

CHARLES UNIVERSITY
FACULTY OF SOCIAL SCIENCES

Institute of Economic Studies



Can Machines Explain Stock Returns?

Master's thesis

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Study program: Economics and Finance

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Year of defense: 2020

Declaration of Authorship

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Prague, September 6, 2019

Karolina Chalupova

Abstract

The abstract should concisely summarize the contents of a thesis. Since potential readers should be able to make their decision on the personal relevance based on the abstract, the abstract should clearly tell the reader what information he can expect to find in the thesis. The most essential issue is the problem statement and the actual contribution of described work. The authors should always keep in mind that the abstract is the most frequently read part of a thesis. It should contain at least 70 and at most 120 words (200 when you are writing a thesis). Do not cite anyone in the abstract.

JEL Classification	C45, G12
Keywords	(interpretable) machine learning, neural networks, stock returns
Title	Can Machines Explain Stock Returns?
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Abstrakt

TODO cesky preklad abstraktu.

Klasifikace JEL	C45, G12
Klíčová slova	(interpretovatelné) strojové učení, neuronové sítě, akciové výnosy
Název práce	Mohou stroje vysvětlit akciové výnosy?
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Acronyms

FDI Foreign Direct Investment

MNC Multinational Company

OFDI Outward Foreign Direct Investment

OLI Ownership, Location, Internalization

Master's Thesis Proposal

Author	Bc. Karolína Chalupová
Supervisor	doc. PhDr. Jozef Baruník, Ph.D.
Proposed topic	Can Machines Explain Stock Returns?

Motivation For the purposes of government policy concerning energy security, optimal taxation, and climate change, precise estimates of the price elasticity of gasoline demand are of principal importance. For example, if gasoline demand is highly price-inelastic, taxes will be ineffective in reducing gasoline consumption and the corresponding emissions of greenhouse gases. During the last 30 years the topic has attracted a lot of attention of economists who produced a plethora of empirical estimates of both short- and long-run price elasticities. Yet the estimates vary broadly.

A systematic method how to make use of all this work is to collect these numerous estimates and summarize them quantitatively. The method is called meta-analysis (Stanley, 2001) and has long been used in economics following the seminal contribution by Stanley and Jarrell (1989). Recent applications of meta-analysis in economics include, among others, Card et al. (2010) on the evaluation of active labor market policy, Havranek (2010) on the trade effect of currency unions, and Horvathova (2010) on the impact of environmental performance on corporate financial performance.

Two international meta-analyses of the elasticity of gasoline demand have been conducted (Brons et al., 2008; Espey, 1998). These meta-analyses study carefully the causes of heterogeneity observed in the literature. The average short- and long-run elasticities found by these meta-analyses were -0.26 and -0.58 (Espey, 1998) and -0.34 and -0.84 (Brons et al., 2008). None of the meta-analyses, however, corrected the estimates for publication bias. It is well-known that publication selection can seriously bias the estimates of price elasticities because positive estimates are usually inconsistent with theory: for instance, Stanley (2005) documents how the price elasticity of water demand is exaggerated fourfold because of publication bias.

Hypotheses

Hypothesis #1: The literature estimating gasoline demand elasticities is affected by publication bias.

Hypothesis #2: The publication bias exaggerates the mean reported elasticity.

Hypothesis #3: The extent of publication bias decreases in time.

Methodology The first step of meta-analysis is the collection of primary studies. I will examine all studies used by the most recent meta-analysis (Brons et al., 2008), but because the sample used by Brons et al. (2008) ends in 1999, I will additionally search the EconLit and Scopus databases for new studies published. To be able to use modern meta-analysis methods and correct for publication bias, I need the standard error of each estimate of elasticity; therefore I will have to exclude studies that do not report standard errors (or any other statistics from which standard errors could be computed). Concerning the definition of short- and long-term elasticity estimates, I will follow the approach described in the first meta-analysis on this topic, Espey (1998).

In the absence of publication bias the estimates of elasticities are randomly distributed around the true mean elasticity. Nevertheless, if some estimates end in the “file drawer” (Rosenthal, 1979) because they are insignificant or have a positive sign, the reported estimates will be correlated with their standard errors (Ashenfelter et al., 1999; Card and Krueger, 1995). For example, if a statistically significant effect is required, an author who has few observations may run a specification search until the estimate becomes large enough to offset the high standard errors. In this specification the regression coefficient corresponding to the standard error measures the magnitude of publication bias and the intercept measures the magnitude of the elasticity corrected for publication bias (thus, the specification directly addresses hypotheses 1 and 2). Because such a regression is likely heteroscedastic (the explanatory variable is a sample estimate of the standard deviation of the response variable), in practice it is usually estimated by weighted least squares with the inverse of standard errors (precision) taken as weights.

