VARMA-GARCH models are 42 and 18 cases, respectively (see Table 4-15-C). From the 42 high correlation cases, 25 cases occur when the asymmetric effects are evident. This means that the occurrence of asymmetric effect does not influence, in general, the correlations forecasts. In addition, from the 18 cases where the correlations between the VARMA-AGARCH and VARMA-GARCH are low, 6 of them occur when asymmetric effect does not occur. This provides additional evidence that asymmetric effect does not have any effect on the correlations forecasts.

Table 4-15-D: Analysis of the Impact of Asymmetric Effect on the Correlations between the Conditional Correlations forecast from VARMA-AGARCH and CCC, Emerging-Developed Markets

High Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	1	4	1	6	2	6	20
No Asymmetric	2	0	1	3	4	2	12
Sum	3	4	2	9	6	8	32
Low Correlations							
Evidence of:	Bond-Bond	Stock-Stock	ER-ER	Bond-Stock	Bond-ER	Stock-ER	Total
Asymmetric	1	3	0	3	1	3	11
No Asymmetric	4	1	2	4	5	1	17
Sum	5	4	2	7	6	4	28

The high and low correlations between the conditional correlations forecasts on the emerging-developed markets resulted from the VARMA-AGARCH and CCC models are evident in 32 and 28 cases, respectively (Table 4-15-D). From the 32 cases of high correlations, 20 occur even when asymmetric effects are evident. This suggests that asymmetric effects do not influence the forecasts of correlations. In addition, from the 28 cases where the correlations between the VARMA-AGARCH and VARMA-GARCH are low, 11 of them occur when asymmetric effects are evident, which means that 17 of them occur even when asymmetric effects are not evident. This supports that conclusion that asymmetric effect does not affect correlations forecasts.

4.2. Conditional Correlations Across International Stock, Bond and Foreign Exchange Markets

This section estimates the dynamic in the conditional correlations between international stock, bond and foreign exchange rates for both developed and emerging countries. Sections 4.2.1 and 4.2.2 consider developed and emerging-developed countries, respectively. This section uses two-step estimation method to estimate the DCC and GARCC models for all the return series.

4.2.1 Conditional Correlations Across Developed Countries

This section estimates the data from developed countries. The returns are bonds, stocks and foreign exchange from 5 developed countries, namely Australia, Japan, New Zealand, Singapore and the USA. Both the DCC and GARCC models are assumed to follow ARMA(1,1)-GARCH(1,1) processes for the conditional first and second moments.

This section uses the data that are used in Chapter 3, Section 1, namely the daily closing price index of bond, stock, and foreign exchange rates from Australia, Japan, New Zealand, Singapore and the USA. The returns of market i at time t are calculated in the same way as in Chapter 3, namely $R_{i,t} = \log(P_{i,t} / P_{i,t-1})$, where $P_{i,t}$ and $P_{i,t-1}$ are the closing prices of asset i for days t and $t-1$, respectively. This section uses shorter data span than that of Section 4.1.1, because the estimation was actually done before the estimation of data in Section 4.1.1, uses the longest data span available.

However, instead of using exchange rates for all pairs of the countries (in which the total assets to be estimated are 20, namely 5 bonds, 5 stocks and 10 foreign exchange rates, like in Section Chapter 3), this section uses only 4 exchange rates,

where each exchange rate is against the USD (in which the total assets to be estimated are 14, namely 5 bonds, 5 stocks and 4 foreign exchange rates). This makes the evaluation simpler and easier to undertake, as the number of pair-wise correlations decreases significantly from 190 to 91. This simplification is made based on the argument that most foreign exchange uses USD as the benchmarks. The bond, stock and foreign exchange returns and their variable names included in the analysis are summarized in Table 4-16. The statistic description and the stationarity of the data are discussed in the previous chapter (Chapter 3).

Table 4-16: Summary of Variables Names, Developed Markets

No	Variable	Variable Description	Names
1	Australian Bond	AU Benchmark 10 Year Govt. Index	Ausbond
2	Japanese Bond	JP Benchmark 10 Year Govt. Index	Japbond
3	New Zealand Bond	NZ Benchmark 10 Year Govt. Index	Nzbond
4	Singaporean Bond	Sg Gov. Bond Long Term Index	Sgbond
5	US Bond	US Benchmark 10 Year Govt. Index	Usbond
6	Australian Stock	S&P ASX 200 Price Index	Ausstock
7	Japanese Stock	Nikkei 225 Stock Average Price Index	Japstock
8	New Zealand stock	NZX ALL Price Index	Nzstock
9	Singaporean Stock	Singapore Straits Time Price Index	Sgstock
10	US Stock	S&P 500 Composite Price Index	Usstock
11	Exchange Rates	USD/AUD	Usdaud
12	Exchange Rates	USD/JPY	Usdjpy
13	Exchange Rates	YSD/NZD	Usdnzd
14	Exchange Rates	USD/SGD	Usdsgd

Table 4-17: DCC and GARCC, Conditional Means and Variances, Developed Markets

No	Returns	Mean Equations			Variance Equations		
		θ_1	θ_2	θ_3	ω	α	β
1	Ausbond	0.000	0.693	-0.724	0.000	0.015	0.984
		-0.39	4.13	-4.51	0.89	5.34	313.51
2	Japbond	0.000	0.286	-0.294	1.3E-7	0.107	0.885
		0.72	0.31	-0.32	5.42	14.38	126.52
3	Nzbond	0.000	0.903	-0.922	5.7E-8	0.034	0.962
		0.35	12.77	-14.54	2.07	5.72	150.60
4	Sgbond	2.5E-4	-0.006	0.136	3.8E-7	0.155	0.801
		3.43	-0.04	0.94	24.33	18.28	102.18
5	Usbond	0.000	0.086	-0.044	1.7E-7	0.033	0.958
		-0.75	0.41	-0.21	2.30	6.13	140.64
6	Ausstock	0.001	-0.780	0.794	9.7E-7	0.072	0.910
		3.80	-6.66	6.94	3.62	8.82	76.29
7	Japstock	0.001	-0.177	0.177	2.9E-6	0.073	0.914
		1.67	-0.87	0.87	3.66	8.07	88.99
8	Nzstock	4.6E-4	-0.288	0.359	7.5E-7	0.078	0.910
		2.32	-1.45	1.85	4.08	10.93	103.06
9	Sgstock	0.001	-0.777	0.806	7.8E-7	0.081	0.917
		3.32	-5.61	6.17	3.08	12.32	150.97
10	Usstock	0.000	0.610	-0.657	4.7E-7	0.050	0.947
		1.55	6.73	-7.50	2.20	7.81	145.30
11	Usdaud	0.000	-0.015	-0.009	5.0E-7	0.036	0.954
		-0.75	-0.01	-0.01	2.81	5.75	117.28
12	Usdjpy	0.000	0.626	-0.625	8.7E-7	0.041	0.938
		-0.16	5.67	-5.61	4.83	8.97	132.96
13	Usdnzd	0.000	-0.210	0.226	0.030	0.030	0.938
		-0.81	-0.20	0.21	2.71	4.55	56.31
14	Usdsgd	0.000	-0.880	0.881	1.9E-7	0.050	0.928
		-1.09	-33.22	33.35	4.78	7.62	109.45

Notes:

1. The two entries for each parameter are their respective estimate and the Bollerslev-Wooldridge (1992) robust t -ratio.
2. AR(1) denotes the own one-period lagged returns.
3. Entries in **bold** are significant at the 5% level.

Table 4-17 gives estimates of the parameters for the conditional means and conditional variances in the DCC and GARCC models. Owing to the two-step estimation procedure, the estimates of the conditional means and conditional variances are the same for both DCC and GARCC models.

Note that the coefficients in the conditional mean are significant in most cases, indicating that the conditional mean is also time-varying. Ignoring the dynamics in the conditional mean could lead to biased estimates in the conditional variance (for further details, see Chan and McAleer (2002)). Since the conditional variance reflects the risk level of the underlying assets, biased estimation of the conditional variance will therefore mislead the evaluation of asset risk. Hence, it is not wise to assume the conditional mean to be constant over time, as has been assumed in many empirical applications in the literature.

For the conditional variances, the own short and long run persistence are given by $\hat{\alpha}_i$ and $\hat{\alpha}_i + \hat{\beta}_i$, respectively. As shown in Table 4-17, not all of the returns are influenced by their own lagged values, which suggest the possibility of impacts from other markets. The estimates of the conditional variances suggest that all returns exhibit significant short and long run persistence of shocks.

In order to check the structural properties of the univariate models, the second moment and log-moment conditions are evaluated for the ARMA(1,1)-GARCH(1,1) model. Table 4-18 shows that for all series, the second moments are less than 1, and the log-moment conditions are negative, which suggests that the estimates are consistent and asymptotically normal, and hence that inferences are valid. This supports the results in Chapter 3, where the univariate AR(1)-GARCH(1,1) are estimated.

Table 4-18: DCC and GARCC, Moment Conditions, Developed Markets

No	Series	Moment Conditions	
		Second Moment	Log Moment
1	Ausbond	0.999	-0.0005
2	Japbond	0.992	-0.0102
3	Nzbond	0.996	-0.0023
4	Sgbond	0.956	-0.0434
5	Usbond	0.991	-0.0044
6	Ausstock	0.982	-0.0108
7	Japstock	0.987	-0.0580
8	Nzstock	0.988	-0.0085
9	Sgstock	0.998	-0.0045
10	Usstock	0.997	-0.0030
11	Usdand	0.990	-0.0050
12	Usdjpy	0.979	-0.0103
13	Usdnzd	0.968	-0.0146
14	Usdsgd	0.978	-0.0115

Table 4-19: DCC Estimates of the Q_t Model, Developed Markets

Parameter	Estimate
ϕ_1	4E-04
	(0.180)
ϕ_2	9E-05
	(0.000)

Notes:

- Two entries for each parameter are their respective estimate and the Bollerslev-Wooldridge (1992) robust t -ratio.
- Entries in **bold** are significant at the 5% level.

The estimates for the conditional correlations of the DCC model in Table 4-19 show that the parameter estimates are not significant, which suggest that the conditional correlations of the returns may be constant and not dynamic. An alternate explanation is that the conditional correlation are only time varying for some pairs of assets, but not for all assets. Therefore, imposing the restriction of all correlations to have the same dynamic could produce misleading empirical results.

