



Are Inflation Targeting Central Banks' Forecasts Internally Consistent with the Taylor Principle?

Jan-Martin Kogelfranz

Dissertation written under the supervision of
Professor Dr. Michael Frenkel,
Professor João Luis César das Neves,
Jin-Kyu Jung.

Dissertation submitted in partial fulfilment of requirements for the MSc in International Finance, at Universidade Católica Portuguesa and for the MSc in Finance, at WHU-Otto Beisheim School of Management,
02.11.2017.

Abstract

This thesis addresses the vital question whether ex ante inflation targeting central banks' forecasts are internally consistent with the undisputable Taylor Principle. Ex ante quarterly published monetary policy forecasts for $t+1$ and $t+2$ years for the Swedish Riksbank, and the Reserve Bank of New Zealand as well as ex ante quarterly published monetary policy forecasts for $t+1$ year for the U.S. Fed are evaluated for the period from Q1/1996 to Q2/2017. Various Taylor-type Rule specifications are used for the analysis. Ex ante central banks' forecasts are proven to be consistent with the Taylor Principle pre-financial crisis for the ex ante forecast horizon of $t+1$ year in all cases and for the $t+2$ year time forecast in the case of New Zealand. Post-crisis evidence for monetary policy behavior, consistent with the Taylor Principle, can only be provided for the Swedish Riksbank, indicating an extreme shift in monetary policy post-financial crisis for the U.S. Fed and the Reserve Bank of New Zealand. Finally, evidence for excessive interest rate smoothing behavior and policy inertia, ranging up to 90% as well as evidence for a potential break in real interest equilibrium rates post-financial crisis, is provided.

Abstrato

Esta tese aborda a questão vital de saber se a inflação antecipada que visa as previsões dos bancos centrais é consistente internamente com o Princípio de Taylor. Por conseguinte, as previsões de política monetária prévias trimestrais anteriores para $t + 1$ e $t + 2$ anos para o Riksbank sueco e o Reserve Bank of New Zealand, bem como previsões de política monetária publicadas trimestrais ex ante por $t + 1$ anos para o Fed são avaliadas para o período de tempo Q1 / 1996 a Q2 / 2017. Várias especificações da regra de tipo Taylor são usadas para a análise. As previsões ex ante dos bancos centrais são consistentes com a crise pré-financeira do Princípio Taylor, para um horizonte de previsão ex ante de $t + 1$ anos em todos os casos e, para a previsão $t + 2$ no caso da Nova Zelândia. Evidências de comportamento da política monetária consistentes com o Princípio de Taylor, no período pós crise, só podem ser fornecidas para o Riksbank sueco, indicando uma mudança extrema na política monetária pós crise financeira para o Fed e o Reserve Bank of New Zealand. Finalmente, são fornecidas evidências de excessiva suavização da taxa de juros e de inércia nas políticas, variando até 90%, bem como evidências de uma ruptura potencial nas taxas de juro reais de equilíbrio pós crise financeira.

Acknowledgement

I am truly grateful to my supervisors Professor João César das Neves, Professor Dr. Michael Frenkel and Jin-Kyu Jung for their helpful support, comments and guidance. Furthermore, I would like to express my gratitude towards Georg Woelfler, Bosco Au-Yeung and Anne-Christin Winkler for supporting discussions and debates.

Table of Content

Content

I.	Table of Abbreviations	VI
II.	List of Figures.....	VII
III.	List of Tables	IX
1.	Introductory Remarks.....	- 1 -
2.	Literature Review	- 3 -
2.1.	A General Framework Overview of Monetary Policy	- 3 -
2.1.1.	Monetary Policy Instruments and the Instrument Problem	- 5 -
2.1.2.	Discretionary Judgment versus Monetary Policy Rules – A Dichotomy Debate... -	9 -
2.1.2.1.	A Revision of the Dynamic Inconsistency Issue.....	- 12 -
2.1.3.	Following the Traces of Modern Monetary Policy Rules.....	- 16 -
2.2.	The Classic Taylor Rule	- 18 -
2.2.1.	The Taylor Principle and Macroeconomic Stability.....	- 20 -
2.2.2.	The Taylor Principle in prospect of the Zero-lower Bound.....	- 22 -
2.3.	The Evolution of Taylor-type Rules	- 25 -
2.3.1.	Interest Rate Smoothing and the Specification of the Taylor Rule	- 26 -
2.3.2.	The Morphology to a Forward-looking, Taylor-type Policy Rule.....	- 28 -
2.3.3.	Dynamic Coefficients - Taylor-type Rules and Business Cycles	- 31 -
2.4.	Inflation Targeting.....	- 33 -
2.4.1.	Strict and Flexible Inflation Targeting.....	- 37 -
2.4.2.	Transparency, Credibility and Accountability	- 40 -
2.4.3.	Optimal Policy Choice under Inflation Targeting	- 43 -
2.4.3.1.	Constant and Time Varying Internal Instrument Rate Path Forecasts	- 45 -

3.	Empirical Analysis	- 50 -
3.1.	Methodological Notes.....	- 51 -
3.2.	Data Description	- 56 -
3.2.1.	Dependent Variable – Policy Interest Rate.....	- 57 -
3.2.2.	Independent Variables – CPI & GDP Growth (Forecasts).....	- 62 -
3.3.	An Estimate of (Forward-looking) Taylor-type Rules	- 65 -
3.4.	Limitations, Assumptions and Avenues for Future Research	- 77 -
4.	Concluding Remarks	- 79 -
IV.	Appendix	X
IV.I.	The Various Channels of Monetary Policy Transmission	X
IV.II.	Empirical Analysis – Realized Macroeconomic Indicators.....	XIV
IV.III.	Empirical Analysis – Potential Output Forecasts.....	XV
IV.IV.	Empirical Analysis – Comparison of Realized and Forecasted CPI.....	XVII
IV.V.	Empirical Analysis – Comparison of Realized and Forecasted GDP Growth	XVIII
IV.VI.	Empirical Analysis – T.R. (Taylor’s Suggested and Estimated Parameters).....	XIX
IV.VII.	Empirical Analysis – T.R. inclusive Interest Rate Smoothing and Time Break ..	XXII
IV.VIII.	Empirical Analysis – T.R. inclusive Dynamic Policy Behavior	XXIV
V.	References	XXVI
VI.	Affirmation in Lieu of Oath.....	XXXVIII

I. Table of Abbreviations

AR	Autoregressive
AD	Aggregate demand
ECB	European Central Bank
CE	Credit easing
CPI	Consumer Price Index
Fed	Federal Reserve Bank of America
FOMC	Federal Open Market Committee
GDP	Gross Domestic Product
HPF	Hodrick-Prescott-Filter
IMF	International Monetary Fund
IS	Investment-Saving
JB Test	Jarque-Bera-Test
MPC	Monetary Policy Committee
OCR	Official Cash Rate
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PA	Price Adjustment
QE	Quantitative easing
QTM	Quantity Theory of Money
T.R.	Taylor Rule
U.K.	United Kingdom
U.S.	United States of America

II. List of Figures

Figure 1: Equilibrium inflation rates for discretionary and rule-based monetary policies..	- 15 -
Figure 2: Stable versus unstable monetary policy rules	- 21 -
Figure 3: Policy interest rate development in Sweden, New Zealand and the U.S.	- 58 -
Figure 4: CPI development in Sweden, New Zealand and the U.S.	XIV
Figure 5: GDP development in Sweden, New Zealand and the U.S.	XIV
Figure 6: Potential output estimate t+1 (Sweden)	XV
Figure 7: Potential output estimate t+2 (Sweden)	XV
Figure 8: Potential output estimate t+1 (New Zealand)	XV
Figure 9: Potential output estimate t+2 (New Zealand)	XV
Figure 10: Potential output estimate t+1 (U.S.)	XVI
Figure 11: Comparison of realized and forecasted CPI (Sweden)	XVII
Figure 12: Comparison of realized and forecasted CPI (New Zealand)	XVII
Figure 13: Comparison of realized and forecasted CPI (U.S.)	XVII
Figure 14: Comparison of realized and forecasted GDP growth (Sweden)	XVIII
Figure 15: Comparison of realized and forecasted GDP growth (New Zealand)	XVIII
Figure 16: Comparison realized and forecasted GDP growth (U.S.)	XVIII
Figure 17: Classic Taylor Rule (Sweden)	XIX
Figure 18: Estimated Taylor Rule (Sweden)	XIX
Figure 19: Classic Taylor Rule based on forecast data (Sweden)	XIX
Figure 20: Estimated Taylor Rule based on forecast data (Sweden)	XIX
Figure 21: Classic Taylor Rule (New Zealand)	XX
Figure 22: Estimated Taylor Rule (New Zealand)	XX
Figure 23: Classic Taylor Rule based on forecast data (New Zealand)	XX
Figure 24: Estimated Taylor Rule based on forecast data (New Zealand)	XX

Figure 25: Classic Taylor Rule (U.S.)	XXI
Figure 26: Estimated Taylor Rule (U.S.).....	XXI
Figure 27: Classic Taylor Rule based on forecast data (U.S.).....	XXI
Figure 28: Estimated Taylor Rule based on forecast data (U.S.)	XXI
Figure 29: T.R. incl. interest rate smoothing and time break (Sweden).....	XXII
Figure 30: T.R. incl. interest rate smoothing and time break based on forecast data (Sweden)	XXII
Figure 31: T.R. incl. interest rate smoothing and time break (New Zealand).....	XXII
Figure 32: T.R. incl. interest rate smoothing and time break based on forecast data (New Zealand).....	XXII
Figure 33: T.R. incl. interest rate smoothing and time break (U.S.)	XXIII
Figure 34: T.R. incl. interest rate smoothing and time break based on forecast data (U.S.)	XXIII
Figure 35: T.R. incl. dynamic policy behavior (Sweden)	XXIV
Figure 36: T.R. incl. dynamic policy behavior based on forecast data (Sweden.).....	XXIV
Figure 37: T.R. incl. dynamic policy behavior (New Zealand).....	XXIV
Figure 38: T.R. incl. dynamic policy behavior based on forecast data (New Zealand)	XXIV
Figure 39: T.R. incl. dynamic policy behavior (U.S.).....	XXV
Figure 40: T.R. incl. dynamic policy behavior based on forecast data (U.S.).....	XXV

III. List of Tables

Table 1: List of inflation targeting central banks	- 35 -
Table 2: Descriptive statistics calculations for policy instruments	- 58 -
Table 3: Policy interest rate correlation matrix	- 59 -
Table 4: Phillips-Perron Test for unit root.....	- 60 -
Table 5: Descriptive summary of realized CPI and CPI forecasts	- 63 -
Table 6: Descriptive summary of realized GDP growth and GDP growth forecasts	- 64 -
Table 7: Various Taylor-type Rules based on (forecast) data of the Swedish Riksbank	- 67 -
Table 8: Various Taylor-type Rules based on (forecast) data of the Reserve Bank of New Zealand	- 68 -
Table 9: Various Taylor-type Rules based on (forecast) data of the U.S. Fed.....	- 69 -
Table 10: CPI correlation matrix	XIV
Table 11: GDP correlation matrix	XIV

1. Introductory Remarks

Heraclitus, a Greek philosopher once said, change is the only constant. This infamous quote appears to be also true for the evolving responsibility of most central banks around the world. While central banks represent an institution that has already been in place since the seventeenth century, their general objectives, functions and operations have undoubtedly evolved over their prevailing time horizons. An enormous pace of new reforms and newly introduced monetary policy approaches have been remarkably visible, especially in recent times. Various studies and academic debates have shed some light into the prolonged discussions of macroeconomic issues. For instance, the realization of the time inconsistency issues and the understanding that monetary policy should largely be concerned with the management of private sector expectations as well as various extensions, and analyses of monetary policy rules are only a few discoveries that have significantly contributed to the rising understanding of macroeconomic policy effects.¹ In recent years, numerous central banks around the world have instituted explicit inflation targeting as their primary monetary policy strategy. One aspect, which corresponds to the increasing number of inflation targeting policy regimes is the generally rising level of transparency pursued by most policymakers. While for most of their existing time central banks have followed the conventional wisdom that “silence is golden”, a recent consensus has emerged that central banks should operate under more transparent frameworks. Hence, several central banks have started to publish the so-called monetary policy reports, explaining and justifying their monetary policy decisions. Moreover, as monetary policy decisions affect the economy with significant time lags, optimal monetary policy should hypothetically be proactive. Thus, monetary authorities should set their instrument in advanced and in accordance with their best judgement about future economic developments. The published economic forecast in the monetary policy reports should then represent the estimated path of economic variables based on current interest rate settings and policymakers judgement about the future state of the economy.

However, with the start of the financial crisis and the vicinity of the zero lower bound in most policy jurisdictions, economic assumptions which were taken for granted have altered dramatically. Therefore, it cannot be assumed that under this problematic economic condition, monetary authorities respond identically to changes in inflation and output as when nominal interest rates were significantly above the lower bound. Therefore, it is of utmost

¹ Mishkin (2004). p. 48

interest to analyze if monetary policy forecasts, published by inflation targeting central banks, are still generally consistent with the undisputed importance of the so-called Taylor Principle. The Taylor Principle states that central banks have to increase real interest rate in order to reduce inflationary pressure and *vice versa*.

In order to answer this question, the thesis provides a detailed overview over recent monetary policy research and is structured as follows: The literature review section lays the foundation for the corresponding research area, which later analyses the internal consistency of inflation targeting central banks forecasts, with the well-known Taylor principle. For this purpose, a comprehensive overview over theoretical models and practical policy implementation approaches will be provided. As the macroeconomic discussions involved are highly complex, partly controversial and dependent on numerous theories, the corresponding theoretical sections have to cover a wide range of different areas. Thus, before immersing into the field of Taylor-type Rules, Principles and inflation targeting, a theoretical foundation over the most important monetary policy transmission channels, over the choice of the monetary instrument as well as over the historical rule vs. discretion debate, will be provided. After elaborating the more general framework overview, this paper will immerse into recent discussions about policy rule implementations, before deriving the well-known Taylor Rule. Based on Clarida, Gali and Gertler the most common Taylor-type Rule morphology implementations will be reviewed. Lastly, the theoretical section will explore the conceptual characteristics of inflation targeting as well as optimal monetary policy, conducted under inflation targeting.

Section 3. discusses and presents a quantitative analyses, which examines the question whether inflation targeting central banks' forecasts are internally consistent with the Taylor Principle. For this purpose, the interest rate setting behavior of the Swedish Riksbank, the Reserve Bank of New Zealand and the U.S. Federal Reserve Bank will be examined by various Taylor-type Rule specifications for the one and two years forecast horizon. In detail, the data used for the empirical analysis is derived from the quarterly monetary policy reports of the respective central banks. Following the quantitative assessment, qualitative interpretations and research limitations will be discussed before ending the thesis with concluding remarks.

2. Literature Review

2.1. A General Framework Overview of Monetary Policy

Before analyzing and evaluating optimal monetary policy frameworks, it is crucial to understand how and to what extent monetary policy decisions are generally transferred into the real economy, a question that lies at the core of macroeconomics. Therefore, it is essential to not only analyze the main monetary policy transmission channels and the question of the right monetary policy instrument, but also to discuss the degree of overall autonomy that should be granted to monetary authorities. Thus, this chapter will provide a short overview of important research in the field of monetary policy transmissions, of the instrument problem and of the traditional rule versus discretion debate, before immersing into the field of Taylor-type Rules and Principles and inflation targeting.

Despite extensive research in the field of monetary transmission channels, many views on the monetary transmission mechanisms in an open economy differ with regards to the emphasis they place on money, credit, long-term interest rates, exchange rates, asset prices and the role of financial institutions.² However, as any extensive analysis of monetary policy transmission channels and monetary policy instruments would go beyond the coverage of this thesis, only a rough overview will be provided here. For a more detailed description of the main monetary policy transmission channels, please refer to Appendix I.

Traditionally, macroeconomic research of monetary transmission mechanisms, the process through which monetary policy decisions impact the real economy, has primarily focused on aggregate demand channels and expectation channels.³ More precisely, it analyzed how unexpected policy-induced variations in the nominal money stock (the sum of currency in circulation and bank reserves held by the corresponding central bank) or the short-term nominal interest rate impact real economic variables, such as aggregate output, employment and inflation, by mainly affecting neoclassical transmission channels, such as investment and consumption of both firms and private households' normally with a time lag.⁴ Hence, according to the traditional Keynesian view, a contractionary monetary policy- ($M \downarrow$) induced increase in short-term nominal interest rates ($i \uparrow$) leads to a decrease in aggregate

² Taylor (1995). p. 11

³ Cecchetti (1994). p. 1

⁴ Ireland (2005). p. 3

demand and total output ($Y \downarrow$) by increasing financing costs, thereby lowering total investment spending ($I \downarrow$) of both firms and private households.⁵

$$M \downarrow (\uparrow) \rightarrow i \uparrow (\downarrow) \rightarrow I \downarrow (\uparrow) \rightarrow Y \downarrow (\uparrow) \quad (1)$$

Additionally, monetary authorities are capable of affecting inflation expectations of private agents, which amongst other, impacts inflation with a time lag via wage and price setting behavior.⁶ The crucial role of private agent expectations for monetary policy decisions will be further elaborated and analyzed in section 2.2. during the Rule vs. Discretion debate.

In open economies with flexible exchange rates, policy-induced changes in short-term nominal interest rates additionally affect real economic variables through the exchange rate channel. The transmission can be explained by the effects of interest parity in combination with price rigidity. If the domestic nominal interest rate exceeds the level of its foreign counterpart, domestic monetary deposits become more valuable relative to other currency deposits. Under the assumption of perfect capital mobility, this leads to an increase in demand and, hence, to a corresponding currency appreciation.⁷ Simultaneously, as both prices and wage contracts are assumed to be sticky, the currency appreciation directly impacts the trade balance of an economy and thus affects total output, until the exchange rate returns to its previous real base line path.⁸

Furthermore, non-neoclassical transmission channels, such as the balance sheet and lending channels, amplify the magnitude of monetary policy decisions. Those effects primarily arise due to private market imperfections or government interferences in credit markets.⁹ However, as the exact magnitude, time effect and interconnectivity of monetary policy effects are uncertain, it is hardly possible for monetary authorities to predict the precise effects of any transmission channels on the economy and general price levels, impeding the analysis of monetary policy.¹⁰

⁵ Mishkin (1995). p. 4 – The essence of Keynesian neoclassical transmission channels can be captured by the user-cost of capital theory, Tobin's q theory and the lifecycle hypothesis of consumption, which are further elaborated in Appendix I.

⁶ Svensson (1998). p. 611

⁷ Mishkin (1995). p. 5

⁸ Taylor (1995). p. 17 – Normally the effect of the direct exchange rate channel is assumed to be shorter than the effect of the aggregate demand channel.

