Report on **Master Thesis**

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

Student:	**Bc. Sylvie Dvořáková**
Advisor:	**PhDr. Jozef Baruník, Ph.D.**
Title of the thesis:	**Fractional Cointegration of Daily High and Low Stock Prices**

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

The author of this thesis clearly formulates the sole goal: to illustrate the recently developed and formalized model of fractionally cointegrated VAR on selected five stock indices.

I have many objections to the structure of the text, to unclear or formally wrong formulations in the text and mathematical expressions. The readability of the text suffers significantly by these shortcomings and results in unfortunate fact, that the reader must invest a lot of energy to follow the text and/or go to the cited texts in order to understand the presented material. On the other hand, what I find also important to be noted, the author uses nearly flawless English. Below, I provide a list of my comments and suggestions for corrections and explain – where possible – the reason for my comments.

I am quite disappointed that although the author is able to provide extensive numerical application of theory behind fractionally cointegrated VAR on real data, there are no other than technical comments on results. I would expect student of economics to draw some conclusions on behavior and modeling of considered stock indices. However, taking into account the goals and hypotheses laid in the thesis proposal, the author of this thesis fulfilled all requirements. Nevertheless, due to the reasons above I recommend the thesis to be awarded grade 2 – good. I recommend the author to work on errata to this thesis based on which my recommendation could change to grade 1 – excellent. In the light of my review, I definitely do not recommend the thesis for "distinction for and extraordinarily good master's diploma thesis" award as I do not find it extraordinarily good.

I suggest the following questions for the defense:

1) "Please, could you show in detail how model (2) is derived from model (1)?"
2) "Could you summarize the impact/usefulness of your results on current modeling and understanding behavior of stock indices considered in your thesis?"

List of objections/comments/typos (mathematical expressions are written using Latex code):

1) As of March 20, 2006, two of the previously used indices of stocks on the Prague Stock Exchange – "PX 50" and "PX-D" – were replaced by one index denoted as "PX Index". The author of the thesis seems not to realize this significant change (although the PX Index is a continuous follow-up of PX 50). I believe, since the author works with nearly 10 year data set, events of this kind should be at least mentioned in the text. The author does not even respect the new official name of the index and one can thus find several versions in the text - most often PX 50 but on occasions also PX 50 Index (pp 2_4), PX stock market index (pp 4_8) and in (only) one case the currently correct name PX Index (pp2_{10}).
2) Every new variable introduced in the text should be accompanied with clear information about the range of values – e.g. it is unclear if b, d (pp 1^{10}) are natural or real – or about dimensions in case of matrices – e.g. α, β (pp 16). This causes confusion with later use of these variables.
3) The author provides summary of results already in section Introduction. I find this quite unconventional and it invokes the feeling that the author wishes the reader not to proceed beyond page 3.

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4) The author often repeats introduced notation – even word by word (e.g. notation for high / low prices (pp.9 – already on pp 5). On more than one occasion the author uses notation earlier than its full explanation (e.g. $I(0), I(1)$ first used on pp1, explained on pp12[1]). I find it irritating.
5) Some terms which are quite important and definitely nontrivial are left unexplained. E.g. dispersion, volatility proxy, frequency ordinate or (and I find it the most serious) fractional process.
6) The author is not afraid to abuse terminology on occasions without warning. E.g. on pp10 the author refers to variable t as to "trend". I am quite confident t denotes discrete time index or simply observation index. Trend, in particular linear trend, using the notation of the author, is affine function $c + \delta t$ where c is the constant part and δt is its linear part. Calling these two components of linear trend as "constant" and "trend" is most unfortunate and confusing.
7) Expressions $\mathcal H_1$ on pages 10 and 11 have a typo where plus sign "+" is omitted in front of the sum. In the present form, the author suggests to multiply the sum with ΠX_{t-1}, which is wrong.
8) The use of Δ in Table 1 with numerical values in the respectful columns invokes the possibility that ΔX_t is a linear expression in X_t with constant Δ instead of the first difference of variables X_t. Also, I suppose the entry in the 8th row and 1st column of the table should not be left blank.
9) I am positively puzzled why the author confuses the reader with tests or models which are subsequently commented on as unusable – e.g. Johansen procedure on pp16,17 and "Empirical model" pp 17,18.
10) The information on properties of Gamma function concerning its behavior around negative integers is misleading and of no consequence for the subsequent text as it refers (possibly without knowledge of the author) to advanced results of Complex analysis. I suggest to completely delete the information about poles and residuals by simple statement that in negative integers the Gamma function has asymptotic discontinuities.
11) The purpose for using numerical labels for equations is to allow for simple referencing. It is very unorthodox to find out that the equation labeled (1) on page 32 is a recall of already presented expression earlier in the text (Empirical model pp 17).
12) It is never recommended to use numerical labels for footnotes related to mathematical expressions (pp38).
13) I suggest the following formal corrections
    - "normal limit distribution" to "asymptotical/limit normal distribution" ($pp23_6$) to reflect classical terminology of statistics
    - "$\hat{T}_0 \rightarrow_d \Xi^2_1$" to "$\hat{T}_0 \rightarrow_d \Xi \sim \Xi^2 (1)$" ($pp30_{11}$) since convergence in distribution is defined for sequence of random variables limiting to random variable and not distribution. Please note also the change in notation of degrees of freedom of Chi-squared distribution according to later use (e.g. pp 41)
    - "generalised" to "generalized" ($pp32_8$)
    - "$LR_T(q) \rightarrow^D \Xi^2(q^2)$" ($pp41^4$) and similarly $pp41^8$ replace with an expression that is consistent with notation of convergence in distribution on $pp30_{11}$.

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

CATEGORY		**POINTS**
Literature	*(max. 20 points)*	20
Methods	*(max. 30 points)*	30
Contribution	*(max. 30 points)*	25
Manuscript Form	*(max. 20 points)*	5
TOTAL POINTS	*(max. 100 points)*	**80**
GRADE	**(1 – 2 – 3 – 4)**	**2**

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

DATE OF EVALUATION:

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