The estimates for the conditional correlations for the GARCC model in Table 4-20 show that more than 50% of pairs of returns (namely, 48 of 91 cases) exhibit dynamic conditional correlations. Specifically, dynamic conditional correlations between the same classes of assets are evident in 13 of 26 (50%), namely in pairs of: (1) bonds markets, for 4 of 10 pairs (40%); (2) stock markets, for 5 of 10 pairs (50%); and (3) foreign exchange markets, for 4 of 6 pairs (67%). It can be concluded that, between the same classes of assets, the conditional correlations between foreign exchange markets are the most dynamic, followed by the conditional correlations between stock markets, and finally the conditional correlations between bond markets.

Table 4-20: GARCC Estimates of the Q_i Model, Developed Markets

No	Pairs of Assets	ϕ_1		ϕ_2	
1	Ausbond - Japbond	0.021	(0.96)	-0.013	(-0.01)
2	Ausbond - Nzbond	0.002	(0.10)	0.554	(0.67)
3	Ausbond - Sgbond	0.014	(1.20)	0.922	(10.66)
4	Ausbond - Usbond	0.006	(0.47)	0.847	(9.37)
5	Ausbond - Ausstock	0.018	(3.16)	-0.973	(-101.05)
6	Ausbond - Japstock	0.028	(2.30)	-0.873	(-17.70)
7	Ausbond - Nzstock	0.033	(1.48)	-0.203	(-0.39)
8	Ausbond - Sgstock	0.007	(1.94)	-0.99	(-181.72)
9	Ausbond - Usstock	0.039	(1.99)	0.714	(3.47)
10	Ausbond - Usdaud	0.019	(1.90)	0.932	(21.11)
11	Ausbond - Usdjpy	0.035	(1.59)	-0.166	(-0.38)
12	Ausbond - Usdnzd	0.031	(1.81)	0.801	(5.11)
13	Ausbond - Usdsgd	0.009	(0.42)	0.04	(0.09)
14	Japbond - Nzbond	0.005	(0.23)	-0.093	(-0.08)
15	Japbond - Sgbond	0.003	(0.16)	0.405	(0.11)
16	Japbond - Usbond	-0.021	(-0.94)	0.309	(0.35)
17	Japbond - Ausstock	-0.034	(-1.52)	-0.365	(-0.71)
18	Japbond - Japstock	0.003	(0.14)	0.088	(0.04)
19	Japbond - Nzstock	-0.013	(-1.04)	-0.865	(-6.21)
20	Japbond - Sgstock	-0.026	(-1.71)	0.831	(6.47)
21	Japbond - Usstock	-0.008	(-2.53)	-0.997	(-422.30)
22	Japbond - Usdaud	0.010	(0.56)	0.715	(1.20)
23	Japbond - Usdjpy	0.031	(2.64)	0.897	(19.81)
24	Japbond - Usdnzd	0.040	(2.04)	0.72	(3.59)
25	Japbond - Usdsgd	0.017	(1.03)	0.719	(3.61)
26	Nzbond - Sgbond	0.007	(2.00)	-0.99	(-198.90)
27	Nzbond - Usboond	-0.006	(-0.50)	-0.847	(-8.96)
28	Nzbond - Ausstock	0.026	(3.51)	-0.951	(-60.56)
29	Nzbond - Japstock	0.022	(1.82)	-0.857	(-14.75)
30	Nzbond - Nzstock	0.057	(2.55)	-0.187	(-0.87)
31	Nzbond - Sgstock	0.034	(1.77)	-0.551	(-3.13)
32	Nzbond - Usstock	0.019	(1.04)	0.575	(2.99)
33	Nzbond - Usdaud	0.041	(2.71)	0.852	(12.20)
34	Nzbond - Usdjpy	0.036	(1.63)	-0.252	(-1.43)
35	Nzbond - Usdnzd	0.035	(1.57)	0.28	(0.66)
36	Nzbond - Usdsgd	0.012	(0.55)	0.186	(1.17)
37	Sgbond - Usbond	0.029	(1.29)	0.087	(0.12)
38	Sgbond - Ausstock	0.012	(2.69)	-0.983	(-140.98)
39	Sgbond - Japstock	0.023	(2.79)	-0.949	(-45.59)
40	Sgbond - Nzstock	0.044	(2.16)	-0.519	(-2.17)
41	Sgbond - Sgstock	0.028	(3.70)	-0.955	(-70.37)
42	Sgbond - Usstock	-0.020	(-1.05)	0.617	(2.02)
43	Sgbond - Usdaud	0.028	(1.28)	-0.434	(-0.78)
44	Sgbond - Usdjpy	0.013	(1.01)	-0.819	(-9.23)
45	Sgbond - Usdnzd	0.023	(1.71)	-0.827	(-8.80)
46	Sgbond - Usdsgd	0.018	(0.85)	0.392	(0.91)
47	Usbond - Ausstock	-0.010	(-0.51)	-0.457	(-1.88)
48	Usbond - Japstock	0.034	(3.66)	0.935	(45.10)

49	Usbond - Nzstock	-0.005	(-0.24)	-0.024	(-0.08)
50	Usbond - Sgstock	0.030	(1.43)	0.428	(1.51)
51	Usbond - Usstock	0.031	(4.30)	-0.958	(-86.66)
52	Usbond - Usdaud	0.046	(2.07)	0.407	(1.08)
53	Usbond - Usdjpy	0.074	(3.34)	-0.226	(-1.12)
54	Usbond - Usdnzd	0.013	(2.53)	-0.978	(-109.41)
55	Usbond - Usdsgd	0.027	(1.19)	0.027	(0.12)
56	Ausstock - Japstock	0.000	(-0.01)	0.742	(3.84)
57	Ausstock - Nzstock	0.037	(2.44)	-0.826	(-8.96)
58	Ausstock - Sgstock	0.016	(0.77)	-0.451	(-1.37)
59	Ausstock - Usstock	0.016	(0.80)	0.489	(1.93)
60	Ausstock - Usdaud	0.018	(0.87)	0.569	(0.93)
61	Ausstock - Usdjpy	-0.015	(-0.72)	-0.358	(-2.08)
62	Ausstock - Usdnzd	0.011	(0.52)	0.328	(0.47)
63	Ausstock - Usdsgd	-0.047	(-2.08)	0.103	(0.64)
64	Japstock - Nzstock	0.009	(0.41)	0.035	(0.08)
65	Japstock - Sgstock	0.017	(1.94)	0.948	(29.43)
66	Japstock - Usstock	-0.034	(-1.54)	-0.359	(-0.82)
67	Japstock - Usdaud	-0.003	(-0.14)	0.105	(0.02)
68	Japstock - Usdjpy	0.016	(0.70)	0.167	(0.52)
69	Japstock - Usdnzd	-0.004	(-0.39)	-0.898	(-27.41)
70	Japstock - Usdsgd	-0.020	(-0.90)	-0.067	(-0.25)
71	Nzstock - Sgstock	0.051	(2.81)	-0.713	(-5.72)
72	Nzstock - Usstock	0.017	(0.88)	0.502	(1.79)
73	Nzstock - Usdaud	0.028	(1.24)	0.087	(0.11)
74	Nzstock - Usdjpy	0.027	(1.21)	-0.187	(-0.99)
75	Nzstock - Usdnzd	-0.005	(-0.26)	0.429	(0.90)
76	Nzstock - Usdsgd	0.034	(1.81)	0.588	(4.88)
77	Sgstock - Usstock	-0.006	(-0.39)	0.741	(4.28)
78	Sgstock - Usdaud	0.041	(1.85)	0.39	(0.90)
79	Sgstock - Usdjpy	0.040	(1.82)	-0.209	(-1.18)
80	Sgstock - Usdnzd	0.023	(1.06)	0.257	(0.49)
81	Sgstock - Usdsgd	-0.014	(-0.65)	0.102	(0.58)
82	Usstock - Usdaud	-0.025	(-1.44)	-0.749	(-3.66)
83	Usstock - Usdjpy	0.003	(0.20)	0.686	(5.06)
84	Usstock - Usdnzd	0.018	(1.06)	-0.701	(-2.74)
85	Usstock - Usdsgd	0.036	(1.73)	-0.396	(-1.57)
86	Usdaud - Usdjpy	-0.094	(-4.18)	0.09	(0.39)
87	Usdaud - Usdnzd	0.02	(1.63)	0.875	(11.41)
88	Usdaud - Usdsgd	0.018	(1.51)	0.852	(18.22)
89	Usdjpy - Usdnzd	0.038	(1.70)	0.055	(0.11)
90	Usdjpy - Usdsgd	0.07	(3.17)	0.199	(1.16)
91	Usdnzd - Usdsgd	0.048	(2.15)	-0.283	(-0.86)

Notes:

1. Two entries for each parameter are their respective estimate and the Bollerslev-Wooldridge (1992) robust *t*-ratio.
2. Entries in **bold** are significant at the 5% level.

Table 4-21: Rank of Pairs of Varying Conditional Correlations, Developed Markets

Rank	Correlations	Dynamics correlation	Percentage
1	Stock-Bond	19 of 25	76
2	Foreign exchange-Foreign exchange	4 of 6	67
3	Bond-Foreign exchange	11 of 20	55
4	Stock-Stock	5 of 10	50
5	Bond-Bond	4 of 10	40
6	Stock-Foreign exchange	7 of 20	35

Note: 1 is the most dynamic, and 6 is the least dynamic.

Table 4-20 also shows that dynamic conditional correlations across different classes of assets are evident in 35 of 65 cases (57%), namely: (1) stock and bond markets, for 19 of 25 pairs (76%); (2) bond and foreign exchange markets, for 11 of 20 pairs (55%); and (3) stock and foreign exchange markets, for 7 of 20 pairs (35%). It can be concluded that across different classes of assets, the conditional correlations between the stock and bond markets are the most dynamic, followed by the conditional correlations between the bond and foreign exchange markets, and finally the conditional correlations between the stock and foreign exchange markets.

Overall, it can be concluded that the conditional correlations between different classes of assets (57%) are more dynamic than that of the same classes of assets (50%). In addition, the conditional correlations between the stock and bond markets are the most dynamic, while the conditional correlations between the stock and foreign markets are the least dynamic. The six ranks of pairs of conditional correlations, from the most dynamic to the least dynamic, are given in Table 4-21.

In terms of their signs, the conditional correlations between the same classes of assets tend to be positive, while those between different classes of assets have a mixture of positive and negative signs.

4.2.2. Conditional Correlations in Emerging and Emerging-Developed Countries

“... Several funds tend to zig when big US stocks zag, advisers admit, which means that such fare, when added to a portfolio heavy in US blue-chip stocks, actually may damp the portfolio's up and downs.”