⁹ Boivin Kiley and Mishkin (2010), p. 15

¹⁰ Ireland (2005). p. 6

2.1.1. Monetary Policy Instruments and the Instrument Problem

Not only the transmission of monetary policies has been historically hotly debated, but also the optimal choice of monetary policy instruments, giving rise to the so-called “instrument problem” (also known as the “target problem”). According to the instrument problem, monetary authorities can either operate through changes in short-term nominal interest rates or through changes in the nominal money stock to pursue their defined objectives, but not use both instruments simultaneously and independently.¹¹ As soon as one operating instrument is determined, the other one cannot be controlled precisely.¹² Conceptually, the two instruments are very similar. Given the demand for money schedule in the money market, controlling the price, which is basically determined by the interest rate instrument, is equivalent to controlling the quantity, which can be varied by the quantity of money instrument. Nevertheless, in practice some differences occur, giving rise to a voluminous amount of literature, which discusses the merits of each instrument.¹³ Again, as a detailed review of this discussion would exceed the main focus of this thesis, only a brief overview will be provided.

In essence, monetarists and other advocates of monetary base based policy instruments mainly supported the view of Milton Friedman, who argued that “Inflation is always and everywhere a monetary phenomenon in the sense that it is and can be produced only by a more rapid increase in the quantity of money than in output.”¹⁴ In order to fully understand the monetarism view and its implications, firstly the general accounting equation of the quantity theory of money hypothesis (QTM), which proposes that the general price level in an economy is directly proportional to the money supply, has to be revised. The QTM hypothesis states that a given change in the quantity of money will result in an equal change in price inflation and nominal interest rates.¹⁵ As the QTM should be seen as an accounting identity, it should theoretically always hold. In detail, the corresponding, simplified quantity equation of money is defined as:

$$M * V = P * Y \tag{2}$$

¹¹ Poole (1970). p. 107

¹² Hooper, Catherine and Mann (1993). p. 5

¹³ Carlstrom, Fürst (1995). p. 247

¹⁴ See Friedman (1970). p. 4

¹⁵ Lucas (1980). p. 1

where

- M is the money supply,
 V is the velocity of money circulation,
 P is the general price level of an economy,
 Y is the real output of an economy.¹⁶

The QTM implies a hypothesis on the behavior of economic variables. Assuming that real economic output and quantity of money are exogenously determined and that the velocity of money has a constant long run equilibrium, price levels would be strictly proportional to the quantity of money.¹⁷ Furthermore, Friedman's revision of the QTM suggests that the money demand function is not only highly stable, but also insensitive to changes in interest rates, as opposed to the Keynesian liquidity preference theory. In light of this hypothesis, Friedman argued that real permanent income is the only determinant of real money demand and can therefore be approximated by:

$$\frac{M^d}{P} = \emptyset(Y_p) \quad (3)$$

where

- M^d represents the money demand,
 P represents the general price level of an economy,
 $\emptyset(Y_p)$ represents a function of permanent real income.¹⁸

By combining equation (2) and (3) and assuming money demand and money supply are in equilibrium, $M = M^d = M^s$, the QTM can be converted into the following velocity equation:

$$V = \frac{Y}{M/P} = \frac{Y}{\emptyset(Y_p)} \quad (4)$$

¹⁶ Darity (2008). p. 659

¹⁷ Serletis (2007). p. 91

¹⁸ Serletis (2007). p. 98 – John Maynard Keynes' liquidity preference theory states that the demand for money as an asset depends on the interest foregone by not holding long term financial assets. Interest rates can therefore, be seen as a reward for the abnegation of liquidity and are assumed to directly impact the general demand for money within an economy.

This equation implies that even though the velocity might not be stable, it still is predictable, resulting in the conclusion that aggregate spending and therefore total output are mainly determined by the quantity of money.¹⁹

Additionally, even though monetarists acknowledge the theory of monetary neutrality in the long run, they argue that unexpected policy-induced changes in the monetary base will still lead to movements in real economic variables in the short run due to temporary wage and price rigidities. This implies that changes in the quantity of money are normally only neutral in the long run, however are non-neutral in the short run.²⁰ The observed relationship between the quantity of money and prices lead to the conclusion that inflation is a phenomenon caused by excessive, monetary over-expansion. Thus, it should be preventable by a proper management of the money supply instrument.²¹ In order to promote the goal of economic and price stability, many advocates of monetarism argue that authorities should mainly focus on a moderate, steady growth in the quantity of nominal money stock, as proposed by Friedman.²²

In comparison, the general concept of an interest rate policy instrument was popularized by the Swedish economist Knut Wicksell's "natural rate" hypothesis. According to the natural rate hypothesis, there exists a natural interest rate compatible with generally stable price levels. An increase in the natural rate should therefore lead to a contractionary economic activity and *vice versa*. Thus, price and economic stability should potentially be obtained if an equality of the natural rate and the market interest rate could be achieved.²³ In later economic research, the natural rate hypothesis was used to connect the general price level to money and credit by economist Maynard Keynes.²⁴

In contrast to pure monetarists, advocates in favor of interest rate policy instruments argue, based on the natural rate hypothesis, that the quantity of money could only indirectly affect the real economy through variations in interest rates.²⁵ With regards to this view, it may seem paradoxical that money supply itself only plays a residual role in monetary policy

¹⁹ Serletis (2007). p. 100

²⁰ Ireland (2005). p. 3 – The theory of monetary neutrality states that changes in the nominal money base only affect nominal variables and have no impact on real economic variables.

²¹ Cagan (1995). p. 196

²² Friedman (1968). p. 17 – Friedman's constant money growth rule (k-percent rule) proposes that money supply should increase by a constant rate, irrespectively of business cycles, thereby eliminating any leeway for monetary authorities. Friedman promoted the view that granting central banks any flexibility about the nominal monetary base could have severe economic consequences, due to the tendency to pursue short-term goals.

²³ Wicksell (2012). p. 212

²⁴ Keynes (1930). p. 7

²⁵ Darity (2008). p. 660

decisions.²⁶ Money demand appears to be endogenous rather than exogenous and therefore, the quantity of money within an economy is demand rather than supply driven.²⁷ Theoretically, central banks only need to supply exactly the quantity of money that is demanded at the preferred interest rate level.²⁸ Furthermore, it is argued that velocity is potentially unstable and unpredictable. Consequently, rapid changes in money supply could be (partially) absorbed by changes in the velocity of money, neglecting its effect on both output and price levels.²⁹ The observed effect of monetary policies, which are based on changes in the nominal monetary base and economic variables, must therefore take place because of the corresponding variations in interest rates.³⁰

Empirical findings of Pool, Carlstrom and Fuerst and Taylor partly advocate the use of interest rates as the primary monetary policy instrument. In short, Pool argued that both instruments have some merit. In an environment with various money demand shocks, the interest rate instrument is superior in decreasing the variability of output, as the goods market is more or less insulated from the shocks, whereas for some other shocks the quantity of money instrument appears to be superior.³¹ Moreover, Carlstrom and Fuerst advocate interest rate rather than money growth rules due to their positive impact on households' expected lifetime utility and higher levels of flexibility in response to economic shocks. They argue that in a portfolio-rigid economy, which follows a money growth rule, private agents' investment decisions are partly deteriorated. Technological innovations and government spending tend to result in large fluctuations in the nominal interest rate under monetary growth rules. Hence, labor input responds only with a considerable time lag. However, by using an interest rate rule and therefore short-term interest rates as the main policy instrument, Carlstrom and Fuerst pointed out that both distortions could potentially be eliminated. Hence, households' investment decisions respond more efficiently to the proposed shocks.³² Furthermore, Taylor also argued, in accordance with the stochastic monetary policy rule simulations of Bryan et. al in 1993, that the interest rate instrument

²⁶ Svensson (1999). p. 610

²⁷ Hannsgen (2004). p. 1

²⁸ Svensson (1999). p. 610

²⁹ Darity (2008). p. 659 – This concern is also commonly referred to as the “velocity-instability” problem.

³⁰ Hannsgen (2004), p. 1

³¹ Pool (1970). p. 204

³² Carlstrom and Fuerst (1995). p. 266

performs substantially better than a money supply instrument in reducing variability in output and inflation under various shocks.³³

The implications by Pool, Carlstrom and Fuerst and Taylor are partly consistent with the “new consensus macroeconomics”, which state that exogenous demand for money is normally highly unstable and that a monetary policy only based on the nominal money base could result in high fluctuations in interest rates, leading to even greater economic instability.³⁴ Nevertheless, the reality is more complicated and monetary policy decisions comprise a high degree of uncertainty. Due to the short-term non-neutrality of the quantity of money on general price levels, both instruments have some merit, each of them stressing one side of a highly complex reality.³⁵ In order to simplify the empirical analysis ahead and to stay focused on Taylor’s initially introduced interest-rate rule, the following parts will primarily consider the short-term interest rate as central banks main monetary policy instrument, at least during conventional times.

2.1.2. Discretionary Judgment versus Monetary Policy Rules – A Dichotomy Debate

After determining the rough, theoretical mechanics of how central banks can broadly transfer their policy objectives into the economy through monetary policy instruments, the question remains how and to what extent they should use those instruments. Should central banks under optimal monetary policy operate under the concept of full discretionary or follow a framework that is based on predetermined, publicly promulgated rules - a dichotomy debate, which has concerned economists for almost a century.³⁶

Under the concept of discretionary monetary policy, authorities are free to act in accordance with their own judgement to achieve desired outcomes and do not need to make consistent commitments about future money and prices. In this context, economic policies are generally more based on ad hoc judgements rather than on a following specific framework.

³³ Taylor (2010). p. 9

³⁴ Brandl (2016). p. 203

³⁵ Setterfield (2013). p. 2 – During periods of extreme economic shocks, traditional monetary policy instruments may lose their usefulness of translating monetary policy objectives into the economy. Unconventional measures, such as QE, may then be used as a recovery tool and to avoid so-called liquidity traps. This phenomenon becomes especially visible during times, when the interest rate instrument hit the zero lower bound. Historically, it was believed that during this time, the interest rate instrument would lose its power, whereas the quantity of money instrument is still operative, indicating an asymmetry in the implementation possibilities of the main monetary policy instruments. (The subject will be further elaborated in Section 2.2.2. The Taylor Principle in prospect of the Zero-lower Bound.)

³⁶ Fischer (1988). p. 1

On the contrary, the concept of rule-based monetary policies imposes certain restrictions on the discretion of policy makers. Those restrictions could either directly or indirectly limit the actions of policy makers by imposing certain requirements and targets that central banks must follow and achieve. Hence, contrary to discretionary frameworks, rule based frameworks impose some degree of required commitment for certain observable economic variables. For instance, simple monetary policy rules could impose either a constant monetary base, thereby limiting the discretion of varying it, or the need for publicly announcing monetary growth targets over some predefined period and therefore, limiting the objectives pursued by monetary authorities.³⁷

Historically, many economists have shown great interest in monetary policy rule based frameworks, ranging from Adam Smiths, who argued that “a well-regulated paper-money” could lead to significant improvements of economic stability, to Knut Wicksell who advocated the importance of monetary rules to avoid monetary excess and corresponding hyperinflation.³⁸ This view was further promoted by Friedman, who empirically analyzed monetary policy behavior of the U.S. Federal Reserve Bank (FED) between its founding date and the beginning of the 1970s. Friedman argued that the discretion of monetary policy authorities was severely deficient and had led to great economic instability in the past.³⁹ Finally, modern policy rules, such as the Taylor rule, were designed to put an end to this observed economic instability.⁴⁰

In essence, the traditional argumentation of economist who were in favor of rule-based monetary policies pointed out that monetary authorities are normally under great political pressure. Thus, policymakers’ propensities might be guided by special, self-serving interests.⁴¹ A rule based policy, however, would not only enable them to withstand political pressure but also provide some objective criteria for critically analyzing and evaluating their performance. Additionally, such a policy framework would enhance certainty about policy developments for private agents.⁴²

On the other hand, other infamous economists, for instance Modigliani, have traditionally argued that discretionary monetary policy conducted by rational expert monetary

³⁷ Dwyer Jr. (1993). p. 4

³⁸ Adam Smith (1811). p.151; Wicksell (2012). p. 210

³⁹ Taylor (2012). p. 1017

⁴⁰ Taylor (2010). p. 2 – The Taylor rule will be discussed in more details in section 2.2.

⁴¹ Barro (1984). p. 4

⁴² Fischer (1988). p. 11

authorities would significantly enhance economic performance and stability.⁴³ Moreover, while most advocates of discretionary policy regimes acknowledge that insulating monetary authorities from political pressure might result in some benefits, they indicate that the other two arguments, namely performance evaluation and economic policy certainty, are rather unpersuasive. Evaluating central banks performances based on rules and exercises, which are irrelevant to the dynamically changing behavior of macroeconomic variables, provides no real economic benefit. In these situations, rules would merely impede central banks to deal with arising problems in an optimal way and, therefore, do more harm than good.⁴⁴ By following a discretionary policy, however, authorities could act in accordance with their own judgement and produce the same outcome as a rule-based policy would, if this were indeed the optimal behavior. Moreover, if deviations from the policy would result in a superior outcome, monetary authorities would be free to pursue them instead.⁴⁵ In addition, advocates of discretionary policy stated that certainty about policy development is not a compelling argument either. Putting financial institutions aside, private agents want primarily certainty about prices and economic output rather than about policy instrument developments. It was argued that if a discretionary policy, which is based on unpredictable patterns, results in price stability and full employment, the monetary policy itself would then be of no account. Hence, the traditional consensus was that discretionary monetary policy pursued by monetary experts could accomplish anything a rule based policy could, without tying up their hands when deviations are necessary.⁴⁶ Discretion appeared to be interchangeable with flexibility and was seen as superior in comparison with a static rule-based policy framework.

Nevertheless, this perspective of the dichotomy debate was suddenly changed by Kydland and Prescott in 1977 due to their analysis of the possible time inconsistency of optimal plans. In short, by looking at policy rules as some forms of contractual future commitments, enforceable rules can decrease the average rate of inflation while producing the exact same amount of unanticipated inflationary shocks, namely zero.⁴⁷ It is argued that under the assumption of rational agents, no beneficial, unanticipated inflationary shocks *ex post* are feasible. Individuals understand the incentives of central banks to deviate from announced policies and already formulate their expectations accordingly. As monetary

⁴³ Dwyer Jr. (1993). p. 3

⁴⁴ Fischer (1988). p. 12

⁴⁵ Dwyer Jr (1993). p. 12

⁴⁶ Fischer (1988). p. 12

⁴⁷ Barro (1984). p. 1

authorities under discretionary policy seem to have no mechanism that indicates real commitment to the previously announced policy, both inflation and inflation expectations are doomed to rise.⁴⁸ By relying on enforced policy rules, however, overall economic performances can be significantly enhanced as it eliminates agents' expectations of inflation surprises. Consequently, the time inconsistency issue of discretionary monetary policy provides a strong argument in favor of rule based framework as it, as opposed to Friedman's less persuasive, traditional argumentations, points out the importance of the timing and magnitude of monetary policy actions.⁴⁹

2.1.2.1. A Revision of the Dynamic Inconsistency Issue

Due to the importance of the time inconsistency issue in the forming of modern monetary policy, a more precise revision will follow in this sub-section.

The dynamic inconsistency issue of monetary policy is based on the paradoxical premise that discretionary policy, which follows a selection of actions that are optimal at each point in time, taking into consideration current and end-of period situations, will not result in a maximization of a previously agreed on, optimal social objective function. This paradoxical premise even holds under the assumption that policymakers know the exact timing and magnitude of their policy actions. Therefore, it is shown that as soon as expectations of agents are assumed to be rational, previously used control theory is not an appropriate tool for economic planning anymore.⁵⁰

In simpler terms, dynamic inconsistency in the context of monetary policy refers to the phenomenon that future optimal macroeconomic policy decisions, which are formulated and announced at an initial point in time, are no longer optimal at a later stage, without any new information arising in the meantime. Under the assumption of potential welfare maximization, central banks adopting discretionary policies are expected to always follow short-run optimal decisions and therefore deviate later from initially formulated optimal policy plans, whenever possible, to gain the economic benefits of unanticipated inflationary shocks.⁵¹ However, as rational agents realize that the initially announced policy does not appear to be credible anymore, those deviations will already be anticipated and incorporated

⁴⁸ Barro (1986). p. 25

⁴⁹ Kydland and Prescott (1977). p. 474-475

⁵⁰ Kydland and Prescott (1977). p. 473

⁵¹ Fischer (1988). p. 23

into agents' expectations to eliminate a consistent pattern of surprises. Consequently, the new equilibrium outcome of inflation increases to a level where the incentives for monetary authorities to create inflationary shocks are fully offset by their corresponding costs.⁵² It follows that not only potential benefits from surprise inflations are eliminated and that central banks gain no significant benefit from their opportunism but also that on average discretionary policy produces a worse outcome than a rule based policy, due to its time inconsistency.⁵³ A credible, enforced rule based framework, however, is time consistent if some mechanics prevent *ex post* violations of initially announced policies. Thus, credible rule-based policies tend to lower the equilibrium rates of inflation and monetary growth, while holding unemployment at equal, natural levels.⁵⁴

A simplified mathematical way to look at the time inconsistency issue can be provided by analyzing a linear form of an augmented Phillips curve function that is used by economists to rationalize the trade-off between unemployment and inflation.

$$u_t = \alpha(\pi_t^* - \pi_t) + u^* \tag{5}$$

where

u_t is the unemployment rate in period *t*,

α is a positive constant,

π_t^{}* is the expected inflation rate at time *t*,

π_t is the actual inflation rate at time *t*,

u^{}* is the natural unemployment rate in absence of any monetary disturbances.

