

DIANA GABRIELIAN

Essays on inflation, expectations
and central bank communication



DISSERTATIONES RERUM OECONOMICARUM
UNIVERSITATIS TARTUENSIS

85

DISSERTATIONES RERUM OECONOMICARUM
UNIVERSITATIS TARTUENSIS

85

DIANA GABRIELIAN

Essays on inflation, expectations
and central bank communication



UNIVERSITY OF TARTU
Press

School of Economics and Business Administration, University of Tartu, Estonia

This dissertation is accepted for the defence of the degree of Doctor Philosophy (in Economics) on the 16th of January 2024, by the Council of the School of Economics and Business Administration, University of Tartu.

Supervisors: Associate Professor Jaan Masso (PhD),
University of Tartu, Estonia

Associate Professor Lenno Uusküla (PhD),
University of Tartu, Estonia,
and Chief Economist, Luminor Bank, Estonia

Opponents: Anita Suurlaht Donaldson (PhD),
Economist, Eesti Pank, Estonia

Vegard Høghaug Larsen (PhD),
BI Norwegian Business School, Norway

The public defence of the dissertation is on the 21st of February 2024 at 14.00 in room 2046, University of Tartu, Narva Rd 18.

The publication of this dissertation is granted by the Doctoral School of Economics and Innovation of University of Tartu created under the auspices of European Social Fund and by University of Tartu School of Economics and Business Administration.



European Union
European Regional
Development Fund



Investing
in your future

ISSN 1406-1309 (print)
ISBN 978-9916-27-462-0 (print)
ISSN 2806-254X (pdf)
ISBN 978-9916-27-463-7 (pdf)

Copyright: Diana Gabrielyan, 2024

University of Tartu Press
www.tyk.ee

CONTENTS

LIST OF AUTHOR'S PUBLICATIONS AND CONFERENCE PROCEEDINGS	6
INTRODUCTION.....	7
List of Original Studies	7
Motivation and Conceptual Idea of the Research	7
Aim and Tasks of the Research.....	12
Structure of the Dissertation.....	15
Contributions of individual authors	18
Acknowledgments.....	18
1. THEORETICAL BACKGROUND FOR THE ARCH.....	20
1.1 The Role of Inflation.....	20
1.2 Forecasting Inflation	22
1.3 Inflation Expectations and Their Formation	25
1.4 Measuring Inflation Expectations	27
1.5 News, Communication, and Expectations	29
2. RESEARCH DATA AND METHODOLOGY	34
3. EMPIRICAL STUDIES.....	37
4. DISCUSSION AND CONCLUSIONS.....	188
4.1 Summary of Studies and Contributions	188
4.2 Opportunities for Future Research and Limitations.....	195
4.3 Conclusions.....	199
REFERENCES.....	201
SUMMARY IN ESTONIAN	207
CURRICULUM VITAE	227
ELULOOKIRJELDUS.....	228

LIST OF AUTHOR'S PUBLICATIONS AND CONFERENCE PROCEEDINGS

Papers in international journals

1. Gabrielyan, Diana (2018): “Forecasting inflation using the Phillips curve in inflation targeting countries”, *International Review of Applied Economics*. 33, pp. 601–623.
2. Alfieri, Luca and Gabrielyan, Diana (2024): “The Communication Reaction Function of the European Central Bank. An Analysis using Topic Modeling”, *Forthcoming in Baltic Journal of Economics*.

Chapter in Books

1. Gabrielyan, Diana, Masso, Jaan and Uusküla, Lenno (2020): “Mining News Data for the Measurement and Prediction of Inflation Expectations”, *Theory and Applications of Time Series Analysis. Contributions to Statistics*. Springer, pp. 253–271.

Working Papers

1. Gabrielyan, Diana and Uusküla, Lenno (2022): “Inflation Expectations and Consumption with Machine Learning”, *University of Tartu Working Paper Series No. 14*.

INTRODUCTION

List of Original Studies

This thesis comprises four studies, with inflation expectations being the centre of attention. Each study is referred to by a Roman numeral in the order below.

- I. **Gabrielyan, Diana** (2018): “Forecasting inflation using the Phillips curve in inflation targeting countries”, *International Review of Applied Economics*. 33, pp. 601–623.
- II. **Gabrielyan, Diana**, Masso, Jaan and Uusküla, Lenno (2020): “Mining News Data for the Measurement and Prediction of Inflation Expectations”, *Theory and Applications of Time Series Analysis. Contributions to Statistics*. Springer, pp. 253–271.
- III. **Gabrielyan, Diana** and Uusküla, Lenno (2022): “Inflation Expectations and Consumption with Machine Learning”, *University of Tartu, School of Economics and Business Administration, Working Paper Series No. 142*.
- IV. Alfieri, Luca and **Gabrielyan, Diana** (2024): “The Communication Reaction Function of the European Central Bank. An Analysis using Topic Modelling”, *Forthcoming in Baltic Journal of Economics*.

Motivation and Conceptual Idea of the Research

One of the main objectives of central banks is controlling inflation, the rate at which prices of goods and services increase. Keeping this rate stable, predictable, and close to target is a crucial task for central bankers. Monetary policymakers are concerned not only about realised inflation but also about future price developments – or rather, inflation expectations. Inflation expectations and economic conditions, in general, directly impact people’s choices and, consequently, immediately affect spending, investing, and borrowing decisions. If inflation expectations deviate from the desired inflation levels or the monetary authority’s inflation target, central banks may be required to act to influence expectations. In the case of inflation above target, necessary policies are contractionary in the short run, for instance, by tightening financial conditions by raising interest rates and cooling the economy. This brings inflation down to target levels in the longer run and contributes to economic growth.

Economic theory puts special emphasis on the role of inflation expectations as a driver of many economic decisions. Having a good understanding of current and future inflation dynamics is essential for making informed decisions. Inflation expectations become especially relevant during extreme economic events or when

the economic landscape is uncertain, as was the case at the time of writing this thesis in 2023.

While inflation has been low since the financial crisis of 2008 (see Figure 1), it has reached high levels globally in 2022 and 2023 across developed and developing countries, with many countries reporting double digits. For the United States, this means the inflation rate was at the highest level since 1982, and for the UK, since 1981. Similarly, for European Union (EU) countries, the inflation rate in 2022 and 2023 was the highest since the euro was introduced.

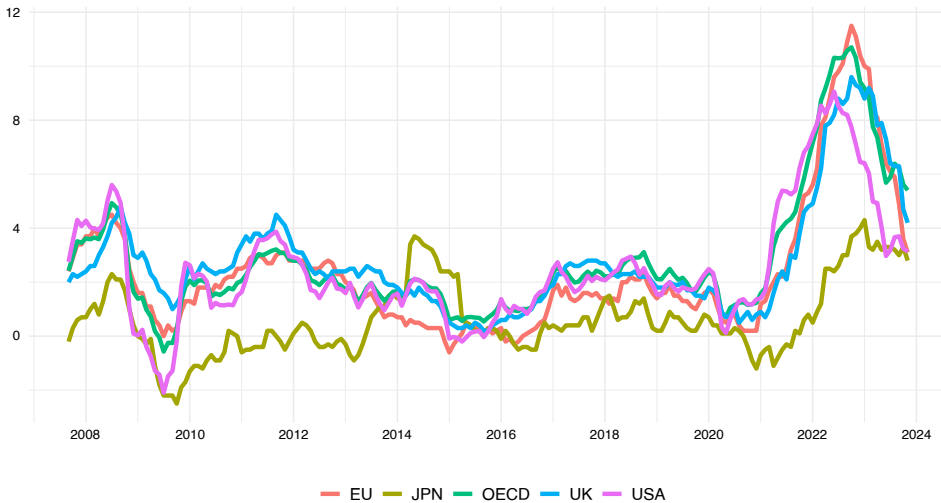


Figure 1: Inflation (Total CPI), December 2007 to November 2023.

Source: OECD

While consumer prices had already started to increase in 2020, such price surges were initially limited to issues with the supply chain due to lockdowns related to the COVID-19 pandemic. Since 2022, however, increases in the inflation rate have been the result of soaring food, electricity, and gas prices, as well as being fuelled by the geopolitical situation. Despite the efforts of many governments to limit the increase of energy prices and increasing interest rates, this was, undoubtedly, a step backwards from the rebound expected after the pandemic and the anticipated economic growth. In addition, the risk of a recession increased, and globally, policymakers were alarmed about the possibility that major economies would plunge into an economic downturn.

In such turbulent times, the shortcomings in measuring, monitoring, and forecasting inflation are exposed, the role of inflation expectations as a monetary policy assessment tool is increased, and the urgency and cruciality to accurately measure and predict such expectations is enhanced. The studies in this thesis have inflation and central bank communication as the common denominator, either directly or indirectly, and emphasise the role of expectations in understanding and forecasting inflation and ensuring relevant communication. Therefore, this work's main goal is to analyse inflation expectations, central bank communication, a

household's economic choices, and the link between the three. The studies of this dissertation focus on inflation-targeting countries, such as Sweden, New Zealand, Canada, the United Kingdom, and Eurozone countries. The choice of countries was based on the relevance to the research aim, as all countries used in the studies of this dissertation are good examples of economies that have introduced inflation targeting as the monetary policy regime.

In recent years, there have been significant improvements not only in econometric methods and techniques but also in machine learning methods. The first dimension through which this study contributes to economic literature is through experiments comparing various machine learning techniques and traditional econometric methods. Particularly in short-term forecasting applications, the novel methods used in this dissertation allow for improved predictions and minimise forecast errors. In addition to improved models, this dissertation also introduces the use of novel data. Most inflation and inflation expectation forecasting models in the literature are still based on traditional datasets and give less attention to alternative data sources. Employing online news data is another novelty and the second contribution of this dissertation, which allows for state-of-the-art results and the establishment of novel, stylised facts. As economic expectations change rapidly, the value of such novel and real-time data sources becomes especially high compared to traditional data sources. Especially considering the high frequency of news data, given its availability on a daily, if not hourly, level. The third major contribution of this dissertation is casting light on the role of media in the inflation expectation formation process of economic agents, which is still relatively unexplored, even though it has become a popular field in macro-economics in recent years (see for example, Shapiro et al., 2022; Lamla and Lein, 2014; Larsen et al., 2021).

These contributions are achieved through the empirical studies of the thesis. In studies I and II, inflation is forecast using Phillips curves and a machine learning model, respectively, with the latter building on the data of inflation expectations. Study I evaluates the performance of Phillips curves for countries that use inflation targeting as the monetary policy regime. The Phillips curve is a key macro-economic concept and defines the dynamics between prices through inflation or inflation expectations and costs and slack in the economy, for example, through wages, unemployment, or the output gap. The paper finds that while Phillips curve models can improve inflation forecasts against simple benchmark models such as random walk and autoregressive models during the periods when the central bank is explicitly targeting inflation, the results from earlier periods indicate heterogeneity in individual model performance. These results highlight the point when the adoption of an inflation-targeting regime changes the economic environment and when Phillips curves are more useful in forecasting and, when not, forming the main contribution to the literature on forecasting and monetary analysis.

Inspired by advancements in computer technology and its application in economics, machine learning models are used for forecasting in Study II. Using such advanced techniques in economics allows one to minimise forecast errors

by trading off bias and variance, handling large amounts of data without sacrificing interpretations, and extracting more data from previously unavailable data sources, such as online news, social media, transaction data, etc. This paper uses a popular machine learning model, the Least Absolute Squared Shrinkage Operator (hereinafter also LASSO), to model both headline inflation and inflation expectations. The performance of the machine learning and benchmark models (similar to those in Study I) is assessed by computing forecast errors. Machine learning methods do a better job in forecasting inflation expectations than naïve models and at least as good a job for inflation.

There are many inflation rates in use by central banks, such as headline inflation, core inflation and inflation expectations. The literature review throughout this dissertation highlights the role of inflation expectations on actual inflation dynamics and policymaking.

Inflation expectations are an important input in intertemporal consumption or investment decisions. The Euler equation model for consumption (or Euler's equations), which captures the relationship between consumption path, nominal interest rates, and inflation expectations, is a great example (see Hall, 1988; Ascari et al., 2021). In times of high expected inflation, with fixed nominal interest rates, consumers expect lower real interest rates. They give less importance to future savings and instead increase current consumption with the expectation of consuming less in the future. Study III, which builds on studies I and II, shows that when inflation expectations are used in a notable macroeconomic model like Euler's models, the model performance can be improved or even make Euler equations "great" again.

To achieve the aim of analysing the effects of inflation expectations on the decisions of economic agents, a novel index of inflation expectations is constructed from news sources, which acts as an alternative to inflation in the real interest rate calculations in Euler's model. Until recently, market or survey-based measures of inflation expectations would act as popular proxies of inflation. However, Study III challenges the usage of survey-based measures and instead proposes a new, high-dimensional, and potentially real-time¹ measure of inflation expectations that can accurately capture a household's true perceptions about the economy.

The argument is that the paradigm of full-information rational expectations (hereinafter FIRE) may only be a benchmark case in analysing the economy, as consumers typically do not adhere to this paradigm. Instead, they form expectations from their often inaccurate prior memories of inflation, subjective economic beliefs, rules of thumb, etc. In addition, different agents interpret economic shocks differently, with most paying very little attention to monetary and fiscal policy and would typically not know the official inflation target. Behavioural responses to policy changes may differ from expert predictions and contradict the key assumptions of FIRE. This makes it harder for economists to gain a deeper

¹ Here, "real-time" refers to data that is available with the smallest possible lag, for instance, one-day lag.

understanding of the expectation formation process and to act on it accordingly. For a review of the recent literature discussing systematic deviations of consumer expectations from the FIRE, see D'Acunto et al. (2022b).

In addition to issues related to FIRE, capturing survey data also comes with an opportunity cost. Methods of collecting survey measures have evolved due to the reduced attention consumers pay to phone calls and emails amid the myriad of daily messages. Therefore, reaching out to a representative group of a population has become increasingly difficult, and surveyors must rely on a mixture of methods to collect necessary data. The shortcoming of a mixed approach is the varying preferences of consumer groups for answering surveys: younger audiences tend to prefer online surveys, whereas that might be challenging for older consumers. Moreover, studies have shown that consumers who have previously responded to surveys on inflation expectations tend to reduce their inflation expectations by 2% on average. Hence, repeat participation may lead to this particular group of consumers not being a representative group anymore (Kim and Blinder, 2021). More discussion on the problems with survey-based measures can be found in Weber et al. (2022).

Advances in the methods used in economics in the last decade allow the measurement of consumer inflation expectations directly from the news. The usage of news data in this thesis has two contributions. First, it is used as a novel and alternative data source to construct a news-based index of inflation expectations. Second, understanding and quantifying the impact of media on inflation expectations provides a springboard for studying central bank communication as a channel by which central banks influence the decision-making of the wider public.

Study IV contributes to the literature on analysing the effects of central bank communication through a discussion and empirical study on the communication reaction function of the European Central Bank (ECB). The latter is analysed by clustering the speeches of bank representatives into topics and transforming these text-based topics into quantitative indices that allow the analysis of the importance of each topic in central bank communication. This allows this dissertation to contribute to the understanding of household expectation formation and, consequently, the impact on policy and decision-making.

The focus on inflation expectations in this thesis is elucidated by the importance of understanding how households form and update their expectations. When inflation levels are historically high, it is natural that policymakers and economists would worry that this rise is persistent and may de-anchor inflation expectations among economic agents. There are multiple possible narratives to make sense of such a surge, and each one is important. Hence, designing accurate and timely policy responses is as crucial. Consequently, understanding what the public expects the future of the economy to look like is just as crucial.

The models in this dissertation focus on short-run inflation expectations, which are defined as expectations for approximately up to one year ahead. While

the policy for some countries provides place to long-run inflation expectations² when thinking of anchored expectations, most models still acknowledge the important influence of short-run inflation expectations on current inflation. Particularly due to shocks and events in recent years, short-run inflation expectations have been shown to be more responsive to inflation surprises, whereas, on the contrary, long-run inflation expectations have become less responsive (see Armantier et al., 2022). This indicates that when thinking about longer horizons, consumers do not consider recent inflation movements as much as they did before these recent economic shocks and that short-term price changes are, in general, not expected to persist into the future.

Generally, central bankers and economists still lack a complete understanding of how consumers' inflation expectations are formed. In the fight for surging prices and interest rates, central banks should recognise that consumers often lack basic economic or financial literacy, have limited attention spans, and that information rigidities exist (Larsen et al., 2021; Lamla and Lein, 2014). Recognising these factors is important for fiscal and monetary policy implications since their effect is reduced due to households not forming their expectations in line with economic incentives (D'Acunto et al., 2019).

A better understanding of the process of how consumers' expectations form would not only improve a bank's own credibility but also help in forecasting these expectations and evaluating their transmission to economic decisions. Naturally, many questions arise. How should central banks best monitor consumers' inflation expectations? What is there to be gained from another measure of inflation expectations? How should the communication process look to guide consumer expectations? This dissertation proposes solutions and answers to these burning questions.

Aim and Tasks of the Research

In most macroeconomic models, inflation is driven by three key factors: the measure of economic slack or resource utilisation (e.g., output, employment, unemployment, and corresponding gaps), past inflation due to rigidities such as indexing, and – most importantly, for the objectives of this dissertation – the expectation of future inflation, which is to say inflation expectations. While the weights of these factors change depending on the model, the expectations of households, firms, and the central bank are always of crucial importance, and a key input both in models on inflationary dynamics and in models focused on evaluating monetary policy. Recent studies show that forward-looking measures of inflation do a better job explaining inflation than do the measures of past inflation (see Fuhrer and Olivei, 2009).

² Long-run inflation expectations highlight an economic agent's beliefs in the central bank's ability and willingness to achieve its inflation targets.

The aim of this dissertation is to provide evidence that the key to the inflation targeting area of economic policy is in understanding and forecasting inflation and inflation expectations and ensuring relevant communication. This evidence is provided through an empirical assessment of inflation expectations vis-a-vis headline inflation for leading macroeconomic models and through forecasting exercises. Additionally, this dissertation proposes a novel way to measure consumer inflation expectations, which can act as an alternative input variable in economic models, as well as for policy and decision-making.

To fulfil its research aim, this dissertation also sets out to review and identify drawbacks in using traditional inflation measures and commonly used measures of inflation expectations. One advantage of this dissertation being written during the years running up to 2024 is the advancements in computational technologies during the last decades, which allows one to build novel methods and identify previously unavailable data sources that can act as alternative measures and proxies for inflation and inflation expectations. The challenge is, however, to quantify the information in some of the data sources or build models that are at least as robust as naïve benchmark models or that can even outperform them in forecasting. Another challenge is to understand exactly how well central banks communicate their policies, including for the purpose of keeping inflation expectations anchored.

Figure 2 presents a stylised overview of the transmission mechanism of inflation expectations for different economic agents and for the transmission of monetary policy. The figure illustrates how different channels matter for inflation expectations. For instance, the inflation expectations of households and firms matter via the real interest rate impact on spending decisions and wage setting. The inflation expectations of financial markets, on the other hand, matter for the setting of asset prices and financing conditions. Lastly, the impact of professional forecasters on inflation expectations works via being an information source for the other agents mentioned, which themselves are relevant to the monetary transmission mechanism. Thanks to its role in the wage and price-setting process, inflation expectations are also an important determinant of future inflation. On the other hand, monetary policy guides economic agents' expectations of inflation and influences economic activity and inflation, affecting household consumption and wage-related decisions, as well as investment and price-setting decisions for firms.

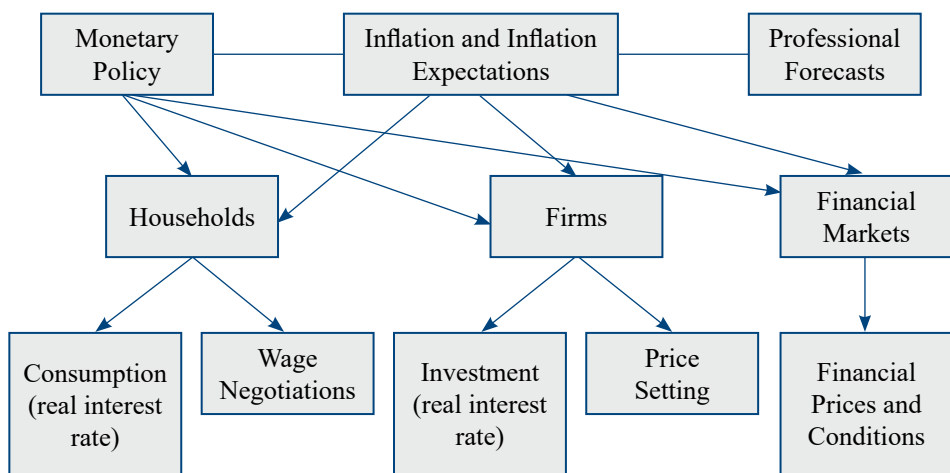


Figure 2: Transmission Mechanism of Inflation Expectations.

Sources: ECB (2021) with modifications by author

The empirical exercises in this dissertation provide verification for the aim of the research, and the following research tasks are carried out to support it, as outlined in Table 1.

Table 1. Research Questions

Study	Research Questions	Tasks
I	<u>RQ1</u> : How good are models that link inflation and economic activity measures in predicting to inflation?	<ol style="list-style-type: none"> 1. To investigate the forecasting performance of Phillips curves, both for the headline and core inflation rate contributing to the literature on which inflation measure helps forecast the inflation best. 2. To evaluate the performance of Phillips curves once an inflation targeting regime is adopted. To analyse the cut-off point when the performance changes.
II	<u>RQ2</u> : How well can online news provide a real-time indication of consumers' inflation expectations?	<ol style="list-style-type: none"> 1. To explore online news as a potential data source for capturing and measuring inflation expectations. 2. To propose a potentially real-time measure of inflation expectations to be used in forecasting. 3. To evaluate the forecasting performance of machine learning models, incorporating a novel news-based indices to simple autoregressive models. 4. To evaluate the forecasts of both inflation and inflation expectations.

Table 2. Continued

<i>Study</i>	<i>Research Questions</i>	<i>Tasks</i>
III	<u>RQ3:</u> How well can news-based measures be used as real-time alternatives for inflation expectations?	<ol style="list-style-type: none"> 1. To evaluate Euler's equations and their various specifications by conducting empirical analyses on their performance. 2. To infuse a novel news-based measure of inflation expectations in the real interest rate calculations and then in Euler's models. 3. To compare the estimates of models based on news-based inflation expectations with those based on traditional inflation measures. 4. To evaluate the impact of news-based inflation expectations and different components of consumption.
IV	<u>RQ4:</u> How it is possible to quantify central bank communication for obtaining more information on the policy reaction function?	<ol style="list-style-type: none"> 1. To use textual data to increase the amount of information in policy reaction function model estimates. 2. To determine how machine learning methods can be used in determining the function of central bank communication.

Structure of the Dissertation

This dissertation consists of three chapters. Chapter 1 provides an overview of the theoretical background of the research with the aim of providing the foundations and history of the models used within. The first section of the chapter provides a general overview of literature on inflation and discusses the implications on monetary policy of having low or high inflation. Inflation targeting and its positive effect on the economy are discussed briefly, since all four studies of this dissertation focus on inflation targeting countries, such as New Zealand, Sweden, Canada, and the United Kingdom, as well some Eurozone countries.

Recent changes in price levels are also examined in this section, along with a review of recent papers that focus on understanding the effects of such price changes in “untypical industries”³ due to the geopolitical and epidemic shocks witnessed in the last years leading up to the writing of this dissertation. Lastly, various measures for inflation are discussed, which includes headline inflation measures as well as core measures, either based on exclusion methods or trimmed-mean (also called median) methods.

The second part of Chapter 1, section 1.2, explores common forecasting methods in macroeconomic literature and summarises the findings. A focus is placed on New Keynesian Phillips curves models, not only because of their popularity in economic literature and applications in central banking, but also as a

³ Here, “untypical industries” refer to those not commonly affected by political shocks, such as airlines, accommodations, retail, and the shipping industry.

highly discussed model for portraying the relationship between inflation and the real economy, and because it is often used for forecasting the inflation rate. Section 1.2 also discusses the limitations and shortcoming of the models, which are important to address since the performance of Phillips curves models is mixed and depends on the choice of the underlying data, model, and other parameters. When aiming to understand what models and measures work best for forecasting and modelling, one also needs to evaluate the impact of the introduction of machine learning to economics as well as enhanced computing power on the performance of the economic models. An updated literature review in this section puts the focus on the machine learning methods that are currently employed by central bankers or academics for forecasting inflation.

Section 1.3 and 1.4 aim to reinforce the reader's understanding of the role of inflation expectations and its link to inflation dynamics, and thereby presents relevant literature that provides the supporting theoretical and empirical evidence. The challenges economists and policymakers face in such measurements are also addressed, along with a review of the inflation expectation formation process. Up until recently, market or survey-based measures of inflation expectations would act as proxies of inflation or inflation expectations.

To complete the understanding of household inflation expectation formation, one must also consider the communication that consumers receive from the central banks, which helps to guide those expectations. Therefore, the last section of Chapter 1 focuses on the communication from central banks through various forms of media. Chapter 2 provides an overview of the research methodologies and dataset used in this dissertation. While Chapter 3 consists of four empirical studies that cover the aforementioned research questions and comprise this dissertation. The first paper, denoted Study I, studies the ability of various Phillips curve specifications to forecast future headline and underlying core inflation measures for Sweden, Canada, and New Zealand. The forecasting performance of these specifications is compared with simple benchmark models, and the changes in the performance and predictive power are assessed in light of adopting an inflation targeting regime.