In meta-analysis I have to take into consideration that estimates coming from one study are likely to be dependent. A common way how to cope with this problem is to employ the mixed-effects multilevel model (Doucouliagos and Stanley, 2009), which allows for unobserved between-study heterogeneity. Between-study heterogeneity is likely to be substantial since in our case the primary studies use data from different countries. I will specify the model following Havranek and Irsova (2011): the overall error term now breaks down into study-level random effects and estimate-level disturbances. To address hypothesis 3 I will add an interaction term between the year of publication of the study and the reported standard error. I expect that the

magnitude of publication bias to decrease in time, which would be in line with the economics-research-cycle hypothesis (Goldfarb, 1995; Stanley et al., 2008).

Expected Contribution I will conduct a quantitative survey of journal articles estimating the price elasticity of gasoline demand. In contrast to previous meta-analyses on this topic, I will take into account publication selection bias using the mixed-effects multilevel meta-regression. Publication bias in this area is expected to be strong; when I correct for the bias, I expect to obtain estimates of short- and long-run elasticities that are much smaller than the results of the previously published meta-analyses and also to the simple mean of all estimates in my sample of literature. The estimates can be directly used in fiscal modeling (calculating the optimal tax on gasoline) and climate change policy (for example, the computation of the social cost of carbon emissions).

Outline

1. Motivation: there are meta-analyses on the price elasticity of gasoline demand, but they do not correct their estimates for publication bias. Publication bias has been shown to distort most areas of empirical economics, so there is a good chance it will be important here as well.
2. Studies on gasoline demand: I will briefly describe how people estimate the price elasticity of gasoline demand.
3. Data: I will explain how I will collect estimates from studies estimating the elasticity.
4. Methods: I will explain modern meta-analysis methods, including the funnel asymmetry test, precision effect test, and multilevel variants of these regressions.
5. Results: I will discuss my baseline regressions and robustness checks.
6. Concluding remarks: I will summarize my findings and their implications for policy and future research.

Core bibliography

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Chapter 1

Introduction

This document serves two purposes. First, it is a template and example for a master's thesis. Second, the text in all sections contains some useful information on structuring and writing your thesis.

The introduction should consist of three parts (as paragraphs, not to be structured into multiple headings): The first part deals with the background of the work and describes the field of research. It should also elaborate on the general problem statement and the relevance. The second part should describe the focus of the thesis, typically the paragraph starts with a phrase like “The objective of this thesis is” The last part should describe the structure of the thesis, for instance in the following manner. The thesis is structured as follows: Chapter 2 cites some formal requirements of the faculty, Chapter 3 gives some hints on basic formatting features and covers also acronyms, figures, boxes and tables. Chapter 4 gives a recommendation on the usage of hyphens in English language in \LaTeX and explains how to use the `itemize` and `quote` environments and shows a few `enumerate`-based environments. Chapter 5 presents a checklist of common mistakes to avoid. Chapter 6 contains numerous hints. Chapter 7 summarizes our findings.

Chapter 2

Title of Chapter Two

2.1 Formal requirements of master's thesis at the Faculty of Social Sciences

According to Dean's Provision no. 18/2017:

- The minimum extent of master's thesis is 60 standard pages (108 thousand characters including spaces) of the text itself, i.e. without an abstract and appendices and a list of literature. In case the master's thesis is written in English, its minimum extent is 50 standard pages (90 thousand characters including spaces) without an abstract and appendices and a list of literature. When writing a standard text document, the minimum requirement is 60 characters per line and 30 lines per page, i.e. 1,800 characters per page (the so-called standard page). Font size, page layout, margins, and line spacing need to be customized.
- Generally, a standard form of the page of the final thesis applies the fonts of 12 points, the gaps between the paragraphs are recommended to be of the size of 6 points. Notes and footnotes can be written in a 10-point font. The text is aligned on both sides (aligned to a block). Electronic version of the thesis will be entered by a student/applicant for a state doctoral examination through the SIS website interface in the archive format of PDF/A version 1.3 or higher. Further details are stipulated by the rector's provision.
- The master's thesis is submitted in the accreditation language of the respective follow-up Master's study program.