According to this simplified formula, central banks have an incentive to create unanticipated inflationary shocks (*π_t^{*} < π_t*) by deviating from their announced policy to stimulate the economy and maximize an agreed on, optimal social objective function,

$$S(\pi_t, u_t), \tag{6}$$

that is dependent on both inflation and unemployment rates at time *t*.⁵⁵

⁵² Kydland and Prescott (1977). p. 479

⁵³ Taylor (1983). p. 1

⁵⁴ Barro and Gordon (1983). p. 101

⁵⁵ Kydland and Prescott (1977). p. 479

However, private agents understand that discretionary policymakers do not need to commit to future money and prices, but rather have the discretion to maximize social welfare at each period individually, namely by creating unanticipated inflationary shocks. Therefore, rational agents form their expectations accordingly, which implies in mathematical terms that expectation of inflation is equal to the expected rate of inflation:

$$\pi_t^* = E(\pi_t). \tag{7}$$

The expected rate of inflation will then be in an equilibrium, at a level where the marginal cost of inflation surprises equals its marginal benefit. By following a discretionary monetary policy, an economy bears the cost of high inflation to offset high, rational inflation expectations without being granted any benefits resulting from unanticipated inflationary shocks (lower short-term unemployment rate). In contrast, a credible, enforced rule that prohibits *ex post* policy violations will eliminate the rise in inflation expectations as no inflation surprises are anticipated by private agents. Thus, it provides the same economic outcome with lower levels of imposed inflation costs for the economy.⁵⁶

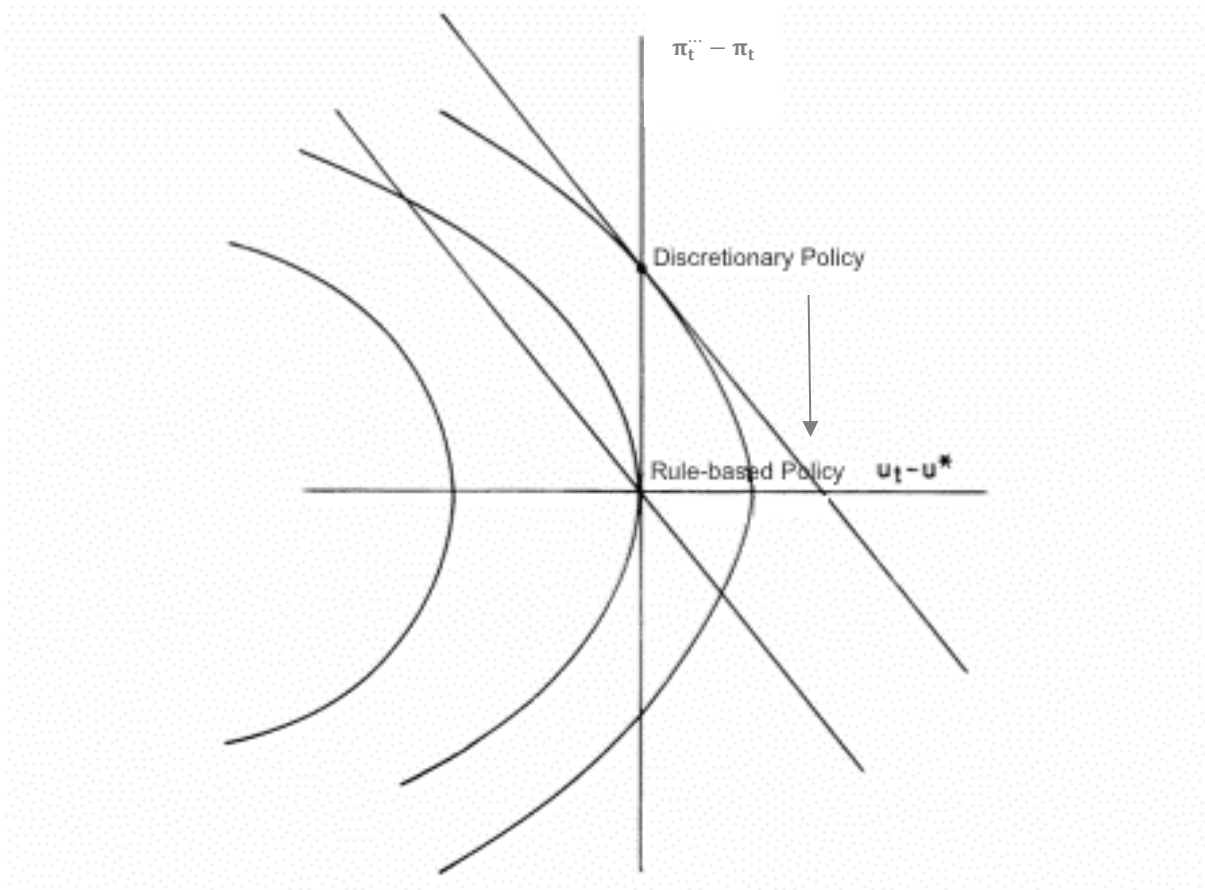
Figure 1 illustrates some Phillips curves and indifference curves for both discretionary and rule-based monetary policies. According to equation (5), the simplified Phillips curves are linear with corresponding slopes of $-\alpha^{-1}$ and intersecting the x-axis at π_t^* . To be at a consistent equilibrium, the indifference curve needs to be tangent to the Phillips curves somewhere along the vertical axis. Only in these cases are agents' expectations rational and the chosen policy is the best, given the situation at hand. Furthermore, $\pi_t^{\dots} - \pi_t$ can be interpreted as the deviation of inflation from its desired, optimal rate.

Obviously, the outcome under discretionary policy is inferior to that under credible rule-based policy if monetary authorities desire price stability. Both policies deliver the same unemployment rate while deviating vastly different from optimal, desired inflation rates.⁵⁷ The superiority of rule-based monetary policies, postulated by the dynamic inconsistency issue, in comparison with discretionary monetary policies in terms of price stability is further supported by the empirical findings of Taylor. Taylor continued Friedman's observational work and analyzed more recent periods. According to Taylor, both a more rule-based era as well as a more discretionary policy era could be observed in the U.S. over the last three

⁵⁶ Barro (1986). p. 25-27

⁵⁷ Kydland and Prescott (1977). p. 479-480

decades. However, their economic performances were remarkably different. Whereas the rule-based era from 1985 until 2003 saw only a few mild recessions with decades of great economic expansion, the discretionary ad hoc period from 2003 onwards has been subject to large volatility in economic performance, ranging from devastating boom and burst periods in housing markets to a great recession with an anemic recovery. Taylor concludes that a key driver of the significant performance differences lies within the different monetary policy regimes and therefore postulates the importance to preserve the concept of more rule-based monetary policy approaches.⁵⁸



*Figure 1: Equilibrium inflation rates for discretionary and rule-based monetary policies.
Based on Kydland and Prescott (1977). p. 479*

⁵⁸ Taylor (2012). p. 14

2.1.3. Following the Traces of Modern Monetary Policy Rules

Even though the time inconsistency issue advocates a strong case towards enforceable rule-based monetary policies, it does not provide evidence for the structure of a concrete, simple monetary policy rule. Therefore, there are numerous and controversial discussions concerning the vital question if one regime approach is superior to others with regards to some objective criteria, such as the variability of inflation and output.⁵⁹

However, when evaluating monetary policies based on some advocated monetary policy rules, it is essential to distinguish among instrument variations because of suggested changes of the monetary policy rules and variations due to movements along the policy.⁶⁰ To avoid any confusion, it is explicitly stated that this section will shortly compare the findings of alternative policy regime structures with a clear focus entirely on interest rate rules, in which short-term interest rates will respond in accordance to changes in some economic variables. This policy rule constraint is based on the previously discussed instrument choice in section 2.1.⁶¹

As it is vital for central banks and governmental institutions to know the stabilization properties and performances of different monetary policy regimes, various rules have been subject to a vast amount of academic and institutional research.⁶² Bryant, Hooper and Mann, for example, analyzed and compared the performance of nine different feedback interest rate policy rules for open economies, which were developed by the International Monetary Fund (IMF), the Federal Reserve Board, the Department of Finance in Canada, and various other individual researchers. Within all evaluated models, monetary authorities were expected to proportionally adjust their interest rate settings from some baseline path in response to deviations of variables from some predefined, optimal target.

$$i - i^* = \beta(z - z^*) \tag{8}$$

⁵⁹ Bryant, Hooper and Mann (1993). p. 3

⁶⁰ Taylor (1999). p. 320

⁶¹ Nevertheless, according to Taylor (1993) even central banks, which primarily use some interest rate rules as guidance should keep close track of the money supply. Taylor (1993) argues that if inflation reaches unconventional levels, either very high or negative, inflation expectation become very volatile. This among others, reduces the usefulness of interest rate rules and eliminates their advantages over money supply rules, which are still operative in this case.

⁶² Bryant, Hooper and Mann (1993). p. 3

where

i represents the short-term nominal interest rate,

i^{*} represents some baseline path,

z represents a target variable,

z^{*} represents a predefined optimal target for the variable under analysis.

β represents the magnitude of the corresponding policy response.

Variables under analysis were, for example, the general price level, the money supply, the exchange rate, the nominal income or the real output. Even though, there were considerable differences in the structure and design of the models under analysis, there was no real consensus on a particular optimal monetary policy rule under various shocks. However, their findings indicated that policy rules, which were based on the exchange rate or money supply, were in general inferior to models that focused directly on general price levels and real output. In other words, monetary policy rules that increased the short-term interest rate instrument in times when the price level and real income were above their targets, and *vice versa*, seemed to work considerably well. The findings of Bryant, Hooper and Mann are generally consistent with the research findings of the multicounty monetary policy models published by Taylor in 1993. According to Taylor, formulating a monetary policy rule that places some positive weight on real output, in addition to a positive weight on price levels, is in general superior to only a simple price or output rule. Therefore, Bryant, Hooper and Mann and Taylor came to the same conclusion that a good interest rate monetary policy rule should clearly react to both, deviations of price levels from some optimal target as well as deviations of real output from some desired target.⁶³ The results were also nearly simultaneously confirmed by Henderson and McKibben, who also argued for a policy rule that incorporated both price and output deviations from some optimal targets.⁶⁴ Those important findings have later become the empirical foundation of the infamous, classic Taylor Rule.

⁶³ Taylor (1992). p. 10-13

⁶⁴ Henderson and McKibbin (1993). p. 310

2.2. The Classic Taylor Rule

Based on the previously explained empirical evidence that captured the essence of the behavior of the Fed fairly well, Taylor developed a simple but elegant monetary reaction function. In his own words, the policy rule is “simple enough to put on the back of a business card”, while still fitting historical monetary policy decisions of the Fed remarkably well.⁶⁵ According to this simple monetary reaction function, the Fed determines the nominal short-term interest rate based on an equilibrium rate from which it deviates whenever inflation and/or output does not correspond to their desired target levels. Thus, to reduce inflationary pressure, resulting from either too high inflation or output above its full-employment level, the rule recommends a “tight” monetary policy with high interest rates, and *vice versa*.

This parameterization not only seemed to fit the Fed policy behavior surprisingly well in a period in which monetary policy was judged to have been widely successful, but also described policy decisions directly in terms of the developments of their two major operational objectives, namely price stability and economy growth. Taylor noted that such a policy rule could provide some clear guidelines for future policy decisions. Thus, it could be adopted as a general principle of behavior.⁶⁶ However, Taylor also pointed out that generally a model-based approach could not be the only incentive for making policy decisions, as no single simplified economic theory provides a clear and reliable picture of the future.⁶⁷ The incorporation of some degree of systematic freedom, which does not deteriorate central banks’ credibility and accountability, into the adaptation and interpretation of the proposed rule is therefore commonly referred to as the broad interpretation of the Taylor Rule and represents an important milestone in the history of the empirical evaluation of monetary policies.⁶⁸ The so-called Taylor Rule is thus, an approximation of the responsiveness of nominal interest rates to changes in economic conditions and can be described as:

$$i_t = r^* + \pi_t + \beta_\pi (\pi_t - \pi^*) + \beta_y (y_t - y^*) + \varepsilon_t^i \quad (9)$$

where

⁶⁵ Orphanides (2003). p. 984

⁶⁶ Taylor (1993). p. 15

⁶⁷ Taylor (1999). p. 320

⁶⁸ Orphanides (2003). p. 991

i_t is the short-term nominal interest rate at time t ,
 r^* is the constant equilibrium real interest rate consistent with full employment,
 π_t is the average inflation rate over the previous four quarters at time t ,
 π^* is the desired rate of inflation,
 γ_t is the (logarithm of) real output at time t ,
 y^* is the (logarithm of) potential output,
 β_π and β_γ are positive coefficients.

Although there was no real consensus about the exact size of the coefficients, Taylor initially proposed settings of 0.5 for both as well as a 2% constant equilibrium real interest rate and a 2% inflation target for the U.S.⁶⁹

Two important propositions arise from the rule above. First, a positive, non-zero coefficient for β_π implies that central banks tend to adjust their interest rate policy instrument disproportionately to increases in inflation. This important proposition, that central banks can potentially stabilize the economy by changing nominal interest rates by more than one for one with inflation and thereby affecting real interest rates, became generally known as the Taylor Principle and is an implied prerequisite to foster economic stability in modern macroeconomics.⁷⁰ Hence, the majority of macroeconomic models require this condition to hold for a unique, stable equilibrium to exist.⁷¹ The intuition behind the Taylor Principle is that monetary authorities must increase real interest rates to affect the real economy and to relieve the inflationary pressure. Secondly, the rule implies that such monetary policy “leans against the wind”. By changing the short-term nominal interest rate instrument when there is a difference between real and potential output, monetary authorities are capable of pushing the economy back to the desired real output and inflation target levels.⁷²

⁶⁹ Taylor (1993). p. 13-14 – The initially proposed settings were not determined by econometrical analysis but rather represent an educated guess that seemed to fit the behavior of the FED and the spirit of recent research remarkably well.

⁷⁰ Davig and Leeper (2007). p. 607 – The Taylor rule is sometimes denoted as $i_t = r^* + \beta_\pi * (\pi_t - \pi^*) + \beta_\gamma * (y_t - y^*) + \epsilon_t^i$. In this case the Taylor Principle would require $\beta_\pi > 1$ in order to change nominal interest rates by more than one for one with inflation.

⁷¹ Woodford (2001), p. 232

⁷² Taylor (2010), p. 10 – The difference between realized and potential output is widely referred to as the so-called output gap.

2.2.1. The Taylor Principle and Macroeconomic Stability

The Taylor Principle, derived from the Taylor Rule, is a relatively simple idea, which has become one of the most vital monetary policy implications to promote economic stability in recent times. It is supported by a vast amount of empirical evidences that underline the importance of having an interest rate responsiveness above a critical stability threshold of one to one to changes in inflation.⁷³ The significance of the Taylor Principle implication can be examined via a simple economic model and a graphical illustration:

$$y_t^* = -\beta(i_t - \pi_t - r) + u_t \quad (10)$$

$$\pi_t = \pi_{t-1} + \alpha * y_{t-1}^* + \varepsilon_t \quad (11)$$

$$i_t = g_\pi * \pi_t + g_y * y_t^* + g_0 \quad (12)$$

where

y_t represents the percentage deviation of real output from potential output,

i_t represents the short-term nominal interest rate,

π_t represents the inflation rate,

u_t and *ε_t* are serially uncorrelated stochastic shocks with a zero mean,

β, r and *α* are the positive parameters of the proposed model,

g_π, g_y and *g₀* are the assumed policy parameters.

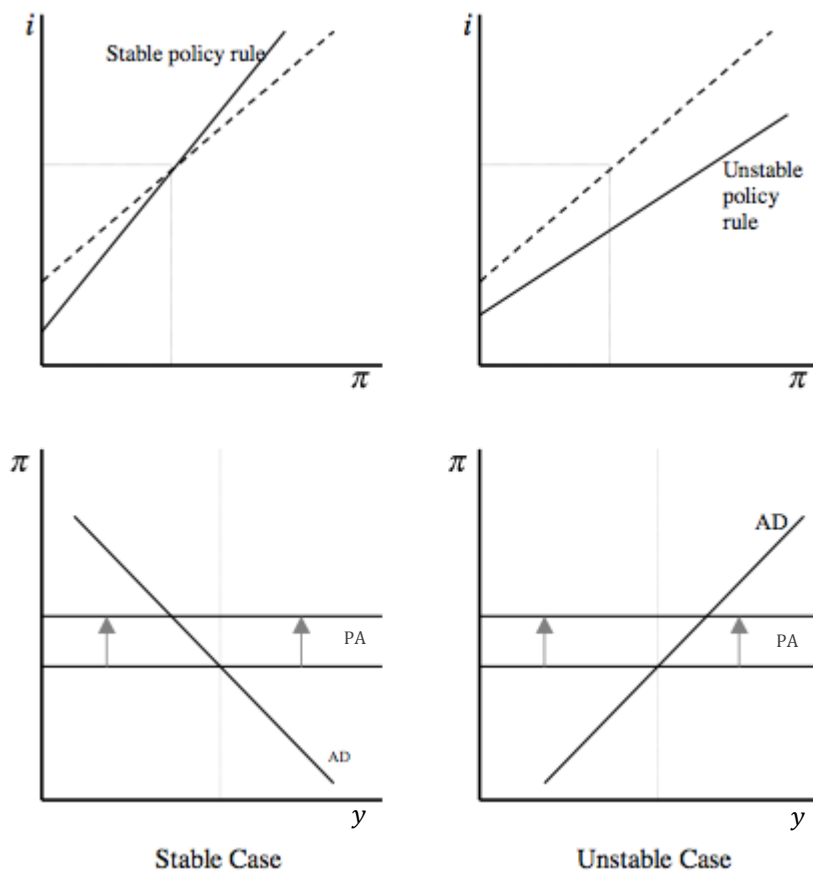
In the model above, the reduced-form parameters *β, r* and *α* can be generalized and depend on the policy parameters *g_π, g_y* and *g₀*. Equation (10) represents the equilibrium condition in the goods market, in the guise of the old IS curve. Furthermore, Equation (11), which implicates that prices are sticky and only slowly vary over time, represents some price adjustment (PA) equation.⁷⁴ By substituting equation (12) into equation (10), an aggregate demand (AD) relationship between *π* and *y* can be obtained. The corresponding, derived slope can then be described as:

⁷³ Taylor (1999). p. 331

⁷⁴ Taylor (1998). p. 10-11

$$-\beta \frac{(g_{\pi}-1)}{(1+\beta \cdot g_y)} \tag{13}$$

It is important to note that the sign of the slope depends on the size of the parameters of the policy rules. A policy induced change in the short-term nominal interest rate of less than one for one in response to an increase in inflation ($g_{\pi} < 1$) would turn the slope of the AD function positive, whereas a change of more than one for one with inflation ($g_{\pi} > 1$) would turn its slope negative. The relationship is graphically illustrated in Figure 2. Moreover, the PA equation is represented as a flat line, as the current level of inflation does not appear in the equation. An assumed surprise price shock ε will then lead to an upwards shift in the PA function.⁷⁵



*Figure 2: Stable versus unstable monetary policy rules
Based on Taylor (1998). p. 34*

⁷⁵ Taylor (1998). p. 12-13

Now consider both illustrative cases in Figure 2, a stable monetary policy that exceeds the critical stability threshold of $g_{\pi} = 1$ (as indicated by the dashed line) and an unstable monetary policy that stays below the critical stability threshold line. The reason the first case is considered to be a stable monetary policy is because an upwards shift in the PA equation would lead to a decline in real output, as monetary authorities raise the real interest rate in response to the inflationary pressure. This in turn will reduce inflation, bringing it back to its desired level. In contrast, an unstable monetary policy will lead to a decrease in the real interest rate, thereby further pushing output and inflation away from their desired levels and consequently promoting economic instability.⁷⁶

Hence, it is shown that the observance of the Taylor Principle is essential for a stabilizing monetary policy. A variety of empirical studies of the Taylor Rule or of Taylor-type Rules for different economies and time periods strongly validate the importance of the Taylor Principle. A small proportion of selected empirical studies includes, for instance, Clarida, Gali, and Gertler (1998) and Taylor (1999) for the U.S., Nelson (2001) for the U.K., and Kuttner and Posen (2004) for Japan.⁷⁷

2.2.2. The Taylor Principle in prospect of the Zero-lower Bound

The Taylor principle, which states that policymakers should increase real interest rates when inflationary pressures arise, is ubiquitous in modern monetary economics. Nevertheless, when nominal interest rates approach the zero-lower bound, monetary policy rule relationships and economic assumptions which were taken for granted alter dramatically. Therefore, it cannot be assumed that under this problematic economic condition, monetary authorities respond identically to changes in inflation and output as when nominal interest rates were significantly above the lower bound.⁷⁸

A zero-lower bound on nominal interest rates – a policy instrument for most modern central banks – is a serious concern, as it drastically restrains monetary policy implementations up to the point where monetary authorities are no longer able to stimulate

⁷⁶ Taylor (1998). p. 13

⁷⁷ Clarida, Gali, and Gertler (1998). p. 17; Taylor (1999). p. 330; Nelson (2001). p. 30
Kuttner and Posen (2004). p. 70

⁷⁸ Chevapatrakul, Kim, Mizen (2009). p. 1705

the economy by using the nominal interest rate channel. This problematic phenomenon is widely referred to as the so-called liquidity trap.⁷⁹

In more detail, until recently it was believed that there was a notable asymmetry in the implementation of monetary policy decisions, which were based on variations in interest rates. In extreme expansionary time periods when inflation could potentially rise to undesirable levels, policymakers could increase the magnitude of their policy rate instrument to any desired level, which they believed to be necessary. Contrarily, during times pronounced as recessions, the policy rate adjustments were assumed to be limited by the zero lower bound. As soon as the zero lower bound were reached, short-term interest rate instruments would potentially lose their power and could not be further downwards adjusted.⁸⁰ Contrarily, the quantity of money instrument is still operative in times of severe recessions where the policy rates approach the zero interest rate floor. Following this phenomenon, a variety of central banks around the globe initiated excessive, large-scale asset purchase programs to stimulate the economy, known as quantitative easing programs (QE).⁸¹

However, various central banks have recently challenged the assumption of a potential limit on interest rates due to the severances of the financial crisis and the disability to sufficiently ensure recovery. Thus, monetary authorities in Bulgaria, Denmark, the European Union, Hungary, Japan, Sweden and Switzerland have started to engage into new territory and lowered policy rates below the zero lower bound, adopting negative nominal interest rates. However, as this approach resembles a completely new, unconventional policy approach, the economic effect incorporates a high degree of uncertainty and has to be subject to future research.⁸² Nevertheless, numerous studies have stressed the importance of avoiding vicinity of the the zero lower bound as conventional policy measures alter dramatically close to the zero interest rate floor.