Karen Damato (1997)

An important implication from the previous section is that conditional correlations are likely to be time varying. In such cases, perhaps a better approach to model dynamic conditional correlation is to estimate dynamic conditional correlation models.

This section estimates the DCC and GARCC models on the data from Emerging-Developed countries. The returns are bonds, stocks and foreign exchange from 4 emerging markets, namely Indonesia, Malaysia, Philippines and Thailand. Two developed countries are also investigated as benchmarks, namely the USA and Japan. As in the previous section, both the DCC and GARCC models are assumed to follow ARMA(1,1)-GARCH(1,1) processes for the conditional first and second moments.

The chapter uses the same data used in Chapter 3, Section 2, namely the daily closing price index of bond, stock, and foreign exchange rates from Indonesia, Malaysia, the Philippines, Thailand, Japan, and the USA. The returns of market i at time t are calculated in the same way as in Chapter 3, namely $R_{i,t} = \log(P_{i,t} / P_{i,t-1})$, where $P_{i,t}$ and $P_{i,t-1}$ are the closing prices of asset i for days t and $t-1$, respectively.

Table 4-22: Summary of Variable Names, Emerging-Developed Markets

No	Variables	Index Names	Variable Names
1	Indonesian Bond	INDOGB (10 Years MT)	Indbond
2	Japanese Bond	JP Total 7-10 Years Govt. Index	Japbond
3	Malaysian Bond	MGS (10 Years MT)	Malbond
4	Philippines Bond	RPGB (10 Years MT)	Phibond
5	Thailand Bond	THAIGB (10 Years MT)	Thabond
6	US Bond	US Benchmark 10 Year Govt. Index	Usbond
7	Indonesian Stock	Composite Stock Price Index	Indstock
8	Japanese Stock	Nikkei 225 Stock Avrg. Price Index	Japstock
9	Malaysian Stock	Kuala Lumpur Comp. Price Index	Malstock
10	Philippines Stock	Philippine SE Index	Phistock
11	Thailand Stock	DJSI World Thailand Subset Price Index	Thastock
12	US Stock	S&P 500 Composite Price Index	Usstock
13	Exchange Rates	USD/IDR	Usdidr
14	Exchange Rates	USD/JPY	Usdjpy
15	Exchange Rates	USD/MYR	Usdmyr
16	Exchange Rates	USD/PHP	Usdphp
17	Exchange Rates	USD/THB	Usdthb

Source: DataStream and Bloomberg database service.

However, instead of using exchange rates for all pairs of the countries (in which the total assets to be estimated are 27, namely 6 bonds, 6 stocks and 15 foreign exchange rates), this section uses only 5 exchange rates, where each exchange rate is against USD (in which the total assets to be estimated are 17, namely 6 bonds, 6 stocks and 5 foreign exchange rates). This makes the evaluation simpler to undertake, as the number of pair-wise correlations decreases significantly from 351 to 136. This simplification is made using the argument that most foreign exchange uses USD as the benchmarks. The bond, stock and foreign exchange returns and their variable names included in the analysis are summarized in Table 4-22. The statistic description and the stationarity of the data are discussed in Chapter 3, Section 2. This section uses shorter data span than that of Section 4.1.2, because the estimation was actually done before the estimation of data in Section 4.1.2, uses the longest data span available

The estimates of the parameters for the conditional means and conditional variances of the DCC and GARCC models for emerging-developed markets are provided in Table 4-23. From the mean equation in Table 4-23, not all of the returns are influenced by their own lagged values, which suggest the possibility of the impact from other markets. From the variance equation in Table 4-23, all returns exhibit a significant influence of both short and long persistence, except for Usdjpy which shows only weak short persistence.

In order to check the structural properties of the first and second moments, the second moment and log-moment conditions are evaluated for the ARMA(1,1)-GARCH(1,1) model. Table 4-24 provides the results of the second moment and log-moment conditions for the GARCH(1,1) model for all returns series. The second moment condition is satisfied for all returns, except for Indbond, Malbond, and Usdmyr. However, the log-moment conditions are satisfied for all series, which suggest that the empirical estimates are statistically valid for these series. Thus, the ARMA(1,1)-GARCH(1,1) model successfully models the conditional mean and volatility in each of the series. This supports the results in Chapter 3, where the univariate AR(1)-GARCH(1,1) are estimated.

Table 4-23: DCC and GARCC, Conditional Means and Variances, Emerging-Developed Markets

No	Series	Mean Equations			Variance Equations		
		θ_1	θ_2	θ_3	ω	α	β
1	Indbond	0.00	-0.03	0.06	0.00	0.25	0.79
		0.86	-0.03	0.05	11.27	20.69	134.83
2	Japbond	0.00	-0.29	0.33	0.00	0.10	0.88
		0.87	-0.38	0.44	3.81	8.72	78.79
3	Malbond	-4.9E-05	0.61	-0.39	0.00	0.06	0.94
		-2.08	5.65	-3.38	5.20	13.75	308.42
4	Phibond	0.00	0.38	-0.31	0.00	0.15	0.81
		-1.02	4.03	-2.98	10.39	9.83	58.81
5	Thabond	0.00	0.47	-0.22	0.00	0.23	0.47
		-0.52	2.62	-1.14	12.98	10.53	12.52
6	Usabond	0.00	-0.93	0.94	0.00	0.02	0.93
		-0.24	-16.90	17.50	1.06	1.46	14.93
7	Indstock	2.1E-03	-0.05	0.22	0.00	0.13	0.77
		3.61	-0.25	1.23	3.98	5.84	18.58
8	Japstock	0.00	0.85	-0.86	0.00	0.07	0.92
		1.25	7.23	-7.57	2.23	4.80	61.31
9	Malstock	0.00	0.31	-0.16	0.00	0.03	0.97
		1.46	1.56	-0.77	2.36	4.11	131.24
10	Phistock	0.00	0.10	0.08	0.00	0.09	0.85
		1.84	0.54	0.44	3.44	4.74	30.82
11	Thastock	0.00	0.96	-0.92	0.00	0.06	0.94
		-0.18	29.88	-20.14	1.89	6.58	121.89
12	Usastock	0.00	0.58	-0.65	0.00	0.04	0.93
		1.64	3.09	-3.73	1.81	2.83	33.13
13	Usdidr	0.00	-0.07	0.07	0.00	0.35	0.62
		0.07	0.00	0.00	7.47	13.83	27.14
14	Usdjpy	0.00	0.09	-0.10	0.00	0.03	0.93
		-0.16	0.05	-0.07	1.34	1.69	19.46
15	Usdmyr	0.00	0.10	-0.72	0.00	0.57	0.52
		-0.56	0.99	-18.49	8.27	4.56	9.06
16	Usdphp	0.00	0.04	-0.17	0.00	0.11	0.89
		-0.16	0.16	-0.67	3.40	7.59	67.68
17	Usdthb	0.00	-0.91	0.92	0.00	0.11	0.81
		-0.91	-28.22	29.26	3.86	6.37	22.90

Notes:

1. The two entries for each parameter are their respective estimate and the Bollerslev-Wooldridge (1992) robust *t*-ratio.
2. AR(1) denotes the own one-period lagged returns.
3. Entries in **bold** are significant at the 5% level.

Table 4-24: DCC and GARCC, Moment Conditions, Emerging-Developed Markets

No	Series	Moment Conditions	
		Second Moment	Log Moment
1	Indbond	1.040	-0.030
2	Japbond	0.983	-0.014
3	Malbond	1.002	-0.004
4	Phibond	0.965	-0.038
5	Thabond	0.698	-0.252
6	Usabond	0.943	-0.026
7	Indstock	0.903	-0.055
8	Japstock	0.991	-0.006
9	Malstock	0.993	-0.003
10	Phistock	0.944	-0.029
11	Thastock	0.999	-0.003
12	Usastock	0.969	-0.014
13	Usdidr	0.974	-0.079
14	Usdjpy	0.953	-0.021
15	Usdmyr	1.090	-0.200
16	Usdphp	0.997	-0.008
17	Usdthb	0.924	-0.045

Table 4-25: DCC Estimates of the Q_1 Model, Emerging-Developed Markets

Parameter Estimates	Estimates in the Q_1 Equation
ϕ_1	4E-06
	(0.001)
ϕ_2	-6E-04
	(-0.003)

Notes: The two entries for each parameter are their respective estimate and t -ratio.

The estimated parameters of the conditional correlations for the DCC model are given in Table 4-25. From Table 4-25, we can see that neither estimated coefficient is significant, suggesting that, on average, the conditional correlations of the overall returns are not dynamic. As in the previous section, this can be interpreted as the conditional correlation are only time varying for some pairs of assets, but not for all assets.

The estimates arising from the DCC model do not provide any information regarding the conditional correlations between any pairs of asset markets. In order to accommodate this purpose, the GARCC model is estimated, for which the empirical results are given in Table 4-26.