Study II extracts a novel high-dimensional measure that corresponds to consumers' inflation perceptions from an online news outlet. The significant relationship between a household's inflation expectations and the news is documented and the forecasting performance of news-based indices is evaluated for different forecast horizons and model variations. Study III builds on the methodologies from Study II and develops a new measure of inflation expectations from online news sources and uses that to build a real interest rate that could capture an underlying base for consumer consumption and savings decision as described by the Euler's equation. The role played by the media for the formation of consumer inflation expectations is highlighted, and the potential to use it for other key macro-economic relationships is touched upon briefly. In Study IV, the communication reaction function of the European Central Bank is analysed with the topic modelling method and text mining. Quantitative Indices are built from speeches from the European Central Bank, which act as dependent variables in policy and communication reaction functions.

Figure 3 visualises the interactions between the papers of the dissertation, related to the main keywords of this dissertation and with key information of each study summarised in the boxes. Along with keywords of inflation, inflation expectations, and central bank communication, which form the foundations of the research aim of this dissertation, machine learning is another frequently occurring and prominent keyword, as the novelty of this dissertation is possible thanks to models and methods from the machine learning field. This includes, for instance, the text mining approaches used to process news data, as well as various clustering and variable selection methods, which are further described in Chapter 2.

Most relationships between keywords and studies, highlighted in Figure 3, are obvious and do not require further explanations, however, some do. For instance, Study I is indirectly linked to inflation expectations in the form of inflation forecasts, which is one of the tasks carried out in the paper. Similarly, Study I is also indirectly linked to central bank communication via its focus on inflation-targeting countries. Study III doesn't explicitly focus on central bank communication, but the findings of the paper allow us to quantify and understand inflation expectations better, providing a springboard for studying economic agents' decision-making stemming from central bank communications. While not explicitly added in Figure 3, but closely linked with the central bank communication is monetary policy. In other words, the communication of central banks makes monetary policy. When households and firms act in a forward-looking way, their inflation expectations are influenced by central banks via communication. This relationship between communication, monetary policy, and inflation expectations strengthens the interactions between the papers.

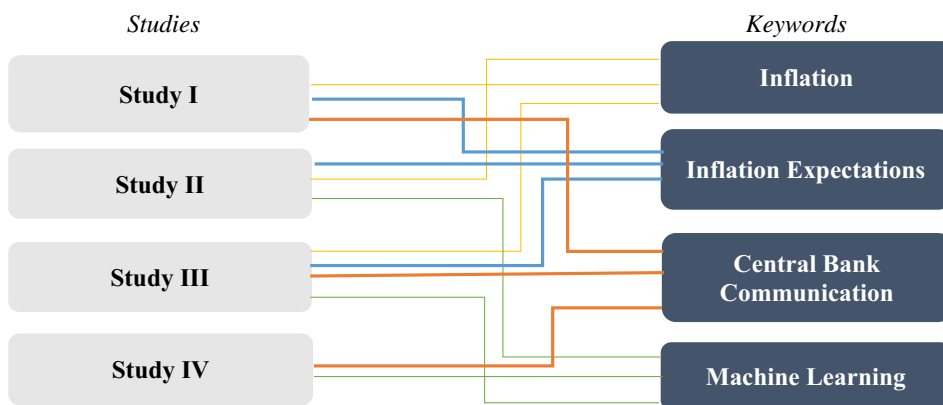


Figure 3: The interaction between the four studies of the dissertation.

Source: Compiled by author

The main findings of each paper, along with the policy implications and limitations, are summarised in Chapter 4, which also aims to relate the findings of each study to the research tasks outlined in the Introduction. Lastly, a number of ideas are suggested for further research, and general conclusions are presented.

Contributions of individual authors

Study I is a solo work. Study II is co-authored with Jaan Masso, and Lenno Uusküla, and Study III is co-authored with Lenno Uusküla. All authors contributed to formulating the research questions, choosing the research methodology, and formulating theoretical background as well as revising the manuscript for publication. Diana Gabrielyan was solely responsible for data collection, clean-up and processing, conducting the empirical analysis, and writing the manuscripts for the three studies.

Study IV is co-authored with Luca Alfieri. Diana Gabrielyan contributed to the text mining segment of the empirical exercise, as well as writing portions of the appendix and revisions of the paper after the first draft. Luca Alfieri was responsible for formulating the design and main idea of the article, performing regressions analysis and robustness checks, and writing the first draft.

Acknowledgments

This dissertation is the outcome of an exciting, albeit challenging, six-year journey. It was written in the period from September 2016 to December 2023 in various libraries, universities, airplanes, airports, cafes, ferries, trains, and accommodations all over the world. For my success, there are many people I owe my gratitude to.

First and foremost, I want to thank my PhD supervisors, Lenno Uusküla and Jaan Masso, for their patience, continuous support, flexibility, and openness to all my research ideas. They have provided me with guidance, expertise, and encouragement for independent research. Most importantly, I am thankful to them for believing in me all along and allowing me to take mental breaks when I needed them most. I am certain that this work would not be complete were they not my supervisors.

I would also like to thank my colleagues and fellow PhD students at the School of Economics and Business Administration for their support throughout the years and for making me feel part of the team even though I have not been a frequent visitor in the faculty. I especially wish to thank Luca Alfieri for co-writing a paper with me and for all the discussions on the exciting topics that eventually got included in this dissertation. I am also thankful to the doctoral seminar and summer school participants for their useful feedback over the years. I am also appreciative of the numerous opportunities the University of Tartu and the School of Economics and Business Administration provided me, such as participating in the 2022 Writing Retreat, which was pivotal in kickstarting my last empirical paper. My gratitude also goes to Anneli Kütt and Katrin Tamm for their help with a number of administrative matters.

I would also like to thank my PhD thesis pre-defence opponents, Eve Parts and Anita Suurlaht Donaldson, for their helpful feedback and notes, which helped to refine this thesis.

Part of this dissertation was written during my research stay at the University of Helsinki, for which I thank Antti Ripatti for welcoming me, even during the pandemic, and for giving me the opportunity to present my research and receive valuable comments from him and his team.

I am also grateful to my colleagues and supervisors outside of university and academia for their trust, flexibility, and understanding while I was pursuing my doctoral degree.

Above all, I am indebted to my family, my father, Bardukh Gabrielyan, my mother, Alla Khosrovyan, and my sister, Anna Gabrielyan, for their endless support, unconditional love in every way possible and inspiration to pursue this doctoral degree and become the fourth and the last (remaining) doctoral degree holder of my family. I am incredibly thankful to my mother: without her support, I would have quit my PhD studies during the first month, or the second month, or the first year – at the latest. Her encouragement and wise counsel motivated me to persevere and continue with my studies until I fell in love with my research. I also wish to thank my partner, Khachatur Hambardzumyan, for his understanding, keeping up with my emotional outbursts and finding ways to entertain himself every evening while I was working on this dissertation. Hence, I should also probably thank Sony PlayStation and Netflix for keeping him company and allowing me to focus on my research.

Last but not least, I am thankful to all my friends all over the world, both in and outside of research, who have supported me with their advice, comments, suggestions, and words of encouragement, thus empowering me and allowing me to share my feelings, frustrations, and happy moments with them.

1. THEORETICAL BACKGROUND FOR THE ARCH

1.1 The Role of Inflation

“Price stability [...] is a good thing in itself, for reasons that economists understand much better today than they did a few decades ago. Inflation injects noise into the price system, makes long-term financial planning more complex, and interacts in perverse ways with imperfectly indexed tax and accounting rules.” Ben Bernanke (2007)

A crucial role of a central bank is to ensure economic and financial stability. This means that central banks aim for a low and stable rate of inflation. When consumers and firms do not have to worry about big changes in prices, in either direction, prices are considered stable (Bernanke, 2007). An optimal rate of inflation should be non-zero and positive but at moderate levels. Neither too high inflation nor too low inflation are good for the economy. High inflation leads to lower purchasing power and uncertainty related to savings and investments. Whereas a persistent decline in the level of prices, known as deflation, leads to wage cuts, increases in unemployment, and the uncertainty and straining of the economy. Monetary authorities such as the Federal Reserve, the European Central Bank (ECB), and the Bank of England find low and stable inflation to be their major objective (see Federal Reserve System, 2016; ECB, 2021a, ECB, 2021b; Bank of England, 2022).

To help households and firms plan for the future, many central banks have adopted inflation-targeting (IT) regimes. The introduction of inflation targeting dates back to 1990 in New Zealand and ever since, its popularity has grown; nowadays, nearly 40 central banks around the world use this approach (Roger, 2010). For example, the Federal Open Market Committee (FOMC) in the United States, the European Central Bank in the Eurozone, and the Bank of England in the United Kingdom have adopted inflation targeting and have set the inflation target at 2%. As stated on the ECB’s website, “An inflation rate of 2% is low enough for the economy to fully reap the benefits of price stability” while also underlining the ECB’s commitment to its monetary policy goals (ECB, 2021b). A positive inflation target, set around 2%, acts both as a safety margin against the risk of deflation and as a sufficient margin to allow for downward wage rigidities, positive measurement bias in the price index and a smoother adjustment of macroeconomic imbalances across the Eurozone (Kilponen and Kontulainen, 2021).

The positive effects of IT on the economy are highlighted in the literature. A recent paper by Arsic et al. (2022) evaluates the effects of IT on macroeconomic performance for 26 small open economies, which includes former socialist countries of Europe and Central Asia. Their results suggest that, as expected, the introduction of IT improves a country’s macroeconomic performance

and is successful in reducing the inflation rate, as well as inflation and GDP volatility. Abo-Zaid and Tuzemen (2021) even find that an inflation-targeting regime in developing countries is also associated with higher and more stable GDP growth. These results are also supported by a study on 36 countries by Gonçalves and Salles (2008), where inflation-targeting countries demonstrated significant drops in inflation rates and volatility of GDP growth rates. Additional benefits, as suggested by the literature, are unemployment reduction, the establishment of fiscal discipline, and increasing the credibility and analytical capabilities of central banks to forecast and model economic developments (Svensson, 1997; Mishkin, 1999; King, 2002; de Mendonça and de Guimarães e Souza, 2012).

There are also sceptics of the regime or, more specifically, those who believe the economic benefits are not due to inflation targeting. However, the benefits might extend beyond the countries that have adopted IT (see Ball and Sheridan, 2005; Lin and Ye, 2007; and Sims, 2005). Since inflation targeting regimes put greater focus on central banks' transparency and credibility in conducting monetary policy in turbulent times and for introducing and analysing novel inflation measures, these characteristics – transparency and credibility – are crucial.

Even with the adoption of an IT regime, prices and, consequently, the consumer price index (CPI) may still fluctuate substantially due to various economic shocks, seasonality, and so on. Hence, economists have sought a less volatile measure of inflation, which would filter out the transitory effects of large price changes unrelated to changes in cyclical inflation pressures. This core measure of inflation, first developed by Gordon (1975), is most often the one used in decision making and forecasting frameworks. Earliest core measures, up until the 1990s, were calculated as headline inflation minus the prices of select items. Commonly, excluded items were, and still are, food and energy as they usually account for the biggest price fluctuations, but, of course, price changes in other sectors may also cause volatility in inflation. See Figure 4 for the dynamics of EU headline inflation alone and core inflation, defined as headline inflation excluding food and energy prices. As can be observed from Figure 4, the underlying inflation, CPI inflation excluding food and energy prices, is more stable in general thanks to the exclusion of those two most volatile components. However, in the last two years, even underlying inflation has spiked, albeit it has remained lower and more stable than headline inflation. It can also be noted from Figure 4 that, starting from late 2022, headline inflation starts to go down, driven by the fall of energy costs, even though food prices still keep upward pressure on prices.

There are other ways to filter out volatility from headline inflation, which are based on medians or trimmed means⁴ and instead of excluding items, outliers are excluded from the distribution of price changes across sectors. Such measures have gained increasing popularity since the 1990s (see Bryan and Pike, 1991; Dolmas, 2005; Dolmas and Koenig, 2019). A paper by Dolmas and Koenig (2019) shows that the trimmed-mean personal consumption expenditure measure of

⁴ A trimmed mean rate of inflation is calculated as the average rate of inflation after trimming away a certain percentage of the distribution of price changes at both ends.

inflation might be more successful in filtering out variation in headline inflation than personal consumption expenditure excluding food and energy prices, i.e. the traditionally used core inflation measure. Their inflation forecasts, using a real-time trimmed mean method, sometimes even outperform models that try to predict headline inflation directly.

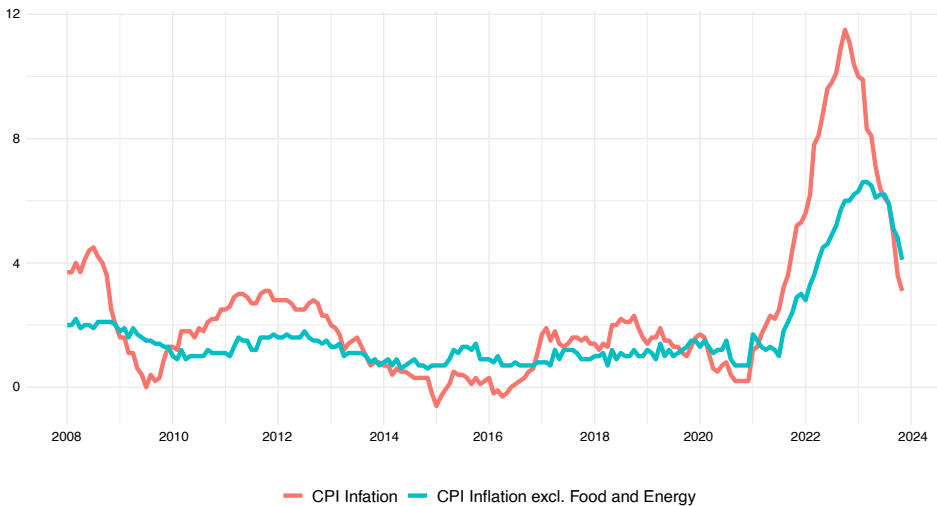


Figure 4: EU Total CPI Inflation and CPI Inflation less food and energy, January 2007 to November 2023.

Source: OECD

More recently, the period of the COVID-19 pandemic has been fruitful for inflation research as the economic disruptions have caused extreme price variations in untypical industries, such as airlines, accommodation, real-estate, and clothing. The traditional headline-excluding-food-and-energy measure of core inflation has been almost as volatile as headline inflation and has performed poorly in most countries. In the United States, for instance, the least volatile measures of inflation during 2020–2021 have been the median inflation rate, the trimmed mean inflation rate, as well as the sticky-price inflation rate (Ball et al., 2021). For more discussion on core inflation measures, see Wynne (2008), which provides a good overview of the history of core inflation and reviews various measurement approaches.

1.2 Forecasting Inflation

With regards to the forecasting powers of core and headline inflation measures, the prevailing view is that core inflation measures are better predictors of total inflation (Dolmas and Koenig, 2019). However, there are also studies pointing to the dependency of a good performance on the time horizon of the forecast, and

on how the inflation is measured, e.g. whether its trimmed-mean and median methods, excluding certain sectors, and so on. Hence, core inflation might not necessarily be the best predictor of inflation; such results are found in Crone et al. (2011) and Crone (2013). Overall, the literature shows results that are mixed and even contradicting. After reviewing several measures, Verbrugge (2019) comes to a similar conclusion.

Regardless of which measure of inflation a central bank selects as the inflation metric, accurate inflation forecasts are critical for policy decisions and are key components of a forward-looking monetary policy. Literature on forecasting inflation is extensive, and there are a number of papers that evaluate the forecasting performance of various economic models, from simple autoregressive or random walk models to Phillips curves, triangle models, time-varying trend models, and combination models, to various extensions of these. The results of these are again quite mixed and depend on the inflation measure used (CPI inflation, core inflation, etc.), time horizon, country, and the model. As an example, time-varying trend models have performed much better for Australia in terms of forecast errors at short horizons than the autoregressive or Philips curve models (Guo et al., 2022). For the United States, generalised Phillips curves based on an aggregated index of real activity (that excludes unemployment) have shown better performance (Stock and Watson, 1999). Other notable papers in the field of inflation forecasting are Stock and Watson (2008) and Faust and Wright (2013).

Most popular models, until the last decade, have utilised (vector) autoregressions, random walks, or Phillips curves. Recently, there has been an increase in the use of machine learning (ML) methods for predicting inflation, especially since the amount of data has skyrocketed as new data sources have become available (e.g., news data, speeches, press releases, online prices, survey data, etc.) Most of these research papers find that ML models, such as random forests, ridge regressions and neural networks, are more accurate than traditional benchmark models, especially when the number of covariates is large. See, for example Chakaraborty and Joseph (2017), Garcia et al. (2017), Nakorji and Aminu (2022), and Medeiros et al. (2019).

All in all, despite the newly available alternative models, Phillips curves are one of the most popular and widely used models used to describe inflation dynamics. Alan Blinder, even called Phillips curves the “clean little secret of macroeconomics”⁵. The ECB, for example, routinely deploy Phillips curves as part of their analytical toolkit to analyse and communicate inflation and wage growth developments.

New Keynesian Phillips curves are modelled as a function of past inflation and other variables, such as inflation expectations, unemployment rate, output gap, etc. The unemployment rate, or unemployment gap, commonly appears in Phillips curves, as it is a good measure of economic slack due to the co-movements with the measure of economic resources usage.

⁵ As seen in Remarks at the Senior Executives Conference of the Mortgage Bankers Association, New York, N.Y., January 10, 1996.

The Phillips curve relationship can be summarized using the following equation: $\pi_t = E_t\pi_{t+1} - \beta(u_t - u_n)$, where coefficient $\beta > 0$, π_t is inflation and $E_t\pi_{t+1}$ is expected inflation at period t , u_t and u_n are unemployment at time t , and the natural rate of inflation rate of unemployment (NAIRU)⁶, respectively $(u_t - u_n)$ is the difference between the unemployment rate and the natural unemployment. Instead of the unemployment gap, there are ample ways of measuring economic slack. A Phillips curve equation can be interpreted both as a response of price to demand and supply, as well as a price-setting equation. If expectations are rational, then $\pi_t = E_t\pi_{t+1}$ and $u = u_n$.

The short-run Phillips curve shows an inverse relationship between inflation and unemployment, whereas the long-run Phillips curve is a vertical line at the u_n , signalling no trade-off. This is because the natural rate of unemployment is achieved only temporarily by generating inflation in excess of economic agents' expectations. This, however, causes workers to demand higher wages, which brings the unemployment rate back to its natural rate and equilibrium is established at a higher inflation rate.

Nevertheless, the stability of Phillips curve models has been under question in the last few decades due to the declining slope of Phillips curves; some researchers would agree that the relationship between inflation and economic activity does not hold any more and that the Phillips equation is no longer a useful descriptor of inflation dynamics (see Coibon and Gorodnichenko, 2015a; Atkenson and Ohanian, 2001). However, one possible explanation may be that inflation has been relatively steady in the last decades and, as such, the basic mechanism of a Phillips curve in connecting demand, supply, and prices is no longer useful or working.

However, is the announcement of the death of the Philips curve premature? While effective monetary policy has kept inflation at target, can global forces change inflation dynamics? At least for developing countries, Jordà et al. (2019) suggest that Phillips curves might still be at play, arguing that while inflation has stayed low in developing countries despite low unemployment rates, there is a hint that the role of past inflation remains dominant in explaining current inflation. Phillips curves also find support in McKnight et al. (2020), who find that theory-based forecasts outperform hard to beat naïve benchmark models, while Banbura and Bobeica (2022) find that Phillips curves help to forecast Eurozone inflation, but conditional on choosing the specification.

One also must consider that changes in some of the Phillips curves components (e.g., inflation expectations, imported input prices, and the behaviour of economic agents) can lead to a shift in the relationship, yet the slope might remain unaffected. Failure to find evidence of inflation and unemployment trade-off can also be attributed to weaknesses in econometric approaches, non-stationarity of variables, and the presence of endogeneity, etc. For instance, Hindrayanto et al. (2019) find that Phillips curves are still alive for Eurozone countries and the

⁶ This is the unemployment rate that exists when the economy is at potential GDP and is often referred to as non-accelerating inflation rate of unemployment (NAIRU).

heterogeneity in results is potentially due to the differences in the structural characteristics of the labour markets and productivity across the countries. Equally important factors to consider in inconclusive Phillips curve model results are the limitations of the data, for instance those of survey measures, discussed in other sections. In summary, as with any other model, Phillips curves come with their limitations and shortcomings.

In Chapter 3, an empirical study on the forecasting performance of Phillips curves is presented. My findings support the above discussion on the episodically successful performance of Phillips curves, and suggested forecast horizons are presented.

1.3 Inflation Expectations and Their Formation

“I am not saying what [inflation expectations] is a function of. We know it’s a very difficult issue, but that is the key variable. It’s important, but just because we can’t make a judgment as to what these driving forces are in an econometric sense doesn’t mean that it’s not real.”
Alan Greenspan (1994)

Economic theory puts a special emphasis on inflation expectations as one of the drivers for inflation. Therefore, it is important to acknowledge the role inflation expectations play on actual inflation dynamics and their role in policymaking. Whereas the definition of inflation expectations is self-explanatory, what is not self-evident from this definition is the magnitude of the impact these expectations have on people’s behaviour, considering that households and firms base their decisions on how they see the future of the economy evolving.

When too high inflation persists, inflation expectations rise and one of the many outcomes of such a rise is that employees start to demand a wage increase to make up for the loss in purchasing power. Similarly, all else equal, when inflation expectations rise, actual inflation tends to increase as well: once firms increase employee wages, operating costs increase, which pushes firms to raise the prices for their products and services. Macroeconomists call this a “wage-price spiral”⁷ (Blanchard, 1986). The reverse holds as well: when inflation is too low, expectations fall as well, increasing the risk of constantly falling prices. Falling inflation and inflation expectations also affect interest rates, as borrowers and investors make their decisions based on such economic outlooks.

Clark and Davig (2008) analyse the response of inflation to shocks on inflation expectations through many vector autoregressive models, which allow for a direct and non-restrictive assessment of the relationship between the two. They consider

⁷ This concept was first used in an article in the New York Times related to a steelworker strike in 1937.

shocks to inflation expectations that are not captured by other variables of the model and cannot be measured adequately, for example, shifts in the perceived credibility of monetary policy or news on the economic outlook, and their findings reinforce the impact of expectations and shocks on inflation. The impact is not always homogenous across short-term and long-term inflation expectations, but the difference is not necessarily substantial. Overall, the empirical evidence from Clark and Davig (2008) supports the theory that long-term survey measures can act as an excellent proxy for the underlying trend rate of inflation, which exerts more influence on short-run inflation expectations than past inflation.

Both inflation and inflation expectations appear in virtually all key macroeconomic models that feature the nominal side of the economy. Expectations are an important input in any intertemporal consumption or investment decision models. The famous consumption model of Euler, which summarises the relationship between interest rates, consumption, and expectations about inflation, is a great example. Euler's model consists of a forward-looking consumption component (Δc_{t+1}), which is the change in consumption and reacting negatively to the real interest rate (r_t), due to the intertemporal substitution (σ). A simple Euler's model equation is as follows: $\Delta c_{t+1} = \alpha + \sigma(i_t - \pi_{t+1}) + \varepsilon_{t+1}$, where π_{t+1} and ε_{t+1} are next period inflation and error term, respectively, and i_t is the nominal interest rate. For forward-looking monetary policy, expected interest rates are just as important as current policy rates. As Woodford (2001, p. 12) notes, "successful monetary policy is not so much a matter of effective control of overnight interest rates... as of affecting... the evolution of market expectations."

According to the Fisher equation⁸, the real rates are a combination of nominal interest rates and inflation expectations. The Euler equation implies that low interest rates bring higher current consumption in the cost of lower future consumption since savings lose worth. Of course, different consumption components may be affected differently, and, for example, agents may decide to spend specifically on a particular type of goods, such as real estate, buildings, etc. For example, Ichiue and Nish Iguchi (2015) test the link between household consumption and the inflation expectations of Japanese households and find that when these households report higher inflation expectations, they increase current consumption by reducing planned savings. Dräger and Nghiem (2021) likewise confirm that macroeconomic expectations matter for economic decisions for German households. They provide a good overview of the related literature, including a few recent papers that report an insignificant link between consumer inflation expectations and consumer readiness to spend on particular goods.

D'Acunto et al. (2022b) provide a good discussion and empirical evidence on how inflation expectations relate to the intertemporal consumption choices of households and the financing of such decisions. Besides intertemporal consumption choices, inflation expectations also affect other economic decisions, such as

⁸ The Fisher equation is as follows: $R = r + \pi$, where R and r are nominal and real interest rates, respectively and π is the inflation.

mortgage and portfolio choices, financial investments, and wage bargaining (Bernake, 2007).

Yet another related role of inflation expectations is how it assists in forecasting inflation. It has been shown in a number of studies that models including inflation expectations have smaller forecast errors (see Tallman and Zaman, 2020; Faust and Wright, 2013; and Chan, Clark, and Koop, 2018). This also applies to forecasting using Phillips curves. As was discussed previously, many papers have declared the death of Phillips curves (e.g., Hall, 2013; Ball and Mazumder, 2011; and Blanchard, 2016) triggered by the resilient inflation rate after the Great Recession followed by surprisingly low inflation after the economic recovery. At the same time, research consistently finds that consumer inflation expectations (including survey-based expectations) deviate from assumptions of FIRE, and some studies on Phillips curves suggest that when this is taken into account, the death prognosis of Phillips curves may be premature.

