Report on **Rigorosus Thesis**

Institute of Economic Studies, Faculty of Social Sciences, Charles University in Prague

Student:	**Mgr. Marek Klaus**
Advisor:	**PhDr. Boril Šopov, MSc., LL.M.**
Title of the thesis:	**Multivariate Dependence Modeling using Copulas**

OVERALL ASSESSMENT *(provided in English, Czech, or Slovak):*

Marek in his thesis deals with a challenging topic of dynamic correlations and dependence in equity returns. This extended version further deepens the analysis and on extended data-sample.

The thesis applies a Copula based dynamic conditional correlation multivariate GARCH model (DCC C-MGARCH) on pairs of selected stocks traded at Prague Stock Exchange. Such results were not, to the reviewer's best knowledge, published anywhere else.

The thesis has a standard structure, where I would like to draw attention to well connected chapters. The author opens each chapter with a short paragraph showing the big picture and introduces reader to wider context. After Introduction, Chapter 2 reviews the relevant literature and describes how several multivariate GARCH models emerged through time. The survey presents fairly wide area and directly links it to the aim of the thesis. Chapter 3 presents the univariate and multivariate GARCH models, narrows down the considered methods and logically follows with chapter 4. Chapter 4 then presents the statistical theory of copulas (a function describing dependence structure of multivariate r.v., thus coupling univariate margins into multivariate distributions). This chapter, in addition, reveals the core model of this thesis; DCC C-MGARCH. The model works similarly to DCC GARCH, yet estimates a copula parameter to describe tail dependence that is supposedly left in the DCC MGARCH residuals.

Chapter 5 presents the used data, estimation techniques and Matlab implementation. In addition to three pairs of Prague stock exchange stocks, one pair consisting of highly liquid indices was added for benchmarking purposes. Importantly, the author, modestly, suppressed to mention the programming difficulty of implementation of such a model, which required not only optimization, yet also numerical integration of Hoeffding's lemma during each objective function evaluation.

Chapter 6 shows the empirical results. I would like to draw attention to Figues 6.2, 6.4, 6.6 and 6.8, which clearly demonstrates that the copula extension is necessary and brings value. The residuals before applying the copula are obviously non-normal, which proves the overall relevance of the thesis's topic. The author comments correctly on the results and the drawn conclusions support usage of the copula extended model over the DCC MGARCH model. This conclusion is an important message for risk management practitioner, who may feel that DCC MGARCH sufficiently captures correlation risk. In this extended version for Rigour examination, Marek recalculated all the results and corrected minor mistakes. Furthermore he extended the data sample SP500-NASDAQ to supplement the analysis with new data.

In comparison to the master thesis version, given the correction in the manuscript form I raised point reward, by contrast having higher requirements for Rigour thesis, I lower the reward for the Methods (which are still exceeding the required level by far) by one point.

In conclusion, the submitted thesis meets the requirements and hence I recommend it for defence. It is a very good thesis with huge publication potential.

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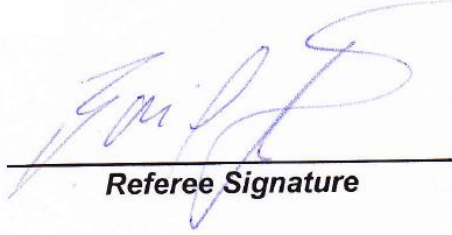
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SUMMARY OF POINTS AWARDED (for details, see below):

CATEGORY	POINTS
Literature (max. 20 points)	18
Methods (max. 30 points)	28
Contribution (max. 30 points)	27
Manuscript Form (max. 20 points)	19
TOTAL POINTS (max. 100 points)	**92**
(doporučuji, nedoporučuji)	**doporučuji**

NAME OF THE REFEREE: PhDr. Boril Šopov, MSc., LL.M.

DATE OF EVALUATION: 12th March 2013

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Referee Signature

EXPLANATION OF CATEGORIES AND SCALE:

LITERATURE REVIEW: *The thesis demonstrates author's full understanding and command of recent literature. The author quotes relevant literature in a proper way.*

Strong	Average	Weak
20	10	0

METHODS: *The tools used are relevant to the research question being investigated, and adequate to the author's level of studies. The thesis topic is comprehensively analyzed.*

Strong	Average	Weak
30	15	0

CONTRIBUTION: *The author presents original ideas on the topic demonstrating critical thinking and ability to draw conclusions based on the knowledge of relevant theory and empirics. There is a distinct value added of the thesis.*

Strong	Average	Weak
30	15	0

MANUSCRIPT FORM: *The thesis is well structured. The student uses appropriate language and style, including academic format for graphs and tables. The text effectively refers to graphs and tables and disposes with a complete bibliography.*

Strong	Average	Weak
20	10	0

Overall grading:

TOTAL POINTS			
81 – 100		= excellent	
61 – 80		= good	
41 – 60		= satisfactory	
0 – 40		= fail	= nedoporučuji k obhajobě