Thus, various studies argue that vicinity of the zero lower-bound should lead to increases in the magnitude and responsiveness of central banks' policy decisions to restrain further unintentional decreases in inflation and to avoid liquidity traps.⁸³ For instance, Kohn stated that in order to fight against the prospect of potential deflation, central banks that

⁷⁹ Kato and Nishiyama (2005). p. 98 – A liquidity trap is a situation in which prevailing interest rates are low, whereas saving rates are high due to the fact that private agents expect an adverse event such as deflation. This situation nullifies monetary policy actions and can lead to severe economic instability as well as to deflationary spirals.

⁸⁰ Billi (2012). p. 2

⁸¹ Joyce, Miles, Scott and Vayanos (2012). p. 271

⁸² IMF (2007). p. 4

⁸³ Chevapatrakul, Kim and Mizen (2009). p. 1706

operate at or close to the lower bound need to behave extraordinarily forceful to any slightest signs of downward demand shocks.⁸⁴ Chevapatrakul et. al. further argued that forward-looking monetary authorities have to analyze the cost of operating under the zero-lower bound and implement precautionary actions to decrease the probability of deflation. This forceful and pre-emptive monetary policy behavior is necessary to directly influence inflation expectations, by indicating to the private sector that the policymakers will try to avoid deflation by all means necessary. If monetary authorities' actions and announcements appear to be credible, inflation expectation should decrease by less in response to the downward demand shock.⁸⁵

Similar behavior is also recommended by Kato and Nishiyama, who define forceful monetary policy aggression by two propositions. Firstly, it comprises an incentive for policymakers to be extremely expansionary in the knowledge of a potential deflationary spiral. This forceful monetary policy behavior leads to a reduction in nominal interest rates by more than normally would have been advocated by an optimal Taylor rule. Secondly, this expansionary behavior should accelerate if the zero-lower bound is sufficiently close. Hence, the more realistic the prospect of deflation appears to be, the more accelerated cuts in interest rates as a direct response to falling inflation should be observed.

Kato and Nishiyama, indeed, found empirical evidence for a more expansionary, monetary reaction function than the simple Taylor rule. Therefore, they argued that an appropriate reaction function should be concave rather than linear in the state variables, inflation and output gaps, close to the zero-lower bound.⁸⁶

Their empirical findings are partly confirmed by Chevapatrakul et al. who also found a nonlinear policy response to inflation, when rates are sufficiently low. Hence, it is stated that optimal monetary policy should consider the variation in the degree of aggression at different quantiles along the interest rate distribution. Both empirical studies showed that monetary policies should respond differently depending on the state of external economic conditions, and thus strongly advocated nonlinear, Taylor-type reaction functions.⁸⁷

⁸⁴ Kohn (1996). p. 7

⁸⁵ Chevapatrakul, Kim and Mizen (2009). p. 1706

⁸⁶ Kato and Nishiyama (2005). p. 118

⁸⁷ Chevapatrakul, Kim and Mizen (2009). p. 1721

2.3. The Evolution of Taylor-type Rules

Over the last two decades, the simple but elegant instrument policy rule developed by Taylor has become a major tool for evaluating monetary policies of central banks and for analyzing their overall performance.⁸⁸ As the Taylor Rule and the incorporated Taylor principle have gained more and more attention, various studies developed and analyzed slightly modified versions of the rule. Those modifications, which still share the spirit of Taylor's initially proposed reaction function, are in the literature often referred to as Taylor-type Rules. Moreover, applications of Taylor-type Rules are not only limited to academic communities and monetary authorities, but are also utilized by many other financial institutions to analyze and forecast monetary policy decisions of central banks, further enhancing their usefulness.⁸⁹

During the last few decades, various well-recognized studies demonstrated the use and viability of Taylor-type rules, most prominently Taylor himself (1999), Judd and Rudebusch (1998) and Clarida et al. (2000). Taylor demonstrated that monetary policy behavior of most of the developed countries can be explained and evaluated to a large extent by his proposed reaction function, initially published in his 1993 paper "Discretion vs. Policy Rules in Practice".⁹⁰ Afterwards, Judd and Rudebusch incorporated the tendency of interest rate smoothing behavior of central banks into the proposed reaction function in a modified way.⁹¹ Lastly, Clarida et al. later examined the fit of the Taylor Rule with a forward-looking character.⁹² All studies demonstrated that the behavior of monetary authorities and their corresponding monetary policy decisions fit Taylor-type Rules reasonably well. Initially, studies on Taylor's reaction function had commonly used *ex post* revised data. Following the empirical work of Orphanides, it has become common practice to use real-time observation data. By using real-time data, namely the information set that was available to monetary authorities during the time the monetary policy actions were decided on, it can be accounted for incomplete information of policymakers. Orphanides found substantial differences between Taylor Rule estimates using *ex post* revised data and real-time data. The resulting differences were due to the previously overlooked fact that output and inflation estimates are not accurately, contemporaneously known to monetary authorities at the time of the policy

⁸⁸ Sauer and Sturm (2007). p. 1

⁸⁹ Fendel, Frenkel and Rülke (2008). p. 1

⁹⁰ Taylor (1999). p. 339

⁹¹ Judd and Rudebusch (1998). p. 7

⁹² Clarida, Gali and Gertler (2000). p. 148

decision.⁹³ Lastly, various academic research has emphasized the possibility of non-linear Taylor-type Rules. For instance, Rabanal provided strong evidence that central bank responses, to changing economic variables, vary over business cycles.⁹⁴ Moreover, further studies, for example conducted by Cukierman and Muscatelli, report asymmetrical behavior of the Fed depending on the policy regime.⁹⁵ Hence, modern Taylor Rule morphologies should incorporate the possibility of non-linearity and asymmetric central bank behavior.

Nevertheless, it is important to mention that despite many new variations of the Taylor Rule, various economists, for example former Fed Chairman Alan Greenspan, emphasized the importance of holding on to the important Taylor Principle as it is an ubiquitous, vital condition for the observance of economic stability and a central tenet of stabilizing monetary policy.⁹⁶

2.3.1. Interest Rate Smoothing and the Specification of the Taylor Rule

One common morphology of Taylor-type Rules is the incorporation of interest rate smoothing behaviors of central banks into the plain form of the Taylor Rule. Rudebusch observed that the Fed often tend to adjust short-term interest rates in gradual, small steps into the same direction, rather than making instantaneous adjustments towards the recommended target level.⁹⁷ Similar patterns have also been observed in various other countries. For instance, Lowe and Ellis have presented strong evidence for interest rate smoothing behaviors of central banks in Australia, Japan, Germany and the U.K.⁹⁸ Furthermore, Goodhart has presented evidence for similar observations in France, Italy, Canada, Spain, the Netherlands, Belgium, Sweden and Austria.⁹⁹

Both studies indicate that the short-term interest rate smoothing behavior, which is evident in the continuous, gradual target adjustments of most central banks, partly discourages fast, frequent reversals of prior interest rate target changes.¹⁰⁰ Thus, Lowe and Ellis, even emphasize that interest rate smoothing represents optimal monetary policy behavior. The time lag of monetary policy effects on real economic activity in combination

⁹³ Orphanides (2001). p. 964

⁹⁴ Rabanal (2004). p. 3

⁹⁵ Cukierman and Muscatelli (2008). p. 1

⁹⁶ Greenspan (2004). p. 38

⁹⁷ Judd and Rudebusch (1998). p. 6

⁹⁸ Lowe and Ellis (1998). p. 308

⁹⁹ Goodhart (1997). p. 168

¹⁰⁰ Rudebusch (1995). p. 271

with the fact that an economy is subject to various shocks suggest that monetary authorities should frequently change the level and direction of interest rates. However, those frequent changes are unlikely to greatly reduce the variation in output and inflation, but would rather generate destabilizing effects. Additionally, frequent changes in the interest rate could significantly harm the credibility and accountability of central banks' initial policy announcements. None of these developments seems desirable as they could lead to economic instability. Therefore, various economists argue that interest rate smoothing has essential, stabilizing characteristics for the economy.¹⁰¹

The hypothesis of deliberately adjusting nominal interest rates in small steps to reduce interest rate volatility was confirmed by the former Fed Chairman Alan Greenspan as well. According to Greenspan, the Fed implemented “measured and deliberated” changes in short-term interest rates to not introduce additional volatility into financial markets and into the real economy.¹⁰² Sack and Wiedland considered this behavior even as evidence that central banks have an additional objective of minimizing interest rate volatility, in addition to their price and output stabilization goals.¹⁰³

As interest rate smoothing appears to be a common practice followed by most central banks, most econometric specifications of the Taylor rule incorporate it in the form of an autoregressive (AR) model with one time lag. In these specifications, it is hypothesized that the current interest rate is a weighted function of the rule based target and its lagged value from the last period. The corresponding AR(1) model can be expressed as:

$$i_t = (1 - p) * i_t^* + p * i_{t-1} + \varepsilon_t \quad (14)$$

where

p (with $0 < p < 1$) represents the degree of interest rate smoothing,

i_t represents the nominal short-term interest rate at time t ,

i_{t-1} represents the nominal short-term interest rate at time $t-1$,

i_t^* represents the target interest rate at time t ,

ε_t represents an *i.i.d.* exogenous random shock to the interest rate at time t .¹⁰⁴

¹⁰¹ Lowe and Ellis (1998). p. 286

¹⁰² See Greenspan (2001) – Remarks by Chairman Alan Greenspan (Speech at the Economic Policy Conference, October 2001).

¹⁰³ Sack and Wiedland (2000). p. 206

¹⁰⁴ Fendel, Frenkel and Rülke (2008). p. 3

The more instantaneous monetary policy authorities change the nominal interest rate towards its desired target level, the more p tends to approach 0, with $p = 0$ stating that the central bank does not follow any interest rate smoothing at all.¹⁰⁵

Substituting equation (14) into equation (9) leads to:

$$i_t = (1-p)(r^* + \pi_t + \beta_\pi(\pi_t - \pi^*) + \beta_y(y_t - y^*)) + p * i_{t-1} + \varepsilon_t^i \quad (15)$$

Equation (15) transforms into the traditional Taylor Rule if p is set to 0 and accounts for common interest smoothing behavior of central banks if $0 < p < 1$.¹⁰⁶

2.3.2. The Morphology to a Forward-looking, Taylor-type Policy Rule

Another common morphology of the Taylor Rule is the incorporation of forward-looking estimates into the policy reaction function, rather than the reliance on lagged values of output and inflation. The importance of a forward-looking dimension with regards to monetary policies has already been acknowledged by Keynes, who emphasized that “if we wait until a price movement is actually afoot before applying remedial measures, we may be too late.”¹⁰⁷ Nearly a century later, former Fed Chairman Greenspan still stressed the importance of forward-looking monetary policy decisions and stated in a testimony: “Because monetary policy works with a lag, it is not the conditions prevailing today that are critical but rather those likely to prevail six to twelve month, or even longer, from now.”¹⁰⁸

Various economic studies during the end of the 1990s confirmed that desired stabilizing monetary policies in the G7 countries during that time, indeed, appeared to be driven more by anticipated future estimates of economic variables than by their corresponding lagged actual outcomes.¹⁰⁹ A few of the most prominent studies include, but are not limited to, Clarida and Gertler (1997), Clarida, Galí and Gertler (1998), Clarida, Galí and Gertler (2000) and Orphanides (2001). Clarida and Gertler showed that the German Central Bank conducted stabilizing monetary policy by adjusting short-term interest rates

¹⁰⁵ Murray, Papell and Razhevskyy (2015). p. 920

¹⁰⁶ Fendel, Frenkel and Rülke (2008). p. 4

¹⁰⁷ See Keynes (1923). p. 148

¹⁰⁸ See Greenspan (1997) – Testimony before the Senate Committee on the Budget.

¹⁰⁹ Batini and Haldane (1999). p. 157

based on anticipated rather than lagged inflation gaps.¹¹⁰ According to Clarida, Gali and Gertler, the G3 countries (Germany, Japan and the U.S.) and to a lesser extent the E3 countries (the U.K., France and Italy) conducted monetary policy decisions based on forward-looking estimates already since 1979.¹¹¹ Furthermore, Clarida, Gali and Gertler provided strong empirical evidence that the Fed conducted systematically different monetary policy approaches in the pre- and post-Volcker regime in their second paper. Whereas during the more unstable pre-Volcker regime, monetary policy decisions of the Fed seemed not to comply with the forward-looking Taylor Principle, the more stable post-Volcker regime periods did.¹¹²

Orphanides further stressed the importance of analyzing policy rules with a forward-looking horizon of six to twelve month based on real time data, as Orphanides stated that monetary policies should be pre-emptive in nature.¹¹³ All of those studies, therefore, postulate that stabilizing monetary policies need to account for forward-looking, anticipated economic variables rather than lagged ones.

As one of the first pioneers in the field of implicit Taylor-type rules, Clarida et al. proposed a forward-looking variant of Taylor's initially proposed reaction function.¹¹⁴ Following Clarida et al. work, the incorporation of forward-looking, expected variables leads to following implicit reaction function:

$$i_t^* = r^* + \pi_{t+h} + \beta_\pi * E_t(\pi_{t+h} - \pi^*) + \beta_y * E_t(y_{t+h} - y^*) \quad (16)$$

where

i_t^* is the desired short-term nominal interest rate,

r^* is the constant long-run equilibrium real interest rate,

$E_t(\pi_{t+h} - \pi^*)$ is the expected deviation of the h -period ahead inflation rate (π_{t+h}) from its desired target level (π^*),

$E_t(y_{t+h} - y^*)$ is the expected deviation of the h -period ahead output (y_{t+h}) from its desired target level (y^*),

¹¹⁰ Clarida and Gertler (1997). p. 405

¹¹¹ Clarida, Gali and Gertler (1998). p. 1065

¹¹² Clarida, Gali and Gertler (2000). p. 177

¹¹³ Orphanides (2001). p. 982

¹¹⁴ Clarida, Gali and Gertler (2000). p. 150

β_{π} and β_y are positive coefficients that indicate the intensity with which monetary authorities react to deviations from desired target levels.

By utilizing forward-looking variables, Clarida et al. accounted for the pre-emptive nature of monetary policy decisions and emphasized the fact that monetary authorities can only affect inflationary pressure with some time lag.¹¹⁵

Furthermore, it is worth noting that Clarida et al.'s forward-looking variant represents a special case of the Taylor Rule. If either lagged inflation or a linear combination of lagged inflation and the output gap is statistically sufficient to predict future inflation, the presented forward-looking policy rule will transform into the basic Taylor Rule. On the other hand, the proposed equation allows for the incorporation of a vast amount of information, which are relevant for forming expectations about the future state of the economy and can be captured by the corresponding forecast variables.

Clarida et al. further argued that by accounting for the interest rate smoothing behavior of central banks, as elaborated in the previous section, the forward-looking policy rule becomes less restrictive and serves as a more appropriate proxy for actual changes in the fund rates. Combining the AR(1) interest rate smoothing equation (15) with the advantageous, forward-looking Taylor-type Rule (16) yields the following policy reaction function:¹¹⁶

$$i_t = (1 - \rho) * \left(r^* + \pi_{t+h} + \beta_{\pi} * E_t(\pi_{t+h} - \pi^*) + \beta_y * E_t(y_{t+h} - y^*) \right) + \rho * i_{t-1} + E_t(\varepsilon_{t+h}^i) \quad (17)$$

Equation (17) represents a common econometrical specification of the initial Taylor Rule that incorporates both previously explained aspects – central banks interest smoothing behavior and the pre-emptive nature of monetary policy decisions. Therefore, it is nowadays widely used to describe and analyze monetary policy actions and to evaluate central banks policy behaviors.¹¹⁷

¹¹⁵ Fendel, Frenkel and Rülke (2008). p. 3

¹¹⁶ Clarida, Gali and Gertler (2000). p. 151-153

¹¹⁷ Fendel, Frenkel and Rülke (2008). p. 4

2.3.3. Dynamic Coefficients - Taylor-type Rules and Business Cycles

So far, all elaborated reaction function morphologies have focused on linear Taylor-type Rules. However, recent empirical papers have stressed the significance of asymmetric, nonlinear policy behavior of most central banks. Within this context, two important questions arise. First of all, have the coefficients of the Taylor Rule changed over time? Secondly, is there any evidence that monetary policy responses vary systematically between business cycles, namely between expansion and recession periods? Apparently, the answer to both questions is positive.¹¹⁸

Past empirical literature on monetary policy rules has primarily analyzed whether any structural break in the Taylor Rule exists. In this context, a strong emphasis has been placed on the analysis of pre- and post-Greenspan regime periods in the U.S. For example, Clarida, Gali and Gertler come to the conclusion that the Fed followed a more excessive inflation stabilization policy in the post-Greenspan period when compared with the pre-Greenspan period.¹¹⁹ Nevertheless, Rabanal pointed out that it is not entirely clear whether the results were mainly driven by different chairman preferences or by different reactions to distinct economic shocks.