Table 4-26: GARCC Estimates of the Q_1 Model, Emerging-Developed Markets

No	Pair of Assets	ϕ_1		ϕ_2	
1	Indbond - Japbond	0.001	0.024	-0.083	-0.028
2	Indbond - Malbond	0.026	0.778	0.048	0.039
3	Indbond - Phibond	0.001	0.016	0.308	0.113
4	Indbond - Thabond	-0.030	-1.623	0.895	10.611
5	Indbond - Usabond	-0.039	-1.199	0.385	0.616
6	Japbond - Malbond	-0.032	-0.952	0.105	0.121
7	Japbond - Phibond	0.015	0.459	0.223	0.440
8	Japbond - Thabond	0.011	0.328	0.183	0.095
9	Japbond - Usabond	-0.010	-0.297	0.176	0.322
10	Malbond - Phibond	-0.027	-2.163	0.948	33.188
11	Malbond - Thabond	0.054	1.627	0.335	0.657
12	Malbond - Usabond	0.059	1.770	0.073	0.144
13	Phibond - Thabond	0.005	0.154	-0.485	-0.701
14	Phibond - Usabond	0.036	1.091	-0.171	-0.479
15	Thabond - Usabond	0.045	1.393	-0.386	-0.827
16	Indstock - Japstock	0.044	1.320	-0.047	-0.124
17	Indstock - Malstock	0.022	0.660	-0.175	-0.321
18	Indstock - Phistock	-0.039	-1.164	-0.138	-0.170
19	Indstock - Thastock	0.043	2.062	-0.863	-10.138
20	Indstock - Usastock	0.055	1.662	-0.168	-0.514
21	Japstock - Malstock	-0.048	-1.461	-0.224	-0.680
22	Japstock - Phistock	-0.025	-0.746	-0.030	-0.024
23	Japstock - Thastock	-0.008	-0.228	0.174	0.244
24	Japstock - Usastock	0.018	0.637	-0.563	-4.053
25	Malstock - Phistock	0.087	2.574	0.287	0.818
26	Malstock - Thastock	-0.012	-0.343	0.128	0.128
27	Malstock - Usastock	-0.013	-0.430	-0.515	-1.901
28	Phistock - Thastock	-0.026	-0.971	-0.772	-2.367
29	Phistock - Usastock	0.026	1.228	-0.830	-5.611
30	Thastock - Usastock	0.023	0.675	0.038	0.058
31	Usdidr - Usdjpy	-0.045	-1.636	-0.770	-3.759
32	Usdidr - Usdmyr	0.025	2.476	-0.971	-66.035
33	Usdidr - Usdphp	0.098	3.013	0.540	2.468
34	Usdidr - Usdthb	-0.039	-1.270	-0.619	-1.511
35	Usdjpy - Usdmyr	0.051	1.628	0.632	1.958
36	Usdjpy - Usdphp	-0.050	-1.523	-0.244	-0.466
37	Usdjpy - Usdthb	0.002	0.140	-0.941	-6.090
38	Usdmyr - Usdphp	0.014	1.316	-0.972	-27.318
39	Usdmyr - Usdthb	-0.011	-0.335	0.305	0.119
40	Usdphp - Usdthb	0.015	0.634	-0.757	-2.401
41	Indbond - Indstock	-0.002	-0.074	0.083	0.029
42	Indbond - Japstock	-0.008	-0.247	-0.152	-0.123
43	Indbond - Malstock	-0.018	-1.842	-0.985	-67.555
44	Indbond - Phistock	-0.030	-0.908	0.227	0.225
45	Indbond - Thastock	0.021	0.629	-0.159	-0.108
46	Indbond - Usastock	0.016	0.488	-0.329	-0.300
47	Japbond - Indstock	0.034	1.026	0.138	0.239
48	Japbond - Japstock	0.020	0.619	0.257	0.547

49	Japbond - Malstock	-0.026	-0.827	-0.379	-0.644
50	Japbond - Phistock	-0.018	-0.658	0.663	1.135
51	Japbond - Thastock	-0.040	-1.206	-0.429	-0.690
52	Japbond - Usastock	-0.013	-0.415	-0.389	-0.912
53	Malbond - Indstock	0.023	0.726	0.454	0.520
54	Malbond - Japstock	0.032	0.985	0.269	0.407
55	Malbond - Malstock	0.070	2.065	-0.035	-0.079
56	Malbond - Phistock	0.009	0.255	-0.027	-0.007
57	Malbond - Thastock	0.032	1.199	0.787	3.109
58	Malbond - Usastock	0.072	2.154	0.004	0.010
59	Phibond - Indstock	-0.020	-0.606	0.133	0.286
60	Phibond - Japstock	-0.024	-0.729	0.123	0.536
61	Phibond - Malstock	-0.005	-0.600	0.968	44.484
62	Phibond - Phistock	-0.070	-2.084	0.080	0.169
63	Phibond - Thastock	0.026	0.810	-0.355	-0.493
64	Phibond - Usastock	-0.020	-0.699	0.527	2.109
65	Thabond - Indstock	-0.057	-1.709	0.046	0.082
66	Thabond - Japstock	0.008	0.273	0.438	0.637
67	Thabond - Malstock	0.006	0.210	0.593	0.811
68	Thabond - Phistock	-0.047	-1.403	0.260	0.409
69	Thabond - Thastock	-0.026	-0.771	0.083	0.066
70	Thabond - Usastock	0.006	0.238	0.609	1.624
71	Usabond - Indstock	0.040	1.216	-0.138	-0.369
72	Usabond - Japstock	0.029	1.450	0.838	8.749
73	Usabond - Malstock	0.012	1.482	0.990	88.533
74	Usabond - Phistock	0.023	1.048	0.822	4.209
75	Usabond - Thastock	-0.030	-0.902	-0.023	-0.035
76	Usabond - Usastock	0.030	1.251	0.718	6.751
77	Indbond - Usdidr	-0.012	-0.371	-0.471	-0.272
78	Indbond - Usdjpy	-0.037	-1.099	0.039	0.058
79	Indbond - Usdmyr	-0.052	-1.570	-0.045	-0.071
80	Indbond - Usdphp	0.047	1.542	-0.602	-1.756
81	Indbond - Usdthb	0.018	0.538	0.091	0.050
82	Japbond - Usdidr	0.026	0.771	0.071	0.057
83	Japbond - Usdjpy	0.017	0.500	0.021	0.067
84	Japbond - Usdmyr	0.042	2.878	0.969	50.384
85	Japbond - Usdphp	-0.051	-1.524	0.293	0.518
86	Japbond - Usdthb	-0.070	-2.533	-0.754	-5.670
87	Malbond - Usdidr	-0.051	-1.639	-0.615	-1.836
88	Malbond - Usdjpy	0.040	1.218	-0.169	-0.318
89	Malbond - Usdmyr	0.017	0.527	0.581	0.530
90	Malbond - Usdphp	0.014	0.864	-0.924	-7.771
91	Malbond - Usdthb	-0.016	-0.678	-0.832	-2.571
92	Phibond - Usdidr	0.013	1.563	0.982	58.770
93	Phibond - Usdjpy	0.010	0.304	0.001	0.004
94	Phibond - Usdmyr	-0.040	-1.330	0.637	1.786
95	Phibond - Usdphp	0.001	0.060	0.671	1.139
96	Phibond - Usdthb	0.007	0.337	-0.828	-1.958
97	Thabond - Usdidr	0.034	1.095	0.614	1.239
98	Thabond - Usdjpy	0.075	2.232	0.060	0.147

99	Thabond - Usdmyr	-0.028	-0.871	-0.551	-0.773
100	Thabond - Usdphp	-0.020	-1.662	-0.971	-34.228
101	Thabond - Usdthb	-0.037	-1.316	-0.733	-2.549
102	Usabond - Usdidr	-0.030	-1.109	-0.778	-2.693
103	Usabond - Usdjpy	0.010	0.304	0.284	0.702
104	Usabond - Usdmyr	0.045	1.856	0.853	6.981
105	Usabond - Usdphp	-0.018	-0.627	0.577	1.219
106	Usabond - Usdthb	0.016	0.526	-0.601	-0.631
107	Indstock - Usdidr	-0.065	-1.935	0.227	0.483
108	Indstock - Usdjpy	0.088	2.635	-0.060	-0.292
109	Indstock - Usdmyr	0.012	1.107	-0.971	-22.705
110	Indstock - Usdphp	0.016	1.401	-0.961	-26.337
111	Indstock - Usdthb	0.015	0.460	0.222	0.115
112	Japstock - Usdidr	0.048	1.431	-0.249	-0.404
113	Japstock - Usdjpy	0.083	2.475	0.031	0.202
114	Japstock - Usdmyr	-0.040	-1.369	0.666	2.046
115	Japstock - Usdphp	0.023	1.676	-0.933	-20.268
116	Japstock - Usdthb	0.044	1.687	0.810	4.955
117	Malstock - Usdidr	-0.053	-1.593	0.379	0.769
118	Malstock - Usdjpy	0.002	0.069	0.040	0.121
119	Malstock - Usdmyr	-0.014	-0.548	-0.793	-1.566
120	Malstock - Usdphp	-0.084	-3.032	-0.775	-7.063
121	Malstock - Usdthb	-0.059	-1.773	-0.489	-1.233
122	Phistock - Usdidr	0.023	0.860	-0.746	-1.868
123	Phistock - Usdjpy	0.013	0.520	0.755	1.618
124	Phistock - Usdmyr	-0.015	-0.662	0.809	2.280
125	Phistock - Usdphp	0.029	1.007	-0.676	-1.572
126	Phistock - Usdthb	0.033	1.118	-0.619	-1.582
127	Thastock - Usdidr	-0.037	-1.111	-0.075	-0.084
128	Thastock - Usdjpy	0.030	1.367	-0.828	-5.464
129	Thastock - Usdmyr	-0.046	-1.490	0.583	1.571
130	Thastock - Usdphp	0.036	1.971	0.910	14.875
131	Thastock - Usdthb	-0.045	-1.349	0.209	0.305
132	Usastock - Usdidr	0.001	0.290	0.997	224.464
133	Usastock - Usdjpy	0.035	1.135	-0.411	-2.389
134	Usastock - Usdmyr	-0.016	-0.647	0.789	1.811
135	Usastock - Usdphp	-0.030	-2.536	-0.959	-42.767
136	Usastock - Usdthb	0.021	0.955	-0.789	-4.332

Notes:

1. Two entries for each parameter are its estimated coefficient and *t*-ratio, respectively.
2. Entries in **bold** are significant at the 5% level.

Table 4-27: Rank of Pairs of Varying Conditional Correlations, Emerging-Emerging Markets

Rank	Correlations	Dynamics correlation	Percentage
1	Foreign exchange-Foreign exchange	4 of 6	67
2	Bond-Bond	3 of 6	50
3	Stock-stock	3 of 6	50
4	Bond-Foreign Exchange	7 of 16	44
5	Stock-Foreign exchange	5 of 16	31
6	Bond-Stock	3 of 12	25

Note: 1 is the most dynamic, and 6 is the least dynamic.

Table 4-28: Rank of Pairs of Varying Conditional Correlations, Emerging-Developed Markets

Rank	Correlations	Dynamics correlation	Percentage
1	Stock-Foreign exchange	8 of 12	67
2	Foreign exchange-Foreign exchange	2 of 4	50
3	Bond-Foreign Exchange	5 of 12	42
4	Bond-Stock	3 of 16	19
5	Stock-stock	1 of 8	13
6	Bond-Bond	0 of 8	0

Note: 1 is the most dynamic, and 6 is the least dynamic

From Table 4-26, we can observe that 38% of pairs of returns (52 of 136) show dynamic conditional correlations. The results for the conditional correlations within the same classes of assets are as follows: (1) between bond markets: 2 of 15 pairs (13%) show dynamic conditional correlations; (2) between stock markets: 4 of 15 pairs (27%) show dynamic conditional correlations; (3) between foreign exchange markets: 6 of 10 pairs (60%) show dynamic conditional correlations. It can be concluded that between the same classes of assets, the conditional correlations between foreign exchange markets are the most dynamic, followed by the conditional correlations between stock markets and between bond markets.

