Report on Master Thesis

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

Student:	**Chopyk Ostap**
Advisor:	**PhDr. Krištoufek Ladislav, PhD.**
Title of the thesis:	**Practical usage of optimal portfolio diversification using maximum entropy principle**

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

In his thesis, Ostap Chopyk studies the relative performance of portfolios constructed using several methods of portfolio selection: the traditional Equally-weighted portfolio, Minimum-variance portfolio, portfolio based on Mean-Variance optimisation and two portfolios based on Maximum-entropy, namely on the Maximum-Shannon-entropy and Maximum-cross-entropy. The comparison is based on mean return-standard deviation pair, graphical analysis of weights of individual assets in the optimised portfolios, Shannon entropy, Sharpe ratio and Certainty equivalent return using both whole sample averages and rolling windows of several lengths under daily, weekly and for one period also monthly rebalancing schemes.

In general, I would like to highlight the extent and detail of the empirical part of the thesis, which shows the aim and skills of the student to do some serious research. On the other hand, the theoretical part and the manuscript form would need, in my opinion, a significant revision. To discuss each evaluation category separately:

Methods: Although it took some time to understand the methodology given the problems mentioned in the Manuscript Form paragraph below, the methods seem to be appropriate and correctly applied, the comments I have would be mostly topics for a discussion rather than a critique. The only thing that I was missing was a discussion of the strength of the test of Sharpe ratios equality. Overall, the empirical analysis is a real strength of the work.

Contribution: Although I see the main contribution in the advancement of the authors' knowledge, skills and experience, the thesis provides also many original results, which can be of interest for other researchers focusing on portfolio optimisation methods.

Literature : In my opinion the use of literature is not very good. Although I would not mind following the methodology from just a few papers, I would expect better choice of works in the literature review that would track, at least briefly, the history and recent advances in the research on Maximum-entropy-based portfolio optimisation. It seems from the thesis that there is almost nothing written about these methods and that they are relatively new, suggested by Bera and Park (2008), which is, as far as I know, not true, see e.g.KAPUR, J. N. (1993). At the same time I believe that there is a wide range of recent literature on these methods, which is not discussed in the thesis.

Manuscript Form: The manuscript form is, in my opinion, the weakest aspect of the work. I am missing a clear structure, as the methodology is somehow present throughout the whole thesis instead of the chapter focusing on it, which results on the one hand in duplicities (formulas, sentences,..,e.g. Chapter 4, section 4.2 p.27-31 should be merged with chapter 3, sentence concerning the number of parameters in single factor model of Sharpe (1963) at p.2 and p.6 seems to be copy-pasted, etc.) and on the other hand in late introduction of some concepts, e.g. the Certainty equivalent return that should be introduced sooner than in the discussion of empirical results (last sentence at p.31) or the rebalancing schemes introduced at p.39, section 4.3.3 .

Next, some statements, explanations and notation were not clear to me, e.g. p.14 under formula 3.2 the author is writing about a random variable, but does not define this variable making it impossible to check the validity of his statements; on p.13-14 π stands once for weights which can be treated as probabilities and once for probabilities which can be used as weights; next, it is not clear when the author works with returns and when he works with excess returns; etc.

Next, some concepts introduced in the methodology are not used in the empirical part, which is quite confusing, as it is not properly discussed in the methodology part, but later in the text. E.g. in chapter 3, p.18-19 the author is introducing methods for portfolio optimisation with allowed short-selling as the final generalized method, but does not use it in the empirical analysis as mentioned in chapter 4, p.26. Similarly at the beginning of

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p.28 the author explains why he does not use the approach described in the methodology part and briefly mentions the alternative method that he is going to apply.

Finally, there are many typos in the work (more than is usual based on my experience) and, in my opinion, the work with paragraphs is not optimal. Together with the other problems mentioned above, it is relatively easy to get lost in the text.

On the other hand, graphical presentation of the results is nice and useful.

Suggested technical questions:

- Why is the variance-covariance matrix estimate called “design-free”?
- Why are the investors not allowed to hold a “risk-free” asset?
- In the case of weekly rebalancing, is it still appropriate to use daily returns for portfolio optimisation?

Suggested question for a general discussion:

- Based on the results, what investment strategy would the author suggest (if the required return was the one used in the analysis and if the assets available were restricted to the set under study) and why?

In the case of successful defense, I recommend the grade **“ good " ("velmi dobře” , 2)**

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

CATEGORY		**POINTS**
Literature	*(max. 20 points)*	12
Methods	*(max. 30 points)*	28
Contribution	*(max. 30 points)*	28
Manuscript Form	*(max. 20 points)*	10
TOTAL POINTS	*(max. 100 points)*	**78**
GRADE	**(1 – 2 – 3 – 4)**	**2**

NAME OF THE REFEREE: Lucie Kraicová
DATE OF EVALUATION: 15.09.2015

Kraicová

Referee Signature

References:

Bera, A. K. and , S. Y. (2008). *Optimal portfolio diversification using maximum entropy principle*. Econometric Review, 27:484–512

Kapur, J. N. (1993). *Maximum-entropy models in science and engineering*. New York [u.a.], Wiley.

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	**GRADE**		
81 – 100	**1**	= excellent	= výborně
61 – 80	**2**	= good	= velmi dobře
41 – 60	**3**	= satisfactory	= dobře
0 – 40	**4**	= fail	= nedoporučuji k obhajobě