According to Rabanal's empirical findings, there is strong evidence that the Taylor rule coefficients shift between expansion and recession cycles, even when accounted for different chairman preferences. During expansion periods, monetary policy appears to be primarily concerned with inflation stabilization, while the focus shifts to output stabilization during recession periods. Additionally, interest rate smoothing behavior tends to be lower in economic downturns when compared to expansion periods, as central banks seem to act quicker and more forceful in sight of prospective recessions.¹²⁰ Similar findings for the U.S. are reported by Petersen.¹²¹ Moreover, the presented results are further supported by the aforementioned phenomenon that central bank behavior appears to be extraordinary forceful in prospect of reaching the zero lower bound, which is normally the case during (great) recessions.¹²² Cukierman and Muscatelli also validated a nonlinear Taylor-type rules in the U.K. and U.S. However, instead of solely attributing the non-linearity to different business

¹¹⁸ Rabanal (2004). p. 3

¹¹⁹ Clarida, Gali and Gertler (2000). p. 148

¹²⁰ Rabanal (2004). p. 6-16

¹²¹ Peterson (2007). p. 19

¹²² Chevapatrakul, Kim and Mizen (2009). p. 1706 – For further details, please refer to Section 2.2.2. The Taylor Principle in Prospect of the Zero-lower Bound.

cycles, they analyzed whether the type of nonlinearity changes among monetary policy regime approaches. Indeed, in addition to the conclusion that the type of asymmetry in monetary policies changes with the economic environment, they emphasized that inflation targeting policy regimes seem to have a convex Taylor rule reaction function whereas non-inflation targeting policy regimes tend to have a concave reaction function. This indicates the advent of dominant inflation avoidance within inflation targeting policy regimes (at least during their initial introduction) and dominant recession avoidance within alternative policy regimes.¹²³ Finally, Castro presented results for a nonlinear monetary policy adopted by the ECB. According to Castro, the ECB only reacts actively to inflation when inflation exceeds 2.5%. Moreover, the ECB seemingly only reacts to business cycles during stabilized inflation periods, normally when inflation is below 2.5%. Castro explains this behavior with asymmetric policy preferences, which depend on the state of the economy. However, he only found weak evidence for a nonlinear policy model in the U.S.¹²⁴

All in all, all of the studies discussed above found at least some evidence for non-linear monetary policy behavior. Therefore, in order to accurately describe and evaluate monetary policy decisions, monetary policy rules should consider incorporating the possibility of nonlinear policy behavior.

¹²³ Cukierman and Muscatelli (2008). p. 3-21

¹²⁴ Castro (2008). p. 3

2.4. Inflation Targeting

In practice, however, no central bank is strictly conducting monetary policy only based on some mechanical instrument rule. Monetary policy authorities in open economies have to take much more information into consideration than ordinary rules normally rely on and thus, need to frequently reconsider their policy decisions whenever receiving new, relevant information. Therefore, a monetary policy instrument rule is never used to commit the bank to some policy actions but rather serves as an evaluation tool and guideline for actual monetary policy decisions, as already roughly elaborated in the broad interpretation of the Taylor Rule in Section 2.2.¹²⁵ Discretionary monetary policy is the rule. This is in line with statements by former Fed Chairman Alan Greenspan and other Fed officials, who frequently point out the disadvantages of rule based frameworks. Even though rules might perform quite well during conventional times, they offer only limited guidelines when the economy faces large, unpredictable shocks.¹²⁶

However, if central banks do not commit to publicly postulated policy rules, their behavior is more similar to a discretionary policy regime. Hence, such behavior should theoretically be inferior, since it should lead to high levels of inflation as a direct result of the postulated inflation bias of discretionary policy regimes, as illustrated in section 2.1.1.

Notwithstanding, several empirical studies argued that some discretionary monetary policy approaches may be capable of avoiding the time inconsistency issue, while providing a high level of desired flexibility. Therefore, operational monetary policy needs to entail some more flexible targeting rules, which have the potential to provide some kind of necessary, credible commitment, namely the commitment of minimizing a predefined loss function.¹²⁷ Moreover, the semantics may be a little misleading. Even though “targeting rules” comprise the word “rule”, it can be argued, as for example by Bernanke and Mishkin, that central banks following such an approach can be seen as some kind of constrained discretionary policy regimes. Bernanke and Mishkin argue that generally targeting rules do not provide operational instructions on how to set instruments based on some independent economic variables. Additionally, unlike simple instrument rules, policymakers do not need to neglect information that are not defined by the respective rule.¹²⁸ Instead, monetary authorities are

¹²⁵ Svensson (1998). p. 674

¹²⁶ Rabanal (2004). p. 3

¹²⁷ Svensson (1998). p. 675

¹²⁸ Bernanke and Mishkin (1997). p. 9

free to act in accordance with their own judgement and set the instruments based on all available information as long as they commit to the predefined target. Such targeting rules provide a significant degree of discretionary freedom and can thus be defined as constrained discretionary policies. One of the most widely used and arguably most successful targeting rules is the so-called inflation targeting policy regime.¹²⁹

During the end of the twentieth century, a number of central banks in both industrialized and emerging countries followed the example of New Zealand's monetary authorities and adopted an innovative strategy framework for monetary policy known as "inflation targeting". The rapidly increasing number of inflation targeting adoptors and its apparently stabilizing effects on the economy have triggered an intensifying debate about the benefits and implications of inflation targeting between academics and practitioners alike, giving rise to vast amount of research.¹³⁰ Nearly three decades since its initial introduction, numerous studies have confirmed that inflation targeting is indeed a powerful tool of monetary policy.¹³¹ Early empirical work includes, for example, Bernanke, who argued that inflation targeting promotes both price stability and well-anchored inflation expectations.¹³² Mishkin et al. postulated a similar view and argued that inflation targeting has been widely successful in maintaining low levels of inflation and increasing transparency.¹³³ And, according to Mervyn King: "Inflation targets form a clear and transparent framework for monetary policy... I think they are here to stay."¹³⁴

While it has been argued that earlier studies could suffer from only having had access to a small number of observations, more recent studies provide similar findings as well.¹³⁵ For instance, Mishkin and Hebbel found significant performance improvements for central banks that adopted inflation targeting, and argued that both inflation and output persistence are significantly lower in inflation targeting regimes when compared to other policy regimes.¹³⁶ Pétursson came to the same conclusion in a later study.¹³⁷ However, empirical work that divided inflation targeting regimes in subgroups of OECD countries and emerging economies indicated that the average beneficial effect on inflation and inflation variability is

¹²⁹ Svensson (1998). p. 681

¹³⁰ Mishkin and Hebbel (2007). p. 3

¹³¹ Martin and Milas (2004). p. 209

¹³² Bernanke (2003). p. 14

¹³³ Mishkin and Posen (1997). p. 96

¹³⁴ See King (1997). p. 3

¹³⁵ Svensson (2010). p. 9

¹³⁶ Mishkin, Hebbel (2007). p. 361

¹³⁷ Pétursson (2004). p. 10

only statistically significant in emerging countries.¹³⁸ While Lin and Ye and Angeriz and Arestis, among others, found insignificant results for most OECD countries, Batini and Laxton found significant results for reduced inflation variability for inflation targeting regimes for a variety of emerging economies.¹³⁹ Nevertheless, despite the different results for OECD countries and emerging economies, the general verdict of inflation targeting has been mostly positive so far. As a result, it has been adopted by more than 25 countries around the globe.¹⁴⁰ Additionally, many major central banks, such as the European Central Bank (ECB), the Swiss National Bank and for a longer timer horizon the U.S. Fed, have adopted many characteristics of inflation targeting regimes, even though they have not officially conducted monetary policy under the concept of inflation targeting.¹⁴¹

List of Inflation Targeting Policy Regimes		
Country	Adoption date	Inflation target rate
New Zealand	1990	1% - 3%
Canada	1991	2% +/-1%
United Kingdom	1992	2% +/-1%
Sweden	1993	2% +/-1%
Australia	1993	2-3%
Czech Republic	1997	3% +/-1%
Israel	1998	2% +/-1%
Poland	1999	2.5% +/-1%
Brazil	1999	4.5% +/-2%
Chile	1999	3% +/-1%
Colombia	2000	2% - 4%
South Africa	2000	3% - 6%
Thailand	2001	0.5% - 3%
Korea	2001	3% +/-1%
Mexico	2001	3% +/-1%
Iceland	2001	2.5% - 1.5%
Norway	2001	2.5% +/-1%
Hungary	2001	3% +/-1%
Peru	2002	2% +/-1%
Philippines	2002	4.5% +/-1%
Guatemala	2005	5% +/-1%
Indonesia	2005	4% - 6%
Romania	2005	3.5% +/-1%
Turkey	2006	6-5% +/-1%
Serbia	2006	4% - 8%
Ghana	2007	14.5% +/-1%
Serbia	2009	2% +/-1%
United States	2012	2%
Japan	2013	2%
India	2016	4%

*Table 1: List of inflation targeting central banks
Based on Roger (2010). p. 47 (Adjusted by recent inflation targeting adopters)*

¹³⁸ Svensson (2010). p. 9

¹³⁹ Lin and Ye (2007). p.10; Angeriz, Arestis (2008). p. 314; Batini, Laxton (2007). p. 494

¹⁴⁰ Svensson (2010). p. 1

¹⁴¹ Roger (2009). p. 4 – The U.S Fed became an official inflation targeting policy regime in 2012.

In practice, despite the fact that various central banks have nowadays instituted explicit inflation targeting in slightly modified forms, some common characteristics can still be identified. Fundamentally, inflation targeting can be described as (1) a monetary policy framework that involves an announcement of an official, explicit numerical target or a range of the inflation rate at one or more horizons by monetary authorities and (2) an operating procedure, which uses internal conditional inflation forecasts as intermediate target variables.¹⁴² Achieving the numerical inflation target becomes the primary objective of central banks, although it still provides some room for additional, secondary objectives, which will be discussed in section 2.4.1. “Strict and Flexible Inflation Targeting”. Furthermore, the optimal instrument rate path is set to be consistent with the corresponding inflation forecasts and therefore sets the basis for current policy instrument settings. Thus, the actual operational decision making process is commonly referred to as inflation forecast targeting.¹⁴³ In some way, the forward-looking procedure is a direct consequence of the time lags in the monetary transmission of monetary policy decisions and the fact that monetary authorities only have an imperfect control over inflation.¹⁴⁴ Moreover, the operating procedures can also be seen as a mathematical necessity to ensure that the first order conditions for a minimum of the under targeting rules required loss functions are approximately fulfilled.¹⁴⁵ Lastly, (3) monetary authorities have to credibly acknowledge that price stability is their primary goal to promote necessary credibility and accountability. Thus, inflation targeting regimes normally encompass a significant degree of transparency.¹⁴⁶ To promote transparency, inflation targeting central banks publish so-called “Inflation or Economic Forecasts Reports” on a regular basis, explaining and justifying policy actions and forecasts to the general public.¹⁴⁷ According to King, inflation targeting can consequently be defined as a “framework for making and communicating policy decisions.”¹⁴⁸

Nowadays, many central banks, especially in emerging markets, call themselves inflation targeting regimes. Yet, their monetary policy framework should not be regarded as real inflation targeting. In order to be characterized as a real inflation targeting regime, a

¹⁴² Svensson (2000), p. 156 – The forecasts are conditional upon current, real time information, specific instrument paths, the bank’s structural models and individual judgement adjustments. For further details please refer to section 2.4.3. “Optimal Policy Choice under Inflation Targeting”.

¹⁴³ Svensson (2002). p. 773-774 – The incorporation of secondary objectives is known as flexible inflation targeting.

¹⁴⁴ Svensson (2000). p. 156

¹⁴⁵ Svensson (1998). p. 681

¹⁴⁶ Bernanke and Mishkin (1997). p. 1

¹⁴⁷ Svensson (2000). p. 157

¹⁴⁸ See King (2005). p. 2

credible, institutional commitment, which includes a clear, preferably legislated mandate for monetary policies directed towards low levels of inflation, is needed. Moreover, central bank must guarantee instrument independency. Lastly, monetary authorities should be accountable in some way for achieving the desired mandate. Only if these additional requirements are fulfilled, central banks inflation targeting announcements can be seen as truly credible and can therefore fulfill their full potential.¹⁴⁹

2.4.1. Strict and Flexible Inflation Targeting

Theoretically, inflation targeting central bank regimes can be further distinguished as strict and flexible regimes. Whereas strict inflation targeting regimes are merely concerned about deviations of projected inflation from their desired target levels, flexible inflation targeting regimes emphasize additionally on other explicit and/or implicit economic variables, such as the variability of output and employment.¹⁵⁰

The consideration whether inflation targeting should solely keep inflation close to the desired target or should incorporate other economic variable as well can also be seen as a discussion over the optimal degree of policy activism. Consider an economic shock that results in an increase in inflation. Strict inflation targeting regimes would follow a vigorous and activist policy with extreme adjustments to policy instruments in order to stabilize inflation around its target level. However, even though drastic and frequent changes in policy instruments might be successful in stabilizing inflation, they are likely to lead to high, undesired variability in other economic variables as well as underpin the predictability and credibility of monetary policies. Moreover, continuous whipsawing of the interest rate policy instrument under over-activist policy could trigger an instrument-instability problem. This problem describes the effect that extreme and frequent changes and reversals of the policy instrument are making it less effective over time. Thus, larger adjustments to the corresponding instruments are necessary to have the desired effect on inflation levels, up to the point where it may have destabilizing rather than stabilizing effects on inflation and other economic variables.¹⁵¹ Instead, flexible inflation targeting is a more gradual approach with less policy activism. More precisely, as inflation is gradually brought back to its desired target

¹⁴⁹ Mishkin (2001b), p. 1

¹⁵⁰ Giannoni and Woodford (2004), p. 94 – The emphasize is on variability of output and employment as it assumes the natural-rate hypothesis to be true.

¹⁵¹ Svensson (1997), p. 8-14 – For similar reasons, central banks normally incorporate smoothing parameters for the corresponding instrument, as already indicated in section 2.3.1.

level, under the consideration of its effect on other economic variables at a longer time horizon, potential economic instability can be avoided.¹⁵²

Unsurprisingly, there is a common consensus among monetary authorities and academics alike that inflation targeting is nearly always flexible in practice. Central banks tend to stabilize inflation around a desired target level as well as to emphasize on stabilizing the variability of output. Furthermore, as monetary policy is most effective if it is pre-emptive due to its lagged impact on target variables and imperfect control over inflation, the monetary policy rate under inflation targeting is set conditional on the forecast target variables. The forecasted economic variables can therefore be seen as intermediate target variables. Thus, the operating procedure is often referred to as inflation forecast targeting. More precisely, the objectives of inflation targeting central banks can be well approximated by a standard quadratic intertemporal loss function, consisting of the sum of the expected, squared inflation gap and a relative weight times the expected squared output gap as the intermediate target variables.¹⁵³

$$L_t = (1 - \delta) * E_t \sum_{\tau=0}^{\infty} \delta^{\tau} ((\pi_{t+\tau} - \pi^*)^2 + \omega * \gamma_{t+\tau}^2) \quad (18)$$

where

E_t represents expectations conditional on information available at time *t*,

π_t denotes inflation at time *t*,

*π** denotes the desired target level of inflation,

γ_t denotes the output gap at time *t*,

ω a relative weight on output gap stabilization efforts,

δ where $0 < \delta < 1$ is a discount factor.¹⁵⁴

With regards to the intertemporal loss function, the set target levels are *π** for inflation and zero for the potential output gap. Furthermore, the relative weighting factor *ω* corresponds to the degree of flexibility, with $\omega > 0$ implying flexible inflation targeting and $\omega = 0$ implying strict inflation targeting.

¹⁵² Svensson (1997). p. 14

¹⁵³ Svensson (2010). p. 13

¹⁵⁴ Svensson (2002), p. 775 – The discount factor *δ* will nearly always be close to one, especially if quarterly data is used. Moreover, if the discount factor is gets close to one, the intertemporal loss function will be equal to the weighted sum of the unconditional variance of its target variables.