When using survey expectations in Phillips curves, many of the model's shortcomings are overcome, the predictive power is increased and the Phillips curves become more stable. For instance, in Coibon et al. (2018), when real-time expectations are incorporated in the New Keynesian Phillips curve and deviations from FIRE are allowed, a number of the shortcomings of Phillips curves that appear under FIRE assumption are addressed. These include a lack of persistence, the need for ad-hoc lags, periods of missing dis(inflation), and the low out-of-sample predictive power of Phillips curves. For more literature on Phillips curves performance with inflation expectations, see Fuhrer et al. (2012), Coibon and Gorodnichenko (2015a), and Adam and Padula (2011).

1.4 Measuring Inflation Expectations

As past inflation cannot be changed, central banks aim at anchoring inflation expectations at the inflation target. Hence, unsurprisingly, the preferred scenario of central banks is when inflation expectations are anchored at the target or, if deviated, quickly return to it. In the context of monetary policy, anchoring refers to inflation expectations being insensitive to the data and staying at target levels. The more strongly inflation expectations are anchored on actual monetary policy goals or targets, the more effective monetary policy will be in achieving its goals.

While inflation expectations are usually 'well-anchored' in normal times, such is not always the case during volatile times. Various economic and political shocks cause inflation expectations to rise by generating persistent increases in inflation. As Mester (2022, p. 3) states in a speech for Federal Reserve Bank of Cleveland, "while the theory is compelling, the real world does not always cooperate". For instance, inflation expectations have deviated significantly for Japan for many years (see Hattori and Yetman, 2017), and the core inflation measure has been running below the target for years in the United States (see Bednar and Clark, 2014).

Indeed, even though inflation expectations are much better anchored now than they were decades ago, there is much evidence to suggest that they remain imperfectly anchored. One such study is by Gürkaynak et al. (2005), where long-term inflation expectations are shown to react significantly to unexpected components of monetary policy announcements and macroeconomic data releases. This reaction violates the assumption of inflation expectations being time-invariant, and, therefore, inflation expectations cannot be considered to be strongly anchored. Similarly, Levin, Natalucci, and Piger (2004) show that some survey measures of inflation expectations also react to changes in the actual rate of inflation in the United States.

It is also worth noting that there is heterogeneity in the extent of ‘anchoring’ in long- and short-term inflation expectations. Long-term inflation expectations carry more variability over time and are rarely perfectly anchored in real economies. However, economists may still consider long-run inflation expectations well anchored when consumers react insignificantly to higher inflation.

The challenge is that households and firms may interpret inflation numbers differently and their expectations of the future rate of inflation may be different from central bankers’ or professional forecasters’ predictions. Such heterogeneity between consumer demographics is partly due to varying economic environments and daily activities. For example, women tend to systematically expect higher inflation than men (D’Acunto et al., 2021; Jonung, 1981), younger consumers’ inflation expectations are lower (Malmendier and Nagel, 2016), while those with lower cognitive abilities have higher inflation expectations compared to others (D’Acunto et al., 2022a). In another study, findings point to lower financial literacy being related to higher inflation expectations (Bruine de Bruin et al., 2010). Similar findings by Burke and Manz (2011) suggest that consumers who are more economically literate choose more relevant information when forming inflation expectations and hence make better forecasts.

There are various ways to measure inflation expectations, from consumer surveys to forecasts by professional economists and through financial instruments (D’Acunto et al., 2022b). The simplest approach is to use direct estimates from consumer surveys and those from professional forecasters. However, in addition to already existing demographic-based heterogeneity, there are also other fundamental problems with both consumer and professional survey data.

For one, household survey answers tend to be skewed, and factors like a household’s consumption basket, prior (possibly) inaccurate memories, shopping habits, and dispersion in cost of living can create a significant bias. Georganas et al. (2014) find that the perceived inflation rates of consumers are biased toward the goods they often buy, while Coibon and Gorodnichenko (2015b) find that oil prices may have higher effect on inflation forecasts for households with a higher share of gasoline in their consumption basket. Survey answers can also be inaccurate due to inaccurate memories, for instance, when trying to remember previously seen supermarket prices at the time of answering surveys (Cavalho et al., 2016). As for professional forecast data, while such data do not represent a specific group of economic agents, there is evidence that trade unions and firms

may use professional forecasts as an information source to form their inflation expectations (ECB, 2021). The problem with professional forecasts, however, is that professionals may often hide their true beliefs for a variety of reasons. One such reason, as suggested by Croushore (1997), is that the forecasters might strategically misreport information to bring their forecasts toward the consensus in order to avoid unfavourable publicity when wrong. For more discussion on this, see Ottaviani and Sørensen (2006) and Laster et al. (1999).

Another measure of inflation expectations comes from the financial markets. Examples include data from inflation-linked securities, such as swaps or differences in yields for securities or index-linked stocks. The advantages of such data are real-timeliness, high frequency, and being entirely forward-looking and, therefore, suitable for inflation forecasting. However, these measures include risk premia, as investors are naturally risk-averse to inflation risk. Moreover, market-based expectations may contain a relatively short history compared to survey data and may also be affected by the mathematical effects of bond convexity⁹. When adjusted for risk premia, differences between market and survey-based measures of inflation expectations might decrease, but one still needs to consider the market distortions that affect the information content.

Regardless of the measure of choice, it is important to acknowledge the unavoidable deviations of inflation expectations from the FIRE paradigm. The models that account for these differences and the heterogeneities, which are described above, are very promising (see Bordalo et al., 2020; Malmendier et al., 2020).

1.5 News, Communication, and Expectations

“Changes in communication are very keenly noticed and analysed. And it is not only what is said but also what is left unsaid that can send a message.” Jens Weidmann (2018)

Market players update their inflation expectations as new information is released. This highlights the importance of high-frequency real-time data for the accurate formations of inflation expectations. As mentioned earlier, available survey-based inflation expectations have low frequency, and the high-frequency market-based forecasts involve risk and may be uncertain. One way to overcome this issue of low-frequency-but-more-reliable and high-frequency-but-unstable data problem is to use the high-frequency multidimensional textual data available on the internet, which makes it possible to build an indicator that is not included in the official statistics.

⁹ Bond’s convexity shows how its duration changes as yields change and shows the relationship between bond price and yield. Convexity arises due to the shape of the price-yield curve.

The idea is that this textual data may contain information about inflation expectations (and not only) that are not included in survey data. Throughout this dissertation, text mining, a branch of machine learning, is utilised. Notably, the ability of text mining to convert large collections of text from an unstructured to a structured form allows for the in-depth quantitative and qualitative analysis of online news websites. For an introduction to text mining and its application in central banking, see Bholat et al. (2015).

One known and well-established source of communication to households is media. Frequently, news is a household's primary and preferred source of information (Blinder and Kureger, 2004; and Curtin, 2008). By analysing news content, one can understand the importance a given topic has on the current and future economy based on the intensity and the extent of how much it is discussed in the media (Larsen et al., 2021). Most economic agents, from households to firms to investors, follow daily news and incorporate interpretations from their own views and expectations. Essentially, news is the societal narratives expressed through the texts. Even though using textual data from the news is a relatively recent trend in the literature, there are already a number of research papers that use such rich data sources for policy analysis, forecasting, modelling and understanding consumer behaviour.

Relevant to this dissertation is the literature that studies the impact of news narratives on inflation expectations. Back in the early 2000s, Doms and Morin (2004) conducted an empirical study using The Economist's recession index to extract a measure of economic reporting for the US and found that during times of high news coverage, consumer inflation expectations were updated more frequently, highlighting that news matters. Households were also more receptive to negative news (Pfajfar and Santoro, 2013).

A number of studies also found evidence of the positive impact of news on inflation and inflation expectations forecasts, for example, Mazumder (2021) and Larsen et al. (2021). One paper by Larsen et al. (2021) is particularly interesting as it also offers an analysis of the role of inflation expectations in information rigidities and finds that relevant news coverage helps to explain the degree of information rigidity among households. In a slightly different forecasting exercise, Shapiro et al. (2022) use a computational text analysis of 16 economic and financial news outlets in the United States to assess time series measures of economic sentiment and find that daily news sentiment is predictive of movements of survey-based measures of consumer sentiment.

Besides the United States, the relationship between news and inflation expectations has been explored, studied, and validated for many countries. For German households, Lamla and Lein (2014) found that both the volume and tone in the media coverage of inflation-related topics influence the inflation expectation formation of consumers. Dräger and Nghiem (2021) reinforce this for Germany by analysing the impact of having read any financial or monetary policy news on the marginal effects of consumers' inflation expectations and interest rates on their spending decisions. Evidence points to the effects being especially strong

for those consumers who recall reading monetary news, i.e. news on monetary policy.

Thorsrud (2020) constructs an accurate new business cycle index for Norway based on quarterly GDP growth and extracted information from a daily business newspaper, which classifies the phases of the business cycle and provides meaningful insights on which types of news drive or reflect economic fluctuations. A paper by Jansen and Neuenkirch (2017) on Dutch households reached similar conclusions on the relationship between inflation perceptions and news consumption, proving that the perceptions of recent price changes as covered by the news are an important driver for inflation expectation accuracy in the period of one year ahead.

Empirical evidence on the impact of media on inflation expectations pushes forward the studies on the relationship between central bank communication and agents' economic choices. In general, monetary policy communication should be simple, direct, and provide a holistic perspective to avoid misinterpretation. In times of low inflation, such communication might not be an issue, but when inflation is high and the global economic landscape is volatile, a lack of appropriate communication is problematic. The communication from central banks should convey the monetary objectives clearly and transmit the policy's reaction function.

In the central banks' policy reaction function, the main policy instrument is the interest rate, which depends on both inflation and the output gap and as provided by Clarida et al. (1998), and looks like the following: $\bar{r}_t^* = \bar{r}^* + \beta_1 E_t(\pi_{t+n} - \pi^*) + \beta_2 E_t(y_t - y_t^*)$, where \bar{r}_t^* and \bar{r}^* are the desired and equilibrium interest rate values, respectively, and π_{t+n} and π^* are the n-step ahead and desired inflation rates, respectively. Output gap is denoted as the difference between the actual output y_t and potential output y_t^* .

The policy reaction function is the channel that provides insights into the factors influencing monetary policy (e.g., inflation targets, output, asset prices, and so on) to avoid uncertainties about how the monetary policy would respond to new information. Additionally, an effective reaction function describes how the monetary policy affects the behaviour of the economic agents and ensures close-knit interactions between central banks and these agents.

So, can central banks be effective in communicating their economic outlook to consumers? What does good central bank communication look like? For one, the monetary policy toolkit should include forward guidance, as it helps to explain a central bank's decisions¹⁰. Clear communication about future monetary policy intentions helps economic agents have a better understanding of current economic conditions and where the economy is headed and thus makes monetary policy more effective. In addition, a communicative central bank that positively

¹⁰ Some central banks, including the European Central Bank (ECB), consider forward guidance a non-standard, unconventional monetary policy to be used when the conventional policy tools were not working or meaningful anymore. The ECB and US Federal Reserve also announced plans to abandon forward guidance on rates and instead, as Lagarde notes, "make monetary policy decisions on a data-dependent basis" (Financial Times, July 2022).

affects the economy has the public's support in achieving the central banks' goals, particularly that of steering consumers' inflation expectations. To help guide these inflation expectations, central banks should ensure transparent and clear communication. As Weidmann (2018, p. 1) states in his lecture at the Centre for European Economic Research, "An independent central bank is not a state within a state and, in a democracy, it needs to explain its monetary policy".

Transparency strengthens public confidence and allows central banks to better understand the inflation expectations of economic agents. These agents themselves influence central banks via communication and by acting in a forward-looking way. This circular impact continues: the better the inflation expectations are steered, the better the central banks can control prices (in their goal of price stability) and aggregate demand. This highlights that a knowledge of monetary policy is relevant for inflation expectations (Cruijsen et al., 2015) and emphasises the role of the future expectations of key rates, such as inflation and interest rates, for the impact of monetary policy.

For two, monetary policy communication should aim to reach all agents (firms, financial markets, and the general public), which is not always the case (see Haldane and McMahon, 2018; Coibion et al., 2019). Blinder et al. (2018, p. 29) noted that "if researchers are interested in testing market responses to [central bank] communication, it may make sense to focus on statements that actually reach market participants, and on the content as conveyed by the media". In addition, it is important to recognise that firms and households may have a limited attention span, heterogeneity in beliefs, and potential for misinterpretation.

Information may also be fragmented and far from perfect (Cruijsen et al., 2015), and audiences may also lack economic and financial literacy. As such, reaching out to the young and less well-off consumer through central bank communication might be challenging. Pro-active communication to younger consumers is particularly important since they may not have been exposed to high inflation or economic crises during their lifetime and may be less likely to get involved in combating high inflation as a society (Ehrmann and Tzamourani, 2012). It may even happen that consumers, regardless of age, literacy, wealth, and education, are not interested in communications from central banks (Blinder, 2018). This disparity in the levels of the knowledge and understanding of agents is a serious challenge for central banks' communication.

One way for central banks to expand the reach of their communication is by using a variety of transmission channels, such as social media, television, news, speeches, and press conferences. This also allows for a more homogenous distribution of customer attention (Weidmann, 2018). Along with the aforementioned benefits of using news data, news is an excellent channel for central banks to reach the general public. As evidenced by Ter Ellen et al. (2020), relevant monetary policy communication does reach the public via news coverage, and as shown in Larsen et al. (2021), the general public does not need to know a lot about monetary policy or read a lot of news in order to learn and 'consume' what the central bank communicates. News outlets also act as information inter-

mediaries by allowing the monitoring of all key economic events, which is otherwise hard or even impossible for any single consumer due to a lack of resources (Nimark and Pitschner, 2019).

Central bank statements, minutes, press releases, and speeches are other channels to reach the public, albeit they are not as effective for reaching a wider group of economic agents, particularly those uninterested or unfamiliar with what central banks do. Still, these speeches, and statements, etc., are crucial means of communication for monetary policy decision makers, and central banks can use these information sources for other analyses as well. For instance, Hendry and Madeley (2010) use Latent Semantic Analysis to extract information from Bank of Canada communication statements and analyse which timeframe of information affects returns and volatility in short-term and long-term interest rate markets. The findings of El-Shagi and Jung (2015) reveal that the minutes of Bank of England's Monetary Policy Committee have contributed to market expectation formations on the future of monetary policy and helped explain future changes regarding the bank's rate. While, finally, Lucca and Trebbi (2009) measure the content of central bank communication about future interest rate decisions based on information from news sources. Thus, it has been shown repeatedly that, while not as effective as news outlets, other central bank data sources act as means of monetary policy communication.

2. RESEARCH DATA AND METHODOLOGY

Inflation analysis requires extensive data and a sufficiently long time-series. This section reviews in detail the data and the methodology of each study separately.

Study I employs data collected from three open economies, Sweden, New Zealand, and Canada, for the duration of 30 years. This includes the consumer price index (CPI) and underlying inflation. This underlying measure, otherwise known as core inflation, is used for robustness as the main results of the study focus on headline inflation forecasts. Both inflation metrics act as the main input for benchmark models and are also used in Phillips curve models on the left-hand side of the equation and as lagged measures corresponding to past inflation. In addition, Phillips curves also include a measure of economic activity.

The unemployment rate, capacity utilisation rate, and index of industrial production are chosen as measures of economic slack, all collected from the national statistic offices of the respective countries and other statistical databases. A version of a Phillips curves model, called the triangle model introduced by Gordon (1990), also includes supply side variables and, for this paper, oil prices are chosen for the latter model. In all models, to verify the robustness of the results, the gaps of economic measures are also used and are constructed using popular filtering methods, such as Hodrick-Prescott (HP) and Kalman filters. Data undergo a number of transformations, as is common when working with time series, such as seasonal adjustments, stationarity checks, lagging of variables, as well as some arithmetic computations (e.g., converting monthly data into quarterly data).

Models used in Study I follow the paper by Stock and Watson (2008). The use of autoregressive integrated moving average (ARIMA) and random walk models of Atkenson and Ohanian (2001) act as benchmark models for comparison while, for multivariate models, two versions of Phillips curves are employed: single-predictor autoregressive distributed lag models and the triangle models mentioned above. Forecasting performance is evaluated by comparing root mean squared errors of the multivariate models versus univariate simple models. The idea is to check if Phillips curve models outperform univariate models, since any good inflation forecasting model should be able to provide more accurate forecasts than a simple atheoretical no change forecast model, such as the naïve models.

Study II and III both use a variety of data, from traditional published data downloaded from official sources to novel data sources extracted from an online UK newspaper, The Guardian. The Guardian was chosen as it offers open-source access to its articles, starting from the early 2000s. This textual data is extracted by connecting to a ready-made Application Programming Interface (API) and with the help of many lines of code written in R language. Official data from both the Bank of England and the National Office of Statistics are also used and comprises of official inflation data, inflation attitude surveys that reflect the public's attitude toward the inflation, as well as consumer confidence survey data for Study III only.

The models used employ both types of data (official and novel) and are compared to one another in terms of their predictive performance (Study II) and in the estimate values when modelling household consumption (Study III). The biggest challenge with such data sources is that it comes in unstructured form, and many steps are required to convert the textual data into quantifiable numbers. In addition to various pre-processing steps suggested in the literature, another novel method that is applied here is topic modelling (see Blei et al., 2003), which allows grouping similar words into clusters and, hence, to extract various topics from the big newspaper corpus.

Latent Dirichlet Allocation (LDA) is used as the approach for the classification of texts into topics as it does so in a similar manner to what humans would do (Chang et al., 2009) and has proven to be a valuable tool in natural language processing for using texts as data (see Thorsrud, 2020; Hansen et al., 2018). Other methods exist as well, however, LDA has an advantage over them by delivering an interpretable output even though it's an unsupervised machine learning method. Following LDA, for each topic, a time series is built that shows the frequency with which each given topic is being discussed in the news examined.

For Study II, the data transformations end, and the resulting dataset is used for forecasting purposes using the LASSO model, a popular machine learning technique for variable selection. This technique is effective in identifying the most influential variables and helps overcome the problem of degree of freedom, commonly occurring with high-dimensional data. Alternatives to LASSO exist, such as LARS (least-angle regression) or factor models. However, LASSO does a satisfactory job in the context of the analysis of Study II, and its outstanding performance in variable selection is well-established in the literature (Ahmed et al., 2010; Medeiros et al., 2021).

In Study II, LASSO allows selecting topics that are more relevant for the prediction of inflation expectations. The argument is that not all topics have the same effect on consumers who read the news and, therefore, not all topics would be as useful in capturing and forecasting their inflation expectations. To evaluate the performance of the models, forecast errors are computed for different horizons and are compared to those from benchmark autoregressive models.

For Study III, news-based indices are initially built with the same approach as in Study II, however, they are also augmented by sentiment scores that measure the tone expressed by the articles' authors¹¹. For this, we use sentiment analysis, which essentially classifies news into positive, neutral, and negative news, assigning relevant scores to each article correspondingly. The final indices are infused in the real interest rate formula, which is then used in Euler's model of consumption, the main empirical model in this study. Various specifications of Euler's equations are constructed, following Ascari et al. (2021). This includes

¹¹ Studies II and III both employ similar data processing methods and approaches to building the measure of inflation expectations. However, since the aims and applications of each study are different, the versions of the final measures differ as well. For instance, the news-based measure of inflation expectations in Study II does not include sentiment indices.

baseline models, as well as those adding consumers' external and internal habits as covariates. Since Euler's equations link consumption with interest rates and inflation, the full dataset of Study III also includes consumption data (aggregate, nondurable, semi-durable) and data on nominal interest rates.

Lastly, in Study IV, the main data comprises the official European Central Bank's speech dataset that stretches back to 1997. The dataset contains speeches from ECB presidents, vice-presidents, and board members. This textual data undergoes various transformations and, here again, topic modelling is applied to cluster common words from the bank's speeches into topics, and resulting topic indices are regressed by inflation to get insights into the communication reaction function of the central banks. The full dataset used in this paper also includes real GDP growth, as well as various control and financial variables, such as the 3-quarter moving average of M3¹² annual growth, the Fed Funds target, the 3-quarter moving average credit, and so on. The full data list follows that of Cour-Thimann and Jung (2021). In terms of models, two, which are suggested by Cour-Thimann and Jung (2021) and Hartmann and Smets (2018), are used.

In general, this dissertation introduces novel approaches to standard macro-economic models. For example, in addition to using various machine learning models for forecasting and modelling, three out of four studies of this dissertation use textual data.

¹² M3 is a measurement of the money supply.

3. EMPIRICAL STUDIES

4. DISCUSSION AND CONCLUSIONS

4.1 Summary of Studies and Contributions

Volatile, too high or too low inflation rates, unanchored inflation expectations, and a lack of relevant communication are major challenges for monetary policy authorities in their price stability goals. Therefore, an understanding of inflation is of crucial importance. It is also the focus of this dissertation, and all studies within have inflation and inflation expectations as the key denominator. The first two studies focus primarily on forecasting inflation by employing a number of traditional and machine learning models and then evaluating the forecasting performance of these models in order to better understand which should be used for inflation forecasting, particularly for countries with an inflation target. Study II also aims to forecast inflation expectations and introduces news data to do so. Study III takes these analyses further, building on the idea of using news-based inflation measures and suggests using these measures in the real interest rates calculation of Euler's models of consumption to analyse consumers' consumption choices. Study IV, on the other hand, is related to the literature on the importance of central bank communication and thereby analyses the European Central Bank's communication reaction function to see which topics have more of an impact. In the following sections, the results of each study are discussed along with contributions and relevant policy implications. The last part of this chapter summarises the main results of this dissertation and relates the results to the research tasks.

Forecasting inflation using the Phillips curve in inflation-targeting countries (Study I)

Study I focuses on small open economies and aims to forecast the quarterly headline and core inflation rates using Phillips curves. A number of contributions are noted; firstly, the performance of Phillips curves is analysed. The prevailing view in the literature is that either these models do not work or their performance is mixed at best. Study I finds support for mixed performance by providing empirical evidence that the performance indeed depends on the sample period, forecast horizon, underlying data, and inflation measure, but also adds to these results by evaluating how the performance of Phillips curves change with the adoption of an inflation targeting regime. For the countries included in this study, during the fixed exchange rate regime, Phillips curves perform relatively poorly and fail to improve upon simple benchmark models. In contrast, when inflation targeting is adopted, and during the inflation targeting regime, inflation forecasts with Phillips curves have higher accuracy. These are potentially important findings for central bank forecasting, but while this pattern holds for all three countries in the study, more research would be needed, especially on larger open economies.

The study also contributes to the research on which inflation measures can be best forecast with Phillips curves. Aiming to forecast both underlying and headline inflation results in improved predictive performance when the model of choice is Phillips curve (any of its specifications), compared to simple benchmark models, leading to positive assessment for using Phillips curves for the purposes of forecasting both headline and underlying inflation in the countries of the study. Here again, the inflation forecasts are much better after the introduction of the inflation targeting regime.

The accuracy of these results can help evaluate the usefulness of Phillips curves for policy analysis, adding to the contributions of the paper. Such accuracy in forecasting allows central banks to stay transparent and increase the discipline in policy design and implementation, particularly since any inflation-targeting policy is primarily based on public confidence. Moreover, Phillips curves can also act as a great model for a structural description of the supply side of the economy, particularly as central banks focus more on inflation targeting.

Through the results and tasks accomplished in this paper, the answer to the first research question of this dissertation – whether models that link inflation and economic activity have good forecasting power and help forecast inflation – is provided. Analysis and implications from this study are particularly relevant nowadays, as external shocks (related to energy prices and supply chain crises) have affected not only headline inflation but also underlying core inflation, which is usually more sticky.

Mining News Data for the Measurement and Prediction of Inflation Expectations (Study II)

Study II explores news as a novel data source for capturing and measuring inflation expectations, arguing that household surveys of inflation expectations can often be inaccurate and household inflation expectations may differ significantly from actual inflation rates or those from professional forecasters. Study II supports the view that news is an essential source of information on which consumers rely when thinking about overall price changes. Therefore, one contribution of this study, among several, is to prove that online news can be used to obtain a real-time and accurate measure of consumers' inflation expectations, contributing as an answer to the second research question – How well can online news provide a real-time indication of consumer's expectations on inflation?

As set in the research tasks, answering this question is achieved by proposing a real-time measure of inflation expectations. For this, various text-mining techniques are applied. Text mining's applications in economics are relatively new, hence, the study also contributes to the growing literature on using textual data for analysing and understanding economic relationships. This consequently contributes to policymaking by making it possible to quantitatively link news narratives to economic theory. For instance, one implication of using news data to capture inflation expectations is understanding the relationship and co-movements between topics discussed in the news and inflation expectations. A topic-

level analysis enables us to understand and quantify the impact of each topic on inflation expectations. Additionally, if households do not adjust their expectations in response to various news topics, that would potentially mean inflation expectations are well anchored and monetary policy may be successful.

Besides documenting the significant relationship between inflation expectations and the news, the study also contributes to the forecasting literature by evaluating the forecasting performance of the news. A forecasting performance comparison is made between benchmark models (similar to those in Study I) and LASSO which is a popular machine learning method for variable selection. The LASSO model, short-term forecast errors on inflation expectations are smaller than those of simple autoregressive models, while for headline inflation, the forecasting accuracy is just as good (not better) as the autoregressive models.

From a policy perspective, these results speak to the literature highlighting the role of media as a contributor to households' inflation expectations formation (see Mazumder, 2021; and Larsen et al., 2021). The recommendation for policymakers is to use news data to better understand households' inflation expectations formation. Improved understanding of these expectations can lead to number of applications both in academia and in central banking, from forecasting, as was shown in Study II, Tallman and Zaman (2020), and Faust and Wright (2013), to modelling household consumption, which is the focus of Study III, as well as Ichiue and Nish Iguchi (2015), and Dräger and Nghiem (2021). Further applications are discussed in the literature review parts of this text and Study II.