Chapter 3

Title of Chapter Three

3.1 Citations

Text text text text text text text text text text text text. Text text text text text text text text. Text text text text text text text text text text text text text text text text. Text text Haufler & Wooton (2006).

Text text text text text text text text text text text text text. Text text text text text text text (see, *inter alia*, Haaparanta 1996, pg. 10).

3.2 Acronyms

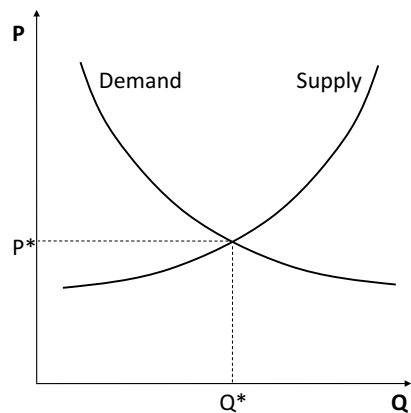
Text text text text text text text text text text text text. Text text text text text text text text text. Text text text text text text. Politicians usually like inward Foreign Direct Investment (FDI) and an Multinational Company (MNC) appreciates FDI subsidies. Are MNCs greedy?

3.3 Figures

To achieve compatibility with PDF/A 2u, your file must not include links to external fonts, audio, video, or scripts. On the other hand, your file must declare each color environment you use, it must include all the pictures/figures either in jpeg or PDF/A 2u format, used fonts compliant under Unicode (your file cannot use any external fonts), and it must include meta-data in XMP format.

Most troubleshooting comes from the conversion of figures to compliant formats. You can convert from simple PDF using Adobe Acrobat:

Figure 3.1: Market equilibrium



Source: Haufler & Wooton (2006).

Look at the Figure 3.1. Text text text text text text text text text. Text text text text text text. Text text text text text text text text text. Text text text text text text text text text text.

3.4 Tables

If you use Stata, you might want to check the `sutex`, `outtable`, `outtex`, and `estout` tools, which help you with exporting Stata tables to L^AT_EX.

Table 3.1: Model’s predictions

<i>Case</i>	Y_1	Y_2	τ_1	τ_2	a	n
CR—Slovakia	10.9	10	0.24	0.19	1,000	2.16
CR—Poland	13.3	12	0.24	0.19	1,000	0.38
CR—Hungary	10.4	8	0.24	0.16	1,000	1.10

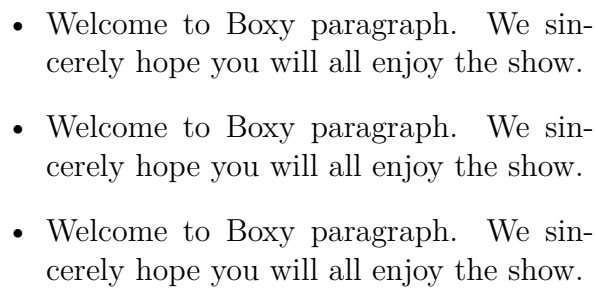
Source: If the source is author himself (like a calculation output), this line is redundant.

Text text text text text text text text text text text text text. Text text text text text text text text text text. Text text text text text text. Text text text text text text text text text text. Text text text text text text text text text text.

3.5 Boxes

Text text text text text text text text text text text text. Text text text text text text text text text. Text text text text text text. Text text text text text text text text text. Text text text text text text text text text text. Let us make a box:

Figure 3.2: Boxy’s example

- 
- Welcome to Boxy paragraph. We sincerely hope you will all enjoy the show.
 - Welcome to Boxy paragraph. We sincerely hope you will all enjoy the show.
 - Welcome to Boxy paragraph. We sincerely hope you will all enjoy the show.

Source: Haaparanta (1996)

Text text text text text text text text text text text text. Text text text text text text text text text text. Text text text text text text. Text text text text text text text text text text. Text text text text text text text text text text.

3.6 Theorems, Definitions, ...

Definition 3.1 (My original definition). This is a definition.

Assumption 3.1 (My realistic assumption). This is an assumption.

Proposition 3.1 (My clever proposition). *This is a proposition.*

Lemma 3.1 (My useful lemma). *This is a lemma.*

Example 3.1. This is an example.

Proof. This is a proof.

