Report on Bachelor Thesis

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

Student:	**Nikanor Goreglyad**
Advisor:	**Mgr. Marek Hauzr**
Title of the thesis:	**The LSTM approach for Value at Risk prediction**

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

Please provide a short summary of the thesis, your assessment of each of the four key categories, and an overall evaluation and suggested questions for the discussion. The minimum length of the report is 300 words.

Short summary

In the thesis, the author provides an evidence that recurrent neural networks can be used in order to calculate Value at Risk for Visegrad group stock market indices.

Contribution

The author replicates methodology from the literature, ignores much of the development in the past two years, invests mainly into sketchy (and slightly sloppy) presentation of the numerical method and shows little to no interest in the financial/economics aspects of this topic. From the presentation of the results, it is unclear**, if he implemented FIGARCH and EVT-POT models as well**, he does not provide any cross reference to his achieved numerical results or performance profiles for the comparison with other numerical approaches; visual inspection of the (in the text mostly uncommented) figures in section 5 is insufficient. Ultimately, the author provides an answer only to the question if recurrent neural networks have an application in finance. Firstly, this was already answered by many authors before submission of this thesis. Secondly, in the current form, the results provided here might be of interest for the computer science community rather than finance community.

Hence, as much as I admire the athor to implement recurrent neural networks and running numerous numerical experiments, looking at it **from the perspective of a thesis at the Economics and Finance department, the contribution is rather low.**

Methods

In chapter 3, the author starts with (rather too) brief presentation of two (advanced and definitly beyond standard bachelor level) econometric models for comparing the outcomes of the recurrent neural networks models. FIGARCH model is displayed without any explanation of some of its components, such as $\beta(L)$ or $\phi(L)$. Density function (3.2) is typographically ill-displayed and the author does not specify its support. Similarly, Generalized Pareto distribution is a three-parameter distribution, and the author presents in (3.3) a density function of a special type with parameter $\mu=0$; and again ignores the specification of its support, which is not all reals in this case. Thus, the reader, if interested in these models, must confront other literature. Moreover, from the further development, it is unclear if the author actually implemented both FIGARCH and EVT-POT models.

Next, the author progresses to present the basics of recurrent neural networks. At start, the presentation can be easily followed, if not for occasionally confusing comments which do not correpond with the display of fomulas, e.g. on page 11, the author claims that „Each input is multiplied by the weighted sum of inputs and then transformed by an activation fucntion“. I suppose the author actually meant that the weighted sum of all inputs, in a sense the inner operation/transformation of inputs, is (then) transformed by an activation function, the outer operation/transformation in the composite mapping, as illustrated by Figure 3.2. Not all figures are as illuminative as the author claims, though, e.g. Figure 3.3 raises a question why input x_2 does not come into play for the output $y_{1,2}$. Further minor shortcomings in the presentation of the underlying concept, such as, **are the lower case bold variables column vectors or row vectors**, or do functions φ_i map from N_i+1 dimensional reals, and inconsistent notation between the subsections, drive the reader,

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again, to study the basics from some monograph on the topic instead, e.g. Bishop 1995, Neural networks for pattern recognition, Oxford University press**. What can be considered very confusing are comments that the author did not require any assuption on distribution of returns for his numerical experiments (e.g.page 44) and at the same time states the assumption of t-distribution with unknown number of degrees of freedom (section 3.2.5)**.

I made a leap of faith (which in a technical manuscript such as this one is a horrible thing to admit) and assumed that $\widehat{VaR}^\alpha_t$ defined in (3.15) is later referred to using notation $\hat{y}^{VaR}_i$ which is used for the first time only after (3.15), but I can just as well be wrong here. Towards the end of Section 3, the reader is lost in a zoo of unexplained variables (e.g. T in (3.42), π in (3.46)) and, again, is forced to confront other sources of literature.