The main objective of inflation targeting policy regimes is to minimize the respective intertemporal loss function. Furthermore, it is widely agreed on that inflation targeting policy regimes generally do not follow overambitious output targets above potential output levels, but rather target an output gap that is consistent with the natural output level.¹⁵⁵ This modification is sufficient to eliminate the time inconsistency issue. Hence, the minimization of the intertemporal loss function provides a commitment that, if credible, would eliminate the postulated inflation bias under discretionary policy regimes suggested by Kydland, Prescott, Barro and Gordan.¹⁵⁶

When analyzing flexible inflation targeting and the relative weight of the output stabilization factor, it is crucial to point out that there is a fundamental difference between the inflation target rate and the implied output gap. Whereas monetary authorities can theoretically achieve sustainable inflation at any non-negative level, they cannot affect the sustainable long-term output level, which is determined by other factors rather than monetary policy alone. For instance, these factors include, but are not limited to, technological improvements and the efficiency of the corresponding economy. Monetary authorities can only affect the stability of the corresponding resource utilization.¹⁵⁷ Consequently, an asymmetry exists since the targeted inflation level is subject to choice, while the output gap is fixed at zero. This is consistent with the assumption that inflation stabilization is the primary objective pursued.¹⁵⁸ Hence, flexible inflation targeting can be defined as a hierarchical mandate. Furthermore, the objective of central banks under flexible inflation targeting is to minimize the respective loss function, which includes both an inflation target and an output stabilization goal. Taking this into account, flexible inflation targeting can also be defined as a dual mandate. According to Svensson, in the end inflation targeting can be interpreted as having both characteristics, a hierarchical and a dual mandate with no direct conflict arising between them.¹⁵⁹

Moreover, it is widely agreed on that the degree of pursued flexibility depends on the level of credibility of the corresponding central banks. For instance, Svensson argued that new inflation targeting policy regimes have to prioritize the establishment of credibility. Thus, they have to put less weight on stabilizing output variability, when compared to mature

¹⁵⁵ Svensson (2002). p. 775-776

¹⁵⁶ Svensson and Woodford (2004). p. 20

¹⁵⁷ Svensson (2008). p. 2

¹⁵⁸ Svensson (2002). p. 775

¹⁵⁹ Svensson (2003). p. 3

inflation targeting central banks. Mature inflation targeting regimes can assign relatively more weight on stabilizing resource utilization, due to their already established credibility of maintaining price stability under low levels of inflation.¹⁶⁰ Alichí et al. shared a similar view and argued that in countries with inflation rates significantly above their target, new inflation targeting adopters' primary goal should be to establish credibility. Therefore, the corresponding policy regimes should place a great emphasis on inflation reduction and less weight on the output gap factor.¹⁶¹ These findings are in line with the already elaborated empirical evidence of Cukierman and Muscatelli who also emphasized the existence of dominant inflation avoidance in newly established inflation targeting regimes.¹⁶²

2.4.2. Transparency, Credibility and Accountability

Over the last three decades, an increasing number of central banks have introduced rising standards of transparency and independence. Although central banks have long recognized the importance of independence, the significance of central bank transparency has only started to emerge during the 1990s. This trend is particularly evident from a well-documented survey of 94 central banks in 1998, which revealed that 74% of all central banks under analysis considered transparency a vital aspect of their current and future monetary policy frameworks.¹⁶³ Furthermore, greater movements towards rising transparency are also evident with the fact that an increasing number of central banks have started to communicate their monetary policy objectives as well as their definition and quantification of price stability and inflation targets to the general public.¹⁶⁴

The announcement of an official, credible numerical inflation target or range and the publication of inflation forecasts are central pillars of inflation targeting and important prerequisites for its operating success. The accompanying emphasis on transparency under inflation targeting is exceptional in the history of central banks and primarily stems from the insight that monetary policy is to a great extent the “management of private sector expectations.” Therefore, a crucial prerequisite for maintaining price stability under inflation targeting is the anchoring of these private sector inflation expectations $E(\pi_t)$ to the

¹⁶⁰ Svensson (2010). p. 2

¹⁶¹ Alichí, et al. (2009). p. 3

¹⁶² Cukierman and Muscatelli (2008). p. 3

¹⁶³ Geraats (2002). p. 1

¹⁶⁴ Melecký, Palenzuela and Söderström (2008). p. 371

announced policy inflation target π_t^* .¹⁶⁵ Leiderman and Svensson and Bernanke et al. proved that an increase in transparency of central banks can improve their credibility and accountability. It facilitates the anchoring of private agents' long-term inflation expectations to announced policy objectives, as private agents have an explicit target against which they can evaluate monetary policy actions.¹⁶⁶ Furthermore, the expectations-augmented Phillips curve states that inflation expectations have a direct impact on realized inflation. Hence, by providing a credible nominal anchor for inflation expectations, which observance can be monitored, inflation targeting should reduce macroeconomic volatility. This volatility arises mainly because of uncertainty and asymmetric information between policymakers and private economic agents about future inflation developments.¹⁶⁷ In this context, the proximity of expectations to actual announced inflation targets is often described by the degree of credibility of the corresponding policy regime.¹⁶⁸ Thus, if the announcement is considered to be credible, it should stabilize inflation around the announced target ($E(\pi_t) = \pi_t^*$) and consequently neglect the inflation bias, which arises under less credible discretionary monetary policy regimes.¹⁶⁹

Empirical evidence for the implicit assumption that inflation targeting coupled with central bank independence can provide a nominal anchor for inflation expectations have been presented by various economic researchers. For example, Levin, Natalucci and Piger demonstrated that private sector inflation forecasts in non-inflation targeting policy regimes, such as the U.S. (before it established inflation targeting as a monetary policy approach), are strongly correlated with a three-year moving average of lagged inflation. Contrarily, this correlation is close to zero for private sector inflation forecast in a variety of inflation targeting policy regimes, indicating that inflation targeting central banks have been successful in delinking expectations from realized inflation.¹⁷⁰ Fujiwara analyzed if economic forecasts published by the central bank of Japan affects expectations of professional forecasters. He concludes that published forecasts have a notable effect on professional external forecasts in Japan, as public forecasts seem to reduce the variance of private sector forecasts. This in turn, indicates a reduction in forecast uncertainty.¹⁷¹ Crowe and Crowe and Meade find further

¹⁶⁵ Svensson (2010). p. 3

¹⁶⁶ Leiderman and Svensson (1995). p. 1; Bernake, et al. (1999). p. 1

¹⁶⁷ Melecký, Palenzuela and Söderström (2008). p. 372

¹⁶⁸ Svensson (2010). p. 3

¹⁶⁹ Melecký, Palenzuela and Söderström (2008). p. 372

¹⁷⁰ Levin, Natalucci and Piger (2004). p. 51

¹⁷¹ Fujiwara (2005). p. 256

evidence that enhanced transparency of inflation targeting central banks affect private sector expectations. According to both studies, inflation targeting is associated with a convergence in private sector forecast errors, indicating that economic forecasts published by central banks indeed provide a nominal anchor for private agents.¹⁷² Similar findings are reported by Ehrmann, Eiiiffinger and Fratzscher who find a significant reduction in forecast disagreements and a convergence of inflation expectations of private agents within inflation targeting policy regimes. However, Ehrmann, Eiiiffinger and Fratzscher further argue that the marginal benefit associated with transparency decreases once the central bank has achieved a certain level of credibility.¹⁷³ A similar conclusion is reached by Mishkin, who argues that even though transparency is a virtue, it can go too far. Some extreme actions of transparency, for instance the publication of a central banks' exact objective function or of the policy instrument projection path, can do more harm than good. Those actions can not only greatly complicate the communication with the general public due to time varying projection paths but also weaken central banks' credibility if policymakers deviate from the announced paths. This, amongst other, can greatly reduce the desired flexibility accompanying inflation targeting.¹⁷⁴ Lastly, Gürkaynak, Levin and Swanson as well as Gürkaynak et al. findings further strengthen the expectation anchoring capability of inflation targeting regimes. They illustrated that long-term inflation expectations respond to a lesser extent to economic news if the monetary policy is conducted under an independent inflation targeting central bank, when compared to countries where the central bank does not follow an inflation targeting policy strategy.¹⁷⁵

Another desired, direct consequence of inflation targeting is a significant enhancement of central banks' accountability. Whereas a majority of monetary authorities seem to have favored opacity to actively avoid accountability for their actions, inflation targeting is subject to a high degree of accountability. Policymakers can be evaluated based on their performance of achieving pre-announced targets. Thus they are exposed to a considered amount of public scrutiny. This extensive accountability is an important part of inflation targeting as it provides incentives for policymakers to achieve their communicated objectives. By holding on to preannounced targets, monetary authorities maintain credibility

¹⁷² Crowe (2010). p. 232; Crow and Meade (2007). p. 772

¹⁷³ Ehrman, Eiiiffinger and Fratzscher (2012). p. 1050

¹⁷⁴ Mishkin (2004). p. 26

¹⁷⁵ Gürkaynak, Levin and Swanson (2010). p. 1210

and do not fall into the time inconsistency trap of discretionary monetary policy of optimizing short run policy objectives.

Due to the importance of accountability in inflation targeting policy regimes, several central banks are subject to even more explicit requirements to foster accountability. For instance, the New Zealand government is bound by a “Policy Target Agreement” which clearly states its responsibilities with regards to monetary policies. Moreover, the U.K. central bank has to publish a public statement, explaining any deviations from targets in excess of one percent and the actions it is taking or will take to eliminate those deviations. Lastly, in several other countries, policymakers have to regularly attend public hearings in the corresponding parliaments, where monetary policy decisions are subject to further detailed analysis.¹⁷⁶ All of these precautionary measures strongly emphasize the importance of policy accountability within inflation targeting policy regimes.

2.4.3. Optimal Policy Choice under Inflation Targeting

After establishing a general definition of inflation targeting and manifesting the most important characteristics of this monetary policy strategy, the question remains how central banks operationalize the inflation targeting policy and adjust their instruments accordingly, with respect to their objective of minimizing the respective intertemporal loss function (18).¹⁷⁷ As a detailed analysis of the optimal policy choice under inflation targeting would exceed the scope of this thesis, only a brief overview of possible considerations monetary authorities have to take into account will be provided.

As explained previously, a variety of theoretical and empirical papers have stressed the importance of forward-looking policies, since monetary policy actions influence the economy with a significant time lag. Realized inflation and output are primarily a result of past investment and consumption decisions of both private firms and households. This implies that forecasts variables have to enter the respective loss function and effectively become intermediate target variables.¹⁷⁸ An efficient monetary policy should thus be proactive. It should react to the underlying determinants of these forecasts variables in order to affect them in the desired way, in which

¹⁷⁶ Svensson (2010). p. 3-4

¹⁷⁷ Leitemo (2003). p. 610

¹⁷⁸ Svensson (2003). p. 7

$$\pi_{t+h} = \pi^* \quad (19)$$

where the four-quarter inflation rate at the forecast time horizon h is equal to the desired target rate of inflation. However, an important issue arising from this assumption is that there exists theoretically an infinitum of monetary policy instrument settings which satisfy equation (19). As long as the time horizon h represents a number greater than the minimum time lag under which the corresponding, implied instrument paths affect the intermediate target variables, generally no unique optimal policy setting can be found.¹⁷⁹ In this case, a variety of different interest rate paths will typically lead to the specified inflation target.¹⁸⁰ Furthermore, consider alternative forecasts of inflation and output at time t for various time horizons h ,

$$\pi_t = \{\pi_{t+h,t}\}_{h=0}^{\infty} \quad (20)$$

and

$$\gamma_t = \{\gamma_{t+h,t}\}_{h=0}^{\infty} \quad (21)$$

in which the policy instrument affects the target variables. The respective forecasts are dependent on alternative instrument rate path projections at time t for the corresponding time horizons,

$$i_t = \{i_{t+h,t}\}_{h=0}^{\infty} \quad (22)$$

as well as on the policymakers imperfect information set at time t , I_t and their judgments about the potential economic effects and transmissions of their decisions at time t , Z_t . That is,

$$\pi_{t+h,t} = E\{\pi_{t+h,t} | i_t, I_t, Z_t\}_{h=0}^{\infty} \quad (23)$$

and

¹⁷⁹ Leitemo (2003). p. 611

¹⁸⁰ Honkapohja and Mitra (2005). p. 1868

$$\gamma_{t+h,t} = E\{\gamma_{t+h}, |i_t, I_t, Z_t\}_{h=0}^{\infty} \quad (24)$$

Depending on the monetary forecast assumptions of monetary policy authorities, their information sets I_t and judgments Z_t , the policymakers should identify the combination of forecasts for π_t , γ_t and i_t that would lead to a minimization of the intertemporal loss function and then adjust the instrument in each period t accordingly. This process will result in the following endogenous reaction function for the prevailing instrument rate plan.

$$F(I_t, Z_t). \quad (25)$$

The projection plan of all feasible options captured by the endogenous reaction function, however, is subject to a considerable amount of subjective judgements, to partial information about the actual state of the economy as well as to various assumptions about the main transmission mechanisms. The set of all feasible policy projections is thus considerably large and contains several alternatives to choose from.¹⁸¹ Some practitioners and academics argue that there is a need for further explicit conditions on the path of possible future instrument developments, and postulate a concept known as constant interest rate inflation forecast targeting.¹⁸² Nevertheless, others favor a time varying instrument rate path given by market expectation of future instrument rates or a majority voting about optimal instrument paths under different economic projections.¹⁸³ As the corresponding debate has captured considerable attention from both academics and practitioners alike, it will be further elaborated in the next sub-section.

2.4.3.1. Constant and Time Varying Internal Instrument Rate Path Forecasts

The internal decision making process of how to forecast certain target variables and decide on certain projections has attracted a considerable amount of attention. Several central banks and academics have viewed different ways to restrict the universe of potential instrument settings and to make optimal monetary policy decisions under various restrictions,

¹⁸¹ Svensson (2010). p. 7-23

¹⁸² Leitemo (2003). p. 612

¹⁸³ Svensson (2006). p. 7

without reaching a real consensus over the optimal settings.¹⁸⁴ One possibility to further narrow down the set of all feasible policy options under inflation targeting and to determine a potentially optimal forecast and instrument rate plan is to impose certain additional requirements on the future development of the chosen instrument. A potential measurement, which has arguably been implemented for some time by the Bank of England, the Fed and the Riksbank is to demand a constancy assumption on the interest rate instrument over the time horizon of the forward-looking policy.¹⁸⁵ Empirical evidence for a constancy assumption on historical interest rate forecasts has been provided by Berg, Jansson and Vreding for Sweden, by Boivin for the U.S. and by Lomax for the U.K.¹⁸⁶

Within this framework, monetary authorities compute forecasts of inflation and output developments for the respective time horizon for various constant interest rate levels. The interest rate is then set to a level that is consistent with the h periods ahead desired inflation forecast, which will eventually converge into the inflation target level. This strategy responds systematically to the state of the economy and is commonly referred to as constant interest rate inflation forecast targeting. It can be denoted as:

$$\pi_{t+h|t}(i_t) = \pi^* . \quad ^{187} \quad (26)$$

A general approach of how constant interest rate inflation forecast targeting is conducted in the U.K. is well explained by Goodhart: “When I was a member of the MPC I thought that I was trying, at each forecast round, to set the level of interest rates so that, without the need for future rate changes, prospective (forecast) inflation would on average equal the target at the policy.”¹⁸⁸ A slightly different practical approach is illustrated by Honkapohja and Mitra for the Swedish Riksbank: “... if the overall picture of inflation prospects (based on an unchanged repo rate) indicates that in twelve to twenty-four months’ time inflation will deviate from the target, then the repo rate should normally be adjusted accordingly.”¹⁸⁹

However, one important consideration, rarely explicitly acknowledged by inflation targeting policy regimes, is that constant interest rate projections are not the optimal forecast

¹⁸⁴ Svensson (2006). p. 1

¹⁸⁵ Goodhart (2005). p. 1

¹⁸⁶ Berg, Jansson and Vreding (2004). p. 8; Boivin (2004). p. 2; Lomax (2005). p. 1

¹⁸⁷ Leitemo (2003). p. 612

¹⁸⁸ See Goodhart (2000). p. 177

¹⁸⁹ See Honkapohja and Mitra (2005). p. 1869

of possible future interest rate developments. The optimal rationally expected instrument rate path within the targeting horizon is rather determined by subsequent inflation forecasts within the respective targeting horizon. Put simply, whenever realized inflation deviates from the previously projected inflation path, the instrument has to be adjusted in a way in which, if held constant, it would bring the inflation projection back to target. The interest rate instrument is not truly held constant over the whole projection time horizon h . Therefore, constant interest rate forecast targeting should be merely seen as a necessary assumption in deriving monetary policy decisions rather than an actual forecast itself.¹⁹⁰

Of course, there are numerous constancy assumptions that central banks could make to develop inflation forecasts. For instance, instead of implying a constancy assumption on nominal interest rates, authorities could implement a constancy assumption on real interest rates or determine the rate in each period by following a predefined reaction function, as for example New Zealand does.¹⁹¹

Generally, constant interest rate inflation forecast targeting has been advocated as a simple approach, that is easily understood by the general public.¹⁹² However, even though this specific targeting rule is both simple and operational, it will most likely not be optimal.¹⁹³ According to numerous empirical findings, specifying forecasts conditional on constant interest rate forecasts will most likely lead to various issues and policy inconsistencies. Most prominently, a constancy assumption on the interest rate instrument for a longer time horizon could lead to Wicksellian Instability, in which inflation veers off its target rather than approaching it.¹⁹⁴ Moreover, Goodhart points out that generally, market expectations of interest rates resemble a time varying rather than constant paths. The money market yield curve, which can be used in deriving a proxy for market expectations of interest rate developments, is rarely approximately flat during the projection period.¹⁹⁵ Consequently, as the constant interest rate does not mirror the best forecast for actual future interest rate developments, the corresponding inflation and output gap forecast will very unlikely be the optimal forecasts of future realized outcomes. Thus, a constancy assumption would impede the accuracy of simple rules in retrospect. This, in turn, makes it not only harder to compare

¹⁹⁰ Leitemo (2003). p. 613

¹⁹¹ Rudebusch and Svensson (1999). p. 219

¹⁹² Honkapohja and Mitra (2005). p. 1868

¹⁹³ Svensson (2003). p. 8

¹⁹⁴ Santomero, Viotti and Vredin (2010). p. 217

¹⁹⁵ Goodhart (2005). p. 2

the optimal forecast under constancy assumptions with actual outcomes, but also makes the comparison less relevant.¹⁹⁶

An alternative forecast model, which was implemented by the Bank of England in 2004, is to set the interest rate instrument conditional on the estimated future interest rate path implied in the money market yield curve. Taking the assumption of rational expectations and efficient markets into consideration, the market forecast itself is ought to be credible, while policymakers do not need to publicly commit to any specific constraints. By following such an approach, policymakers have got another policy instrument, namely their separate ability to influence future interest rate expectations independently. If the inflation targeting policy regime appears to be credible, then the publication of the corresponding deviation should leeway market participant expectations in the desired direction.