The estimates for the conditional correlations between different classes of assets are as follows. (1) between bond and stock markets: 11 of 36 pairs (31%) show dynamic conditional correlations; (2) between bond and foreign exchange markets: 12 of 30 pairs (40%) show dynamic conditional correlation; (3) between stock and foreign exchange

markets: 15 of 30 (50%) pairs show dynamic conditional correlation. It can be concluded that between different classes of assets, the conditional correlations between stock and foreign exchange markets are the most dynamic, followed by the conditional correlations between bond and foreign exchange markets, and between bond and stock markets.

From Table 4-26, it is possible to compare the conditional correlations between emerging-emerging countries and between emerging-developed countries, which are summarized in Tables 4-27 and 4-28, respectively. Comparing both tables, we can learn that: (1) between bond markets, the conditional correlations between developed and emerging countries are constant, while the conditional correlations between emerging countries are dynamic, that is, 2 of 6 pairs (30%) are dynamic; (2) between stock markets, the conditional correlations between developed and emerging countries are relatively constant, as only 1 of 8 (12.5%) is dynamic, while the conditional correlations between emerging countries are more dynamic, that is, 3 of 6 pairs (50%) are dynamic; (3) between foreign exchange markets, the conditional correlations between emerging-emerging countries are more dynamic, namely 4 of 7 pairs (67%), compared to that of emerging-developed countries which is 2 of 4 pairs (50%) being dynamic; (4) between bond and stock markets, the conditional correlations between developed and emerging countries are more dynamic, with 3 of 16 (19%) being dynamic, compared with that between emerging markets, which show dynamic conditional correlations in only 3 of 12 pairs (25%); (5) between bond and foreign exchange markets, the conditional correlations between emerging countries are slightly more dynamic, with 7 of 16 (44%) being dynamic, compared with that between emerging-developed countries, which show dynamic conditional correlations in 5 of 12 pairs (42%); (6) between stock and foreign exchange markets, the conditional correlations between emerging-developed countries are more dynamic, with 8 of 12 (67%) being dynamic, compared with that between

emerging countries, which show dynamic conditional correlations in only 5 of 16 pairs (31%).

4.3. Concluding Remarks

From Subsection 4.1, it can be concluded that volatility spillovers was important in forecasting correlation. This might be caused by the fact that even though returns of financial assets move together, one set of assets serves as leading source of volatility for other sets of assets, which resulted in dissimilar assets has varying degrees of return correlation (see Vargas (2006)). This contributed to the literature as papers that forecasted correlations using multivariate GARCH model did not stress on the importance of the volatility spillovers, even though they use models that incorporate such spillovers.

The finding is of importance in including assets from both developed and emerging markets in searching for lower risk portfolio. This follows the suggestion from previous chapter that volatility spillovers are evident particularly from developed to emerging markets, thereby stressing the importance of using models that incorporate volatility spillovers in such quest.

The estimates for the conditional correlations of the DCC model in Tables 4-19 and 4-25 show that the parameter estimates are not significant, which suggest that the conditional correlations of the returns may be constant and not dynamic. An alternate explanation is that the conditional correlation are only time varying for some pairs of assets, but not for all assets. Therefore, imposing the restriction of all correlations to have the same dynamic could produce misleading empirical results. It is proven in Chapter 5 that estimating the DCC model for each pair of assets provide significance of most parameters in the model (see Tables 5-19 and 5-24).

Appendix 4-1

Table 4-29-A: Correlation between Forecasts of Conditional Correlation Resulted from Each Model, Bond-Bond, Developed Markets

No		Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-AGARCH
	Bond-Bond			
1	Ausbond-Japbond	0.99	0.99	1.00
2	Ausbond-Nzbond	0.94	0.93	0.91
3	Ausbond-Sgbond	0.99	1.00	1.00
4	Ausbond-Usbond	0.98	0.98	1.00
5	Japbond-Nzbond	0.99	0.99	1.00
6	Japbond-Sgbond	0.94	0.99	0.94
7	Japbond-Usbond	1.00	1.00	1.00
8	Nzbond-Sgbond	0.99	0.99	0.99
9	Nzbond-Usbond	0.98	0.98	1.00
10	Sgbond-Usbond	0.99	0.99	1.00

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-29-B: Correlation between Forecasts of Conditional Correlation Resulted from Each Model, Stock-Stock, Developed Markets

No		Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-AGARCH
	Stock-Stock			
11	Ausstock-Japstock	0.99	0.98	0.99
12	Ausstock-Nzstock	0.99	0.97	0.97
13	Ausstock-Sgstock	0.95	0.95	0.98
14	Ausstock-Usstock	0.72	0.72	0.98
15	Japstock-Nzstock	0.99	1.00	1.00
16	Japstock-Sgstock	0.99	1.00	1.00
17	Japstock-Usstock	0.58	0.62	0.88
18	Nzstock-Sgstock	0.99	0.99	0.99
19	Nzstock-Usstock	0.93	0.94	0.99
20	Sgstock-Usstock	0.78	0.78	0.97

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-29-C: Correlation between Forecasts of Conditional Correlation Resulted from Each Model, ER-ER, Developed Markets

No		Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-AGARCH
21	Usdaud-Usdjpy	0.96	0.96	1.00
22	Usdaud-Usdnzd	0.89	0.89	1.00
23	Usdaud-Usdsgd	0.70	0.72	0.98
24	Usdjpy-Usdnzd	0.98	0.98	0.98
25	Usdjpy-Usdsgd	0.98	0.98	0.98
26	Usdnzd-Usdsgd	0.94	0.95	0.95

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-29-D: Correlation between Forecasts of Conditional Correlation Resulted from Each Model, Bond-Stock, Developed Markets

No		Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-AGARCH
	Bond-Stock			
27	Ausbond-Ausstock	0.91	0.92	0.85
28	Ausbond-Japstock	0.98	0.98	0.99
29	Ausbond-Nzstock	0.98	0.87	0.84
30	Ausbond-Sgstock	0.89	0.93	0.94
31	Ausbond-Usstock	0.82	0.86	0.90
32	Japbond-Ausstock	0.97	0.99	0.97
33	Japbond-Japstock	1.00	1.00	1.00
34	Japbond-Nzstock	0.99	0.99	0.99
35	Japbond-Sgstock	0.99	0.99	1.00
36	Japbond-Usstock	0.86	0.88	0.92
37	Nzbond-Ausstock	0.95	0.95	0.91
38	Nzbond-Japstock	0.99	0.99	1.00
39	Nzbond-Nzstock	0.99	1.00	0.99
40	Nzbond-Sgstock	0.95	0.95	0.92
41	Nzbond-Usstock	0.89	0.92	0.90
42	Sgbond-Ausstock	0.96	0.98	0.97
43	Sgbond-Japstock	0.99	1.00	0.99
44	Sgbond-Nzstock	0.78	0.97	0.78
45	Sgbond-Sgstock	0.98	1.00	0.98
46	Sgbond-Usstock	0.98	0.98	0.98
47	Usbond-Ausstock	0.99	0.99	1.00
48	Usbond-Japstock	0.99	0.99	1.00
49	Usbond-Nzstock	1.00	1.00	1.00
50	Usbond-Sgstock	0.99	1.00	1.00
51	Usbond-Usstock	0.99	0.99	0.99

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-29-E: Correlation between Forecasts of Conditional Correlation Resulted from Each Model, Bond-ER, Developed Markets

No		Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-AGARCH
	Bond-ER			
52	Ausbond-Usdaud	0.78	0.80	0.95
53	Ausbond-Usdipy	0.97	0.97	1.00
54	Ausbond-Usdnzd	0.80	0.77	0.85
55	Ausbond-Usdsgd	0.99	0.99	1.00
56	Japbond-Usdaud	0.91	0.94	0.98
57	Japbond-Usdipy	0.77	0.84	0.95
58	Japbond-Usdnzd	1.00	1.00	1.00
59	Japbond-Usdsgd	0.95	0.94	0.99
60	Nzbond-Usdaud	0.96	0.96	0.98
61	Nzbond-Usdipy	0.96	0.96	0.99
62	Nzbond-Usdnzd	0.93	0.94	0.99
63	Nzbond-Usdsgd	0.95	0.97	0.98
64	Sgbond-Usdaud	0.93	0.96	0.96
65	Sgbond-Usdipy	0.92	0.96	0.96
66	Sgbond-Usdnzd	0.97	0.98	0.98
67	Sgbond-Usdsgd	0.92	0.97	0.91
68	Usbond-Usdaud	0.99	0.99	1.00
69	Usbond-Usdipy	1.00	1.00	1.00
70	Usbond-Usdnzd	1.00	1.00	1.00
71	Usbond-Usdsgd	1.00	0.99	1.00

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-29-F: Correlation between Forecasts of Conditional Correlation Resulted from Each Model, Stock-ER, Developed Markets

No	Stock-ER	Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-AGARCH
72	Ausstock-Usdaud	0.86	0.93	0.93
73	Ausstock-Usdjpy	0.90	0.87	0.90
74	Ausstock-Usdnzd	0.97	0.99	0.97
75	Ausstock-Usdsgd	0.98	0.98	0.99
76	Japstock-Usdaud	0.98	0.98	1.00
77	Japstock-Usdjpy	0.99	0.99	1.00
78	Japstock-Usdnzd	1.00	1.00	1.00
79	Japstock-Usdsgd	0.98	0.97	0.99
80	Nzstock-Usdaud	0.78	0.81	0.99
81	Nzstock-Usdjpy	0.96	0.96	0.98
82	Nzstock-Usdnzd	0.99	0.98	0.99
83	Nzstock-Usdsgd	0.97	0.96	0.95
84	Sgstock-Usdaud	0.97	0.98	0.99
85	Sgstock-Usdjpy	0.96	0.98	0.98
86	Sgstock-Usdnzd	0.99	0.99	0.99
87	Sgstock-Usdsgd	0.91	0.93	0.93
88	Usstock-Usdaud	0.93	0.93	0.99
89	Usstock-Usdjpy	0.96	0.97	0.97
90	Usstock-Usdnzd	0.98	0.98	0.98
91	Usstock-Usdsgd	0.97	0.93	0.93

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-30-A: Summary of Volatility Spillovers and Asymmetric Effect, Bond-Bond, Developed Markets