Chapter 4 is pleantly concise and illuminative. **There is just a minor confusion about Figure 4.1 and its comment on page 27 as I believe the author should refer to the period of the second half of 2015 and the first half of 2016 as the period of (visibly) higher volatility.**

Chapter 5 presents the results of the numerical experiments in a rather sterile and uninformative way. In the first part, the author presents a series of figures (without any comments) for the considered cases, and, as the figures contain also the „realized VaR“, the reader can at least visually inspect the quality of the numerical outputs. In the subsection 5.1.2, not even that is possible anymore. **Section 5.2 attempts at a brief evaluation of the achieved results but many claims are unsupported by the displayed results so the reader cannot verify those claims. In case the appedices play a role in that, the author should have properly guided the reader through the supplemental material then.**

In the limited time, I was unable to replicate the autors numerical experiments to verify his numerical findings. But, I would like to point out a fact which the author of the thesis left out, that „machine learning methods on their own do not identify deep fundamental associations without human scientists designing hypothesized mechanism into an estimation problem“ (Gu et al 2020, https://doi.org/10.1093/rfs/hhaa009) and as such many of the presented results are inherently dependent on the choices the author made progressively throughout the thesis, namely about the number of layers, specification of epochs and choice of activation functions.

Literature

Study of neural netwoks is a rapidly progressing field and the literature in this field can, in rather short publication period, advance and present multiple previously unknown results. The author of this thesis seem an unfortunate victim to that as he claims that the literature on the topic of the thesis is scarce, which is indeed true as of 2019, but unfortunately, many author published on this very topic in 2020 and 2021, cf. Gu et al 2020: Empirical Asset Pricing via Machine Learning https://doi.org/10.1093/rfs/hhaa009, which to the current date already sports more than 300 citations. From what I understand, Gu et al 2020 gave the proverbial push for the extensive literature of machine learning in finance to rapidly emerge. Athough the author of the thesis should be aware of the literature development of past 18 months prio completion of his thesis, it also sadly makes most of his achived results rather obsolete.

This, however, does not provide an excuse for futile display of unfamiliarity with the financial literature on risk measures and Value at Risk. I can tolerate a rather irritating plurality of reference to the Value at Risk (the author uses Value-at-Risk, Value-at-risk, value-at-risk, VaR, Value at Risk, Value at risk, value at risk and possible more). I can also make an exception that in the Introduction, the author uses Value at Risk in the context of general risk measures. However, confusing the essential reference to Markowitz 1952 of his seminal „Portfolio Selection“ published in the Journal of

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Finance, where he indeed presented variance (and standard deviation) as a risk measure to be considered along with the expected returns when designing diversified portfolia, which indeed paved foundation to modern risk theory, for his other celebrated paper „The utility of wealth“ published (incidentally) also in 1952 in the Journal of Political Economy, in which he presents discussion about the form and inflection points of the utility function of wealth in the context of lotteries and insurance; that just shows total ignorance for the finance/economics aspect of this thesis. The author effectively alienated me already on page 2 out of 50.

Manuscript form

In the manuscript the author demostrates high English proficiency and the text is corrupted by just a (resonable) small number of typos or misprints, except for the cases pointed out above. All tables and figures are properly labeled and are displayed in high graphical quality.

Some of the references have incomplete record, e.g. Parrondo 1997. The author could improve the presentation of formulas by proper use of punctuation between the text and the mathematical environment.

Overall evaluation and suggested questions for the discussion during the defense

The results of the Urkund analysis do not indicate significant text similarity with other available sources.

Despite all criticism above, in my view, the thesis still fulfills the requirements for a bachelor thesis at IES, Faculty of Social Sciences, Charles University, I recommend it for the defense and suggest a **grade E**.

Some of my objections and questions which are suitable for the discussion during the thesis defense were already stated in the text above, highlighted in bold.

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

CATEGORY		**POINTS**
Contribution	*(max. 30 points)*	8
Methods	*(max. 30 points)*	25
Literature	*(max. 20 points)*	4
Manuscript Form	*(max. 20 points)*	18
TOTAL POINTS	*(max. 100 points)*	**55**
GRADE	**(A – B – C – D – E – F)**	**E**

NAME OF THE REFEREE: RNDr. Michal Červinka, Ph.D.

DATE OF EVALUATION: 31.8.2021

Michal Cervinka

Digitally signed by Michal Cervinka
Date: 2021.08.31 21:59:33 +02'00'

Referee Signature

EXPLANATION OF CATEGORIES AND SCALE:

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.*

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.*

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

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.*

Overall grading:

TOTAL	**GRADE**
91 – 100	**A**
81 - 90	**B**
71 - 80	**C**
61 – 70	**D**
51 – 60	**E**
0 – 50	**F**