

# Report on Bachelor Thesis

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

<b>Student:</b>	<b>Martin Hronec</b>
<b>Advisor:</b>	<b>PhDr. Jozef Baruník, Ph.D.</b>
<b>Title of the thesis:</b>	<b>Forecasting stock market returns and volatility in different time horizons using Neural Networks</b>

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

In his thesis, Martin Hronec focuses on the application of artificial neural networks in the area of returns and volatility modelling. In the first part, after a brief introduction to the topic and motivation for his work, the author lists and describes methods used in the analysis conducted. In the second part, he describes and discusses the results. Finally, he concludes with a summary of the work and suggestions for the experiment setup improvement.

In general, the thesis is relatively easy to read and the extent of both the theoretical part and the empirical analysis is, in my opinion, reasonable for a Bachelor thesis. Concerning the topic, I appreciate the interest of the student in advanced econometric methods and his aim to contribute to the current literature with some new, interesting results. Also, I would like to highlight the use of R and Python for all the calculations, which requires some programming skills on the top of the theoretical background that the author had to build up to successfully conduct the analysis. On the other hand, there are also some deficiencies, which I have to mention and consider in the assessment. To discuss each evaluation category separately:

**Methods:** In my opinion, the methods used are appropriate, correctly applied and by their complexity, they seem to be well above the level usual for Bachelor theses at our institute. My only critique goes to the fluency of the methodology description. Although the topic of the thesis and the methodology are clear, the lack of overall fluency of the text in the first part of the thesis makes the introduction to the methodology slightly confusing. It seems to me as if the author wanted to build the theory from the very basics – start with behavior of asset prices, then move to the features of returns time series (plus their modelling), volatility of the returns (plus its modelling), follow with an introduction to the modelling of the last two variables using neural networks and end up with model performance evaluation criteria, but did not succeed in keeping it simple, yet somewhat complete. In my opinion, given the goal of the thesis mentioned on p.24 “*In this thesis all examined models will be compared with simple AR(1) model, since we are interested only in the predictability and not in the relative comparison of neural networks and standard econometric models.*”, the first part could be simpler, without formulas of models which are not used, focused more on the general predictability and the experiment setup and structured in a way so that the statement above about using AR(1) was not surprising. (AR(1) model is not even among those introduced in the case of volatility modelling). To give more examples of problematic links between the theoretical and the empirical part I could mention the differing definition of the alternative hypothesis in the Diebold-Mariano test (p.59 and p.71), or the fact that without any explanation the author is using the least efficient out of three range-based volatility estimators introduced (p.20 and p.21-22). Next, problematic notation and several mistakes in formulas (e.g. p.20, p.52, p.56 - eq. 3.2.6 and 3.2.7) make the reading and understanding more difficult. Finally, the conclusion (p.82) seems to be biased to the desired outcome, as the evaluation based on RMSE and the absolute values of the evaluation criteria are neglected. On the other hand, the introduction to the neural networks theory is very good, all aspects of the analysis are discussed or at least mentioned in the first part and all the (sub-)sections are logically ordered.

**Contribution:** In general, I see the main contribution in the advancement of the authors' knowledge, skills and experience, which he might appreciate in his further studies and/ or in his job. Moreover, the results presented seem to be a reliable contribution to the current literature.

**Literature :** In my opinion the use of literature is at a good level. I appreciate the extent of the publications covered, there are only few cases of missing references, e.g. p.10-12. Next, the list of references should be revised (manuscript form), since there are some double-entries and a few references that I could not find in the text, but their number is small compared to the total number of entries.

**Manuscript Form:** The thesis is well structured and relatively easy to read, tables and graphs are used effectively, although it would be interesting to see the AR(1)-based forecasts plotted next to those based on neural networks. On the top of that I would only suggest to revise the bibliography and to use appendix for all but the most important and directly interpretable results.

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## Suggested questions:

- Why is the author using the least efficient out of three range-based volatility estimators introduced (p.20 and p.21-22)?
- If the AR(1) model should work better than the neural network-based model, does it really mean that the variable in focus is not predictable?
- Does the author see a bright future for the returns and/ or volatility models based on artificial neural networks (and why)?

In the case of successful defense, I recommend the grade “ **excellent** ” (“**výborně**” , 1)

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

<b>CATEGORY</b>	<b>POINTS</b>
<i>Literature</i> (max. 20 points)	18
<i>Methods</i> (max. 30 points)	26
<i>Contribution</i> (max. 30 points)	30
<i>Manuscript Form</i> (max. 20 points)	16
<b>TOTAL POINTS</b> (max. 100 points)	<b>90</b>
<b>GRADE</b> (1 – 2 – 3 – 4)	<b>1</b>

**NAME OF THE REFEREE:** Lucie Kraicová

**DATE OF EVALUATION:** 09.06.2015



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