On the other hand, Goodhart points out that influencing market expectations is not a policy instrument that monetary authorities can vary at will. If policymakers were ever suspected of manipulating forecast to achieve short-term gains, they would lose all credibility and again fall into the time inconsistency trap of discretionary monetary policy.¹⁹⁷ Moreover, basing the interest rate instrument conditional on market expectations seems to have a number of further disadvantages. For instance, if the deviation of realized inflation from its target is considerably large or the deviation is continuously worsening, it would raise severe concerns why no preventive policy action was taken. On the other hand, if monetary authorities initiates actions that have not been anticipated by private agents, while normally basing their instrument conditional on money market yield curve, it will most likely affect future private agent's estimations of interest rates. This, amongst other, could lead to distortion of the market yield curve and a potential loss of credibility.¹⁹⁸ Additionally, numerous academic researchers pointed out that the money market yield curve is itself a poor predictor of future interest rate developments, especially for longer time horizons. Rudebusch and Goodhart both provide empirical evidence for large root mean squared errors in the implied interest rate forecast for the U.S.¹⁹⁹ Thorton provides similar findings for Japan.²⁰⁰

Lastly, Svensson strongly advocates a median consensus instrument rate plan. According to this strategy, each member of the monetary policy committee (MPC) should

¹⁹⁶ Svensson (2003). p. 1-11

¹⁹⁷ Goodhart (2005). p. 9

¹⁹⁸ Goodhart (2005). p. 10

¹⁹⁹ Rudebusch (2002). p. 1163; Goodhart (2005). p. 2

²⁰⁰ Thorton (2004). p. 66

plot his/her preferred instrument plan settings on an aggregated plot graph. The chosen instrument rate plan represents the median instrument settings for each future quarter under discussion. Forecasts of inflation and output gaps are then estimated conditional on the agreed on policy. Hence, the corresponding results could be interpreted as some kind of majority voting procedure. According to Svensson, the combined outcome of inflation, output gap and interest rate plan would represent the best forecast of economic target variables, conditional on the information set available and the authorities' personal judgement, without facing most of the discussed disadvantages of constant or market based interest rate forecasts.²⁰¹

²⁰¹ Svensson (2003). p. 12-14

3. Empirical Analysis

While most monetary authorities and central banks have already been in place since the seventeenth century, their general objectives, functions and operations have undoubtedly evolved over their prevailing time horizons. Especially over the past decades the fast pace of new reforms and newly introduced monetary policy approaches have been remarkably visible around the globe. The aforesaid phenomena of the realization of time inconsistency issues, the benefits of independence and transparency and various extensions and analyses of monetary policy rules have significantly contributed to the rising understanding of macro-economic policy effects.²⁰² One aspect, which particularly stands out, is the rising level of transparency of most central banks. While for most of their existing time central banks have followed the conventional wisdom that “silence is golden”, a recent consensus has emerged that central banks should operate under more transparent frameworks. Therefore, central banks should reveal policy-relevant information, unless there exists a justifiable reason for not disclosing them.²⁰³ This perspective is partly supported by Greenspan who noted that “openness is an obligation of a central bank in a free and democratic society.” However, Greenspan additionally pointed out that even though transparency is a desirable state, the most effective policymaking is conducted in absence of the immediate glare of the public.²⁰⁴

Mainly due to the rise of inflation targeting policy regimes and the corresponding rise of transparency, central banks have started to increase their communication with the general public. Most of today’s inflation targeting policy regimes disclose their inflation forecasts and output forecasts, normally with uncertainty bands, on which they base their monetary policy decisions on, in so-called Inflation Reports (with the exception of the Bank of Israel and the Central Bank of Turkey). Despite the increasing efforts towards a higher degree of policy transparency, only a limited number of central banks publish their interest rate projection path. Furthermore, not a single central bank publishes its exact objective function, nor their exact quantitative reasoning for specific policy decisions.²⁰⁵

Generally speaking, monetary policymaking is a highly complex, nonlinear process based on partly temporary relationship among economic variables. However, for both descriptive and prescriptive reasoning, economists are looking for simplified character-

²⁰² Mishkin (2004). p. 48

²⁰³ Faust and Leeper (2005). p. 1

²⁰⁴ See Greenspan (2002). p. 933-934

²⁰⁵ Mishkin (2004). p. 47

izations of this nonlinear policymaking process. Thus, numerous academic and independent researchers have proposed different, simplified policy evaluation rules. One of the most prominent and most widely used simplifications is the previously discussed Taylor Rule and its suggested morphologies.

This section tries to answer the question whether economic forecasts published by inflation targeting central banks are consistent with their monetary policy decisions today. More precisely, this section evaluates if monetary policy decisions today incorporate a pre-emptive perspective of these economic forecasts. Therefore, it is empirically analyzed whether adjustments to the interest rate instrument can be characterized by reduced information policy simplifications of forward-looking, mostly linear Taylor-type Rules and even more important if these adjustments are consistent with the inherit Taylor Principle, proposedly necessary for economic stability. Moreover, as a direct response to the financial crisis in 2008 and later due to the European sovereign debt crisis, numerous central banks engaged into excessive expansionary policy behavior. Thus, various monetary authorities have effectively hit the zero lower bound on their policy interest rate instrument, which severely limited its further use. Thus, another important question arises. Can a change in policy behavior, pre- and post-crisis, within the central banks under analysis be observed? For simplicity, the empirical part focusses on a limited sample of inflation targeting central banks. In order to assess whether inflation targeting central bank' forecasts are generally consistent with the Taylor Principle and if central banks responds differently to these forecasts pre- and post-financial crisis, the analysis will be based on forecast data of the Reserve Bank of New Zealand, the Sveriges Riksbank and the U.S. Fed. By analyzing these three central banks, the analysis comprises three diverse geographical and political areas.

3.1. Methodological Notes

Since the initial introduction of Taylor's seminal paper "Discretion versus policy rules in practice", it has become common practice to describe interest rate setting behavior of most monetary authorities in terms of monetary policy reaction functions. Moreover, various academic research has focused on modifications of Taylor's initially proposed reaction function with the goal of increasing its explanatory power of describing monetary policy behavior, while still holding on to its elegant simplicity. These rules, which are still in the spirit of the initial Taylor Rule are, as aforementioned, in the literature commonly referred to

as Taylor-Type Rules.²⁰⁶ With regards to the empirical analysis of monetary policy behavior, various Taylor Rules and Taylor-type Rules that are based on published economic forecasts by the central banks under analysis will be compared. For the empirical research in section 3.4., Taylor's initially proposed reaction function with estimated coefficients based on published central bank forecasts is used. The Taylor-type Rule, as described in section 2.3.2, will then be analyzed for zero, one and two years forecast horizons and can be denoted as:

$$i_t^* = r^* + \pi_{t+h} + \beta_\pi * E_t(\pi_{t+h} - \pi^*) + \beta_y * E_t(y_{t+h} - y^*) \quad (27)$$

where

h represents the respective forecasted time horizons under analysis, namely 0, 1 and 2 years.

Following the derived specification of Rudebusch and Clarida et al., a Taylor-Type morphology, which incorporates an interest rate smoothing term with a forward-looking character, will be analyzed as well. The adaptation of an interest rate smoothing term is based on the numerous empirical findings, which state that central banks adjust policy instruments in small, gradual manners rather than changing it instantaneously towards the recommended target level.²⁰⁷ Moreover, as indicated by the graphical illustration of the policy rate developments in section 3.3.1. and the corresponding unit root tests, all policy rate time series seem to inherit a structural break post-financial crisis in 2007/2008. To account for the possibility of a structural break in the dependent variable, a dummy for a changing intercept will be integrated into the corresponding Taylor Rule morphology. Following the reasoning of section 2.3.2., while also incorporating a dummy variable for a possible time break into the proposed reaction function, the forward-looking Taylor-type Rule takes on the following shape:\

$$i_t = (1 - \rho) * (r^* + \pi_{t+h} + \beta_\pi * E_t(\pi_{t+h} - \pi^*) + \beta_y * E_t(y_{t+h} - y^*) + \delta_{time\ break}) + \rho * i_{t-1} + E_t(\varepsilon_{t+h}^i) \quad (28)$$

²⁰⁶ Fendel, Frenkel and Rülke (2008). p. 2. – For a detailed explanation of Taylor-type Rules, please refer to section 2.3.

²⁰⁷ Rudebusch (1995). p. 271; Clarida, Gali and Gertler (2000). p. 153 – For a more detailed description of interest rate smoothing behavior of monetary authorities, please refer to section 2.3.1.

where

h represents the respective forecasted time horizons under analysis, namely 0, 1 and 2 year,

$\delta_{time\ break}$ represents a dummy variable for a changing constant post-financial crisis.

Lastly, as aforementioned, various central banks around the globe effectively reached the zero lower bound on their interest rate policy instrument. Consequently, its applicability for further expansionary policy decisions was severely limited and monetary policy authorities had to recourse to other policy instruments instead, such as the monetary supply instrument. For instance, in effort to fight, what turned out to be the worst recession since 1937 in the U.S., the Federal Open Market Committee (FOMC) cut the policy rate to almost zero, facing the danger of a liquidity trap. During this temporary, unconventional economic state, monetary authorities were restrained from using their normal policy instrument and had to rely on other policy instruments. Thus, as a response to the severe recession, several central banks, for instance the ECB or the Fed, engaged into the so-called unconventional quantitative easing programs. In short, such a monetary strategy refers to the large scale purchase of longer-term government securities to induce large amounts of liquidity into the market and stimulate the economy as well as to reduce persisting term premiums along the yield curve due to imperfect market arbitrage.²⁰⁸

To factor in the important possibility of changing coefficients due to a restricted use of the ordinary monetary policy interest rate instruments or due to changing policy behavior as a necessary response to the unconventional time, a third reaction function with changing coefficients will be estimated for the aforesaid time horizons. Following this approach, the corresponding equation will incorporate dynamic dummy variables for all coefficients and will hence take on the following shape:

$$\begin{aligned}
 i_t = & (1 - \rho) * (r^* + \pi_{t+h} + \beta_\pi * E_t(\pi_{t+h} - \pi^*) + \beta_y * E_t(y_{t+h} - y^*) + \delta_{time\ break} + \\
 & \delta_{\pi\ (post\ financial\ crisis)} * E_t(\pi_{t+h} - \pi^*) + \delta_{\gamma\ (post\ financial\ crisis)} * E_t(\gamma_{t+h} - \gamma^*)) + \\
 & \rho * i_{t-1} + E_t(\varepsilon_{t+h}^i)
 \end{aligned} \tag{29}$$

²⁰⁸ Blinder (2010). p. 465-467

where

h represents the corresponding forecasted time horizons under analysis, namely 0,1 and 2 years,

$\delta_{time\ break}$ represents a dummy variable for a changing constant post-financial crisis,

$\delta_{\pi\ (post\ financial\ crisis)}$ represents a dynamic dummy variable for a changing policy behavior in response to inflation deviations from target,

$\delta_{\gamma\ (post\ financial\ crisis)}$ represents a dynamic dummy variable for a changing policy behavior in response to output deviations from potential, optimal target levels

Equation (27), (28) and (29) represent the basis for different models under analysis. However, in order to be assessable by an OLS regression, slight modifications are necessary. For illustration purposes, the modifications will be emphasized on equation (29) and be partly based on the explanation of Fendel, Frenkel and Rülke and Calarida, Gali and Gertler. Firstly, the long term real equilibrium interest rate r^* is not directly observable. However, consistent with Calarida, Gali and Gertler, it can be treated as time-invariant and therefore be aggregated into the constant θ with a possible structural break post-financial crisis, captured by $\delta_{time\ break}$. Furthermore, β_{π}^* can be interpreted as $(1 + \beta_{\pi})$. Thus, using β_{π}^* as the coefficient for the inflation targeting gap, the Taylor Principle holds if $\beta_{\pi}^* > 1$.²⁰⁹ Moreover, one of the most difficult variables to quantify in a Taylor-type Rule framework is the estimation of the potential output forecasts. In order to obtain estimates of the potential outputs for the respective forecasts horizon, a standard Hodrick-Prescott filter (HPF) with the smoothing parameter set at $\tau = 1600$ is applied on the respective GDP growth forecasts. The HPF follows the succeeding shape:

$$Min_{\{\tau_t\}_{t=1}^T} [\sum_{t=1}^T (\gamma_t - \tau_t)^2 + \lambda * \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2] \quad (30)$$

where

τ is a trend component set at 1600 for quarterly data,

γ_t represents the respective GDP growth forecasts.

²⁰⁹ Calarida, Gali and Gertler (1998). p. 5

Finally, by using the notation below, a slightly adapted Taylor-type Rule, inclusive interest rate smoothing term can be derived.

I.

$$a = (1 - \rho) * \theta \leftrightarrow \theta = \frac{a}{(1 - \rho)}$$

II.

$$b = (1 - \rho) * \beta_{\pi} \leftrightarrow \beta_{\pi} = \frac{b}{(1 - \rho)}$$

III.

$$c = (1 - \rho) * \beta_{\gamma} \leftrightarrow \beta_{\gamma} = \frac{c}{(1 - \rho)}$$

IV.

$$d = (1 - \rho) * \delta_{time\ break} \leftrightarrow \delta_{time\ break} = \frac{d}{(1 - \rho)}$$

V.

$$e = (1 - \rho) * \delta_{\pi\ (post\ financial\ crisis)} \leftrightarrow \delta_{\pi\ (post\ financial\ crisis)} = \frac{e}{(1 - \rho)}$$

VI.

$$f = (1 - \rho) * \delta_{\gamma\ (post\ financial\ crisis)} \leftrightarrow \delta_{\gamma\ (post\ financial\ crisis)} = \frac{f}{(1 - \rho)}$$

Following the notation above, equation (29) transforms into:²¹⁰

$$i_t = a + b * E_t(\pi_{t+h} - \pi^*) + c * E_t(y_{t+h} - y^*) + d + e * E_t(\pi_{t+h} - \pi^*) + f * E_t(\pi_{t+h} - \pi^*) + \rho * i_{t-1} + E_t(\varepsilon_{t+h}^i)$$

(31)

²¹⁰ Fendel, Frenkel and Rülke (2008). p. 10 – Following this approach the above mentioned equation can be estimated by OLS regressions and does not need to rely on a General Method of Moments estimation.

The adaptation demonstrated above is used for both equation (28) and equation (29) and represents the empirical basis for the following OLS estimations in section 3.3.2.

3.2. Data Description

All data are retrieved from the corresponding central banks and represent actual real-time, *ex-ante* forecast data published in the inflation forecasts reports of the respective inflation targeting central banks unless otherwise indicated. Generally, these inflation forecasts reports are issued by the Open Market Committee (OMC) (for some countries the committee is also referred to as the MPC) on a quarterly basis and portray a snapshot of the overall development of the economy from the view of monetary authorities. The reports also contain future outlooks on key economic variables, such as inflation, output and unemployment based on current interest rate and policy projection paths of the respective central banks. For the U.S, the forecast data are based on staff projections of the Federal Open Market Committee's (FOMC) historical transcript materials prior to the publication of the official Monetary Policy Reports in 2012. In detail, the used economic forecast data represents zero, one and two years, quarter on quarter *ex ante* forecast data for inflation and GDP growth estimates. Furthermore, the policy rates correspond to real time policy rates at time $t+0$.

The time series for the Sveriges Riksbank starts at Q1/1996, as prior to this date inflation targeting reports were only issued on a trimester or semi-annual basis. The time series for the U.S. Fed follows this time span and starts at Q1/1996 as well. However, as the Fed seems to publish two-year output forecasts only on a semi-annual basis prior to Q1/2012 (first publication of official monetary policy reports), the following analysis for the monetary policy of the Fed will only take one-year forecasts into consideration. Lastly, the Reserve Bank of New Zealand only started to use a short-term interest rate instrument, namely the so-called Official Cash Rate (OCR), as their main policy instrument since Q1/1999. Prior to this date New Zealand relied on other policy instrument. Therefore, the overall analysis for the Reserve Bank of New Zealand will be based on a slightly smaller sample.

The following sections briefly describe and analyze the data used in the empirical analysis in descriptive terms. Moreover, graphical illustrations for all dependent variable developments can be found in Appendix IV.II to IV.V.

3.2.1. Dependent Variable – Policy Interest Rate

The main monetary policy instruments through with monetary policy decisions are implemented in Sweden, New Zealand and the U.S. are the repo rate, the OCR and the effective federal fund rate. Thus, these rates will serve as the independent variables in the empirical analysis in section 3.5.

Generally speaking, the repo rate and OCR are short-term interest rates and represent the general price levels at which depository institutions can shortly borrow or deposit funds at the corresponding central banks on an uncollateralized basis.²¹¹ Furthermore, the effective federal fund rate represents the weighted average rate at which depository institutions trade their excess funds overnight on an uncollateralized basis in order to balance their accounts. Even though the effective federal fund rate is directly determined by the market, it is influenced by the Fed towards the desired target level through its open market operations, namely by selling or buying short-term government bonds.²¹²

A brief descriptive analysis of the policy interest rate data reveals no real surprises. Analyzing the quarterly time horizon from Q1/1996 to Q2/2017 and Q1/1999 to Q2/2017 for Sweden, the U.S. and New Zealand grants 86 and 74 observations, respectively. Moreover, the average policy interest rate is highest in New Zealand and amounts to 4.56% compared to 2.27% and 2.42% in Sweden and the U.S. The skewness is positive in the case of New Zealand and the U.S., however, negative in the case of Sweden. This phenomenon can mainly be attributable to recent negative policy rates of c. -0.5% (minimum value), implemented by the Swedish Riksbank. Contrarily, the minimum values for the policy rates are positive in the case of New Zealand and the U.S., and amount to 1.75% and 0.07%, respectively. A negative kurtosis in all cases indicate platykurtotic distributions with less frequent extreme policy adjustments. Combined with a high degree of first order autocorrelation of 0.70 to 0.83, it could be seen as a reasonable indicator for the aforementioned phenomena of interest rate smoothing and policy inertia of central banks. Lastly, a calculated Jarque-Bera-Test (JB Test) rejects the null-hypothesis of a normal distribution in all cases at the 5% significance level. The following table provides a brief summary about the descriptive statistics for the monetary policy rates

²¹¹ Riksbank (2017) - <http://www.riksbank.se/en/Interest-and-exchange-rates/Explanation-of-the-series/Riksbank-interest-rates/> (23/10/2017)

Reserve Bank of New Zealand (2017) - <https://www.rbnz.govt.nz/monetary-policy/about-monetary-policy/what-is-the-official-cash-rate> (23/10/2017)

²¹² FRED (2017) - <https://fred.stlouisfed.org/series/FEDFUNDS> (23/10/2017)

The descriptive summary is calculated for the time horizon from Q1/1996 to Q2/2017 for Sweden and the U.S. and for the time horizon Q1/1999 to Q2/2017 for New Zealand. All values correspond to percentage values.

Policy Interest Rates	Sweden	New Zealand	United States
Nr. of Observations	86	74	86
Average	2.27	4.56	2.42
Standard Deviation	1.62	2.03	2.30
Skewness	-0.29	0.28	0.40
Excess Kurtosis	-1.29	-1.32	-1.56
JB-test Statistics	7.17	6.33	10.97
p-value	0.03	0.04	0.00
Max	4.54	8.25	6.53
0.90 Percentile	4.10	7.25	5.50
0.75 Percentile	3.80	6.44	5.16
Median	2.18	4.63	1.67
0.25 Percentile	1.00	2.50	0.16
0.10 Percentile	-0.18	2.50	0.11
Min	-0.50	1.75	0.07
Autoregression (-1)	0.81	0.83	0.70
p-value	0.00	0.00	0.00

Table 2: Descriptive statistics calculations for policy instruments

Furthermore, the following graph illustrates the development of the policy rate paths during the time horizon under consideration.

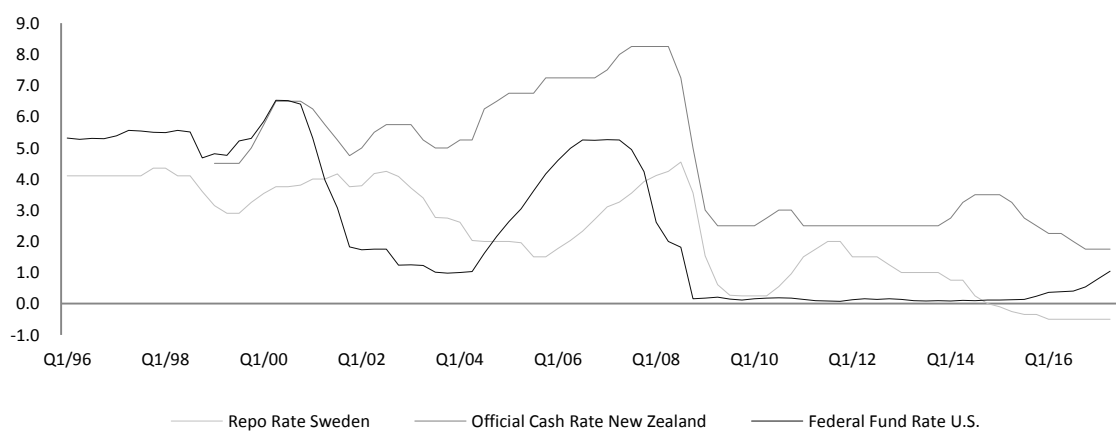


Figure 3: Policy interest rate development in Sweden, New Zealand and the U.S.