Inflation Expectations and Consumption with Machine Learning (Study III)

Study III addresses understanding consumption and real interest rate relationships, concentrates on Euler's equations, and proposes that applying machine learning methods can help improve the performance and estimates of Euler's models. The focus is on the real interest rates used in the Euler's equation. The argument of Study III is that these interest rates are misspecified since the inflation expectations measure traditionally used in its calculation are unobservable and do not reflect an agent's true perceptions about the economy. As a solution, an alternative measure of inflation expectations is proposed, built from news sources, an augmented version of the news-based inflation expectations measure in Study II.

Findings from this analysis contribute to the economic literature from multiple angles and have important implications for policymaking. The first contribution is to the research on Euler's models, which are currently mostly based on actual inflation rates or survey-based measures of inflation expectations. Instead, Study III uses the above-mentioned news-based measure of inflation expectations. Capturing true consumer expectations for accurate model estimations is important, as is discussed in the paper, and the findings reinforce this.

When estimating various Euler's model specifications using novel inflation expectations, the estimation improves. Results show stronger instruments, estimates of the elasticity of intertemporal substitution that are more consistent with

other empirical evidence, and robust models, as validated by various tests commonly applied in the literature. Results are especially promising for the consumption of non-durable goods and services, although less promising for other consumption components. However, the aim of the paper is not to find the best fit or strongest parameters but instead to show that when using a novel measure of inflation expectations and, consequently real interest rates, Euler's models are more effective, whereas they usually fail when actual inflation or traditional survey-based measures are used.

Implications from this finding alone are numerous. For one, this suggests that central bankers should recognise that consumers generally have more information on their consumption patterns than an econometrician does. This means that both current and future consumption should not be treated as exogenous variables in Euler's equations to avoid correlated residuals. Secondly, while this is not new information for central bankers, the findings of Study III imply that survey data might not always be the best choice, given that it's very often inaccurate, comes with delays and is costly to get. The strong co-movement between survey measures and news-based measures observed in Study III supports the growing idea that news-based measures can be used as alternatives to survey-based ones. Contrary to survey-based measures, news-based measures are available in real-time, have a higher frequency, and are relatively cheaper to construct and contain new information. They can help to explain consumers' intertemporal choices better than traditionally used measures of inflation.

Another contribution of the study is adding to the growing strand of literature analysing the impact of news on inflation expectations and, particularly, applications in consumption modelling. Overall, evidence linking inflation expectations with consumers' spending decisions is limited due to a lack of viable data. With the novel, rich dataset of this study, opportunities open for in-depth research not only on the link between consumer spending decisions and inflation expectations but also on households' decisions about borrowing, mortgages and investing.

Taking this contribution further, another novelty in this paper is the topic modelling and topic-based classification of the news, which sheds interesting insights on which type of news and topics affect consumer spending the most. For policymakers, this is a validation that news-based measures of inflation expectations can be used for macroeconomic modelling and real-time predictions of inflation expectations and consumption. Last but not least, the usage of news data opens new opportunities for other key macroeconomic relationships as well, such as the New Keynesian Phillips curve.

The summary above demonstrates the positive answer to the third research question of this dissertation. News-based measures can be used as alternative indicators for inflation expectations.

The Communication Reaction Function of the European Central Bank. An Analysis Using Topic Modelling (Study IV)

Study IV tackles the fourth research question of this paper, showing that central bank communication can be studied in more detail by a combination of 1) using novel textual data that increases the information content in policy reaction function model estimates and 2) employing machine learning models to help determine the central bank communication reaction function. For this, the communication reaction function of the European Central Bank is analysed using topic modelling, and it is determined whether topics and indices derived from the bank's speeches are useful in estimating the communication reaction function of the bank. The approach of deriving topic-based indices is similar to the methods of Study II and III, highlighting the versatility of text mining and topic modelling for various purposes and giving hints on possible applications in central banking.

Results show that these topic indices contain more information and can provide a more detailed analysis compared to the studies based on discrete dependent variables. Most of the findings of Study IV are in line with the literature, but some of the findings are hard to interpret, especially if the communication reaction function is estimated in one or two dimensions. Nevertheless, extracting topics allows us to overcome this issue and analyse the results in all aspects of the communication reaction function.

It has been shown that different households respond to various policy messages differently (see D'Acunto et al. 2020). For instance, simpler messages are well understood, whereas central bank communication on more complex policy tools, such as asset purchases, often does not receive any reaction from households. Similarly, as D'Acunto et al. (2021) show, communications about forecasts coming from minority group representatives tend to have more impact on the inflation expectation formation of fellow minority group representatives. Such heterogeneity not only creates limitations in research but, more importantly, reflects the need for better and more innovative ways to reach the wider public.

Study IV provides a starting point for developing such communication tools, both in the form of discussion as well as with an empirical exercise on analysing central bank communication strategies. These strategies themselves have a direct impact on inflation, inflation expectations, and other economic variables. Particularly, for inflation-targeting central banks, interactions between inflation targets and implicit targets of various economic indicators are modelled via policy reaction function and communicate the underlying goals of monetary policy. This, in turn, creates expectations of achieving these goals. Therefore, understanding the mechanism by which central bank communication works and contributing factors will ultimately provide policymakers with new and powerful tools to support their goals.

Summary of Main Results of the Thesis and Research Tasks

The main results of the studies of this dissertation are provided in Table 2 below, along with the link to the research tasks.

Table 2. Research questions, tasks, and results

<i>Research Questions</i>	<i>Tasks</i>	<i>Results</i>
<u><i>RQ1</i></u> : How good are models that link inflation and economic activity measures in predicting to inflation?	1. To investigate the forecasting performance of Phillips curves both for the headline and core inflation rate contributing to the literature on which inflation measure helps forecast inflation best.	Forecasting both underlying and headline inflation using Phillips curves results in improved predictive performance.
	2. To evaluate the performance of Phillips curves once an inflation targeting regime is adopted. To analyse the cut-off point when the performance changes.	When inflation targeting is adopted, and during an inflation targeting regime, inflation forecasts with Phillips curves have higher accuracy. In contrast, during a fixed exchange rate regime, the Phillips curves perform relatively poorly and fail to improve upon simple benchmark models.
<u><i>RQ2</i></u> : How well can online news provide a real-time indication of consumers' inflation expectations?	1. To explore online news as a potential data source for capturing and measuring inflation expectations.	Online news can be used to get a real-time and accurate measure of consumers' inflation expectations.
	2. To propose a potentially real-time measure of inflation expectations to be used in forecasting.	A real time measure of inflation expectations is built using machine learning techniques.
	3. To evaluate the forecasting performance of machine learning models incorporating a novel news-based index to simple autoregressive models.	When using LASSO models, short-term forecast errors are similar or smaller than those of simple autoregressive models.
	4. To evaluate forecasts of both headline inflation and inflation expectations.	The forecasting performance of inflation expectations is better than that of benchmark model, while the forecasting accuracy is just as good for inflation.

Table 2. Continued

<i>Research Questions</i>	<i>Tasks</i>	<i>Results</i>
<u>RQ3</u> : How well can news-based measures be used as real-time alternatives for inflation expectations?	1. To evaluate Euler's equations and their various specifications by conducting empirical analyses on their performance.	Baseline specifications of Euler's equations, along with specifications that include consumers' external and internal habits are estimated.
	2. To infuse a novel news-based measure of inflation expectations in the real interest rate calculations and then in Euler models.	When estimating various Euler's model specifications using novel inflation expectations, the estimation improves.
	3. To compare estimates of models based on news-based inflation expectations with those based on traditional inflation measures.	Euler's models built with a novel news-based measure of inflation expectations result in stronger instruments, and in estimates of the elasticity of intertemporal substitution that are more consistent with other empirical evidence. They also produce more robust estimates compared to models with traditional inflation measures.
	4. To evaluate the impact of news-based inflation expectations and different components of consumption.	The relationship is particularly strong for non-durable goods and services consumption measures.
<u>RQ4</u> : How it is possible to quantify central bank communication for obtaining more information on the policy reaction function?	1. To use textual data to increase the amount of information in policy reaction function model estimates.	Central bank communication can be studied quantitatively and in more detail by analysing central bank speeches datasets using text mining techniques.
	2. To determine how machine learning methods can be used in determining the function of central bank communication.	Topic indices, extracted using the machine learning technique of topic modelling, contain more information and are able to provide more detailed analysis compared to the studies based on discrete dependent variables.

4.2 Opportunities for Future Research and Limitations

These days, ensuring price stability is especially challenging not only due to a sequence of supply and demand shocks, such as the COVID-19 pandemic, an energy crisis, wars, and rising inflation levels, but also due to the changing economic environments globally. Despite this, central banks stay committed to their mandates of ensuring inflation expectations remain anchored, even with high inflation. For instance, Lagarde (2022, p. 1) states that “in order to overcome ongoing challenges, other public players will need to help accelerate the transition to a greener, more digital and productive economy”. While this refers to the acceleration of improvements in the economic environment in the context of the natural environment, one may argue that machine learning techniques – or the digitalization of novel datasets – are no less necessary in central banks themselves to support central banks’ goals, which should apply to both skills and technologies.

Opportunities for Modelling

The new methodologies and datasets presented in this dissertation are one of the many available examples in the literature of how using novel data sources, and combining applications of machine learning with traditional econometrics can improve the quality and speed of economic analysis. As shown in this dissertation, employing machine learning models on economic data improves the timeliness and performance of forecasting models, allowing for improved and real-time forecasts. For instance, Study II emphasises the forecast gains when the LASSO model is used. Such a successful application of a machine learning model opens opportunities to take advantage of other state-of-the-art machine learning models, especially since there is evidence in the literature that these models often outperform traditional benchmark forecasting models, particularly when combined with big data (see, for example, Medeiros et al., 2021; and Coulombe et al., 2020).

Besides machine learning models, novel methodologies and datasets also contribute to the success of this paper. The wealth of textual data that became available in recent years has opened exciting frontiers for academics in most fields, including economics. As was shown in the empirical studies of this dissertation, as more data becomes available through novel methods of data extraction, more insights can be derived, most of which were not available before, such as analysing the impact of specific topics discussed in news media on consumer inflation expectations and consumption. Topic modelling, thanks to its ability to provide a quantitative description and measurement of changing economic narratives, has multiple potential applications in other areas of economics, which can lead to important implications for policymaking.

Several methods of measuring inflation expectations are discussed in this work, from survey measures of household inflation expectations and professional forecasts to those derived from financial market instruments, and the limitations and benefits of each are addressed. What was made clear through the results of the studies of the dissertation and supported by relevant literature is that none of

the traditional methods of measuring inflation expectations are perfect, nor accurately reflect consumers' perceptions about the economy. These are due to various stylized facts, such as the quantitative upward bias of inflation expectations compared to the actual inflation (even though they are co-moving together), the negative relationship inflation expectations and overall economic sentiment, uncertainty about the future, heterogeneity across customer demographics, and so on.

All these factors contribute to inaccurate reports of inflation expectations from economic agents, and the consequence is that inflation expectations data are limited, especially the data on households and firms, which are the most relevant agents for monetary policy transmission. While the degree of data limitation varies between central banks, and some banks may be more successful in getting accurate and sufficient data, this is not the case for the Eurozone (ECB, 2021c). Although the commonly used survey data from the ECB, the Consumer Expectations Surveys, is adequate and has increased the amount of data available, it is still almost impossible to surpass the volume of big data that comes from novel sources, such as news, bank speeches, press releases, social media, and more.

Opportunities for Theory

Another potential application of the rich textual data employed in this dissertation are Phillips curves. Their practical importance, as highlighted in Study I, means that researchers must continue to search for specifications that fit the data reliably. While Study I is focused on predicting headline and core inflation, an idea for further research would be to also include direct measures of inflation expectations in the models to evaluate both their usefulness in Phillips curves forecasts and to analyse their response to supply-side shocks. However, one of the issues for estimating Phillips curves is that the inflation expectations are hard to measure and are naturally unobservable, and most studies employ survey-based measures of inflation expectations. As discussed already, survey data comes with its own set of limitations, particularly related to the length of the data (e.g., shorter time series) and not being representative of economic agents' true perceptions. Again, this limits the econometric analysis. A solution to these two issues is proposed in this dissertation by introducing news-based inflation expectations measures, which go far back in time, are available in real-time, and reflect the public's true perceptions about the economy. The empirical application of employing these novel news-based measures as an alternative to inflation in Phillips curves models is left for further research.

Returning to topic modelling applications, it may also be interesting to investigate whether integrating news topic-based inflation expectations into Phillips curves can help recover the inverse relationship between inflation and unemployment. To the author's best knowledge, at the time of writing this, there are no studies on Phillips curves that employ textual datasets and topic modelling. Nevertheless, the positive results from topic modelling applications in Euler's models and inflation forecasting in Studies II and III hint at a possible positive outcome.

Opportunities for Policy

Besides applications in popular econometric models, high-volume and real-time online news data also allows monitoring the evolution of inflation expectations, which is especially crucial in times of extended high inflation. As is the case with the current increased inflation rates, consumers and investors are grappling with its effects, while economists are trying to understand whether this inflation is transitory or persistent. Such distinction is important, as it directly influences the actions of economic agents. It is also important to understand the circular relationship between inflation, inflation expectations, and inflation persistence: high inflation may cause inflation expectations to rise, which itself contributes to the persistence of inflation. Inflation persistence is characterised by its length, but how long is too long? Perceptions of time may vary, and so will the interpretations of the term ‘transitory’. Unsurprisingly, assessing whether inflation is transitory or persistent is very difficult in real time and can be classified retrospectively.

As pandemic-related shocks started to subside, the energy crisis and war in Ukraine came into play; thus, central bankers began to worry that the unusually high inflation may, after all, not be temporary but instead be chronic, and central banks are starting to view inflation as less transitory. The worries of persistent inflation are reflected in the central bank communication of the ECB, the Federal Reserve Board, the Bank of England, the Bank of Canada, and many more. As a result, central banks have announced their intentions to raise interest rates further and for longer. In changing perceptions of the situation, central bank communication is vital, both for steering inflation expectations and for making the central bank decision-making process more transparent, particularly when phasing out non-standard monetary policy measures, such as forward guidance. Studies III and IV, along with further discussion in this dissertation, highlight the importance of central bank communication and its effect on consumer inflation expectations, and who will base their spending and borrowing choices on their beliefs and sentiments of inflation. This, in turn, will affect inflation levels and, therefore, significantly impact economic stability.

If high inflation becomes embedded into long-run inflation expectations, inflation might become more persistent and affect the return to the target levels. A similar situation may arise if the contrary happens, that is, if inflation goes below the target set by the central bank for a longer time. Since this dissertation focuses on one-year-ahead inflation expectations only, a suggestion for further research is to study longer horizons to gauge what economic agents’ expectations are regarding longer-term inflation levels and if these economic agents expect the current inflation levels to persist. This will allow building a metric of sensitivity to various ‘inflation surprises,’ which then can be used to assess how shocks to inflation are embedded into the inflation and inflation expectation levels.

Textual data allows a novel angle in understanding the impact of policy interventions and the reaction to a variety of shocks. Among monetary policy shocks, there are information shocks that take place when the central bank’s assessment of the economic outlook changes unexpectedly. Various shocks are included in

the central bank discussion as contributing drivers of short-term inflation expectations towards the inflation anchor and a re-anchoring channel. While research on information shocks and their impact is relatively small (ECB, 2021), models proposed in Study IV can be applied to analyse the effects of shocks on economic agents' inflation expectations and perceptions of the economy.

Other factors affecting economic policy may include supply-side shocks, such as oil prices. With the exception of being included in some of Phillips curves specifications in Study I, none of the other models in this dissertation are used to analyse the role of oil prices as direct or indirect drivers of headline inflation and inflation expectations. However, this matters as oil shocks reflect the underlying developments in global economic activity. Therefore, another suggestion and opportunity for research and policy is to delve into the role of oil and, even broader, energy prices in the formation of inflation expectations. This can be done relatively easily following the machine learning models and text mining techniques proposed in Studies II and III, which will allow for the easy extraction of oil price-related information from macroeconomic news, social media (e.g., Twitter), or central bank communication. Twitter tweets and central bank minutes and speeches might be particularly interesting as oil prices and their impact on monetary policy are very often included in policy debates.

Last but not least, every analysis contained within this dissertation can be extended to other countries, both inflation-targeting ones and others, for further validation of the models and econometric approaches. This will undoubtedly lead to several new implications in economic theory and policy.

Limitations

Throughout Study II and III, an assumption is made and is supported by results in the literature that news coverage is reached homogeneously across the public, meaning that the potential impact of each news piece separately is not taken into account. One limitation of this work is that we do not deep dive into observed uncertainty, heterogeneity, and the dispersion of subjective expectations. Hence, only inflation expectation trends can be estimated, not the quantitative values. This means that while the news can model and predict inflation perceptions, along with trends in price changes and consumption paths, for estimating inflation levels and for better modelling and forecasting results, one should still also consider factors shaping consumers' subjective expectations. This includes differences in economic agents' shopping preferences in terms of shopping baskets, preferred shopping outlets, and suppliers, as well as differing observed price changes. Estimating and including an uncertainty framework should also be considered, along with its links to heterogeneity, as it has been reported that inflation expectations are higher during periods of uncertainty.

What is also left to further research related to inflation expectations is evaluating the role of financial markets in the formation of inflation expectations, as these expectations have been shown to affect stock prices and interest rates (see

Bernanke and Kuttner, 2005). Financial market participants' expectations are not the focus of this dissertation, but the same models can be applied using this data.

Among the limitations of Study IV are the conclusions related to the performance of topic indices. It has been shown that topic extraction allows the analysis of the communication reaction function in more detail, and the findings of the study do add new insights into the communication reaction function allowing central bankers to observe the impact of significant variables on its different components. However, there is some difficulty in interpreting the signs of the coefficients, and there is a risk of misspecification due to the nonlinearity of the central bank's loss function. These limitations, however, remain to be addressed in further research.

4.3 Conclusions

Inflation expectations are at the core of the theoretical monetary policy transmission mechanism and are central determinants of future inflation, as well as the wage and price-setting processes. In turn, the effectiveness of the expectation transmission channel depends on the central bank's credibility and how well the inflation expectations are anchored. Globally rising inflation levels between 2020 and 2023 have turned understanding the nature and formation of inflation expectations into an urgent policy challenge as central banks started looking for ways to bring inflation down to promote growth, economic stability, and sustainable employment. While pandemics, recessions, and supply chain disruptions come and go, not to mention wars, the economy is prone to many surprises and to demand and supply shocks, which drive the macroeconomy, including inflation.

This dissertation provides novel tools and techniques for extracting information for understanding and measuring inflation expectations with a focus on inflation, inflation expectations and central bank communication. By analysing, understanding and quantifying the role and impact of inflation expectations on consumers' economic choices, central banks are able to steer these expectations better to support their price stability goals and keep output and employment rates stable. Unstable or off-target inflation expectations trigger a loss of equilibrium in economic conditions related to not only inflation but also other variables of interest, such as unemployment.

An economy can only be healthy when consumers have confidence in its institutions, as this guarantees effective policymaking. Therefore, central bank communication plays a significant role in keeping inflation rates stable and expectations well anchored by shaping the public view on inflation. Improving channels of communication in general but also about policy actions may improve the accuracy of economic agents' expectations regarding central banks' actions, objectives, and policy strategy, and by doing so, help mitigate any shocks to inflation and large swings in interest rates.

While recent research shows that central bankers have improved their understanding of the formation process of consumer inflation, the bad news is that their

understanding of this process is still far from perfect. Policymakers still need to make decisions based on very limited data. The textual data proposed in this dissertation, which can be extracted from the news and other previously unavailable sources (such as public speeches), significantly increases the volume and length of the data. Furthermore, quantifying this textual data by employing machine learning techniques allows researchers to better capture information about consumer inflation expectations, which can be used in macroeconomic modelling and when making forecasts.

The empirical evidence in this dissertation on the impact of news data on inflation expectations acts as a springboard for studying central bank communication as a channel by which central banks influence the decision-making of consumers and firms. If central banks leverage these novelties to make their communication policies more powerful, then one may expect significant improvements in steering inflation expectations and monetary policy impact in general. This, in turn, will allow the evaluation of how well the monetary policy is operating and meeting its goals.

In addition to the above contribution to central bank communication, this dissertation also studies the link between inflation expectations and economic decisions in a novel way. By proposing a news-based measure of inflation expectations built using machine learning methods, it is shown that the performance of Euler's models can improve, thus, also providing yet more evidence that news-based measures can be used as real-time alternatives for inflation expectations.

This dissertation supports using news data to forecast short-term inflation expectations. Together with other results of the thesis, it fulfils the main aim of this dissertation, to provide evidence that the key to inflation targeting is in understanding and forecasting inflation and inflation expectations and ensuring relevant communication.

Nonetheless, academic research has so far only scratched the surface. Many questions are still left to be addressed, and more research is needed on several topics. One issue is to understand the forecasting properties of news at longer horizons. Another issue is to get a grasp on sources of systematic heterogeneity that may be present in different economies and show up among households even with similar socio-demographic characteristics. And last but not least, how inflation expectations impact economic decisions at the individual level. These points suggest multiple narratives for future studies.

In summary, this dissertation provides evidence that new approaches open new opportunities. The work done as part of this dissertation provides tools to uncover any additional information of interest and opens fruitful opportunities for further research, especially in the context of today's turbulent economic landscape.

REFERENCES

- Adam, K. and Padula, M. (2011): “Inflation dynamics and subjective expectations in the United States”, *Economic Inquiry* 49 (1), pp. 13–25.
- Ahmed, N., Atiya, A., Neamat El, N. and Hisham, E. (2010): “An Empirical Comparison of Machine Learning Models for Time Series Forecasting”, *Econometric Reviews* 29 (5-6), p. 594–621. <https://doi.org/10.1080/07474938.2010.481556>
- Armantier, O., Bruine de Bruin, W., Topa, G., Klaauw, W. and Zafar, B. (2015): “Inflation Expectations and Behavior: Do Survey Respondents Act on their Beliefs?”, *International Economic Review* 56(2), pp. 505–536.
- Armantier, O., Goldman, L., Koşar, G., Topa, G., Van der Klaauw, W. and Williams, J. C. (2022): “What Are Consumers’ Inflation Expectations Telling Us Today?”, *Liberty Street Economics* 20220214, Federal Reserve Bank of New York. <https://libertystreeteconomics.newyorkfed.org/2022/02/what-are-consumers-inflation-expectations-telling-us-today/>
- Ascari, G., Magnusson, L. and Mavroeidis, S. (2021): “Empirical Evidence on the Euler Equation for Consumption in the US”, *Journal of Monetary Economics* 117(C), pp. 129–152.
- Atkeson, A., and Ohanian, L. E. (2001): “Are Phillips Curves Useful for Forecasting Inflation?”, *Federal Reserve Bank of Minneapolis Quarterly Review* 25(1), pp. 2–11. <https://ideas.repec.org/a/fip/fedmqr/y2001iwinp2-11nv.25no.1.html>
- Ball, L., and Sheridan, N. (2006): “Does Inflation Targeting matter?”, *National Bureau of Economic Research Studies in Income and Wealth*.
- Ball, M. L., Leigh, D., Mishra, P., and Spilimbergo, A. (2021): “Measuring U.S. Core Inflation: The Stress Test of COVID-19”, *NBER Working Papers* (29609). <https://ideas.repec.org/p/nbr/nberwo/29609.html>
- Ball, L., and Mazumder, S. (2011): “Inflation Dynamics and the Great Recession”, *Brookings Papers on Economic Activity* (1), pp. 337–381
- Bañbura, M., and Bobeica, E. (2022): “Does the Phillips Curve Help to Forecast Euro Area Inflation?”, *International Journal of Forecasting*, Forthcoming.
- Bank of England (2022, April 9): “Bank of England Market Operations Guide: Our Objectives”. <https://www.bankofengland.co.uk/markets/bank-of-england-market-operations-guide/our-objectives>
- Bednar, W., and Todd, C. (2014): “Methods for Evaluating Recent Trend Inflation”, *Economic Trends*, Federal Reserve Bank of Cleveland.
- Bernanke, B. (2007): “Inflation Expectations and Inflation Forecasting”, Technical report, Board of Governors of the Federal Reserve System (US).
- Bernanke, B. and Kuttner, K. N. (2005): “What Explains the Stock Market’s Reaction to Federal Reserve Policy?”, *Journal of Finance* 60(3), pp. 1221–1257. <https://doi.org/10.1111/j.1540-6261.2005.00760.x>
- Binder, C. (2017): “Fed Speak on Main Street: Central Bank Communication and Household Expectations”, *Journal of Macroeconomics* 52, pp. 238–251.
- Blanchard, O.J. (1986): “The Wage Price Spiral”, *The Quarterly Journal of Economics* 101(3), pp. 543–565. <https://doi.org/10.2307/1885696>
- Blanchard, O.J. (2016): “The US Phillips Curve: Back to the 60s?”, *Policy Briefs* PB16-1, Peterson Institute for International Economics. <https://doi.org/10.1257/aer.p20161003>
- Blei, D.M., Ng, A.Y., Jordan, M.I. (2003): “Latent Dirichlet Allocation”, *Journal of Machine Learning Research* 3, pp. 993–1022.