□

3.7 Equations

3.7.1 Nonumbered Equations

Text text text text text text text text text text text text. Text text text text text text text text. Text text text text text text. Text text text text text text text text text text. Text text text text text text text text text text text.

$$U = \underbrace{\int_0^\infty \frac{1}{1-\sigma} (C^{1-\sigma} - 1) e^{-\rho t} dt}_{\text{meaning of life}}$$

3.7.2 Numbered Equations

Text text text text text text text text text text text text. Text text text text text text text text text. Text text text text text text. Text text text text text text text text text text. Text text text text text text text text text text text.

$$U = \int_0^\infty \overbrace{\frac{1}{1-\sigma} (C^{1-\sigma} - 1)}^{\text{instantaneous utility}} e^{-\rho t} dt \quad (3.1)$$

3.7.3 Matrix Equations

Text text text text text text text text text text text text. Text text text text text text text text text. Text text text text text text. Text text text text text text text text text text. Text text text text text text text text text text text.

$$\mathbf{A} = \mathbf{B} + \mathbf{C} \quad (3.2)$$

3.8 Cross-references

- to literature (Bjorvatn & Eckel 2006, pg. 10) or Haufler & Wooton (2006, pg. 10),
- to Figure 3.1,
- see Table 3.1,
- to Section 3.7,

- to Definition 3.1, to Proposition 3.1, Example 3.1,
- to equations like this: see (3.1).

3.9 Source codes

You can input a source code like this:

```
omega = 1;
syms zeta;
jmn = [1 2*zeta*omega omega^2];
figure(1);
    for zeta = 1E-5 : 0.2 : 1+1E-12
        G = tf(omega^2,subs([1 2*zeta*omega omega^2]));
        bode(G); hold on;
    end
legend('\zeta = 0', '\zeta = 0,2', '\zeta = 0,4', '\zeta = 0,6',');
```

Should you prefer a different font size, redefine file `Styles/Mystyle.sty`.

3.10 Paragraphs

Usually you should not use the first person singular (I) in your text, write we instead. As a general recommendation, use the first person sparsely, sometimes it can be replaced by a phrase like “This work presents . . .”

Text text text text text text text text text text text text text.
Text text text text text text text text text text. Text text text text text.
Text text text text text text text text text. Text text text text text text text text text text. Text text text text text text (Haufner & Wooton 2006). Let us make two paragraphs:

Proin Text text text text text text text text text text text text.
Text text text text text text text text text text. Text text text text text.
Text text text text text text text text text. Text text text text text text text text text text. Text text text text text text text text text text text text text. Text text text text text text text text text text. Text text text text text text. And a subparagraph:

Velit Text text text text text text text text text text text text text text. Text text text text text text text text text text. Text text text text text text. Text text text text text text text text text text. Text text text text text text text text text text.

Text text text text text text text text text text text text text text. Text text text text text text text text text. Text text text text text text. See what Edmund Burke said about the duties of a Member of Parliament (Speech To The Electors Of Bristol At The Conclusion Of The Poll, November 3, 1774):

It ought to be the happiness and glory of a representative to live in the strictest union, the closest correspondence, and the most unreserved communication with his constituents. Their wishes ought to have great weight with him; their opinion, high respect; their business, unremitted attention. It is his duty to sacrifice his repose, his pleasures, his satisfactions, to theirs; and above all, ever, and in all cases, to prefer their interest to his own. But his unbiassed opinion, his mature judgment, his enlightened conscience, he ought not to sacrifice to you, to any man, or to any set of men living. These he does not derive from your pleasure; no, nor from the law and the constitution. They are a trust from Providence, for the abuse of which he is deeply answerable. Your representative owes you, not his industry only, but his judgment; and he betrays, instead of serving you, if he sacrifices it to your opinion.

Text text text text text text text text text text text. Text text text text text text text text. Text text text text text. Text text text text text text text. Text text text text text text text text. Text text text text text text text text. Text text text text text text.

- (i) The first item, the first item, the first item, the first item, the first item,
the first item,
 - (ii) and the second item.
-
- (a) The first item, the first item, the first item, the first item, the first item,
the first item,
 - (b) and the second item.

Text text text text text text text text text text text text. Text text text text text text. Text text text text text text. Text text text text text text text text text text text. Text text text text text text text text. Text text text text text text text text text text text text text text text text. Text text text text text text text text. Text text text text text text text text Blomstrom & Kokko (2003).

Chapter 5

Title of Chapter Five

5.1 Title of Section One

The following checklist should help in avoiding some frequently made mistakes, if any of the following propositions apply for your thesis, there is a problem:

- You have citations in your abstract.
- The introduction does not cover the three parts as described in Chapter 1.
- The introduction contains subheadings.
- You described different aspects than promised in the title.
- You copied some parts of the text from other work without proper referencing and citing.
- You used automatic translation tools to produce text by translating it from another language.
- Your thesis contains many typos and grammatical errors. (Use an electronic spell checker. Please!)
- You used color in your figures and refer to the “blue” line (assume that your readers use a monochrome printer).
- You mainly used websites and other unrefereed material as your sources or you used Wikipedia as your source.
- You refer to something in your conclusion which you have not mentioned before.