No	Bond-Bond	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
1	Ausbond-Japbond	0	0	0
2	Ausbond-Nzbond	1	1	2
3	Ausbond-Sgbond	0	1	0
4	Ausbond-Usbond	0	0	0
5	Japbond-Nzbond	0	1	0
6	Japbond-Sgbond	0	0	0
7	Japbond-Usbond	0	0	0
8	Nzbond-Sgbond	1	1	0
9	Nzbond-Usbond	0	0	1
10	Sgbond-Usbond	1	1	1

Table 4-30-B: Summary of Volatility Spillovers and Asymmetric Effect, Stock-Stock, Developed Markets

No	Stock-Stock	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
11	Ausstock-Japstock	0	1	2
12	Ausstock-Nzstock	1	0	2
13	Ausstock-Sgstock	0	1	2
14	Ausstock-Ustock	1	2	2
15	Japstock-Nzstock	0	0	2
16	Japstock-Sgstock	0	1	1
17	Japstock-Ustock	1	1	2
18	Nzstock-Sgstock	0	1	1
19	Nzstock-Ustock	0	0	2
20	Sgstock-Ustock	2	2	1

Table 4-30-C: Summary of Volatility Spillovers and Asymmetric Effect, ER-ER, Developed Markets

No	ER-ER	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
21	Usdaud-Usdjpy	0	0	0
22	Usdaud-Usdnzd	2	2	1
23	Usdaud-Usdsgd	1	1	0
24	Usdjpy-Usdnzd	0	0	1
25	Usdjpy-Usdsgd	1	1	0
26	Usdnzd-Usdsgd	1	1	0

Table 4-30-D: Summary of Volatility Spillovers and Asymmetric Effect, Bond-Stock, Developed Markets

No	Bond-Stock	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
27	Ausbond-Ausstock	0	0	1
28	Ausbond-Japstock	0	0	1
29	Ausbond-Nzstock	1	0	1
30	Ausbond-Sgstock	0	0	0
31	Ausbond-Usstock	0	0	1
32	Japbond-Ausstock	1	2	1
33	Japbond-Japstock	1	1	1
34	Japbond-Nzstock	0	0	1
35	Japbond-Sgstock	1	1	0
36	Japbond-Usstock	1	0	1
37	Nzbond-Ausstock	1	1	1
38	Nzbond-Japstock	0	0	1
39	Nzbond-Nzstock	0	0	1
40	Nzbond-Sgstock	0	0	0
41	Nzbond-Usstock	0	0	1
42	Sgbond-Ausstock	0	0	1
43	Sgbond-Japstock	0	2	1
44	Sgbond-Nzstock	0	0	1
45	Sgbond-Sgstock	1	1	0
46	Sgbond-Usstock	0	0	1
47	Usbond-Ausstock	1	1	1
48	Usbond-Japstock	0	0	1
49	Usbond-Nzstock	1	1	1
50	Usbond-Sgstock	0	0	0
51	Usbond-Usstock	1	1	1

Table 4-30-E: Summary of Volatility Spillovers and Asymmetric Effect, Bond-ER, Developed Markets

No	Bond-ER	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
52	Ausbond-Usdaud	2	1	2
53	Ausbond-Usdjpy	0	0	0
54	Ausbond-Usdnzd	0	0	1
55	Ausbond-Usdsgd	0	0	0
56	Japbond-Usdaud	0	0	0
57	Japbond-Usdjpy	0	0	0
58	Japbond-Usdnzd	0	0	1
59	Japbond-Usdsgd	0	0	0
60	Nzbond-Usdaud	2	1	1
61	Nzbond-Usdjpy	0	0	0
62	Nzbond-Usdnzd	1	2	2
63	Nzbond-Usdsgd	0	0	0
64	Sgbond-Usdaud	1	1	0
65	Sgbond-Usdjpy	1	1	0
66	Sgbond-Usdnzd	0	0	1
67	Sgbond-Usdsgd	0	0	0
68	Usbond-Usdaud	0	0	0
69	Usbond-Usdjpy	0	0	0
70	Usbond-Usdnzd	0	0	1
71	Usbond-Usdsgd	0	0	0

Table 4-30-F: Summary of Volatility Spillovers and Asymmetric Effect, Stock-ER,
Developed Markets

No	Stock-ER	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
72	Ausstock-Usdaud	1	1	2
73	Ausstock-Usdjpy	1	2	2
74	Ausstock-Usdnzd	1	0	2
75	Ausstock-Usdsgd	2	1	1
76	Japstock-Usdaud	0	0	1
77	Japstock-Usdjpy	1	1	1
78	Japstock-Usdnzd	0	0	2
79	Japstock-Usdsgd	1	1	1
80	Nzstock-Usdaud	1	1	1
81	Nzstock-Usdjpy	0	0	1
82	Nzstock-Usdnzd	0	0	2
83	Nzstock-Usdsgd	1	1	0
84	Sgstock-Usdaud	1	0	0
85	Sgstock-Usdjpy	1	1	0
86	Sgstock-Usdnzd	0	0	1
87	Sgstock-Usdsgd	1	1	0
88	Usstock-Usdaud	1	1	1
89	Usstock-Usdjpy	1	1	1
90	Usstock-Usdnzd	0	1	1
91	Usstock-Usdsgd	1	1	1

Appendix 4-2

Table 4-31-A: Correlation between Forecasts of Conditional Correlations, Bond-Bond, Emerging-Developed Markets

No	Bond-Bond	Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-GARCH
1	Indbond-Japbond	0.01	0.21	0.32
2	Indbond-Malbond	0.99	0.99	0.99
3	Indbond-Phibond	0.85	0.93	0.79
4	Indbond-Thabond	0.35	0.38	0.50
5	Indbond-Usbond	0.77	0.82	0.77
6	Japbond-Malbond	0.96	0.95	0.98
7	Japbond-Phibond	0.75	0.79	0.87
8	Japbond-Thabond	0.95	0.96	0.94
9	Malbond-Phibond	0.92	0.91	0.90
10	Malbond-Thabond	0.89	0.96	0.88
11	Malbond-Usbond	0.64	0.58	0.67
12	Phibond-Thabond	0.96	0.97	0.98
13	Phibond-Usbond	0.62	0.65	0.85
14	Thabond-Usbond	0.90	0.91	0.94

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-31-B: Correlation between Forecasts of Conditional Correlations, Stock-Stock, Emerging-Developed Markets

No	Stock-stock	Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-GARCH
1	Indstock-Japstock	0.97	0.98	0.97
2	Indstock-Malstock	0.99	0.99	1.00
3	Indstock-Phistock	0.98	0.99	0.98
4	Indstock-Thastock	0.98	0.97	0.97
5	Indstock-Usstock	0.86	0.88	0.96
6	Japstock-Malstock	0.93	0.98	0.96
7	Japstock-Phistock	0.99	0.99	0.99
8	Japstock-Thastock	0.41	0.42	0.98
9	Malstock-Phistock	1.00	1.00	1.00
10	Malstock-Thastock	0.89	0.90	0.95
11	Malstock-Usstock	0.90	0.91	0.94
12	Phistock-Thastock	0.73	0.73	0.97
13	Phistock-Usstock	0.79	0.81	0.95
14	Thastock-Usstock	0.86	0.85	0.85

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-31-C: Correlation between Forecasts of Conditional Correlations, ER-ER,
Emerging-Developed Markets

No	ER-ER	Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-GARCH
1	Usdldr-Usdjpy	0.72	0.74	0.93
2	Usdldr-Usdmyr	0.96	0.96	0.99
3	Usdldr-Usdphp	0.98	0.92	0.92
4	Usdldr-Usdthb	0.86	0.82	0.80
5	Usdjpy-Usdmyr	0.96	0.95	0.94
6	Usdjpy-Usdphp	0.89	0.87	0.93
7	Usdjpy-Usdthb	0.96	0.95	0.98
8	Usdmyr-Usdphp	0.97	0.96	0.99
9	Usdmyr-Usdthb	0.94	0.92	0.91
10	Usdphp-Usdthb	0.98	0.98	0.98

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-31-D: Correlation between Forecasts of Conditional Correlations, Bond-Stock, Emerging-Developed Markets

No	Bond-Stock	Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-GARCH
1	Indbond-Indstock	0.99	0.99	0.99
2	Indbond-Japstock	0.92	0.93	0.93
3	Indbond-Malstock	0.96	0.97	0.95
4	Indbond-Phistock	0.97	0.97	0.98
5	Indbond-Thastock	0.41	0.46	0.86
6	Indbond-Usstock	0.73	0.64	0.71
7	Japbond-Indstock	0.95	0.98	0.95
8	Japbond-Malstock	0.97	0.98	0.99
9	Japbond-Phistock	0.98	0.96	0.97
10	Japbond-Thastock	0.04	0.03	0.87
11	Malbond-Indstock	0.99	0.99	0.99
12	Malbond-Japstock	0.95	0.95	0.94
13	Malbond-Malstock	0.98	0.98	0.97
14	Malbond-Phistock	0.94	0.94	0.91
15	Malbond-Thastock	0.76	0.81	0.82
16	Malbond-Usstock	0.84	0.91	0.92
17	Phibond-Indstock	0.94	0.92	0.97
18	Phibond-Japstock	0.90	0.94	0.93
19	Phibond-Malstock	0.99	0.98	0.99
20	Phibond-Phistock	0.93	0.92	0.95
21	Phibond-Thastock	0.39	0.37	0.69
22	Phibond-Usstock	0.88	0.85	0.92
23	Thabond-Indstock	0.98	0.96	0.95
24	Thabond-Japstock	0.96	0.97	0.97
25	Thabond-Malstock	0.99	0.99	1.00
26	Thabond-Phistock	0.97	0.98	0.99
27	Thabond-Thastock	-0.32	-0.39	0.71
28	Thabond-Usstock	0.87	0.93	0.92
29	Usbond-Indstock	0.96	0.96	0.96
30	Usbond-Malstock	0.76	0.77	0.77
31	Usbond-Phistock	0.92	0.94	0.98
32	Usbond-Thastock	0.15	0.26	0.40

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-31-E: Correlation between Forecasts of Conditional Correlations, Bond-ER, Emerging-Developed Markets