- Blinder, A. S. (2018): "Through a Crystal Ball Darkly: The Future of Monetary Policy Communication", AEA Papers and Proceedings 108, pp. 567–571.
- Blinder, A. S., Ehrmann, M., Fratzscher, M., De Haan, J. and Jansen, D-J (2008): "Central Bank Communication and Monetary Policy: A Survey of Theory and Evidence", *Journal of Economic Literature* 46, pp. 910–45.
- Blinder, A.S. and Krueger, A. B. (2004): "What Does the Public Know about Economic Policy, and How Does It Know It?", *Brookings Papers on Economic Activity* 35(2004-1), pp. 327–397.
- Bholat, D., Hansen, S., Santos, P. and Schonhardt-Bailey, Ch. (2015): "Text Mining for Central Banks", *Handbook. Centre for Central Banking Studies* (33). pp. 1–19. <http://dx.doi.org/10.2139/ssrn.2624811>
- Bordalo, P., Coffman, K., Gennaioli, N., Schwerter, F. and Shleifer, A. (2020): "Memory and Representativeness", *Psychological Review*.
- Bruine de Bruin, W., Vanderklaauw, W., Downs, J.S., Fischhoff, B., Topa, G. and Armantier O. (2010): "Expectations of Inflation: The Role of Demographic Variables, Expectation Formation, and Financial Literacy", *Journal of Consumer Affairs* 44 (2), pp. 381–402.
- Bryan, M. F., and Pike, Ch. J. (1991): "Median price changes: an alternative approach to measuring current monetary inflation", *Economic Commentary, Federal Reserve Bank of Cleveland*. https://econpapers.repec.org/article/fipfedcec/y_3a1991_3ai_3adecl.htm
- Burke, M.A and Manz, M. (2011): "Economic Literacy and Inflation Expectations: Evidence From a Laboratory Experiment", *Public Policy Discussion Paper 11-8, Federal Reserve Bank of Boston*.
- Cavallo, A., Cruces, G., & Perez-Truglia, R. (2017): "Inflation Expectations, Learning, and Supermarket Prices: Evidence from Survey Experiments", *American Economic Journal: Macroeconomics* 9(3), pp. 1–35.
- Chakraborty, C. and Joseph, A. (2017): "Machine Learning at Central Banks", *Bank of England Working Papers* 674.
- Chang, J., Gerrish, S., Wang, C., Boyd-graber, J.L. and Blei, D. M. (2009): "Reading Tea Leaves: How Humans Interpret Topic Models", *Advances in Neural Information Processing Systems* 22, pp. 288–296.
- Clarida, R., Gali, J. and Gertler, M. (1998): "Monetary Policy Rules in Practice: Some International Evidence", *European Economic Review* 42, pp. 1033–1067.
- Coibion, O. and Gorodnichenko, Y. (2012): "What Can Survey Forecasts Tell Us About Information Rigidities?" *Journal of Political Economy* 120(1), pp. 116–59.
- Coibion, O. and Gorodnichenko, Y. (2015a): "Is the Phillips Curve Alive and Well After All? Inflation Expectations and the Missing Disinflation", *American Economic Journal: Macroeconomics* 7 (1), pp. 197–232.
- Coibion, O. and Gorodnichenko, Y. (2015b): "Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts", *American Economic Review* 105 (8), pp. 2644–2678.
- Coibion, O., Gorodnichenko and Y., Kamdar, R. (2018): "The Formation of Expectations, Inflation and the Phillips Curve", *Journal of Economic Literature* 56 (4), pp. 1447–1491.
- Coibion, O., Gorodnichenko, Y., Kumar, S. and Pedemonte, M. (2020): "Inflation Expectations as a Policy Tool?", *Journal of International Economics* 124 (C).
- Coulombe, P. G. (2022): "A Neural Phillips Curve and a Deep Output Gap", *Working paper*.

- Cour-Thimann, P., & Jung, A. (2021): “Interest Rate Setting and Communication at the ECB in its First Twenty Years”, *European Journal of Political Economy* 70 (102039).
- Clark, T. E., and Davig, T. A. (2008): “An Empirical Assessment of the Relationships Among Inflation and Short- and Long-Term Expectations”, Research Working Paper RWP 08-05, Federal Reserve Bank of Kansas City.
- Crone, T.M., Khettry, N. N. K., Mester, L. J., and Novak, J. A. (2013): “Core Measures of Inflation as Predictors of Total Inflation”, *Journal of Money, Credit, and Banking* 45(2-3), pp. 505–519.
- Croushore, D. (1997): “The Livingston Survey: Still Useful After all These Years”, Federal Reserve Bank of Philadelphia Business Review March/April, pp. 15–26.
- Curtin R. (2008), “What US Consumers Know About Economic Conditions”, in *Statistics, Knowledge and Policy 2007: Measuring and Fostering the Progress of Societies*.
- D’Acunto, F., Hoang, D., Paloviita, M., and Weber, M. (2019): “Human Frictions in the Transmission of Economic Policy”, Chicago Booth Research Paper, pp.19–21.
- D’Acunto, F., Hoang, D., Paloviita, M., and Weber, M. (2020): “Effective Policy Communication: Targets versus Instruments”, Becker Friedman Institute Working Paper 148.
- D’Acunto, F., Malmendier, U. and Weber, M. (2021): “Gender Roles Produce Divergent Economic Expectations”, *Proceedings of the National Academy of Sciences* 118 (21).
- D’Acunto, F., Hoang, D. and Weber, M. (2022a): “Managing Households’ Expectations With Unconventional Policies”, *Review of Financial Studies* 35(4), pp. 1597–1642.
- D’Acunto, F., Malmendier, U. and Weber, M. (2022b): “What Do the Data Tell Us About Inflation Expectations?”, NBER Working Papers 29825, National Bureau of Economic Research, Inc.
- de Mendonça, F. H., and de Guimarães e Souza, G. (2012): “Is Inflation Targeting a Good Remedy to Control Inflation?”, *Journal of Development Economics* 98, pp. 178–191. <https://doi.org/10.1016/j.jdeveco.2011.06.011>
- Dolmas, J., and Koenig, E.F. (2019): “Two Measures of Core Inflation: A Comparison”, Federal Reserve Bank of St. Louis Review 101(4), pp. 245–58. <https://doi.org/10.20955/r.101.245-58>
- Dolmas, J. (2005): “Trimmed Mean PCE Inflation”, Federal Reserve Bank of Dallas Research Department Working Paper (0506). <https://www.dallasfed.org/~media/documents/research/papers/2005/wp0506.pdf>
- Doms, M. E. and Morin, N. J. (2004): “Consumer Sentiment, the Economy, and the News Media”, FRB of San Francisco Working Paper (2004-09).
- Dräger, L. and Nghiem G. (2021): “Are Consumers’ Spending Decisions in Line with A Euler Equation?”, *The Review of Economics and Statistics* 103(3), pp. 580–596.
- ECB (2021a, July): “An Overview of the ECB’s Monetary Policy Strategy”. https://www.ecb.europa.eu/home/search/review/pdf/ecb.strategyreview_monopol_strategy_overview.en.pdf
- ECB (2021b, September): “The ECB’s Price Stability Framework: Past Experience, and Current and Future Challenges”. <https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op269~3f2619ac7a.en.pdf?1b757c1547bbc94bcebd18c4a151e665>
- ECB (2021c, September): “Inflation Expectations and Their Role in Eurosystem Forecasting”, ECB Occasional Paper Series 264. <https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op264~c8a3ee35b5.en.pdf>
- Ehrmann, M. and Tzamourani, P. (2012): “Memories of High Inflation”, *European Journal of Political Economy* 28 (2), pp. 174–191. <https://doi.org/10.1016/j.ejpoleco.2011.11.005>

- Ellen, S.T., Larsen V. H., Thorsrud, L. A. (2022): “Narrative Monetary Policy Surprises and the Media”, *Journal of Money, Credit and Banking* 54 (5), pp. 1525–1549.
- Faust, J. and Wright, J. H. (2013): “Forecasting Inflation”, *Handbook of Economic Forecasting* 2(1), pp. 2–56.
- Federal Reserve System (2016, October): “The Federal Reserve System: Purposes and Functions”, 10th edition. <https://fraser.stlouisfed.org/title/federal-reserve-system-5298>
- Friedman, M. (1969): “The Optimal Quantity of Money, and Other Essays”, Chicago: Aldine.
- Fuhrer, J.C., Olivei, G.P., and Tootell, G.M.B. (2012): “Inflation Dynamics When Inflation is Near Zero”, *Journal of Money, Credit and Banking* 44, pp. 83–122. <https://doi.org/10.1111/j.1538-4616.2011.00479.x>
- Garcia, M. G., Medeiros, M. C. and Vasconcelos, G. F. (2017): “Real-Time Inflation Forecasting with High-Dimensional Models: The Case of Brazil”, *International Journal of Forecasting* 33(3), pp. 679–693. <https://doi.org/10.1080/07350015.2019.1637745>
- Georganas, S., Healy, P. J. and Li, N. (2014): “Frequency Bias in Consumers’ Perceptions of Inflation: An Experimental Study.” *European Economic Review* 67, pp. 144–158.
- Goncalves, C. E. S., and Salles, J. M. (2008): “Inflation Targeting in Emerging Economies: What do the Data say?”, *Journal of Development Economics* 85(1), pp. 312–318.
- Gordon, R. J. (1975): “The Impact of Aggregate Demand on Prices”, *Brookings Papers on Economic Activity* (2), pp. 613–62
- Gordon, R. J. (1990): “U.S. Inflation, Labor’s Share, and the Natural Rate of Unemployment.” *Economics of Wage Determination*
- Guo, N., Zhang, B., and Cross, J. L. (2022): “Time-varying Trend Models for Forecasting Inflation in Australia”, *Journal of Forecasting* 41(2), pp. 316–330. <https://doi.org/10.1002/for.2814>
- Gürkaynak, R., Brian, S. and Eric, S. (2005): “The Sensitivity of Long-Term Interest Rates to Economic News: Evidence and Implications for Macroeconomic Models”, *American Economic Review* 95, pp. 425–36. <https://doi.org/10.1257/0002828053828446>
- Haldane, A. and McMahon, M. (2018): “Central Bank Communications and the General Public”, *AEA Papers and Proceedings* 108, pp. 578–583.
- Hall, R. E. (2013): “The Routes into and Out of the Zero Lower Bound.” Prepared for the Federal Reserve Bank of Kansas City’s Jackson Hole Symposium, *Global Dimensions of Unconventional Monetary Policy*.
- Hall, R. (1988): “Intertemporal Substitution in Consumption”, *Journal of Political Economy* 96(2), pp. 339–357. <https://doi.org/10.1086/261539>
- Hansen, S., McMahon, M. and Prat, A. (2018): “Transparency and Deliberation Within the FOMC: A Computational Linguistics Approach”, *The Quarterly Journal of Economics* 133 (2), pp. 801–870.
- Hartmann, P., and Smets, F. (2018): “The First Twenty Years of the European Central Bank: Monetary Policy”, ECB Working Paper 2219.
- Hattori, M., and James, Y. (2017): “The Evolution of Inflation Expectations in Japan”, *Journal of the Japanese and International Economies* 46, pp. 53–68. <https://doi.org/10.1016/j.jjie.2017.09.001>
- Hindrayanto, I., Samarina, A., and Stanga, I. M. (2019): “Is the Phillips Curve Still Alive? Evidence From the Euro Area”, *Economics Letters*, Elsevier 174(C), pp. 149–152. <https://doi.org/10.1016/j.econlet.2018.11.021>

- Ichiiue, H., and Nishiguchi, S. (2015): "Inflation Expectations and Consumer Spending at the Zero Bound: Micro Evidence", *Economic Inquiry* 53, pp. 1086–1107.
- Jansen, D. J. and Neuenkirch, M. (2017): "News Consumption, Political Preferences, and Accurate Views on Inflation" *Universität Trier, Research Papers in Economics* (3/17).
- Jordà, Ò., Chitra, M., Fernanda, N., and Tallman, E. (2019): "Inflation: Stress-Testing the Phillips Curve", *Federal Reserve Bank of San Francisco Economic Letter*. <https://www.frbsf.org/economic-research/publications/economicletter/2019/february/inflation-stress-testing-phillips-curve/>
- Jonung, L. (1981): "Perceived and Expected Rates of Inflation in Sweden", *American Economic Review* 71 (5), pp. 961–968.
- Kilponen J., and Kontulainen J. (2021): "ECB Revised its Monetary Policy Strategy – What's Changed?", *Bank of Finland, Articles on the Economy*. <https://www.bofbulletin.fi/en/2021/4/ecb-revised-its-monetary-policy-strategy-whats-changed/>
- Kim, G., and Binder, C. (2020): "Learning-Through-Survey in Inflation Expectations", Conditionally accepted in *American Economic Journal: Macroeconomics*.
- Lagarde, Ch. (2022): "Monetary Policy in a new Environment", *Speech, European Banking Congress*. <https://www.ecb.europa.eu/press/key/date/2022/html/ecb.sp221118~639420cee0.en.html>
- Lamla, M. J., and Lein, S. M. (2014): "The Role of Media for Consumers' Inflation Expectation Formation", *Journal of Economic Behavior & Organization* 106, pp. 62–77.
- Larsen, V. H., Thorsrud, L. A. and Zhulanova, J. (2021): "News-Driven Inflation Expectations and Information Rigidities", *Journal of Monetary Economics* 117, pp. 507–520.
- Laster, D., Bennett, P. and Geoum, I. S. (1999): "Rational Bias in Macroeconomic Forecasts", *Quarterly Journal of Economics* 114 (1), pp. 293–318.
- Levin, A., Natalucci, F. and Piger, J. (2004): "The Macroeconomic Effects of Inflation Targeting", *Federal Reserve Bank of St. Louis Review* 86, pp. 51–80. <https://files.stlouisfed.org/files/htdocs/publications/review/04/07/LevinNatalucciPiger.pdf>
- Lin, S., and Ye, H. (2007): "Does Inflation Targeting Really Make a Difference? Evaluating the Treatment Effect of Inflation Targeting in Seven Industrial Countries", *Journal of Monetary Economics* 54(8), pp. 2521–2533.
- Malmendier, U. and Nagel, S. (2016): "Learning from Inflation Experiences", *The Quarterly Journal of Economics* 131(1), pp. 53–87.
- Malmendier, U., Pouzo, D. and Vanasco, V. (2020): "Investor Experiences and Financial Market Dynamics", *Journal of Financial Economics* 136 (3), pp. 597–622.
- McKnight, S., Mihailov, A. and Rumler, F. (2020): "Inflation Forecasting Using the New Keynesian Phillips Curve with a Time-Varying Trend", *Economic Modelling* 87(C), pp. 383–393. <https://doi.org/10.1016/j.econmod.2019.08.011>
- Medeiros, M. C., Vasconcelos, G.F.R., Veiga, A. and Zilberman, E. (2021): "Forecasting Inflation in a Data-Rich Environment: The Benefits of Machine Learning Methods", *Journal of Business & Economic Statistics* 39(1), pp. 98–119.
- Mester, L. J (2022): "The Role of Inflation Expectations in Monetary Policymaking: A Practitioner's Perspective", *Speech 94404, Federal Reserve Bank of Cleveland*.
- Milojko, A., Mladenović, Z., and Nojković, A. (2022): "Macroeconomic Performance of Inflation Targeting in European and Asian Emerging Economies", *Journal of Policy Modelling* 44(3), pp. 675–700. <https://doi.org/10.1016/j.jpolmod.2022.06.002>

- Madhou, A, Sewak, T., Moosa, I., and Ramiah, V. (2020): "Forecasting Inflation in a Small Open Developing Economy," *Applied Economics* 52(20), pp. 2123–2134. <https://doi.org/0.1080/00036846.2019.1683145>
- Nakorji, M., and Aminu, U. (2022): "Forecasting Inflation Using Machine Learning Techniques", *The Review of Finance and Banking* 14(1), pp. 45–55. <https://EconPapers.repec.org/RePEc:rff:journl:v:14:y:2022:i:1:p:45-55>
- Nimark, K. P., and Pitschner, S. (2019): "News Media and Delegated Information Choice", *Journal of Economic Theory* 181, pp. 160–96.
- Ottaviani, M. and Sørensen, P.M. (2006): "The Strategy of Professional Forecasting", *Journal of Financial Economics* 81, pp. 441–466. <https://doi.org/10.1016/j.jfineco.2005.08.002>
- Pfajfar, D., and Santoro, E. (2013): "News on Inflation and the Epidemiology of Inflation Expectations", *Journal of Money, Credit and Banking* 45(6), pp. 1045–1067.
- Salem, A., and Didem, T. (2012): "Inflation Targeting: A Three-Decade Perspective", *Journal of Policy Modelling* 34(5), pp. 621–645. <https://doi.org/10.1016/j.jpolmod.2011.08.004>
- Roger, S. (2010): "Inflation Targeting Turns 20", *Finance & Development* 47(1), pp.46–49.
- Shapiro, A. H, Sudhof, M. and Wilson, D. J. (2022): "Measuring News Sentiment", *Journal of Econometrics*, 228(2), pp. 221–243. <https://doi.org/10.1016/j.jeconom.2020.07.053>
- Sims, C. (2005): "Limits to Inflation Targeting", *National Bureau of Economic Research Studies in Business Cycles* 32(7), pp. 283–310.
- Stock, J. H. and Watson, M. W. (1999): "Forecasting Inflation", *Journal of Monetary Economics* 44(2), pp. 293–335. [https://doi.org/10.1016/S0304-3932\(99\)00027-6](https://doi.org/10.1016/S0304-3932(99)00027-6)
- Stock, J. H. and Watson, M. W. (2008): "Phillips Curve Inflation Forecasts", NBER Working Paper 14322.
- Thorsrud, L.E. (2020): "Words are the New Numbers: A Newsy Coincident Index of the Business Cycle", *Journal of Business & Economic Statistics* 38(2), pp. 393–409.
- Van der Cruysen, C., Jansen, D-J., de Haan J. (2015): "How Much Does the Public Know about the ECB's Monetary Policy? Evidence from a Survey of Dutch Households", *International Journal of Central Banking*, *International Journal of Central Banking* 11(4), pp. 169–218. <https://ideas.repec.org/a/ijc/ijcjou/y2015q5a5.html>
- Verbrugge, R. (2019): "Behavior of a New Median PCE Measure: A Tale of Tails", *Federal Reserve Bank of Cleveland Working Paper* (2019–10). <https://www.clevelandfed.org/en/newsroom-and-events/publications/economic-commentary/2019-economic-commentaries/ec-201910-behavior-of-a-new-median-pce-measure.aspx>
- Weber, M., D'Acunto, F., Gorodnichenko, Y., and Coibion, O. (2022): "The Subjective Inflation Expectations of Households and Firms: Measurement, Determinants, and Implications", *Journal of Economic Perspectives* 36 (3), pp. 157–84.
- Weidmann J. (2018, May), *Lecture at the Centre for European Economic Research, Mannheim*. <https://www.bis.org/review/r180511a.pdf>
- Woodford, M. (2001): "Monetary Policy in the Information Economy", *Economic Policy for the Information Economy*, pp. 297–370.
- Wynne, M. A. (2008): "Core Inflation: A Review of Some Conceptual Issues", *Federal Reserve Bank of St. Louis Review* 90(2), pp. 205–28.

SUMMARY IN ESTONIAN

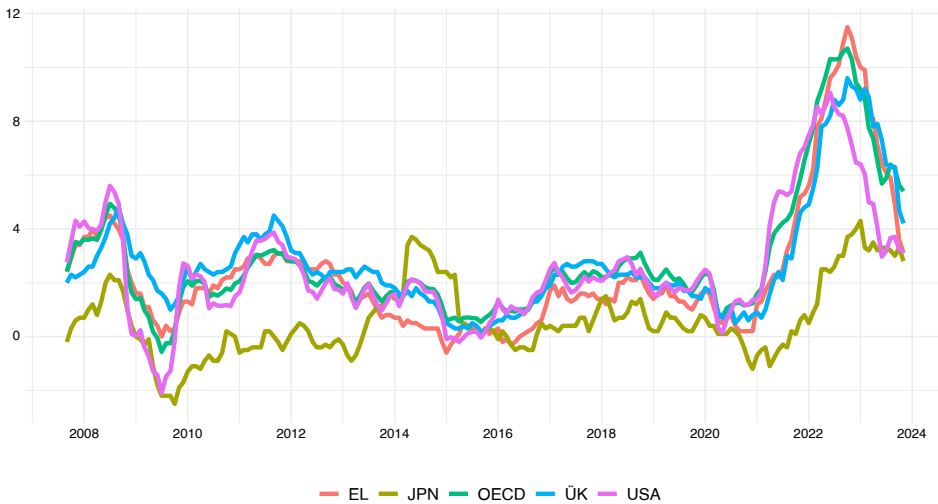
Esseed inflatsioonist, ootusest ja keskpanga kommunikatsioonist

Keskpankade üks peamisi eesmärke on ohjeldada inflatsiooni ehk tempot, millega tõusevad kaupade ja teenuste hinnad. Keskpankurite põhiülesanne on hoida inflatsiooni stabiilsena, prognoositavana ja lähedal seatud eesmärgile. Raha- poliitika kujundajaid ei huvita mitte ainult juba toimunud inflatsioon, vaid ka tulevikus oodatavad hinnamuutused. Inflatsiooniootused mõjutavad otseselt inimeste valikuid, suunates nende praeguse hetke kulutamise-, investeerimis- ja laenuotsuseid aga ka kuidas ettevõtteid kujundavad hindu. Kui inflatsiooniootus kaldub soovitud keskpanga inflatsioonieesmärgist kõrvale, võib keskpankadel tekkida vajadus seda ohjata. Eesmärgist kõrgema inflatsiooniootuse korral on vaja võtta meetmeid selle lühiajaliseks kahandamiseks, näiteks karmistades finantstingimusi intressimäärade tõstmise ja majanduse jahutamise kaudu. See viib inflatsiooni pikemas perspektiivis sihttasemele ja aitab kaasa majanduskasvu saavutamisele.

Inflatsiooniootused on majandusteoorias erilise tähelepanu all kui paljude majandusotsuste tõekehjõud. Hea arusaam inflatsiooni praegusest ja tulevasest dünaamikast võimaldab teha teadlikke otsuseid. Kvaliteetne tulevikuprognoos muutub eriti aktuaalseks äärmuslike majandussündmuste ajal või siis, kui majanduses valitseb ebakindlus, mis teeb ka inflatsiooni mõistmise keerulisemaks, nagu siinse doktoritöö kokkuvõtte kirjutamise ajal 2023. aastal.

Kui 2008. aasta finantskriisist (vt joonis 1) alates jäi inflatsioon madalale tasemele, siis 2022. aastal tõusis see kõrgele nii arenenud riikides kui ka arengumaades, kerkides paljudes maailma riikides kahekohaliste numbriteni. Ameerika Ühendriikides oli olnud inflatsioonimäär viimati nii kõrge 1982. aastal, Ühendkuningriigis 1981. aastal. Euroopa Liidu liikmesriikide inflatsioonimäär ületas 11 protsenti ja euroala riikide inflatsioonimäär ei olnud nii kõrgele tõusnud alates rahaliidu loomise ajast.

Kui tarbijahinnad 2020. aastal tõusma hakkasid, olid hinnatõusu taga esialgu tarneahelaprobleemid, mis tekkisid seoses COVID-19 ja pandeemia vastaste meetmete tõttu. 2022. aastal tõukas inflatsioonitempot tagant geopoliitiline olukord, mis viis gaasi- ja elektrihindade hüppelise tõusuni. Vaatamata valitsuste püüdlustele hindade tõusu piirata ja kerkivate intressimäärade mõju leevendada, ei ole pandeemiajärgse majanduse taastumise ootused täies ulatuses teoks saanud. Lisaks sellele on suurenenud majandussurutise oht ja poliitikakujundajad on töö valmimise ajal mures võimaluse pärast, et suuremad majandused võivad sattuda langusfaasi.



Joonis 1: Tarbijahinna indeksi (THI) aastane kasvumäär (%), 2007. a detsember kuni 2023. a november.

Allikas: OECD

Heitlikud ajad toovad esile inflatsiooni mõõtmise, tajumise ja prognoosimise puudused, suurendavad inflatsiooniootuste rolli rahapoliitika hindamise vahendina ning rõhutavad, miks on pakiliselt vajalik inflatsiooniootusi täpselt mõõta ja prognoosida. Selle doktoritöö moodustavad uurimused, mille kord otsesemad, kord kaudsemad ühised märksõnad on inflatsioon ja keskpanga sõnumid ning kommunikatsioon. Uurimustes rõhutatakse inflatsiooniootuste rolli inflatsiooni mõistmisel, prognoosimisel ja asjakohaste sõnumite tagamisel. Töö põhieesmärk on analüüsida inflatsiooniootusi, keskpanga sõnumeid, leibkondade majanduslikke valikuid ja nende kolme nähtuse omavahelisi seoseid. Doktoritöö uurimused keskenduvad riikidele, mis kasutavad inflatsiooni juhtivat rahapoliitikat, nagu Rootsi, Uus-Meremaa, Kanada, Ühendkuningriik ja euroala.

Viimastel aastatel on oluliselt arenenud mitte ainult ökonomeetrilised meetodid, vaid ka masinõppe lahendused. Esiteks täiendab doktoritöö majandusteaduslikku kirjandust muu hulgas katsetega võrrelda erinevate masinõppe ja traditsiooniliste ökonomeetriliste meetodite edukust. Töös kasutatud uued masinõppe meetodid võimaldavad vähendada vigu eelkõige lühiajaliste prognooside puhul.

Lisaks täiustatud mudelitele, kasutatakse käesolevas doktoritöös uudeid andmekogumeid. Enamik erialakirjanduses leiduvaid inflatsiooni ja inflatsiooniootuste prognoosimise mudeleid põhineb endiselt traditsioonilistel andmekogumitel, vähem on tähelepanu pööratud alternatiivsetele andmeallikatele. Seejärel on teise uuenduse ja uurimispänuks kasutatud töös veebiuudiste andmeid, mis võimaldavad luua ajakohaseid prognoose ja kindlaks teha uudeid stiliseeritud fakte. Kuna ootused võivad muutuda väga kiiresti, saavad uued ja

reaalajalised andmeallikad traditsiooniliste andmeallikate kõrval üha väärtuslikumaks, eriti arvestades veebiuudiste andmete lisandumise igapäevast sagedust.