-
- Some forenames in the references are abbreviated, some not.
 - Some references miss a publishing date.

Chapter 6

Useful Hints

If you write in English, you might find the following hint useful: The indefinite article *a* is used as an before a vowel sound—for example an apple, an hour, an unusual thing, an MNC (because the acronym is pronounced Em-En-See). Before a consonant sound represented by a vowel letter *a* is usual—for example a one, a unique thing, a historic chance. Few more tips to follow:

- Don't give orders—don't write in the imperative mood—unless you are training to be a teacher.
- Avoid the use of questions. You may know the answer: does your reader? It's much safer to tell her, or him.
- Do not become entangled in the problems of 'sexist' language. It is much easier to write in the plural. "Students should check their work" is good English. "A student should check—" is also good English, but now the problems begin: "—her work?" "—his work?" Which? You can write "his or her," but that seems clumsy. Stick to the plural.
- If you must refer to yourself, use the third person such as "The present writer would recommend that . . ." may be useful.
- Use the full forms of words and phrases, not contractions like "he's," "don't," etc. Keep the apostrophe to indicate possession—and use it correctly. Academics really sneer at students who use the "Greengrocer's apostrophe."
- Do not despise short, workmanlike, and effective plain English words. If they mean what you want to say. Accurately.

- Avoid the use of humor in academic writing—unless you are very sure of yourself.
- Even when you are not being funny, avoid the use of irony or sarcasm.
- Paragraphs in academic English should contain more than one sentence. (Short paragraphs look as if you are writing for a tabloid newspaper—or a simple Template!) I guess that the average academic book runs to two or three paragraphs per page. Look at the books in your subject, and get a feel for how long your own paragraphs should be when you are imitating the academic style.
- Use the word that more in formal writing than most of us do in speech—particularly after such verbs of utterance as to say, to report, to think etc. It can help to make your writing much clearer.
- Develop an academic vocabulary. The ‘long words’ you learn in the course of your studies are long usually because they have more precise meanings than their less formal equivalents. They are therefore better when you want to be accurate. (Also they allow you to sound like someone who deserves a degree.)
- Use as few words as you can; but use enough words to express your meaning as fully as you can. Your judgment of what is appropriate here is part of what you should learn throughout your course.
- Avoid lazy words such as “nice”. It is usually better to say “acquire” or “obtain” than “get;” and it may be better, if you mean “through the use of money,” to say “purchase” or—better still—“buy.”
- A short word like “buy” is better than a long one like “purchase”—unless the long one is more accurate. A “statutory instrument” is better than a “rule”—to a lawyer, at any rate.
- Proof-read with care. Ask someone else to help—you may be too close to your work to be able to see your mistakes.
- If in doubt, choose the more formal, or possibly just the more old-fashioned, of two words. For example, say quotation rather than quote whenever you mean the use of somebody else’s words.

-
- You will often sound more academic if you include doubts in your work—and qualifications. Within the scope of this thesis, the current writer cannot hope to cover all the possible implications of the question.
 - In this context, the use of litotes sounds very academic. This is the construction where a writer uses a negative with a negative adjective, e.g. it is not unlikely that ... This does not mean the same as it is probable that ... It has a shade of meaning and qualification that can be useful to academic writers.

Chapter 7

Conclusion

The conclusion should briefly summarize the problem statement and the general content of the work and the emphasize on the main contribution of the work.

When writing the conclusion keep in mind that some readers may not have gone through the whole thesis, but have jumped directly to the conclusion after having read the abstract in order the decide on the personal relevance of the thesis. Therefore, the conclusion should be self contained, which means that a reader should be able to understand the essence of the conclusion without having to read the whole thesis.

The conclusion typically ends with an outlook that describes possible extensions of the presented approaches and of planned future work.

Bibliography

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Appendix B

Content of Enclosed DVD

This is optional: you may enclose a DVD to this thesis which contains empirical data and MatLab/R/Stata source codes. Even better so, you can create a special website for your project. Stating in your thesis that the data and source codes are available upon request is enough but please, have them prepared for such requests.

- Folder 1: Source codes
- Folder 2: Empirical data