No	Bond-ER	Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-GARCH
1	Indbond-Usdldr	0.97	0.98	0.98
2	Indbond-Usdjpy	0.57	0.65	0.42
3	Indbond-Usdmyr	0.94	0.92	0.95
4	Indbond-Usdphp	0.80	0.82	0.75
5	Indbond-Usdthb	0.41	0.49	0.61
6	Japbond-Usdldr	0.85	0.84	0.88
7	Japbond-Usdmyr	0.95	0.95	0.96
8	Japbond-Usdphp	0.98	0.99	0.98
9	Japbond-Usdthb	0.91	0.92	0.96
10	Malbond-Usdldr	0.99	0.99	0.98
11	Malbond-Usdjpy	0.94	0.95	0.97
12	Malbond-Usdmyr	0.93	0.94	0.91
13	Malbond-Usdphp	0.84	0.86	0.82
14	Malbond-Usdthb	0.90	0.95	0.90
15	Phibond-Usdldr	0.94	0.94	0.96
16	Phibond-Usdjpy	0.93	0.91	0.96
17	Phibond-Usdmyr	0.82	0.77	0.86
18	Phibond-Usdphp	0.94	0.94	0.97
19	Phibond-Usdthb	0.98	0.97	0.99
20	Thabond-Usdldr	0.74	0.79	0.78
21	Thabond-Usdjpy	0.98	0.98	0.99
22	Thabond-Usdmyr	0.94	0.92	0.92
23	Thabond-Usdphp	0.97	0.97	0.98
24	Thabond-Usdthb	0.95	0.94	0.93
25	Usbond-Usdldr	0.45	0.43	0.51
26	Usbond-Usdmyr	0.84	0.85	0.87
27	Usbond-Usdphp	0.08	0.03	0.91
28	Usbond-Usdthb	0.88	0.90	0.89

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-31-F: Correlation between Forecasts of Conditional Correlations, Stock-ER, Emerging-Developed Markets

No	Stock-ER	Correlations		
		CCC - VARMA-AGARCH	CCC - VARMA-GARCH	VARMA-AGARCH - VARMA-GARCH
1	Indstock-Usdldr	0.98	0.97	0.99
2	Indstock-Usdjpy	0.81	0.88	0.91
3	Indstock-Usdmyr	0.95	0.97	0.97
4	Indstock-Usdphp	0.95	0.98	0.95
5	Indstock-Usdthb	0.95	0.96	0.93
6	Japstock-Usdldr	0.96	0.97	0.99
7	Japstock-Usdmyr	0.94	0.93	0.95
8	Japstock-Usdphp	0.98	0.99	0.98
9	Japstock-Usdthb	0.96	0.97	0.96
10	Malstock-Usdldr	0.99	0.99	0.99
11	Malstock-Usdjpy	0.95	0.95	0.97
12	Malstock-Usdmyr	0.96	0.96	0.99
13	Malstock-Usdphp	1.00	0.99	0.99
14	Malstock-Usdthb	0.98	0.98	0.99
15	Phistock-Usdldr	0.99	0.99	0.99
16	Phistock-Usdjpy	0.95	0.95	0.99
17	Phistock-Usdmyr	0.92	0.90	0.98
18	Phistock-Usdphp	0.99	0.99	0.99
19	Phistock-Usdthb	0.95	0.98	0.97
20	Thastock-Usdldr	0.53	0.45	0.72
21	Thastock-Usdjpy	0.68	0.64	0.85
22	Thastock-Usdmyr	0.51	0.61	0.64
23	Thastock-Usdphp	0.01	0.02	0.91
24	Thastock-Usdthb	-0.49	-0.06	0.00
25	Usstock-Usdldr	0.91	0.90	0.91
26	Usstock-Usdmyr	0.44	0.67	0.68
27	Usstock-Usdphp	0.94	0.96	0.96
28	Usstock-Usdthb	0.88	0.92	0.96

Notes: Entries in **bold** are considered as low correlation coefficients.

Table 4-32-A: Summary of Volatility Spillovers and Asymmetric Effect, Bond-Bond, Emerging-Developed Markets

No	Bond-Bond	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
1	Indbond-Japbond	1	1	0
2	Indbond-Malbond	0	1	0
3	Indbond-Phibond	2	1	0
4	Indbond-Thabond	1	1	0
5	Indbond-Usbond	1	0	0
6	Japbond-Malbond	2	1	1
7	Japbond-Phibond	2	2	1
8	Japbond-Thabond	1	2	0
9	Malbond-Phibond	2	1	0
10	Malbond-Thabond	2	2	0
11	Malbond-Usbond	2	2	0
12	Phibond-Thabond	2	2	0
13	Phibond-Usbond	1	1	0
14	Thabond-Usbond	2	2	0

Table 4-32-B: Summary of Volatility Spillovers and Asymmetric Effect, Stock-Stock, Emerging-Developed Markets

No	Stock-Stock	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
1	Indstock-Japstock	0	0	1
2	Indstock-Malstock	0	1	0
3	Indstock-Phistock	1	1	1
4	Indstock-Thastock	1	1	1
5	Indstock-Usstock	0	0	2
6	Japstock-Malstock	0	0	1
7	Japstock-Phistock	0	0	1
8	Japstock-Thastock	1	1	0
9	Malstock-Phistock	0	0	0
10	Malstock-Thastock	1	1	0
11	Malstock-Usstock	0	0	1
12	Phistock Thastock	1	1	0
13	Phistock-Usstock	1	1	1
14	Thastock-Usstock	0	0	1

Table 4-32-C: Summary of Volatility Spillovers and Asymmetric Effect, ER-ER,
Emerging-Developed Markets

No	ER-ER	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
1	Usdidr-Usdjpy	0	0	0
2	Usdidr-Usdmyr	1	1	0
3	Usdidr-Usdphp	2	2	0
4	Usdidr-Usdthb	1	0	0
5	Usdjpy-Usdmyr	1	1	0
6	Usdjpy-Usdphp	0	1	0
7	Usdjpy-Usdthb	2	2	1
8	Usdmyr-Usdphp	2	2	0
9	Usdmyr-Usdthb	2	2	0
10	Usdphp-Usdthb	0	0	0

Table 4-32-D: Summary of Volatility Spillovers and Asymmetric Effect, Bond-Stock, Emerging-Developed Markets

No	Bond-Stock	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
1	Indbond-Indstock	1	1	1
2	Indbond-Japstock	1	0	1
3	Indbond-Malstock	2	2	0
4	Indbond-Phistock	1	1	0
5	Indbond-Thastock	1	0	0
6	Indbond-Ustock	2	2	1
7	Japbond-Indstock	0	0	1
8	Japbond-Malstock	1	0	0
9	Japbond-Phistock	0	0	0
10	Japbond-Thastock	2	2	0
11	Malbond-Indstock	0	0	1
12	Malbond-Japstock	1	1	1
13	Malbond-Malstock	0	1	0
14	Malbond-Phistock	2	2	0
15	Malbond-Thastock	1	1	0
16	Malbond-Ustock	0	0	1
17	Phibond-Indstock	2	2	1
18	Phibond-Japstock	1	1	1
19	Phibond-Malstock	1	1	0
20	Phibond-Phistock	1	1	0
21	Phibond-Thastock	2	1	0
22	Phibond-Ustock	1	1	0
23	Thabond-Indstock	0	0	1
24	Thabond-Japstock	1	1	1
25	Thabond-Malstock	2	2	0
26	Thabond-Phistock	0	0	0
27	Thabond-Thastock	1	1	0
28	Thabond-Ustock	0	1	1
29	Ustock-Indstock	1	1	1
30	Ustock-Malstock	1	1	0
31	Ustock-Phistock	1	1	0
32	Ustock-Thastock	2	2	0

Table 4-32-E: Summary of Volatility Spillovers and Asymmetric Effect, Bond-ER, Emerging-Developed Markets

No	Bond-ER	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
1	Indbond-Usdldr	0	0	0
2	Indbond-Usdjpy	1	0	1
3	Indbond-Usdmyr	1	1	0
4	Indbond-Usdphp	2	2	0
5	Indbond-Usdthb	2	1	0
6	Japbond-Usdldr	0	1	0
7	Japbond-Usdmyr	2	1	0
8	Japbond-Usdphp	1	1	0
9	Japbond-Usdthb	1	1	0
10	Malbond-Usdldr	0	0	0
11	Malbond-Usdjpy	0	1	0
12	Malbond-Usdmyr	2	1	0
13	Malbond-Usdphp	1	0	0
14	Malbond-Usdthb	2	2	0
15	Phibond-Usdldr	1	1	0
16	Phibond-Usdjpy	2	0	1
17	Phibond-Usdmyr	2	2	1
18	Phibond-Usdphp	1	2	0
19	Phibond-Usdthb	2	2	0
20	Thabond-Usdldr	1	1	0
21	Thabond-Usdjpy	1	1	1
22	Thabond-Usdmyr	2	1	0
23	Thabond-Usdphp	0	0	0
24	Thabond-Usdthb	1	1	0
25	Usbond-Usdldr	1	1	0
26	Usbond-Usdmyr	2	2	0
27	Usbond-Usdphp	2	2	0
28	Usbond-Usdthb	1	2	0

Table 4-32-F: Summary of Volatility Spillovers and Asymmetric Effect, Stock-ER, Emerging-Developed Markets

No	Stock-ER	Number of Volatility Spillovers		Number of Asymmetric Effects
		VARMA-AGARCH	VARMA-GARCH	
1	Indstock-Usdldr	1	0	1
2	Indstock-Usdjpy	0	0	1
3	Indstock-Usdmyr	1	1	1
4	Indstock-Usdphp	0	0	0
5	Indstock-Usdthb	0	0	1
6	Japstock-Usdldr	0	0	1
7	Japstock-Usdmyr	1	0	1
8	Japstock-Usdphp	2	2	1
9	Japstock-Usdthb	1	1	1
10	Malstock-Usdldr	1	1	0
11	Malstock-Usdjpy	1	1	0
12	Malstock-Usdmyr	1	1	0
13	Malstock-Usdphp	0	0	0
14	Malstock-Usdthb	2	2	0
15	Phistock-Usdldr	1	1	0
16	Phistock-Usdjpy	0	0	1
17	Phistock-Usdmyr	2	1	0
18	Phistock-Usdphp	2	2	0
19	Phistock-Usdthb	0	0	0
20	Thastock-Usdldr	0	1	0
21	Thastock-Usdjpy	1	1	0
22	Thastock-Usdmyr	1	2	0
23	Thastock-Usdphp	2	2	0
24	Thastock-Usdthb	1	1	0
25	Usstock-Usdldr	1	0	1
26	Usstock-Usdmyr	1	1	1
27	Usstock-Usdphp	1	1	0
28	Usstock-Usdthb	0	1	1

Appendix 4-3:

Figures 4-1 to 4-91 are the forecasts of conditional correlations between pair of assets resulted from the CCC, VARMA-AGARCH and VARMA-GARCH models for Developed Markets.