Doktoritöö kolmas suur uurimispanus on meedia rolli esiletõstmine majandusagentide ootuste kujunemises. Kuigi viimastel aastatel on meedia muutunud makromajanduses populaarseks valdkonnaks (vt nt Lamla ja Lein 2014, Larsen *et al.* 2021 ja Shapiro *et al.* 2022), on seda seni veel võrdlemisi vähe uuritud.

Need panused moodustuvad doktoritöö raames tehtud empiirilistest uurimustest. Esimeses uurimuses prognoositakse inflatsiooni Phillipsi kõvera abil, hinnates seejuures Phillipsi kõvera toimivust riikides, mille rahapoliitiline režiim hõlmab inflatsioonijuhtimist. Phillipsi kõver on makroökonoomikas keskseid mõisteid, mis seostab hindade dünaamikat inflatsiooniootuse ja kulude ning majandusliku aktiivsuse kaudu, näiteks palkade, tööpuuduse või SKP lõhe kaudu. Artiklis leitakse, et võrreldes lihtsate võrdlusmodelitega, nagu juhuslik ekslemine ja autoregressiivsed mudelid, võivad Phillipsi kõvera mudelid inflatsiooni-prognoose parandada just perioodide puhul, mil keskpang tegeleb inflatsioonijuhtimisega. Varasemate perioodide ja erinevate rahapoliitika režiimide korral osutavad tulemused modelite tulemuste heterogeensusele ja Phillipsi kõver pakub vähem abi inflatsiooni prognoosimisel. Need tulemused võimaldavad kindlaks teha perioodi, millal majanduskeskkond inflatsioonijuhtimise režiimile üle minnes muutub ja millal on Phillipsi kõver inflatsiooni prognoosimisel rohkem, millal vähem kasulik. Artikkel panustab nii inflatsiooni prognoosimisse kui rahapoliitilist analüüsi käsitlevasse kirjandusse.

Inspireerituna arvutusvõimsuste ning masinõppe meetodite arengust ja rakendustest majandusteaduses, kasutab teine uurimus inflatsiooni prognoosimiseks masinõppemudeleid. Masinõppel põhinevad kõrgtehnoloogilised lahendused võimaldavad minimeerida majandusteaduslikes käsitlustes prognoosivigu, arvestades prognooside nihet ja hajuvust, töödelda suuri andmehulki tõlgendustes mõõndusi tegemata ja hankida rohkem andmeid varem kättesaamatuks jäänud teabeallikatest, nagu veebiuudised, sotsiaalmeedia, tehinguandmed jne. Artiklis kasutatakse nii koguinflatsiooni kui ka inflatsiooniootuse modelleerimiseks populaarset masinõppe mudelit LASSO (*Least Absolute Squared Shrinkage Operator*). Masinõppemudeli ja võrdlusmodelite tulemuslikkust hinnatakse, samamoodi nagu esimeses uurimuses, prognoosivigade arvutamise teel. Tulemused näitavad, et masinõppemeetodid teevad inflatsiooniootuse prognoosimisel paremat ja inflatsiooni prognoosimisel vähemalt sama head tööd kui naiivsed mudelid (nt juhusliku ekslemise mudelid).

Kesk pangad kasutavad mitmesuguseid inflatsioonimäärasid – koguinflatsiooni, alusinflatsiooni ja oodatavat inflatsiooni. Kirjanduse ülevaade toob töö eri osades läbivalt esile inflatsiooniootuste rolli tegelikus inflatsioonidünaamikas ja poliitika kujundamises.

Inflatsiooniootus on oluline sisend tänaste ja tulevaste planeeritavate tarbimis- ja investeerimisotsuste tegemisel. Hea näide on Euleri võrranditest tuletatud tarbimismudel, mis väljendab seost tarbimise dünaamika, nominaalintressimäärade ja inflatsiooniootuse vahel (vt Hall 1988, Ascari *et al.* 2021). Kõrge inflatsiooniootuse ja fikseeritud nominaalintressimäärade korral ootavad tarbijad

madalamaid reaaltressimäärasid. Säästmist tulevikuks tähtsustatakse vähem ja hetketarbimist suurendatakse eeldusel, et tulevikus tarbimine väheneb. Kolmas uurimus põhineb esimesel ja teisel uurimisel ning näitab, et kui inflatsiooniootust kasutada sellises keskses makroökonomilises mudelis nagu Euleri tarbimis-mudel, saab mudeli tulemuslikkust parandada võrreldes uurimustega, mis kasutavad tavapäraseid inflatsiooniootuste mõõdikuid.

Selleks, et analüüsida inflatsiooniootuse mõju majandusagentide otsustele, koostatakse artiklis uudiste andmete põhjal uudne inflatsiooniootuste indeks. Seda kasutatakse reaaltressimäärade arvutamisel Euleri võrrandis tavapärase inflatsiooniootuste alternatiivina. Senini on olnud populaarsete inflatsiooni-mõõdikutena kasutusel turu- või küsitluspõhised inflatsiooniootuse näitajad. Kolmas uurimus seab just küsitluspõhiste näitajate kasutamise kahtluse alla ja pakub nende asemel välja uue, suure dimensionaalsusega ja potentsiaalselt rea-alajalise inflatsiooniootuste mõõdiku, mis suudab kajastada seda, kuidas leib-konnad inflatsiooni meediast lugedes tajuvad.

Täiuslikust informatsioonist lähtuvate ratsionaalsete ootuste (*full-information rational expectations*, edaspidi FIRE) paradigma võib majandusanalüüsis toimida võrdlusalusena, kuid tarbijate ootused sellele reeglina ei vasta. Selle asemel põhinevad nende ootused sageli ebatäpsetel mälestustel varasemast inflatsiooni-kogemusest, subjektiivsetel majandusarusaamadel, mitmesugustel rusikareeglitel jne. Käitumuslik reaktsioon poliitikamuutustele võib erineda ekspertide ennustustest ja olla vastuolus FIRE põhieeldustega. See raskendab majandusteadlaste jaoks ootuste kujunemise protsessi sügavamalt mõistmist ja sellele vastavalt tegutsemist. Hiljutisest kirjandusest, mis käsitleb tarbijate ootuste süstemaatilist kõrvalekallet FIRE-st, annavad ülevaate D'Acunto *et al.* (2022b).

Lisaks FIRE-ga seotud probleemidele kaasneb küsitlusandmete hankimisega ka kulu. Küsitluspõhiste näitajate kogumise meetodid on muutunud, kuna tarbijad vastavad harvemini telefonikõnedele ja kipuvad igapäevases sõnumitulvas e-kirju eirama. Seetõttu on järjest raskem jõuda esindusliku valimini ning küsit-lejad peavad vajalike andmete kättesaamiseks kasutama erinevaid meetodeid. Kombineeritud lähenemisviisi puuduseks on tarbijarühmade erinevad eelistused küsitlustele vastamisel: nooremad sihtrühmad eelistavad pigem veebiküsitlusi, samas kui vanematele tarbijatele võib nende täitmine osutuda vaevanõudvaks. Pealegi on uuringud näidanud, et tarbijad, kes on inflatsiooniootuste küsitlustes varem osalenud, kalduvad oma inflatsiooniootusi keskmiselt 2% võrra alandama. Seega võib korduv küsitlustes osalemine viia selleni, et konkreetne tarbijarühm ei ole enam esinduslik (Kim ja Blinder, 2021). Küsitluspõhiste näitajatega seotud probleeme on põhjalikumalt lahanud Weber *et al.* (2022).

Andmeteaduses viimase kümnendi jooksul tehtud edusammud võimaldavad mõõta tarbijate inflatsiooniootusi uudiste põhjal. Uudiste kasutamine käesolevas doktoritöös panustab erialakirjandusse kahte moodi. Esiteks kasutatakse uudiseid uudse ja alternatiivse andmeallikana uudistel põhineva inflatsiooniootuste indeks koostamiseks. Teiseks, kui juba meedia mõju inflatsiooniootustele saab mõõta ja kvantifitseerida, on võimalik sarnaselt uurida keskpanga sõnumeid kui kanalit, mille kaudu mõjutatakse laiemat avalikkuse majandusotsuseid.

Neljas uurimus panustab keskpanga sõnumite mõjude analüüsi käsitlevasse kirjandusse Euroopa Keskpanga (EKP) sõnumite reaktsioonifunktsiooni teemalise empiirilise uurimusega. EKP sõnumite reaktsioonifunktsiooni analüüsimiseks jaotatakse panga esindajate sõnavõttud teemade kaupa gruppideks ja teisendatakse seejärel kvantitatiivseteks indeksiteks, mis võimaldavad analüüsida, kui oluline on iga teema keskpanga kommunikatsioonis. See aitab meil mõista, kuidas kujunevad leibkondade ootused ja milline on omakorda nende mõju poliitikale ja otsuste tegemisele.

Inflatsiooniootused on doktoritöö teemaks valitud vajaduse pärast mõista, kuidas leibkonnad oma ootusi kujundavad ja ajakohastavad. Ajal, mil inflatsioonitase on olnud ajaloolises võrdluses väga kõrgel tasemel, teeb rahapoliitika kujundajatele ja majandusteadlastele muret võimalus, et see tõus võib majandusagentide inflatsiooniootused paigast lükata. Inflatsioonitaseme tõusul on mitu võimalikku selgitust, mis kõik väärivad tähelepanu. Seetõttu on rohkem kui kunagi varem vaja kavandada täpseid ja õigeaegseid poliitikameetmeid. See aga tähendab, et rohkem kui kunagi varem on vaja mõista, millisena avalikkus majanduse tulevikku ette kujutab.

Käesoleva doktoritöö mudelid keskenduvad lühiajalisele oodatavale inflatsioonile ehk kuni aasta ettepoole suunatud ootusele. Kui mõne riigi majanduspoliitikas käsitletakse stabiilset ootust enamasti pikaajalise inflatsiooniootuse kontekstis, siis enamik mudeleid tunnistab lühiajalise inflatsiooniootuse olulist mõju praegusele inflatsioonile. Eelkõige viimaste aastate vapustuste ja ootamatute sündmuste tõttu on selgunud, et lühiajalised inflatsiooniootused reageerivad inflatsiooniliikumistele tugevamini, samas kui pikaajalised inflatsiooniootused jällegi nõrgemini (vt Armantier *et al.* 2022). See viitab sellele, et pikevalt ette vaadates ei arvesta tarbijad hiljutiste inflatsiooniliikumistega sama palju kui varem ning lühiajaliste hinnamuutuste püsivaks muutumist reeglina ei oodata.

Üldiselt võib öelda, et keskpankadel ja majandusteadlastel puudub endiselt hea arusaam sellest, kuidas tarbijate inflatsiooniootused kujunevad. Tõusvate hindadega võidelnud keskpangad peaksid enam endale tunnistama, et tarbijatel puudub sageli märkimisväärne majandus- või rahandusalane kirjaoskus, nende tähelepanuvõime on piiratud ja info jõuab kohale viitajaga ning osaliselt (Larsen *et al.* 2021; Lamla ja Lein 2014). Neid tegureid on oluline teadvustada ka eelarve- ja rahapoliitilise mõju mõistmise seisukohast, sest kui leibkonnad ei kujunda oma ootusi kooskõlas majanduslike stiimulitega, väheneb poliitikameetmete tulemuslikkus (D'Acunto *et al.* 2019).

Selgem arusaam tarbijate ootuste kujunemisest mitte ainult ei suurendaks keskpankade usaldusväärsust, vaid aitaks ka prognoosida tarbijate ootusi ja hinnata nende edasikandumist majandusotsustesse. Loomulikult tekib sealjuures mitmeid küsimusi. Kuidas oleks keskpankadel kõige targem tarbijate inflatsiooniootust jälgida? Mis kasu on järjekordsest inflatsiooniootuse mõõdikust? Milline võiks välja näha kommunikatsioon, mis suunab tarbijate ootusi? Doktoritöö pakub neile põletavatele küsimustele lahendusi ja vastuseid.

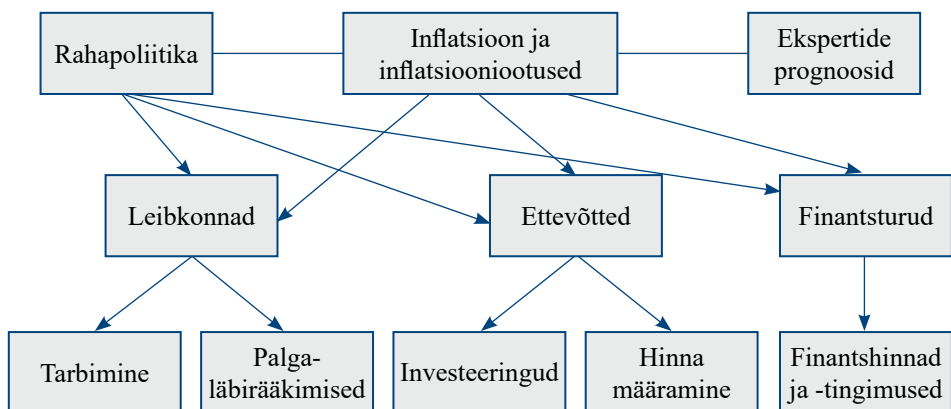
Uurimistöö eesmärk ja ülesanded

Uus-keinsistlikes makromajanduslikes mudelites sõltub inflatsioon kolmest peamisest tegurist. Esimeseks on majandusliku aktiivsuse või ressursside kasutamise näitaja (nt toodang, tööhõive, tööpuudus ja nende näitajate erinevused tasakaalutasemest). Teiseks on palkade ja hindade indekseerimine või muudest jäikustest tingitud varasem inflatsioon. Kolmandaks, ja käesoleva töö vaatenurgast kõige olulisemaks teguriks on tulevase inflatsiooni ootused. Kuigi nende tegurite tähtsus on mudeliti erinev, on mudelite eri osades leibkondade, ettevõtete ja keskpanga ootused alati määrava tähtsusega ja moodustavad peamise sisendi nii inflatsiooni dünaamika mudelites kui ka rahapoliitika mõistmiseks kasutatavates mudelites. Hiljutised uuringud näitavad, et inflatsiooni ootused on inflatsiooni mõistmiseks paremad kui juba toimunud inflatsioon (vt Fuhrer ja Olivei 2009).

Käesoleva doktoritöö eesmärk on näidata, et inflatsiooni ja inflatsiooniootuse mõistmine ja prognoosimine ning asjakohase kommunikatsiooni tagamine on inflatsioonijuhtimise olulised eeldused. Selleks hinnatakse empiiriliselt makromajanduslikes mudelites inflatsiooniootusi ning tehakse prognoose. Tarbijate inflatsiooniootuse mõõtmiseks pakutakse välja uudne moodus, millel on potentsiaali alternatiivse sisendmuutujana majandusmudelites, poliitika kujundamisel ja otsuste tegemisel.

Uurimiseesmärgi saavutamiseks vaadatakse töös üle ka traditsioonilised inflatsioonimõõdikud ja levinumad inflatsiooniootuste mõõdikud ning tehakse kindlaks nende puudused. 2024. Aasta eel kirjutatud doktoritöö empiiriliste uurimuste üks eeliseid peitub viimastel aastakümnetel jõudsalt arenenud arvutusvõimsuses, võimaldades võtta kasutusele uudseid meetodeid ja seni kättesaamatud andmeallikad, mida saab kasutada alternatiivsete mõõdikutena inflatsiooni ja inflatsiooniootuse jaoks. Väljakutseks on andmeallikates sisalduva teabe kvantifitseerimine ja mudelite loomine, mis oleks võrreldes naiivsete võrdlusmudelitega prognoosimisel vähemalt sama stabiilsed või isegi stabiilsemad. Samuti pole otseselt võimalik määratleda, kui hästi edastavad keskpanga sõnumid nende poliitikat, sealhulgas inflatsiooniootuse ankurdamise eesmärki.

Joonisel 2 on esitatud stiliseeritud ülevaade eri majandusagentide inflatsiooniootuste ja rahapoliitika ülekandumise mehhanismidest. Joonis ilmestab just eri kanalite tähtsust inflatsiooniootuse kujunemises. Näiteks mõjutavad leibkondade ja ettevõtete ootused reaaltressimäära kaudu kulutamisoskuseid ja palkade kujunemist. Finantsturgude inflatsiooniootused seevastu kujundavad varade hindu ja finantseerimistingimusi. Prognoose koostavad eksperdid mõjutavad inflatsiooniootusi, olles teabeallikaks teistele mainitud agentidele, kes ise on olulised rahapoliitika ülekandemehhanismi jaoks. Kuna inflatsiooniootus mõjutab palga- ja hinnakujundust, on ta ühtlasi oluline tulevase inflatsiooni määraja. Leibkondade, ettevõtete ja finantsturgude inflatsiooniootusi juhib aga rahapoliitika, mis mõjutab majandusaktiivsust ja inflatsiooni, suunates leibkondade tarbimis- ja palgaotsuseid ning ettevõtete investeerimis- ja hinnakujundusotsuseid.



Joonis 2: Inflatsiooniootuse ülekandemehhanism.

Allikad: EKP (2021), autori kohandustega

Töös püstitatud uurimiseesmärgi saavutamiseks teostatakse empiirilised uurin-
gud ja lahendatakse uurimisülesanded, mis on välja toodud tabelis 1.

Tabel 1. Uurimisküsimused

Uurimus	Uurimisküsimused	Ülesanded
I	1: Kui head on mudelid, mis inflatsiooni prognoosimisel seovad inflatsiooni majandusaktiivsuse näitajatega?	<ol style="list-style-type: none"> 1. Uurida Phillipsi kõverate prognoosimisvõimet nii kogu- kui ka alusinflatsiooni-määra osas, et panustada teaduskirjandusse, mis otsib parima inflatsiooni prognoosi-mise võimega inflatsioonimõõdikut. 2. Hinnata Phillipsi kõverate toimivust enne ja pärast üleminekut inflatsioonijuhtimise režiimile. Analüüsida majanduses tegelikult toimunud muutuste aega.
II	2: Kui hästi suudavad veebi-uudised anda reaajas teavet tarbijate inflat-siooniootuse kohta?	<ol style="list-style-type: none"> 1. Uurida veebiuudiseid kui potentsiaalset andmeallikat inflatsiooniootuse hinda-miseks ja mõõtmiseks. 2. Pakkuda välja potentsiaalselt reaajaline inflatsiooniootuse mõõdik, mida prognoosi-misel kasutada. 3. Hinnata uudseid uudistel põhinevaid masinõppemudelite prognoosimisvõimet lihtsate autoregressiivsete mudelite suhtes. 4. Hinnata nii inflatsiooni kui ka inflatsiooniootuse prognoose.

Tabel 1 järg

<i>Uurimus</i>	<i>Uurimisküsimused</i>	<i>Ülesanded</i>
III	3: Kui hästi saab uudistel põhinevaid mõõdikuid kasutada inflatsiooni-ootuse reaalaajalise alternatiivina?	<ol style="list-style-type: none"> 1. Hinnata Euleri võrrandite ja nende spetsifikatsioonide toimivust empiirilise analüüsiga. 2. Kohaldada uudseid uudistel põhinevaid inflatsiooniootuste mõõdikuid reaalintressimäära arvutustes ja seejärel Euleri võrrandites. 3. Võrrelda uudistel põhinevatel inflatsiooni-ootusel hinnatud mudeleid traditsioonilistel inflatsioonimõõdikutel põhinevate mudelitega. 4. Hinnata uudistel põhinevate inflatsiooni-ootuste ja eri tarbimiskomponentide seotust.
IV	4: Kuidas saab uusi andmeid ja meetodeid kasutades keskpanga sõnumitest rohkem kvantifitseeritavat informatsiooni?	<ol style="list-style-type: none"> 1. Täiendada rahapoliitika reaktsiooni-funktsiooni teabehulka tekstiandmetega. 2. Teha kindlaks, kuidas saab keskpanga sõnumite toimivuse kindlakstegemisel kasutada masinõppe meetodeid.

Uurimisandmed ja metoodika

Inflatsiooni analüüsimine nõuab piisava pikkusega aegridu ja ulatuslikke andmeid, et hinnata ajas pikalt toimuvaid seoseid. Esimeses uurimuses kasutatakse 30 aasta andmeid kolme avatud majandusega riigist – Rootsist, Uus-Meremaalt ja Kanadast. Uurimis fookuses on tarbijahinnaindeks (THI) ja alusinflatsioon. Alusinflatsiooni kasutatakse eelkõige tulemuste usaldusväärsuse tagamiseks, kuna töö peamised tulemused keskenduvad koguinflatsiooni prognoosidele. Mõlemad inflatsioonimõõdikud moodustavad võrdlusmodelite peamise sisendi. Neid kasutatakse Phillipsi kõvera mudelites võrrandi vasakul poolel sõltuva muutujana ja varasemale inflatsioonile vastavate viitajaga mõõdikutena.

Phillipsi kõvera mudelid sisaldavad ka majandusaktiivsuse mõõdikuid. Majanduslikku aktiivsust mõõdetakse töötuse määra, tootmisvõimsuste rakendusastme ja tööstustoodangu indeksi põhjal, mille andmed pärinevad vastavate riikide statistikaametitest ja muudest statistika andmebaasidest. Phillipsi kõverate mudeli versioon, mida nimetatakse kolmnurga mudeliks (Gordon 1990), sisaldab ka pakkumise poole muutujaid, milleks siin töös on valitud naftahinnad.

Tulemuste usaldusväärsuse kontrollimiseks kasutatakse kõigis mudelites ka majandusmõõdikute lõhesid ehk nende erinevusi pikaajalise trendi väärtustest, mis konstrueeritakse populaarsete filtreerimismeetodite abil, näiteks Hodrick-Prescott (HP) ja Kalmani filter. Nagu aegridadega töötamise puhul tavaline,

läbivad andmed mitmeid teisendusi, näiteks aritmeetilisi arvutusi (nt kuuandmete teisendamine kvartaliandmeteks), hooajalisi kohandusi, mitte-statsionaarsuse eemaldamist muutujatest muutuste võtmisena ja viitaegadega muutujate kasutamist. Esimeses uurimuses kasutatud mudelid järgivad Stocki ja Watsoni (2008) artiklit. Autoregressiivse integreeritud libiseva keskmise (ARIMA) mudelid ning Atkensoni ja Ohaniani (2001) juhusliku ekslemise mudelid toimivad võrdlusmudelitena, samas kui mitme muutujaga mudelite puhul kasutatakse Phillipsi kõverate kahte versiooni: ühe prognoosijaga autoregressiivne jaotatud viitajaga mudel ja juba eespool mainitud kolmnurga mudel.

Prognoosimise edukuse hindamiseks võrreldakse mitme muutujaga mudelite ja lihtsate ühe muutujaga mudelite ruutjuurt keskmisest ruutveast (RMSE). Eesmärk on kontrollida, kas Phillipsi kõvera mudelid toimivad paremini, kui ühe muutujaga mudelid. Iga hea inflatsiooni prognoosimise mudel peaks andma täpsemaid prognoose kui naiivsed prognoosimudelikud.

Teises ja kolmandas uurimuses kasutatakse mitmesuguseid andmeid, alates ametlikest allikatest alla laaditud traditsioonilistest avaldatud andmetest kuni ühest Ühendkuningriigi uudisteportaalist pärinevate uudisteni. Uudisteväljaandeks valiti *The Guardian*, sest see ajaleht pakub juba alates 2000. aastate algusest oma artiklitele avatud lähtekoodiga juurdepääsu. Tekstiandmete kättesaamiseks ühendatakse portaal valmis rakendusliidesega (API) ja kood kirjutatakse R-keeles. Ametlikud andmed pärinevad Ühendkuningriigi keskpangast ja statistikaametist ning hõlmavad ametlikke inflatsiooniandmeid, inflatsioonihoiaku küsitlusuuringuid ja kolmandas uurimuses ka tarbijaussalduse küsitlusuuringu andmeid.

Mudelites kasutatakse nii traditsioonilisi ametlikke kui ka uudseid andmeid ning võrreldakse nende prognoosivõimet (teises uurimuses) ja hinnangulisi väärtusi leibkonna tarbimise modelleerimisel (kolmandas uurimuses). Uudiste kasutamist andmeallikana raskendab asjaolu, et andmed on struktureerimata. Tekstiandmete kvantifitseeritud andmeteks teisendamine nõuab tööd mitmes etapis. Lisaks erialakirjanduses soovitatud eeltöötlusetappidele kasutatakse töös meetodit, milleks on teemamodelleerimine (vt Blei *et al.* 2003), mis võimaldab rühmitada sarnaseid sõnu ja eraldada suurest ajalehekorpusel seeläbi erinevad teemad.

Tekstide teemadeks jaotamisel kasutatakse latentset Dirichlet' allokatsiooni (LDA), sest selle loogika on sarnane inimõtlemisele (Chang *et al.* 2009) ja see on osutunud teksti andmetena kasutamisel väärtuslikuks loomuliku keele töötlemise vahendiks (vt Thorsrud 2020, Hansen *et al.* 2018). Kuigi leidub ka teisi meetodeid ja LDA on juhendamata masinõppemeetod, on selle eelis tõlgendatava väljundi loomine. LDA järgi koostatakse iga teema jaoks aegrida, mis näitab, kui sageli antud teemat uudistes käsitletakse.