Figure 4-1: Ausbond-Japbond

Figure 4-4: Ausbond-Usbond

Figure 4-2: Ausbond-Nzbond

Figure 4-5: Japbond-Nzbond

Figure 4-3: Ausbond-Sgbond

Figure 4-6: Japbond-Sgbond

Figure 4-7: Japbond-Usbond

Figure 4-11: Ausstock-Japstock

Figure 4-8: Nzbond-Sgbond

Figure 4-12: Ausstock-Nzstock

Figure 4-9: Nzbond-Usbond

Figure 4-13: Ausstock-Sgstock

Figure 4-10: Sgbond-Usbond

Figure 4-14: Ausstock-Usstock

Figure 4-15: Japstock-Nzstock

Figure 4-19: Nzstock-USstock

Figure 4-16: Japstock-Sgstock

Figure 4-20: Sgstock-USstock

Figure 4-17: Japstock-USstock

Figure 4-21: Usdaud-Usdjpy

Figure 4-18: Nzstock-Sgstock

Figure 4-22: Usdaud-Usdnzd

Figure 4-23: Usdaud-Usdsgd

Figure 4-27: Ausbond-Ausstock

Figure 4-24: Usdjpy-Usdnzd

Figure 4-28: Ausbond-Japstock

Figure 4-25: Usdjpy-Usdsgd

Figure 4-29: Ausbond-Nzstock

Figure 4-26: Usdnzd-Usdsgd

Figure 4-30: Ausbond-Sgstock

Figure 4-31: Ausbond-Usstock

Figure 4-35: Japbond-Sgstock

Figure 4-32: Japbond-Ausstock

Figure 4-36: Japbond-Usstock

Figure 4-33: Japbond-Japstock

Figure 4-37: Nzbond-Ausstock

Figure 4-34: Japbond-Nzstock

Figure 4-38: Nzbond-Japstock

Figure 4-39: Nzbond-Nzstock

Figure 4-40: Nzbond-Sgstock

Figure 4-41: Nzbond-Usstock

Figure 4-42: Sgbond-Ausstock

Figure 4-43: Sgbond-Japstock

Figure 4-44: Sgbond-Nzstock

Figure 4-45: Sgbond-Sgstock

Figure 4-46: Sgbond-Usstock

Figure 4-47: Usbond-Ausstock

Figure 4-51: Usbond-Ustock

Figure 4-48: Usbond-Japstock

Figure 4-52: Ausbond-Usdaud

Figure 4-49: Usbond-Nzstock

Figure 4-53: Ausbond-Usdjpy

Figure 4-50: Usbond-Sgstock

Figure 4-54: Ausbond-Usdnzd

Figure 4-55: Ausbond-Usdsgd

Figure 4-59: Japbond-Usdsgd

Figure 4-56: Japbond-Usdaud

Figure 4-60: Nzbond-Usdaud

Figure 4-57: Japbond-Usdjpy

Figure 4-61: Nzbond-Usdjpy

Figure 4-58: Japbond-Usdnzd

Figure 4-62: Nzbond-Usdnzd

Figure 4-63: Nzbond-Usdsgd

Figure 4-67: Sgbond-Usdsgd

Figure 4-64: Sgbond-Usdaud

Figure 4-68: Usbond-Usdaud

Figure 4-65: Sgbond-Usdjpy

Figure 4-69: Usbond-Usdjpy

Figure 4-66: Sgbond-Usdnzd

Figure 4-70: Usbond-Usdnzd

Figure 4-71: Usbond-Usdsgd

Figure 4-75: Ausstock-Usdsgd

Figure 4-72: Ausstock-Usdaud

Figure 4-76: Japstock-Usdaud

Figure 4-73: Ausstock-Usdjpy

Figure 4-77: Japstock-Usdjpy

Figure 4-74: Ausstock-Usdnzd

Figure 4-78: Japstock-Usdnzd

Figure 4-79: Japstock-Usdsgd

Figure 4-83: Nzstock-Usdsgd

Figure 4-80: Nzstock-Usdaud

Figure 4-84: Sgstock-Usdaud

Figure 4-81: Nzstock-Usdjpy

Figure 4-85: Sgstock-Usdjpy

Figure 4-82: Nzstock-Usdnzd

Figure 4-86: Sgstock-Usdnzd

Figure 4-87: Sgstock-Usdsgd

Figure 4-91: Usstock-Usdsgd

Figure 4-88: Usstock-Usdaud

Figure 4-89: Usstock-Usdjpy

Figure 4-90: Usstock-Usdnzd

Appendix 4-4

Figures 4-92 to 4-217 are the forecasts of conditional correlations between pair of assets resulted from the CCC, VARMA-AGARCH and VARMA-GARCH models for Emerging and Emerging-Developed Markets.

Figure 4-92: Indbond_Japbond

Figure 4-96: Indbond_Usbond

Figure 4-93: Indbond_Malbond

Figure 4-97: Japbond_Malbond

Figure 4-94: Indbond_Phibond

Figure 4-98: Japbond_Phibond

Figure 4-95: Indbond_Thabond

Figure 4-99: Japbond_Thabond

Figure 4-100: Malbond_Phibond

Figure 4-104: Phibond_Usbond

Figure 4-101: Malbond_Thabond

Figure 4-105: Thabond_Usbond

Figure 4-102: Malbond_Usbond

Figure 4-106: Indstock_Japstock

Figure 4-103: Phibond_Thabond

Figure 4-107: Indstock_Malstock

Figure 4-108: Indstock_Phistock

Figure 4-112: Japstock_Phistock

Figure 4-109: Indstock_Thastock

Figure 4-113: Japstock_Thastock

Figure 4-110: Indstock_Usstock

Figure 4-114: Malstock_Phistock

Figure 4-111: Japstock_Malstock

Figure 4-115: Malstock_Thastock

Figure 4-116: Malstock_Usstock

Figure 4-120: Usdldr_Usdjpy

Figure 4-117: Phistock_Thastock

Figure 4-121: Usdldr_Usdmyr

Figure 4-118: Phistock_Usstock

Figure 4-122: Usdldr_Usdphp

Figure 4-119: Thastock_Usstock

Figure 4-123: Usdldr_Usdthb

Figure 4-124: Usdjpy_Usdmyr

Figure 4-128: Usdmyr_Usdthb

Figure 4-125: Usdjpy_Usdphp

Figure 4-129: Usdphp_Usdthb

Figure 4-126: Usdjpy_Usdthb

Figure 4-130: Indbond_Indstock

Figure 4-127: Usdmyr_Usdphp

Figure 4-131: Indbond_Japstock

Figure 4-132: Indbond_Malstock

Figure 4-136: Japbond_Indstock

Figure 4-133: Indbond_Phistock

Figure 4-137: Japbond_Malstock

Figure 4-134: Indbond_Thastock

Figure 4-138: Japbond_Phistock

Figure 4-135: Indbond_Usstock

Figure 4-139: Japbond_Thastock

Figure 4-140: Malbond_Indstock

Figure 4-144: Malbond_Thastock

Figure 4-141: Malbond_Japstock

Figure 4-145: Malbond_Usstock

Figure 4-142: Malbond_Malstock

Figure 4-146: Phibond_Indstock

Figure 4-143: Malbond_Phistock

Figure 4-147: Phibond_Japstock

Figure 4-148: Phibond_Malstock

Figure 4-152: Thabond_Indstock

Figure 4-149: Phibond_Phistock

Figure 4-153: Thabond_Japstock

Figure 4-150: Phibond_Thastock

Figure 4-154: Thabond_Malstock

Figure 4-151: Phibond_Usstock

Figure 4-155: Thabond_Phistock

Figure 4-156: Thabond_Thastock

Figure 4-160: Usbond_Phistock

Figure 4-157: Thabond_Usstock

Figure 4-161: Usbond_Thastock

Figure 4-158: Usbond_Indstock

Figure 4-162: Indbond_Usdldr

Figure 4-159: Usbond_Malstock

Figure 4-163: Indbond_Usdjpy

Figure 4-164: Indbond_Usdmyr

Figure 4-168: Japbond_Usdmyr

Figure 4-165: Indbond_Usdphp

Figure 4-169: Japbond_Usdphp

Figure 4-166: Indbond_Usdthb

Figure 4-170: Japbond_Usdthb

Figure 4-167: Japbond_Usdidr

Figure 4-171: Malbond_Usdidr

Figure 4-172: Malbond_Usdjpy

Figure 4-176: Phibond_Usdldr

Figure 4-173: Malbond_Usdmyr

Figure 4-177: Phibond_Usdjpy

Figure 4-174: Malbond_Usdphp

Figure 4-178: Phibond_Usdmyr

Figure 4-175: Malbond_Usdthb

Figure 4-179: Phibond_Usdphp

Figure 4-180: Phibond_Usdthb

Figure 4-184: Thabond_Usdphp

Figure 4-181: Thabond_Usdldr

Figure 4-185: Thabond_Usdthb

Figure 4-182: Thabond_Usdipy

Figure 4-186: Usbond_Usdldr

Figure 4-183: Thabond_Usdmyr

Figure 4-187: Usbond_Usdmyr

Figure 4-188: Usbond_Usdphp

Figure 4-192: Indstock_Usdmyr

Figure 4-189: Usbond_Usdthb

Figure 4-193: Indstock_Usdphp

Figure 4-190: Indstock_Usdldr

Figure 4-194: Indstock_Usdthb

Figure 4-191: Indstock_Usdjpy

Figure 4-195: Japstock_Usdldr

Figure 4-196: Japstock_Usdmyr

Figure 4-200: Malstock_Usdjpy

Figure 4-197: Japstock_Usdphp

Figure 4-201: Malstock_Usdmyr

Figure 4-198: Japstock_Usdthb

Figure 4-202: Malstock_Usdphp

Figure 4-199: Malstock_Usdidr

Figure 4-203: Malstock_Usdthb

Figure 4-204: Phistock_Usdldr

Figure 4-208: Phistock_Usdthb

Figure 4-205: Phistock_Usdjpy

Figure 4-209: Thastock_Usdldr

Figure 4-206: Phistock_Usdmyr

Figure 4-210: Thastock_Usdjpy

Figure 4-207: Phistock_Usdphp

Figure 4-211: Thastock_Usdmyr

Figure 4-212: Thastock_Usdphp

Figure 4-216: Usstock_Usdphp

Figure 4-213: Thastock_Usdthb

Figure 4-217: Usstock_Usdthb

Figure 4-214: Usstock_Usdldr

Figure 4-215: Usstock_Usdmyr