Teises uurimuses andmete teisendus sellega piirdub. Saadud andmekogumiga luuakse prognoose LASSO masinõppemudeli abil, mis on populaarne meetod muutujate valimiseks mudelisse. LASSO on tulemuslik kõige mõjukamate muutujate tuvastamisel ja aitab ületada suure dimensionaalsusega andmete puhul sageli esilekerkivat vabadusastmete vähesuse probleemi. LASSO-le on olemas

alternatiivid, näiteks LARS (väikseima nurga regressioon) või faktorimudelid. Kuid esiteks teeb LASSO teise uurimuse analüüsiosas piisavalt head tööd ja teiseks on selle silmapaistvad tulemused muutujate valimisel mitmel pool kinnitust leidnud (Ahmed *et al.* 2010, Medeiros *et al.* 2021).

Teises uurimuses kasutatakse LASSOt, et valida inflatsiooniootuse prognoosimiseks kõige asjakohasemad teemad. Kuna eri teemad mõjutavad uudiseid lugevaid tarbijaid erineval määral, on mõni teema nende inflatsiooniootuse jäädvustamisel ja prognoosimisel rohkem, mõni vähem kasulik. Mudelite toimivuse hindamiseks arvutatakse erinevate horisontide jaoks prognoosivead ja neid võrreldakse autoregressiivsete võrdlusmodelite omadega.

Kolmandas uurimuses tuginetakse uudistele põhinevate indeksite koostamisel esialgu samale lähenemisviisile nagu teises uurimuses. Kuid seejärel täiendatakse seda sentimendipunktidega, mis väljendavad uudiseartiklite tekstide tonaalsust. Selleks kasutatakse sentimendianalüüsi, mis sisuliselt liigitab uudised positiivseteks, neutraalseteks ja negatiivseteks, määrates igale artiklile vastavad punktid (skoori).

Lõplikud indeksid sisestatakse inflatsiooniootusena reaalintressimäära arvutamisel. Reaalintressi kasutatakse seejärel Euleri tarbimise empiirilises mudelis. Ascari *et al.* (2021) eeskujul koostatakse Euleri võrrandite mitmesugused spetsifikatsioonid. Nende hulka kuuluvad nii baasmudelid kui ka mudelid, mis lisavad ühismuutujatena tarbijate erinevaid harjumuste mustreid, mis annavad rolli ka tarbimise varasematele otsustele tuleviku otsuste mõjutajana.. Kuna Euleri võrrand seob nominaalse intressimäära ja inflatsiooniootuse tarbimisega, sisaldab kolmanda uurimuse andmekogum ka erinevaid tarbimisandmeid (agregeeritud tarbimine, mittekestvuskaupe tarbimine, poolkestvuskaupe tarbimine) ja andmeid nominaalsete intressimäärade kohta.

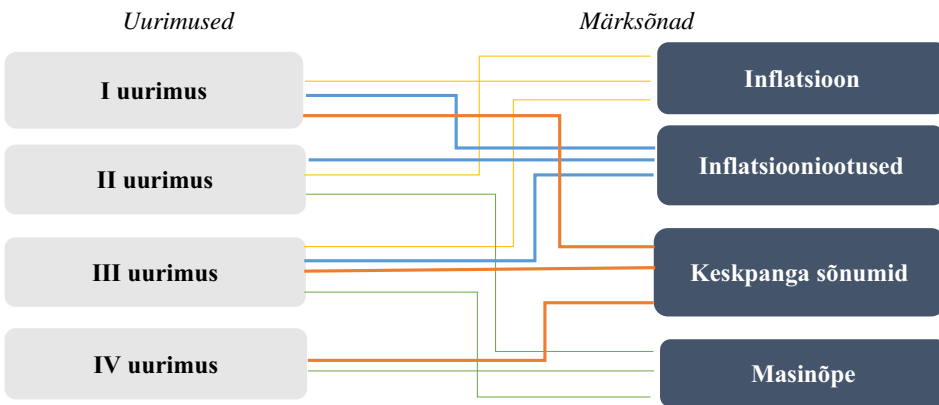
Viimase, neljanda uurimuse peamine andmekogum pärineb Euroopa Keskpanga kõrgete ametnike alates 1997. aastast peetud kõnedest. Täpsemalt koosnevad andmed EKP presidentide, asepresidentide ja juhatuse liikmete kõnedest. Neid tekstiandmeid teisendatakse korduvalt ja ka siin rakendatakse teemamodelleerimise meetodit, et koondada kõnedes korduvad sõnad teemadeks. Saadud teemaindeksite ja inflatsiooni vahel leitakse seos regressiooniga, et saada ülevaade keskpanga kommunikatsiooni reaktsioonifunktsioonist. Selles artiklis kasutatud täielik andmestik sisaldab lisaks SKP reaalkasvu ja lisaks erinevaid finantsturgude kontrollimuutujaid, nagu laia raha agregaadid M3 aastakasvu kolme kvartali libisev keskmine, USA Föderaalreservi inflatsioonieesmärk, kolme kvartali libisev keskmine laenumaht jne. Andmete täielik loend lähtub Cour-Thimanni ja Jungi (2020) artiklist. Artiklis kasutatakse kahte mudelit, ühe on välja pakkunud Cour-Thimann ja Jung (2020) ning teise Hartmann ja Smets (2018).

Kokkuvõtlikult võib öelda, et doktoritöö pakub välja uudsed lähenemisviise vastamaks standardsetele makroökonomilistele küsimustele. Lisaks erinevate masinõppemudelite kasutamisele prognoosimisel ja modelleerimisel kasutatakse neljast uurimusest kolmes ka tekstiandmeid

Uurimuste ja tulemuste kokkuvõte

Liialt volatiilsed, kõrged või madalad inflatsioonimäärad, ankurdamata inflatsiooniootused ja asjakohase rahapoliitilise suhtluse vähesus on rahapoliitika tegijatele hinnastabiilsuse eesmärgi saavutamisel suureks takistuseks. Inflatsiooni kujunemise mõistmine laiemalt on seepärast olulise tähtsusega. Inflatsioon on ka siinse doktoritöö teema ning inflatsioon ja inflatsiooniootused on läbivad olulised märksõnad doktoritöö raames tehtud neljas uurimuses. Neist esimesed kaks artiklit keskenduvad peamiselt inflatsiooni prognoosimisele, kasutades selleks mitmeid traditsioonilisi ja masinõppemudeleid. Esimeses hinnatakse nende prognoosivõimet, et paremini mõista, milliseid prognoosimudeleid tuleks kasutada just inflatsiooni juhtivates riikides. Teises uurimuses võetakse inflatsiooniootuse prognoosimisel kasutusele uudiste andmed. Kolmandas uurimuses täiendatakse kahe eelneva uurimuse analüüsi uudistel põhinevaid inflatsioonimõõdikuid kasutades ja kohaldades neid reaaltressimäärade arvutamiseks, et hinnata Euleri võrrandit analüüsima tarbijate tarbimisotsuseid. Neljas uurimus aga seondub keskpanga sõnumite mõju käsitleva kirjandusega ja analüüsib Euroopa Keskpanga kommunikatsiooni reaktsioonifunktsiooni, et selgitada, millised teemad on kesksel kohal.

Joonisel 3 on kujutatud doktoritöö artiklite (uurimuste) seosed peamiste märksõnadega. Lisaks märksõnadele, millest lähtub käesoleva töö uurimiseesmärk – inflatsioon, inflatsiooniootus ja keskpanga sõnumid –, on töös läbivalt olulisel kohal masinõppe mõiste, sest masinõppe meetodid ja konkreetsed mudelid olid olulisel kohal töö uudsete uurimispärusteni jõudmisel.



Joonis 3: Doktoritöö nelja uurimuse seosed.

Allikas: autori koostatud

Järgnevalt käsitletakse iga uurimuse tulemusi koos uurimispärusteni ja oluliste poliitikajäreldustega. Seejärel võetakse kokku doktoritöö olulisimad tulemused ja seotakse need uurimisülesannetega.

Inflatsiooni prognoosimine Phillipsi kõvera abil inflatsiooni juhtivates riikides (esimene uurimus)

Esimene uurimus keskendub väikestele avatud majandusega riikidele. Selle eesmärk on prognoosida Phillipsi kõvera abil kvartaalseid koguinflatsiooni ja alusinflatsiooni määrasid. Uurimus panustab inflatsiooni uurimisse mitmel moel. Esmalt analüüsitakse Phillipsi kõverate toimivust. Erialakirjanduses valitseb seisukoht, et need mudelid kas empiiriliselt ei kehti või on liiga ebaühtlase kvaliteediga. Esimene uurimus annab varasematele hinnangutele kinnitust, pakkudes empiirilisi tõendeid selle kohta, et prognoosi kvaliteet sõltub tõepoolest valitud perioodist, prognoosihorisonidist, alusandmetest ja inflatsioonimõõdikust. Kuid lisaks täpsustab uurimus varasemaid seisukohti, hinnates seda, kuidas muutub Phillipsi kõverate toimivus inflatsioonijuhtimise režiimile üle minnes. Artiklis vaadeldud riikide puhul toimivad Phillipsi kõverad fikseeritud vahetuskursi režiimis suhteliselt halvasti ega edesta täpsuse poolest prognoosimisel lihtsaid võrdlusemudeleid. Seevastu inflatsioonijuhtimise režiimile üleminekul ja inflatsioonijuhtimise režiimi vältel on Phillipsi kõveratega inflatsiooniprognosid võrdlusemudelitest täpsemad. Olgugi, et see on keskpanga prognooside vaates oluline järeldus ja muster kehtib kõigi kolme uurimuses vaadeldud riigi puhul, oleks teemat vaja rohkem uurida laiemalt, sealhulgas suuremate avatud majanduste kontekstis.

Uurimus lisab teadmisi ka selle kohta, millised on Phillipsi kõverate abil kõige paremini prognoositavaid inflatsioonimäärad. Kui eesmärk on prognoosida nii alus- kui ka koguinflatsiooni, on Phillipsi kõvera abil (sealjuures mis tahes spetsifikatsioonis) prognoositud tulemus lihtsatest võrdlusemudelitest parem. See lubab hinnata uurimuses vaadeldud riikides Phillipsi kõverate kasutamist positiivselt nii kogu- kui ka alusinflatsiooni prognoosimise puhul sest ka alusinflatsiooni puhul paranevad inflatsiooniprognosid oluliselt pärast inflatsioonijuhtimise režiimile üleminekut.

Uurimustulemus tähendab ka uurimispanuseid sest prognooside täpsus aitab hinnata Phillipsi kõverate kasulikkust poliitikaanalüüsis. Prognoositäpsuse parandamine võimaldab keskpankadel jääda oma tegemistes läbipaistvaks ning parandada poliitika kujundamise ja rakendamise distsipliini, eriti kuna igasugune inflatsioonijuhtimise poliitika põhineb eeskätt ühiskonna usaldusel. Peale selle võivad Phillipsi kõverad toimida ka suurepärase mudelina majanduse pakkumise poole struktuursel kirjeldamisel, eriti ajal, mil keskpangad rohkem inflatsioonijuhtimisele keskenduvad.

Uurimisülesannete ja nende tulemuste kaudu antakse vastus doktoritöö esimesele uurimisküsimusele: kas inflatsiooni ja majandusaktiivsust seostavad mudelid aitavad inflatsiooni prognoosida? Saadud järeldused on eriti olulised tänapäeval, mil energiahindade ja tarneahela kriisiga seotud välised šokid on mõjutanud mitte ainult koguinflatsiooni, vaid ka alusinflatsiooni, mis on tavaliselt rahapoliitikale tundlikum.

Uudisteandmete kaeve inflatsiooniootuse mõõtmiseks ja prognoosimiseks (teine uurimus)

Teises uurimuses uuritakse uudiseid kui uudset andmeallikat inflatsiooniootuse mõõtmiseks. Lähtutakse arusaamast, et leibkondadele suunatud inflatsiooni-teemalised küsitlused võivad sageli olla ebatäpsed. Leibkondade ootused võivad oluliselt erineda tegelikest inflatsioonimääradest ja ekspertide prognoosidest. Uurimuse aluseks on seisukoht, et uudised on tarbijatele üldise hinnamuutuse mõtestamisel oluline teabeallikas. Uurimuse üks panuseid ongi pakkuda tõendeid, et veebiuudiseid saab kasutada tarbijate inflatsiooniootuse reaajaliseks ja täpseks mõõtmiseks, vastates seejuures teisele uurimisküsimusele tarbijate inflatsiooniootuse mõõtmisest.

Nagu uurimisülesannetes kirjeldatud, võetakse uurimisküsimusele vastamiseks kasutusele inflatsiooniootuse reaajaline mõõdik. Selleks kasutatakse erinevaid tekstikaeve (i.k. *text mining*) tehnikaid. Tekstikaeve on majandusteaduses suhteliselt vähe kasutatud leidnud tehnika ja uurimuse üks panuseid on lisada teaduslikke andmeid tekstiandmete kasutamise kohta majandussuhete analüüsimisel ja mõistmisel. Nii on võimalik siduda uudistes käibivaid narratiive kvantitatiivsel moel majandusteooria hüpoteesidega ja näiteks saab hõlbustada rahapoliitika kujundamist. Uudiste andmete kasutamine võimaldab mõista uudistes käsitletud temade ja inflatsiooniootuse seoseid ja koosmõjusid. Teematasandi analüüs võimaldab mõista ja kvantifitseerida iga teema mõju inflatsiooniootustele. Kui leibkonnad ei kohanda oma ootusi erinevatele uudistes käsitletud temadele, tähendaks see potentsiaalselt, et inflatsiooniootused on hästi ankurdatud.

Lisaks inflatsiooniootuse ja uudiste vahelise olulise seose dokumenteerimisele panustab uurimus ka prognoosimist käsitlevasse kirjandusse, hinnates uudiste prognoosivõimet. Masinõppe mudelite prognoosivõimet võrreldakse lihtsamate mudelite omaga (sarnased esimese uurimuse mudelitega). Tulemused viitavad sellele, et lühiajaliste inflatsiooniootuste prognooside puhul on LASSO-mudelite vead väiksemad kui lihtsatel autoregressiivsetel mudelitel, samas kui inflatsiooni prognoosides on nende täpsus sama hea (mitte parem) kui autoregressiivsetel mudelitel.

Poliitika seisukohast toetavad need tulemused varasemaid järeldusi, mis toovad esile meedia rolli leibkondade inflatsiooniootuste kujunemisel (vt Mazumder 2021, Larsen *et al.* 2021). Poliitikakujundajatel soovitakse kasutada uudisteandmeid, et leibkondade ootuste kujunemist paremini mõista. Parema arusaama tarbijate inflatsiooniootustest võib leida mitmesugust rakendust nii akadeemilistes töödes kui ka keskpankade tegevuses. Kasu on sellest alates prognoosimisest, nagu näitas teine uurimus tuginedes Tallman ja Zaman (2020) ning Faust ja Wright (2013) uurimustele, kuni leibkonna tarbimise modelleerimiseni, millele keskendus kolmas uurimus, baseerudes Ichiue ja Nish Iguchi (2015) ning Dräger ja Nghiem (2021) töödel. Alternatiivseid võimalikke rakendusi käsitletakse doktoritöö kirjanduse ülevaates ja teises uurimuses.

Inflatsiooniootus ja tarbimine masinõppega (kolmas uurimus)

Kolmandas uurimuses käsitletakse tarbimise ja reaaltressimäärade seoseid, keskendudes seejuures Euleri võrranditel tuginevatele mudelitele. Uurimuses pakutakse välja, et masinõppemeetodite rakendamine võib aidata parandada nende mudelite toimivust ja prognoose. Tähelepanu keskmes on Euleri võrrandis kasutatavad reaaltressimäärad. Võib kahtlustada, et need ei ole korrektsed, sest nende arvutamisel traditsiooniliselt kasutatavad inflatsiooniootuste mõõdikud ei väljenda majandusagentide tegelikke arusaamu majandusest sest inflatsiooniootused pole otseselt mõõdetavad. Alternatiivse lahendusena pakutakse uurimuses välja alternatiivne inflatsiooniootuse mõõdik, mis toetub uudiste andmetele, täiendades teises uurimuse kasutatud uudistepõhist inflatsiooniootuste mõõdikut.

Selle analüüsi tulemused panustavad majandusteaduslikku kirjandusse mitmel moel ja avaldavad olulist mõju rahapoliitika kujundamisele. Esimene järeldus puudutab Euleri võrrandeid, mis põhinevad praegu enamasti tegelikel inflatsioonimääradel või küsitlustepõhistel inflatsiooniootuse mõõdikutel. Nende asemel kasutatakse kolmandas uurimuses ülalmainitud uudistel põhinevat inflatsiooniootuste mõõdikut. Nagu artiklis osutatakse, on tarbimise mõistmiseks vaja lähendada tarbijate inflatsiooni ootustest. Seda kinnitavad ka uurimistulemused.

Euleri võrrandite eri spetsifikatsioonide hindamisel uudsete inflatsiooniootuse mõõdikute abil mudeli kvaliteet paraneb. Tulemuseks on tugevamad instrumendid ja sisukamad perioodidevahelise asendamise elastsuse hinnangud. Need on paremini kooskõlas alternatiivsete empiiriliste tõendite ja stabiilsete mudelitega väljendudes mitmesugused teaduskirjanduse testide tulemustes. Teooriaga kooskõlaliselt, on tulemused eriti paljulubavad mittekestvuskaukade ja -teenuste tarbimise mõistmise osas ning vähem lootustandvad muude tarbimiskomponentide osas. Töö peamine eesmärk ei ole aga leida kõige sobivamad või teooriaga paremini sobivaid parameetrite väärtuseid, vaid hoopis näidata, et kui kasutada uut inflatsiooniootuse ja sellest tulenevalt ka reaaltressimäära mõõdikut, töötavad Euleri võrrandid paremini, kui traditsioonilisi küsitluspõhiseid mõõdikuid kasutades.

Ainuüksi Euleri mudeli hindamise tulemuse põhjal saab teha mitu järeldust. Esiteks viitab see, et keskpangad peaksid teadvustama, et tarbijatel on oma tarbimisharjumuste kohta üldiselt rohkem teavet kui ökonomeetrikul. See tähendab, et ei praegust ega ka tulevast tarbimist ei tohiks Euleri võrrandis käsitleda eksogeense muutujana, et vältida jääkliikmetes korrelatsiooni. Teiseks – kuigi see ei ole keskpankade jaoks uus teave, osutavad kolmanda uurimuse tulemused sellele, et küsitluspõhised andmed inflatsiooniootuste kohta ei pruugi alati olla parim valik, kuna need on väga sageli ebatäpsed, kättesaadavad olulise viitajaga ja kulukad koguda. Uurimuses täheldati küsitluspõhiste mõõdikute ja uudispõhiste mõõdikute puhul koosliikumist, mis toetab ideed, et uudiste-põhiseid mõõdikuid saab kasutada küsitluspõhiste mõõdikute alternatiivina. Erinevalt küsitluspõhistest mõõdikutest on uudistepõhised mõõdikud saadaval reaalajas, nende sagedus on suurem, neid on suhteliselt soodsam (kuluefektiivsem) koostada ja

sisaldavad uut informatsiooni. Uus mõõdik võimaldab tarbijate valikuid potentsiaalselt paremini selgitada kui traditsioonilised inflatsiooninäitajad.

Teiseks panustab see uurimus üha mahukamasse teadustöösse, milles analüüsitakse uudiste mõju inflatsiooniootusele, sealhulgas selle rakendusi tarbimis-mudelites. Üldiselt on tõendid inflatsiooniootuse seose kohta tarbimisotsustega vajalike andmete puudumise tõttu piiratud. Uurimuse uudne ja rikkalik andmestik avab võimalusi käsitleda põhjalikult mitte ainult tarbimise ja reaaltressimäära seost, vaid ka leibkondade otsuseid laiemalt, näiteks laenamise ja investeerimisega.

Siit edasi mõeldes annavad artiklis kasutatud teemamodelleerimine ja uudiste teemapõhine klassifitseerimine aimu sellest, millised uudised ja teemad tarbijate tarbimisotsuseid kõige rohkem mõjutavad. Poliitikakujundajate jaoks on see kinnitus, et uudistel põhinevaid inflatsiooniootuse mõõdikuid saab kasutada makromajanduslikuks modelleerimiseks ning inflatsiooniootuste ja tarbimise reaajas prognoosimiseks. Uurimuse viimase, ent samuti olulise panusena avavad uudisteandmed uusi võimalusi ka muude oluliste makromajanduslike suhete, näiteks uuskeinslike Phillipsi kõverate paremaks modelleerimiseks. Need tulemused võimaldavad anda positiivse vastuse doktoritöö kolmandale uurimisküsimusele, osutades, et uudistepõhiseid mõõdikuid saab edukalt kasutada alternatiivsete inflatsiooniootuse mõõdikutena.

Euroopa Keskpanga kommunikatsiooni reaktsioonifunktsioon. Teemamodelleerimisel põhinev analüüs (neljas uurimus)

Neljandas uurimuses otsitakse vastust doktoritöö neljandale uurimisküsimusele – kuidas saab uusi andmeid ja meetodeid kasutades keskpanga sõnumitest rohkem kvantifitseeritavat informatsiooni? Leitakse, et keskpanga sõnumeid on tõepoolest võimalik põhjalikumalt uurida, kui kombineerida 1) uudseid tekstiandmeid, mis suurendavad andmehulka rahapoliitika reaktsioonifunktsiooni mudeli hinnangutes ja 2) rakendada keskpanga kommunikatsiooni reaktsioonifunktsiooni analüüsimiseks masinõppe mudeleid. Uurimuse küsimusele vastamiseks analüüsitakse Euroopa Keskpanga kommunikatsiooni reaktsioonifunktsiooni teemamodelleerimise abil ning tehakse kindlaks, kas kõrgete ametnike kõnedes käsitletud teemadest ja nende põhjal tuletatud indeksitest on panga kommunikatsiooni reaktsioonifunktsiooni hindamisel kasu. Teemapõhiste indeksite tuletamine sarnaneb teises ja kolmandas uurimuses kasutatud meetoditega ning annab aimu tekstikaeve ja teemamodelleerimise mitmekülsusest, nende sobivusest mitmesuguste eesmärkide teenistusse, andes ühtlasi vihjeid nende võimalike kasutusvõimaluste kohta keskpankades.

Tulemused näitavad, et võrreldes diskreetsetel sõltuvatel muutujatel põhinevate uurimustega sisaldavad need teemaindeksid rohkem teavet ja suudavad pakkuda põhjalikumat analüüsi. Enamik uurimuse tulemusi on kooskõlas varasemate käsitlustega. Osasid tulemusi on raske tõlgendada, eriti kui kommunikatsiooni reaktsioonifunktsiooni hinnatakse rohkem kui ühes dimensioonis. Teemade koondamine võimaldab aga selle raskuse ületada ja analüüsida tulemusi kõigis kommunikatsiooni reaktsioonifunktsiooni aspektides.

D'Acunto *et al.* (2020) on näidatud, et erinevad leibkonnad reageerivad erinevatele rahapoliitikat edastavatele sõnumitele erinevalt. Näiteks lihtsamad sõnumid on hästi arusaadavad, samas kui keerukamate rahapoliitika vahendite (nt varaostude) teemalised teated ei tekita leibkondades sageli mingit reaktsiooni. Nagu D'Acunto *et al.* (2021) näitavad, mõjutavad vähemusrühmade esindajate loodud prognoosid ka just nende endi inflatsiooniootuse kujunemist. Selline heterogeensus ei piira ainult uurimistööd, vaid, mis veelgi olulisem, kõneleb vajadusest kasutada laiema avalikkuseni jõudmiseks paremaid ja uuenduslikumaid vahendeid.

Neljas uurimus annab selliste kommunikatsioonivahendite väljatöötamiseks lähtepunkti keskpanga kommunikatsioonistrateegiate empiirilise analüüsi kaudu. Need kommunikatsiooni strateegiad mõjutavad otseselt inflatsiooni, inflatsiooniootust ja loomulikult ka muid majandusnäitajaid. Eelkõige just inflatsiooni juhtivate keskpankade puhul modelleeritakse inflatsioonieesmärgi ja võimalike teiste majandusnäitajate varjatud eesmärkide rolli ja koostoimeid poliitika reaktsioonifunktsiooni kaudu. Erinevate eesmärkide olemasolu tekitab omakorda ootusi, et need eesmärgid saavutatakse. Seega annab keskpanga kommunikatsiooni mõjude mehhanismi ja kaasaaitavate tegurite mõistmine rahapoliitika kujundajatele uued ja võimsad vahendid, mis saavad kaasa aidata eesmärkide saavutamisele.

Doktoritöö põhiliste järelduste ja uurimisülesannete kokkuvõte

Doktoritöö uurimuste põhilised järeldused ja nende seos uurimisülesannetega on esitatud tabelis 2.

Tabel 2. Uurimisküsimused, ülesanded ja järeldused

<i>Uurimisküsimused</i>	<i>Ülesanded</i>	<i>Järeldused</i>
<u>1:</u> Kui head on mudelid, mis inflatsiooni prognoosimisel seovad inflatsiooni majandusaktiivsuse näitajatega?	1. Uurida Phillipsi kõverate prognoosimisvõimet nii kogu- kui ka alusinflatsioonimäära osas, et panustada teaduskirjandusse, mis otsib parima inflatsiooni prognoosimise võimega inflatsioonimõõdikut.	Phillipsi kõvera kasutamine parandab inflatsiooni prognoosivõimet nii alus- kui ka koguinflatsiooni osas.
	2. Hinnata Phillipsi kõverate toimivust enne ja pärast üleminekut inflatsiooni-juhtimise režiimile. Analüüsida majanduses tegelikult toimunud muutuste aega.	Fikseeritud vahetuskursi režiimis toimivad Phillipsi kõverad suhteliselt halvasti ega suuda edestada lihtsaid võrdlusemudeleid. Seevastu inflatsiooni-juhtimise režiimile üleminekul ja inflatsiooni-juhtimise režiimi vältel on Phillipsi kõveratega saadud inflatsiooniprognosid võrdlusmudelitest täpsemad.
<u>2:</u> Kui hästi suudavad veebiuudised anda reaajas teavet tarbijate inflatsiooniootuse kohta?	1. Uurida veebiuudiseid kui potentsiaalset andmeallikat inflatsiooniootuse hindamiseks ja mõõtmiseks.	Veebiuudiseid saab kasutada tarbijate inflatsiooniootuse reaajas mõõtmiseks.
	2. Pakkuda välja potentsiaalselt reaajaline inflatsiooniootuse mõõdik, mida prognoosimisel kasutada.	Masinõppetehnikate ja uudiste andmete abil töötatakse välja inflatsiooniootuse mõõdik.
	3. Hinnata uudseid uudistel põhinevate masinõppe-mudelite prognoosivõimet lihtsate autoregressiivsete mudelite suhtes.	LASSO-mudelite puhul on lühiajalised prognoosivead sarnased või väiksemad kui lihtsate autoregressiivsete mudelite puhul.
	4. Hinnata nii inflatsiooni kui ka inflatsiooniootuse prognoose.	Inflatsiooniootuse puhul on LASSO-mudelite prognoosivõime võrdlusmudelitega võrreldes parem, inflatsiooni puhul sama hea.

Tabel 2 järg

<i>Uurimisküsimused</i>	<i>Ülesanded</i>	<i>Järeldused</i>
3: Kui hästi saab uudistel põhinevaid mõõdikuid kasutada inflatsiooniootuse reaalsajalise alternatiivina?	1. Hinnata Euleri võrrandite ja nende spetsifikatsioonide toimivust empiirilise analüüsiga.	Hinnatakse Euleri võrrandite erinevaid spetsifikatsioone, sealhulgas erinevaid võimalikke tarbimise harjumustega, kus varasemad tarbimise otsused mõjutavad tänaseid valikuid.
	2. Kohaldada uudseid uudistel põhinevaid inflatsiooniootuse mõõdikuid reaallintressimäära arvutustes ja seejärel Euleri võrrandites.	Euleri võrrandite eri spetsifikatsioonide hindamisel uudsete inflatsiooniootuse mõõdikute abil mudeli kvaliteet paraneb.
	3. Võrrelda uudistel põhinevatel inflatsiooni-ootusel hinnatud mudeleid traditsioonilistel inflatsioonimõõdikutel põhinevate mudelitega.	Võrreldes traditsiooniliste inflatsiooninäitajatega hinnatud mudelitega on uudsete uudistel põhinevate inflatsiooniootuse mõõdikutega koostatud Euleri mudelite kasutamise tulemuseks tugevamad instrumendid ja teooriaga ja alternatiivsete empiiriliste tulemustega paremini kokku sobivad perioodidevahelise asendamise elastsuse hinnangud.
	4. Hinnata uudistel põhinevate inflatsiooniootuste ja eri tarbimiskomponentide seotust.	Teooriaga kooskõllaliselt paranesid eelkõige mittekestvuskapade ja teenuste tarbimise näitajate mudelid.
4: Kuidas saab uusi andmeid ja meetodeid kasutades keskpanga sõnumitest rohkem kvantifitseeritavad informatsiooni?	1. Täiendada rahapoliitika reaktsioonifunktsiooni teabehulka tekstiandmetega.	Keskpanga sõnumeid saab kvantitatiivselt uurida ja saada enam informatsiooni, kui analüüsida keskpanga kõnede andmes-tikku tekstikaeve tehnikate abil.
	2. Teha kindlaks, kuidas saab keskpanga kommunikatsiooni reaktsioonifunktsiooni hindamisel kasutada masinõppe meetodeid.	Teemaindeksid, mis on koostatud masinõppe teemamodelleerimise tehnika abil, sisaldavad võrreldes diskreetsetel sõltuvatel muutujatel põhinevate uurimustega rohkem teavet ja suudavad pakkuda sisulisemat analüüsi.

Kokkuvõte

Inflatsiooniootus on rahapoliitika teoreetilise ülekandemehhanismi tähtsaim komponent ning tulevase inflatsiooni, aga ka palga- ja hinnakujundusprotsesside keskne tegur. Inflatsiooniootuse ülekandekanali efektiivsus sõltub omakorda keskpanga usaldusväärsusest ja sellest, kui hästi on inflatsiooniootust ankurdatud. Inflatsiooni ülemaailmne suur tõus alates 2021. aastast ja hiljem toimunud inflatsiooni märkimisväärne langus on teinud inflatsiooniootuse olemusest ja kujunemisest arusaamise rahapoliitika kujundajate jaoks kiireloomulise ülesande. Keskpangad otsivad võimalusi stabiliseerida inflatsiooni eesmärgiks seatud taseme juures, et edendada majanduskasvu, majanduse stabiilsust ja jätkusuutlikku tööhõivet. Pandeemia, tarneahelate häired ning muidugi mõista ka regionaalsed konfliktid mõjutavad majandusi nii nõudluse kui ka pakkumise muutuste kaudu. Need muutused omakorda juhivad majandustsükli dünaamikat ning inflatsiooni.

Doktoritöö pakub uudseid tööriistu ja tehnikaid, mille abil hankida teavet hindade arengute mõõtmiseks ja mõistmiseks, keskendudes inflatsioonile, inflatsiooniootusele ja keskpanga sõnumitele. Kvantifitseerides ja analüüsides inflatsiooniootuse rolli ja mõju tarbijate majandusvalikutele, suudavad keskpangad ootusi paremini juhtida. See aitab toetada hinnastabiilsuse eesmärkide saavutamist ning ka teiste eesmärkide, nagu kogutoodangu ja tööhõive stabiilsel tasemel hoidmist. Ebastabiilne või sihtmärgist kõrvalekalduv inflatsiooniootus lööb majandused tasakaaluolukorrast välja, mõjutades mitte ainult inflatsiooni, vaid ka muid olulisi näitajaid, näiteks tööpuudust.

Majandus saab olla heas seisus siis, kui tarbijatel on majandusasutuste vastu usaldus, kuna see tagab tulemusliku poliitikakujundamise. Keskpanga sõnumid kujundavad ühiskonna inflatsiooniootusi ning mängivad seeläbi olulist rolli inflatsioonimäärade stabiilsena hoidmises ja avalikkuse inflatsiooniootuse ankurdamises. Keskpanga sõnumid peaksid olema lihtsad, otsekohesed ja edastama selgelt rahapoliitika reaktsioonifunktsiooni. Kommunikatsioonikanalite parandamine tervikuna, aga ka kitsamalt rahapoliitika meetmete osas, viib majandusagentide ootused keskpankade tegevuse, eesmärkide ja poliitika strateegiaga paremini kooskõlla, aidates mõista mitmesuguseid inflatsiooni ja intressimäärade muutuseid.

Uurimused on näidanud, et keskpankade arusaam tarbijate ootuste kujunemise protsessist on oluliselt paranenud, kuid halb uudis on see, et see ei ole veel kaugeltki täiuslik. Oma otsustes lähtuvad rahapoliitika kujundajad endiselt väga piiratud andmetest. Doktoritöös välja pakutud tekstiandmed, mida on võimalik koguda uudistest ja näiteks avalikest kõnedest, suurendavad kasutada olevate andmete mahtu ja ulatust märkimisväärselt. Lisaks võimaldab nende tekstiandmete kvantifitseerimine masinõppetehnikate abil koguda paremini teavet tarbijate inflatsiooniootuse kohta, mida saab kasutada makromajanduslikus modelleerimises ja majandusproгноoside koostamisel.

Doktoritöös toodud empiirilised tõendid uudiste andmete mõju kohta inflatsiooniootusele loovad pinnase, millelt uurida keskpanga kommunikatsiooni kui kanalit, mille kaudu mõjutatakse tarbijate ja ettevõtete otsuseid. Kui keskpangad

need uuendused oma kommunikatsioonipoliitika mõju suurendamiseks käiku lasevad, võib oodata, et nende võime suunata inflatsiooniootuste, aga ka rahapoliitika kui terviku mõju suureneb märkimisväärselt. See omakorda võimaldab parandada rahapoliitika toimimist ja seatud eesmäärke saavutamist.

Lisaks keskpanga kommunikatsiooni parandamisse panustamisele uurib doktoritöö uudsel moel ka inflatsiooniootuste ja majandusotsuste seost. Masinõppemeetodite abil koostatud uudistel põhinev inflatsiooniootuste mõõdiku abil näidatakse, et Euleri tarbimismudeli toimivust saab parandada läbi parema inflatsiooniootuste mõõtmise, ning ühtlasi näidatakse, et uudistel põhinevaid mõõdikuid saab edukalt kasutada traditsiooniliste inflatsiooniootuse alternatiivina.

Doktoritöö pakub tõendeid ka uudisteandmete kasutamise kohta lühiajalise inflatsiooniootuse prognoosimiseks. Koos teiste doktoritöö tulemustega vastab see doktoritöö peamisele eesmärgile näidata, et inflatsiooni ja inflatsiooniootuse mõistmine ja prognoosimine ning asjakohaste sõnumite tagamine on inflatsiooni juhtimise olulised osad.

Ometi tuleb tunnistada, et paljud küsimused on veel lahendamata. Rohkem uurimist vajavad mitmed teemad. Rohkem infot on vaja näiteks pikemaajaliste inflatsiooni prognooside kohta. Tulemused võivad sõltuda üldisest majanduskeskkonnast nii üle aja aga ka riikide vahel. Uurimist väärib ka see, kuidas erinevad inflatsiooniootused muidu sarnaste sotsiaal-demograafiliste tunnustega leibkondades. Samuti, milline on inflatsiooniootuste mõju üksikisiku majandusotsustele. Need teemad pakuvad mitmesuguseid küsimusi uuteks uuringuteks.

Kokkuvõttes pakub doktoritöö tõendeid selle kohta, et uued lähenemisviisid avavad uusi uurimisvõimalusi. Tehtud uurimistöö pakub tööriistu mis tahes huvipakkuva teabeni jõudmiseks, luues viljaka pinnase edasiseks uurimistegevuseks, eriti tänapäeva heitlikul majandusmaastikul.

CURRICULUM VITAE

Name: Diana Gabrielyan
Date of Birth: 29.12.1992
Address of home institution:
Narva mnt 18, Tartu, Estonia.

Education

2016– Ph.D. studies in Economics, University of Tartu, Estonia.
2014–2016 MA in Quantitative Economics (Cum laude), University of Tartu, Estonia.
2015–2016 Study Abroad Program, University of Bologna, Italy.
2009–2013 BSc in Computer Science and Applied Mathematics, Yerevan State University, Armenia

Studies and Trainings

2022 Summer School in Data Science.
Organized by *Barcelona Graduate School of Economics*, Spain.
2022 Summer School High-Dimensional Time Series Modelling.
Organized by *Barcelona Graduate School of Economics*, Spain.
2020 SoFiE Financial Econometrics Summer School “The Econometrics of Mixed Frequency (Big) Data”.
Organized by *NYU Shanghai*. Online
2018 Machine Learning for Economists.
Organized by *CEMFI*. Madrid, Spain.
2018 4th International Winter School on Big Data.
Organized by *University of Timisoara*. Romania.
2017 International Business Masterclasses.
Organized by *Henley Business School*, Reading, UK
2017 PhD course in Monetary Policy.
Organized by *Kiel University, Centre for Advanced Studies*. Kiel, Germany.

Research and Teaching experience

2019– Lecturer, University of Tartu.
Courses taught: Introduction to Business Analytics and Data Science, Multivariate Statistics Course, Basics of SQL.
2020–2021 Visiting Research Student at the Helsinki Graduate School of Economics. Helsinki, Finland.
2015, 2016 Intern in Economic and Research Department at Bank of Estonia. Tallinn, Estonia.

ELULOOKIRJELDUS

Nimi: Diana Gabrielyan
Sünniaeg: 29.12.1992
Töökoha aadress: Narva mnt 18, Tartu, Eesti

Haridus

2016– majandusteaduse doktoriõpe, Tartu Ülikool, majandus-
teaduskond
2014–2016 sotsiaalteaduste bakalaureus matemaatilise majandus-
teaduse erialal (MA, *cum laude*), Tartu Ülikool, Eesti
2015–2016 välismaal õppimise programm, Bologna Ülikool, Itaalia
2009–2013 arvutiteaduste ja rakendusmatemaatika bakalaureus (BSc),
Jerevani Riiklik Ülikool, Armeenia

Õpingud ja koolitused

2022 andmeteaduse suvekool
korraldaja: Barcelona Majanduskõrgkool (*Barcelona Graduate School of Economics*), Barcelona, Hispaania
2022 kõrgedimensiooniliste aegridade modelleerimise suvekool
korraldaja: Barcelona Majanduskõrgkool (*Barcelona Graduate School of Economics*), Barcelona, Hispaania.
2020 SoFiE finantsökonomeetria suvekool “Segasageduslike
(suurte) andmete ökonomeetria”
korraldaja: New Yorgi Ülikool Shanghais (*NYU Shanghai*),
Hiina (onlainis)
2018 masinõpe majandusteadlastele
korraldaja: CEMFI, Madrid, Hispaania
2018 IV rahvusvaheline suurandmete talvekool
korraldaja: Timișoara ülikool, Timișoara, Rumeenia
2017 rahvusvahelise ettevõtluse meistrikursused
korraldaja: Henley Ärikool (*Henley Business School*),
Reading, Ühendkuningriik
2017 rahapoliitika doktorikursus
korraldaja: Kieli Ülikool, Kõrgemate Uuringute Keskus (*Centre for Advanced Studies*), Kiel, Saksamaa

Uurimis- ja õpetamiskogemus

2019– õppeülesande täitja, Tartu Ülikool
õppeained: sissejuhatus andmeteadusse ja ärianalüütikasse,
mitmemõõtmeline statistika, SQL baasteadmised
2020–2021 külalisüliõpilane, Helsingi majandusülikool, Helsingi, Soome
2015, 2016 praktikant, Eesti Panga majandusuuringute osakond, Tallinn,
Eesti

DISSERTATIONES RERUM OECONOMICARUM UNIVERSITATIS TARTUENSIS

1. **Олев Раю.** Экономическая ответственность и ее использование в хозяйственном механизме. Tartu 1991, 390 с.
2. **Janno Reiljan.** Majanduslike otsustuste analüütiline alus (teooria, metodoloogia, metoodika ja meetodid). Tartu 1991.
3. **Robert W. McGee.** The theory and practice of public finance: some lessons from the USA experience with advice for former socialist countries. Tartu 1994, 123 p.
4. **Maaja Vadi.** Organisatsioonikultuur ja väärtused ning nendevahelised seosed (Eesti näitel). Tartu 2000, 220 lk.
5. **Raul Eamets.** Reallocation of labour during transition. Disequilibrium and policy issues: The case of Estonia. Tartu 2001, 252 p.
6. **Kaia Philips.** The changes in valuation of human capital during the transition process in Estonia. Tartu 2001, 289 p.
7. **Tõnu Rooliht.** The internationalization of Estonian companies: an exploratory study of relationship aspects. Tartu 2002, 193 p.
8. **Tiia Vissak.** The internationalization of foreign-owned enterprises in Estonia: An extended network perspective. Tartu 2003, 221 p.
9. **Anneli Kaasa.** Sissetulekute ebavõrdsuse mõjurite analüüs struktuurse modelleerimise meetodil. Tartu 2004, 260 lk.
10. **Ruth Alas.** Organisational changes during the transition in Estonia: major influencing behavioural factors. Tartu 2004, 210 p.
11. **Ele Reiljan.** Reasons for de-internationalization: An analysis of Estonian manufacturing companies. Tartu 2004, 235 p.
12. **Janek Uiboupin.** Foreign banks in Central and Eastern European markets: their entry and influence on the banking sector. Tartu 2005, 185 p.
13. **Jaan Masso.** Labour reallocation in transition countries: efficiency, restructuring and institutions. Tartu 2005, 241 p.
14. **Katrin Männik.** The impact of the autonomy on the performance in a multinational corporation's subsidiary in transition countries. Tartu 2006, 252 p.
15. **Andres Vesilind.** A methodology for earning excess returns in global debt and currency markets with a diversified portfolio of quantitative active investment models. Tartu 2007, 170 p.
16. **Rebekka Vedina.** The diversity of individual values and its role for organisations in the context of changes. Tartu 2007, 177 p.
17. **Priit Sander.** Essays on factors influencing financing decisions of companies: risk, corporate control and taxation aspects. Tartu 2007, 178 p.
18. **Kadri Ukrainski.** Sources of knowledge used in innovation: an example of Estonian wood industries. Tartu 2008, 263 p.
19. **Kristjan-Olari Leping.** Heterogeneity of Human Capital and its Valuation in the Labour Market. Tartu 2008, 160 p.

20. **Kadri Männasoo.** Essays on financial fragility – evidence from the corporate and banking sectors in Central and Eastern Europe. Tartu 2008, 152 p.
21. **Made Torokoff.** Patterns of learning organisation – Estonian experiences. Tartu 2008, 163 p.
22. **Helena Rozeik.** Changes in ownership structures, their determinants and role in the restructuring of enterprises during transition: evidence from Estonia. Tartu 2008, 268 p.
23. **Jaanika Meriküll.** Technological change and labour demand. Tartu 2009, 148 p.
24. **Anne Aidla.** The impact of individual and organisational factors on academic performance in Estonian general educational schools. Tartu 2009, 219 p.
25. **Alexander Gofman.** Experimentation-Based Product Development in Mature Food Categories: Advancing Conjoint Analysis Approach. Tartu 2009, 273 p.
26. **Anne Reino.** Manifestations of organizational culture based on the example of Estonian organizations. Tartu 2009, 272 p.
27. **Krista Jaakson.** Management by values: the analysis of influencing aspects and its theoretical and practical implications. Tartu 2009, 225 p.
28. **Eve Parts.** Social capital, its determinants and effects on economic growth: comparison of the Western European and Central-Eastern European countries. Tartu 2009, 293 p.
29. **Egle Tafenau.** Welfare effects of regional policy in the constructed capital model. Tartu 2010, 187 p.
30. **Epp Kallaste.** Employee workplace representation: an analysis of selected determinants. Tartu 2010, 173 p.
31. **Danel Tuusis.** Interest rate influence on the behavior of economic subjects. Tartu 2010, 201 p.
32. **Elina Kallas.** Emotional intelligence, organizational culture and their relationship based on the example of Estonian service organizations. Tartu 2010, 304 p.
33. **Dorel Tamm.** Alignment between the factors of the innovation process and public sector innovation support measures: an analysis of Estonian dairy processors and biotechnology enterprises. Tartu 2010, 231 p.
34. **Rasmus Kattai.** The links between private sector indebtedness and banking sector vulnerability: An Estonian case study. Tartu 2011, 164 p.
35. **Kurmet Kivipõld.** Organizational Leadership Capability and its evaluation based on the example of Estonian service organizations. Tartu 2011, 199 p.
36. **Janno Järve.** Downward Nominal Wage Rigidity in the Estonian Private Sector. Tartu 2011, 197 p.
37. **Kristina Toming.** The impact of integration with the European Union on the international competitiveness of the food processing industry in Estonia. Tartu 2011, 241 p.

38. **Andrus Kotri.** Customer experience evoking and management in services. Tartu 2011, 360 p.
39. **Andres Kuusik.** Segmentation of repeat visitors using passive mobile positioning data: customer loyalty based approach. Tartu 2011, 158 p.
40. **Tuuli Pärenson.** Social impact evaluation in social enterprises in Estonia: need, readiness and practices. Tartu 2011, 216 p.
41. **Indrek Saar.** Optimal alcohol taxation in Estonia. Tartu 2011, 185 p.
42. **Kertu Lääts.** Management accounting change in a dynamic economic environment based on examples from business and public sector organizations. Tartu 2011, 250 p.
43. **Reelika Irs.** Teacher performance appraisal and remuneration aspects of performance management on the example of Estonian general educational schools. Tartu 2012, 322 p.
44. **Anne Lauringson.** The impact of the generosity of unemployment benefits on Estonian labour market outcomes in a period of crisis. Tartu 2012, 268 p.
45. **Peeter Peda.** The relationship between governance and performance in water services provision in Estonian municipalities. Tartu 2012, 326 p.
46. **Andres Kuusk.** Financial contagion during times of crisis: a meta-analysis based approach with special emphasis on CEE economies. Tartu 2012, 211 p.
47. **Kerly Espenberg.** Inequalities on the labour market in Estonia during the Great Recession. Tartu 2013, 312 p.
48. **Xiaotian Zhang.** Internationalization processes of Chinese firms: The role of knowledge. Tartu 2013, 274 p.
49. **Helen Poltimäe.** The distributional and behavioural effects of Estonian environmental taxes. Tartu 2014, 141 p.
50. **Eneli Kindsiko.** Organisational Control in University Management: A Multiparadigm Approach on the Example of the University of Tartu. Tartu 2014, 211 p.
51. **Diana Eerma.** A bookkeeping approach to social accounting for a university faculty: the case of the University of Tartu. Tartu 2014, 293 p.
52. **Kaia Kask.** Public sector real estate asset management models and their evaluation. Tartu 2014, 264 p.
53. **Ott Pärna.** Managerial and contextual factors influencing innovation in information technology-based public sector services: an exploratory cross-national study. Tartu 2014, 410 p.
54. **Merle Tambur.** Workplace bullying in Estonian organizations: The prevalence and causes. Tartu 2015, 210 p.
55. **Sten Anspal.** Essays on gender wage inequality in the Estonian labour market. Tartu 2015, 195 p.
56. **Oliver Lukason.** Characteristics of firm failure processes in an international context. Tartu 2016, 180 p.
57. **Marko Viiding.** Role of electricity price in competitiveness of the manufacturing industry in liberalised electricity markets: the case of NordPool. Tartu 2016, 188 p.

58. **Bianka Plüschke-Altöf.** Images of the Periphery Impeding Rural Development? Discursive Peripheralization of Rural Areas in Post-Socialist Estonia. Tartu 2017, 237 p.
59. **Tarmo Puolokainen.** Public Agencies' Performance Benchmarking in the Case of Demand Uncertainty with an Application to Estonian, Finnish and Swedish Fire and Rescue Services. Tartu 2018, 247 p.
60. **Karin Sakowski.** The Role of National-Institutional Context in Organisations and in Organisational Innovation: The Case of Western and Central and Eastern European Countries. Tartu 2018, 135 p.
61. **Maryna Tverdostup.** Human capital and labour market disparities. Tartu 2018, 248 p.
62. **Bradley James Loewen.** Towards territorial cohesion? Path dependence and path innovation of regional policy in Central and Eastern Europe. Tartu 2018, 232 p.
63. **Kärt Rõigas.** University-industry cooperation in the context of the national innovation system. Tartu 2018, 208 p.
64. **Tatyana Tsukanova.** Insights into the Export Behavior of SMEs from Emerging Economies: Evidence from Russia and China. Tartu 2019, 251 p.
65. **Gerdien Margreeth Grootens.** Leadership of peripheral places: a comparative study of leadership processes in Estonian and Dutch peripheral places. Tartu 2019, 186 p.
66. **Tõnis Tänav.** Dynamics of firm innovation strategies: relationship with public sector support. Tartu 2020, 280 p.
67. **Gaygysyz Ashyrov.** Essays on firm-level corruption. Tartu 2020, 193 p.
68. **Tõnis Eerme.** Big Science as innovation intermediaries – micro- and meso-level effects from the collaboration with the European Space Agency. Tartu 2020, 173 p.
69. **Isaac Nana Akuffo.** The relationship between authentic leadership competences and nepotism, favouritism, and cronyism – the case of the Ghanaian banking sector. Tartu 2020, 147 p.
70. **Virgo Süsi.** Corporate governance and performance of private SMEs. Tartu 2021, 130 p.
71. **Mariia Chebotareva.** Functional Overlapping Competing Jurisdictions (FOCJs) as a Possible Tool for Inter-municipal Cooperation in the Provision of Russian School Services. Tartu 2021, 343 p.
72. **Aare Värk.** Practice-based exploration of knowledge, knowing and knowledge management. Tartu 2021, 128 p.
73. **Nataliia Ostapenko.** Information, Business cycles and Monetary policy. Tartu 2021, 197 p.
74. **Artur Meerits.** First-level military leaders' leadership competencies and their relationship with unit effectiveness in terms of collectivistic leadership with the example of the Estonian Defence Forces. Tartu 2022, 178 p.
75. **Magnus Piirits.** The Impact of Pension Reforms on Pension Inequality in Estonia: An Analysis with Microsimulation and Typical Agent Models. Tartu 2022, 219 p.

76. **Liina Joller-Vahter.** The government as an enabler and accelerator of diffusion of radical innovations. Tartu 2022, 134 p.
77. **Liis Roosaar.** Essays on labour mobility and labour productivity. Tartu 2022, 182 p.
78. **Sigrid Rajalo.** University-industry collaboration: interaction structure and preconditions. Tartu 2023, 117 p.
79. **Nino Kokashvili.** Public sector evolution under conditions of political business cycle – theory and empirical evidence. Tartu 2023, 194 p.
80. **Alo Lilles.** The relationship between university-industry cooperation and regional capabilities in Europe. Tartu 2023, 142 p.
81. **Mark Kantšukov.** Valuation of companies under the distributed profit taxation system. Tartu 2023, 233 p.
82. **Iulia Trabskaia.** Idea and opportunity identification and implementation within the entrepreneurial process and journey. Tartu 2023, 160 p.
83. **Laura Helena Kivi.** Regional labour markets and assimilation of foreign labour force. Tartu 2023, 157 p.
84. **Vladyslav Soloviov.** The role of culture for innovative processes. Tartu 2024, 138 p.