When evaluating the graphical illustration of the policy rates, four distinct features stand out. Firstly, the policy rates seem to partly follow the same underlying trend, resulting in significant co-movements across time. This apparently linear relationship is partly confirmed by the following correlation matrix.

The correlation matrix is calculated on historical data from Q1/1999 to Q2/2017 for New Zealand and Sweden and New Zealand and the U.S.. The correlation analysis between Sweden and the U.S. is based on historical instrument data between Q1/1996 and Q2/2017.

Correlation Matrix	Sweden	New Zealand	United States
Sweden	1.00		
New Zealand	0.75	1.00	
United States	0.70	0.76	1.00

Table 3: Policy interest rate correlation matrix

All policy rates inherit a correlation between 0.70 and 0.76, with the highest, observable correlation between the policy interest rate instruments of New Zealand and of the U.S. The global synchronization of interest rates is in macroeconomics a widely discussed phenomenon and has been confirmed by various academic research. Byrne, Fazio and Fiess, among others, attributed this circumstance to the rise of global business cycles, the convergence of global monetary policy and the global savings glut.²¹³

Secondly, the policy rates seem to partly follow consistent, gradual changes towards a specific target level rather than being completely adjusted every quarter. The observation confirms the high level of first order autocorrelation. Moreover, the direction of the interest rate seems to be only infrequently reversed. This phenomenon, which is widely referred to as interest rate smoothing or policy inertia, has been extensively discussed in modern literature. A small selection of published findings comprises Lowe and Ellis, who presented strong evidence for interest rate smoothing behaviors of central banks in Australia, Japan, Germany and the U.K., Judd and Rudebusch and Calarida, Gali and Gertler, who provided policy inertia findings for the U.S. and Goodhart who presented evidence for similar observations in France, Italy, Canada, Spain, the Netherlands, Belgium, Sweden and Austria.²¹⁴

²¹³ Byrne, Fazio and Fiess (2012). p. 184

²¹⁴ Lowe and Ellis (1998). p. 308; Calarida, Gali and Gertler (1998). p. 10; Judd, and Rudebusch (1998). p. 6; Goodhart (1997). p. 168

Thirdly, all policy rates seem to be subject to a sudden, excessive decline between 2007 and 2009 as a direct response to the financial crisis. Sweden reduced its policy rate by 2.1% between Q3/2008 and Q4/2008 as a response to the collapse of Lehman Brothers and in total by more than 4% between Q3/2008 and Q3/2009, hitting temporary the zero lower bound. The Fed reacted slightly earlier to the signs of an upcoming financial crisis and already reduced the effective fund rate by 1.6% between Q4/2007 and Q1/2008. Another dramatic reduction of c. 1.7% followed as a direct consequence to the collapse of Lehman Brothers, pushing the effective fund rate towards the zero lower bound, where it stayed for almost seven years. Similar behavior was observed in New Zealand, although the OCR did not reach the zero lower bound. Nevertheless, New Zealand's monetary authorities followed an extraordinary cut in policy rates of 2.3% between Q3/2008 and Q4/2008. In total, New Zealand's monetary authorities initiated a historical high contraction in policy rate of c. 5.8% between Q2/2008 and Q2/2009.

Taking the financial crisis 2007/2008 and the occurrence of the zero lower bound into account, the policy interest rates do not seem to comprise a continuous trend during the entire observation period, but rather seem to follow different trends pre- and post-crisis. Whereas sufficient variations in the policy rates are observable pre-crisis, only small changes were initiated post-crisis, especially in the case of New Zealand and the U.S. In order to test for a non-stationary process, a Phillips-Perron test is applied to test for stationary breaks.

The Phillips Perron test is calculated on data ranging from Q1/1996 to Q2/2017 for Sweden and the U.S. and from Q1/1999 to Q2/2017 for New Zealand.

Repo-Rate: Phillips-Perron Test for Unit Root							
Country	Test Statistics	1% Critical Value	5% Critical Value	10% Critical Value	P-Value	Nr. of Observations	Newey-West lags
Riks Bank - Z(t)	-0.934	-19.53	-13.58	-10.91	0.901	86	3
Riks Bank - Z(rho)	-0.453	-3.531	-2.902	-2.586	0.901	86	3
Reserve Bank of New Zealand - Z(t)	-9.729	-19.833	-13.7	-11.013	0.089	74	4
Reserve Bank of New Zealand - Z(rho)	-2.62	-3.507	-2.889	-2.579	0.089	74	4
Federal Reserve Bank U.S.	-7.142	-19,833	-13.720	-11.013	0.1862	86	4
Federal Reserve Bank U.S.	-2.257	-3.507	-2.889	-2.579	0.1862	86	4

Table 4: Phillips-Perron Test for unit root

The Phillips-Perron test confirms the initial assumptions of structural breaks in the dependent variables. The H_0 hypothesis, which indicates that the time series variable is non-stationary and possesses a unit root, cannot be rejected for Sweden and the U.S. and can only be rejected at the 10% significance level for New Zealand. Hence, the conducted test further strengthens the necessity of implementing a structural break post-crisis.

Lastly, a clear violation of the zero lower bound appears to be the case in Sweden since Q1/2015. The corresponding policy rate crossed the zero lower bound and is denoted at -0.5% as of Q2/2017. This phenomenon presents a clear anomaly to the previous assumed limit of how much interest rates could be cut. According to monetary authorities of the Swedish Riksbank, unconventional monetary policy measures were necessary to remain extremely expansionary and to provide sufficient economic stimulus to keep inflation close to the 2% target. Thus, the unconventional, temporary measure of breaking the zero-interest rate floor was decided on.²¹⁵ However, Sweden is not the only central bank embarking on so-called negative policy rates. While inflation appears to be still below target in many economies, even after moving policy rates close to the zero lower bound and initiating large-scale asset purchase programs, several central banks broke effectively the zero lower bound (e.g. Denmark in 2014, ECB in 2015 etc.)

As the emergence of negative policy rates is a relatively new phenomenon in macroeconomics, the experience with it is rather limited. Nevertheless, an initial study of the International Monetary Fund (IMF) indicated first positive effects on the economy, while elaborating on potential limits of extreme negative policy adjustments. For instance, when policy rates approach a threshold at which agents switch to holding cash rather than holding on to a deposit, further cuts will most likely be ineffective. Hence, negative policy rate decisions should be complemented by other monetary policy strategies to gain efficient economic stimulus and to move rates above the zero lower bound once again.²¹⁶ However, to predict an exact effect of negative policy rates on banks, asset prices, transmission mechanism and private agents behaviors, which are most likely different from positive rate territory effects due to the existence of physical cash holding, a more extensive research is required. As further research the phenomenon would exceed the initial scope of this thesis, the corresponding analysis of negative rate effects is left for further research

²¹⁵ Swedish Riksbank (2015). p. 8

²¹⁶ IMF (2017). p. 1

3.2.2. Independent Variables – CPI & GDP Growth (Forecasts)

The following part briefly describes inflation targeting central banks' ex ante forecasts of CPI and GDP in descriptive terms, across the entire sample period. Noticeably, the average one- and two-year ex ante inflation forecasts, across the entire sample, are remarkably similar to the realized levels of inflation for the U.S. and New Zealand (0.0% - 0.1 % difference), however differ significantly for the Swedish Riksbank (0.6% - 1.3% difference), as illustrated in table 5. This phenomenon could partly be attributed to the fact that Sweden was also exposed to the European sovereign debt crisis, due to the geographical proximity in addition to the financial crisis in 2008. Two severe recession, with temporary deflation within five to six years were the dramatic consequence. However, the corresponding forecasts seem not to accurately predict the extreme reaction to the proposed economic shocks. This hypothesis can partly be confirmed by comparing the minimum inflation forecasts values to the minimum realized inflation values. The difference between minimum realized and minimum forecast value amounts to -2.8% for the Swedish Riksbank, whereas, the difference in minimum forecast and minimum realized inflation amounts to only -1.2% for New Zealand and -0.9% for the U.S.²¹⁷ Moreover, the standard deviation of the entire forecast samples appears to be significantly lower when compared to the actual realized CPI for all central banks. This indicates that realized inflation appears to be much more volatile around the mean than projected by monetary policy authorities' forecasts. This observation is further supported by the larger spread between the realized minimum and maximum inflation value when compared to the corresponding forecasts for all cases. This, in turn, could be partly attributed to the fact that central banks derive their economic forecasts based on their policy projection path. Thus, the policy projection path should correspond to a value, which ensures that the desired target levels for price and output stabilization are reached in the medium-term. However, as monetary authorities base their decisions on an incomplete information set, their economic projections are subject to a high degree of uncertainty, normally captured by uncertainty bands. As the provided data is based on median values within the uncertainty area, it appears to inherit much less volatility. Similar observations can be made with regard to GDP growth (forecasts). Finally, the JB-Test rejects the null hypothesis for a normal distribution in all cases, for both CPI and GDP growth (forecasts) at the 5% significance level.

²¹⁷ The values are calculated by subtracting the minimum forecasts value of inflation from the minimum realized inflation value.

The descriptive statistics are calculated on the data set for the time horizon from Q1/1996 to Q2/2017 for Sweden and the U.S. and from Q1/1999 to Q2/2017 for New Zealand. All values, with the exception of the JB-test statistic and the Autoregression correspond to percentage values.

CPI (Forecasts)	Sweden			New Zealand			United States		
	+0 Year	+1 Year	+2 Year	+0 Year	+1 Year	+2 Year	+0 Year	+1 Year	+2 Year
Nr. of Observations	86	86	86	74	74	74	86	86	86
Average	1.13	1.75	2.37	2.15	2.30	2.34	2.20	2.15	2.17
Standard Deviation	1.19	0.51	0.47	1.20	0.65	0.34	1.24	0.77	0.67
Skewness	0.44	0.88	0.42	0.51	0.10	-0.25	-0.36	-0.63	-0.02
Excess Kurtosis	0.17	0.58	0.50	-0.18	-0.60	-0.53	0.71	0.65	-0.75
JB-test Statistics	2.87	12.22	3.44	3.27	1.22	1.61	3.63	7.12	2.04
p-value	0.24	0.00	0.18	0.19	0.54	0.45	0.16	0.03	0.36
Max	4.37	3.42	3.79	5.30	3.85	3.00	5.00	3.76	3.54
0.90 Percentile	2.92	2.42	2.90	3.85	3.08	2.76	3.65	3.17	3.08
0.75 Percentile	1.82	2.07	2.69	2.98	2.76	2.60	2.98	2.72	2.71
Median	1.00	1.57	2.34	1.95	2.30	2.33	2.25	2.19	2.13
0.25 Percentile	0.22	1.38	2.04	1.33	1.90	2.17	1.50	1.76	1.68
0.10 Percentile	-0.16	1.17	1.77	0.73	1.42	1.85	0.85	1.11	1.32
Min	-1.87	0.86	1.30	0.10	1.09	1.63	-1.40	-0.48	0.56
Autoregression (-1) %	0.81	0.68	0.83	0.83	0.88	0.90	0.70	0.62	0.83
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5: Descriptive summary of realized CPI and CPI forecasts

The descriptive statistics are calculated on the data set for the time horizon from Q1/1996 to Q2/2017 for Sweden and the U.S. and from Q1/1999 to Q2/2017 for New Zealand. All values, with the exception of the JB-test statistic and the Autoregression correspond to percentage values.

GDP (Forecasts)	Sweden			New Zealand			United States		
	+0 Year	+1 Year	+2 Year	+0 Year	+1 Year	+2 Year	+0 Year	+1 Year	+2 Year
Nr. of Observations	86	86	86	74	74	74	86	86	49
Average	1.32	2.57	2.78	2.72	2.33	2.49	2.40	3.73	3.68
Standard Deviation	2.37	0.82	0.42	1.61	0.69	0.43	2.53	1.54	1.30
Skewness	-0.58	-0.47	0.03	-0.75	-1.76	-3.36	-1.05	0.12	0.12
Excess Kurtosis	3.32	1.03	-0.24	1.12	4.35	17.15	3.58	-1.61	-1.42
JB-test Statistics	44.40	6.97	0.21	10.74	96.49	1046.30	61.69	9.52	4.24
p-value	0.00	0.00	0.18	0.00	0.54	0.45	0.00	0.03	0.36
Max	8.00	4.47	3.70	6.00	3.33	3.10	7.80	6.60	5.80
0.90 Percentile	4.08	3.45	3.45	4.67	2.99	2.86	5.15	5.60	5.44
0.75 Percentile	2.58	3.05	3.00	3.40	2.75	2.77	3.78	5.25	4.90
Median	0.93	2.60	2.80	2.85	2.47	2.57	2.70	3.75	3.25
0.25 Percentile	0.41	2.00	2.50	2.20	2.09	2.34	1.20	2.20	2.55
0.10 Percentile	-0.06	1.77	2.32	0.89	1.70	2.20	-0.20	2.00	2.10
Min	-6.40	-0.16	1.62	-1.80	-0.24	-0.08	-8.20	1.50	1.40
Autoregression (-1) %	0.84	0.72	0.76	0.93	0.86	0.73	0.40	0.89	0.96
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6: Descriptive summary of realized GDP growth and GDP growth forecast

3.3. An Estimate of (Forward-looking) Taylor-type Rules

Table 7, 8 and 9 display the main results of the estimated equations (27), (28) and (29). Generally, the results are reasonable in magnitude and seem to explain ex-ante monetary policy behavior remarkably well. The significantly high R^2 s suggest high explanatory powers of the overall models and amount to values in excess of 90% for equation estimations (28) and (29) for all central banks under analysis. However, these high values have to be treated with cautions and mainly result from the large lagged interest rate smoothing parameters. Furthermore, the primary objective of granting sufficient evidence for all central banks under analysis that central banks' inflation targeting forecasts, are consistent with the Taylor Principle, is accomplished, at least for the time horizon before the financial crisis. Post-crisis, evidence for monetary policy behavior, consistent with the Taylor Principle can only be provided for the Swedish Riksbank. This strongly indicates a significant shift in monetary policy behavior pre- and post-financial crisis, captured by the corresponding dynamic policy coefficients (equation (29)) for the U.S. and New Zealand. Furthermore, only limited output stabilization behavior can be observed in the forecast estimations for New Zealand and Sweden and no direct output stabilization behavior can be observed in the forecast estimation for the U.S. Finally, all estimations of the smoothing parameter seem to be extremely high, indicating a significant policy rate inertia.

More precisely, tables 7, 8 and 9 are built on the following structure: The vertical headline represents the dependent policy rate variable under analysis, namely the Swedish repo rate, the OCR in New Zealand or the federal fund rate in the U.S. The horizontal headlines represent the parameters of the independent variables under analysis. From left to right, the parameters correspond to the realized inflation gap ($t+0$ year), the forecasted inflation gap ($t+1$ year) and ($t+2$ years), the realized bank estimate of the output gap ($t+0$), the realized output gap based on the HP filter approach conditional on realized GDP growth ($t+0$), the forecasted output gaps based on the HP filter approach conditional on the GDP growth forecasts for ($t+1$ year) and ($t+2$ years), the smoothing interest rate parameter ρ , the change in real interest equilibrium rate post-crisis (captured by a time break in the constant), a dynamic coefficient capturing a change in inflation gap policy post-crisis, a dynamic coefficient capturing a change in output gap policy post-crisis and the constant (proxy for the real interest equilibrium rate). R^2 represents a general measure of fit for the proposed reaction function in comparison to realized policy rates. Finally, $\beta\pi(t+h) \geq 1$ (Taylor Principle) and $\beta\gamma$

$(t+h) \geq 0$ represent strict abidance of policy rule characterizations for the respective inflation and output gap parameters at various time horizons, necessary for economic stability in most economic models. The coefficients are tested at the 99%, 95% and 90% significance level.

Furthermore, the policy rates of the Swedish Riksbank, the Reserve Bank of New Zealand and the U.S. Fed are regressed against the respective, realized inflation and output gaps for $t+0$ (bank estimate and HP filter estimate) as well as against the inflation and output gaps forecasts for $t+1$ year and $t+2$ years in regressions x.1 to x.4 (equation (27) estimations). Following the observations of section 3.4., regressions x.5 to x.8 incorporate an interest rate smoothing term as well as a time break for a changing medium to long-term real interest equilibrium rate post-financial crisis (equation (28) estimations). Lastly, regressions x.9 to x.12 assimilate dynamic coefficients for a changing policy behavior in terms of price and output stabilization with regards to the corresponding interest rate policy instrument for all time horizons. The potential policy change is captured by the coefficients “ Δ Inflation Gap Policy (Post-Crisis)” and “ Δ Output Gap Policy (Post-Crisis)”, in addition to the modifications mentioned above.

The graphical illustrations for all policy rules under analysis can be found in the corresponding appendix chapters IV.V to IV.VII.

The regression estimations below correspond to $t+h=0=1=2$ (forecast) data of the Swedish Riksbank, published in their quarterly monetary policy reports and follow equations (27), (28) and (29), respectively. ***, ** and * indicate significance at 99%, 95% and 90% level for all parameters > 0 . +++, ++ and + indicate significance at the 99%, 95% and 90% level for the strict abidance of $\beta\pi(t+h) > 1$ (Taylor Principle) and $\beta\gamma(t+h) > 0$.

Regression Results Sweden Q1/1996-Q2/2017															
Policy Interest Rate	Inflation Gap (t+0): $\beta\pi$	Inflation Gap (t+1): $\beta\pi$	Inflation (t+2): Gap $\beta\pi$	Output Gap (t+0): $\beta\gamma$ Bank Estimate	Output Gap (t+0): $\beta\gamma$ HP Filter	Output Gap (t+1): $\beta\gamma$ HP Filter	Output Gap (t+2): $\beta\gamma$ HP Filter	Smoothing Interest Rate (t-1): ρ	Financial Crisis Time Break	Δ Inflation Gap Policy (Post Crisis)	Δ Output Gap Policy (Post Crisis)	Constant	R ²	$\beta\pi(t+h) > 1$	$\beta\gamma(t+h) > 0$
(1.1) Repo Rate	0.39** (0.16)			0.19** (0.09)								2.65*** (0.20)	0.22	-	++
(1.2) Repo Rate	0.64*** (0.14)				-0.11 (0.08)							2.83*** (0.20)	0.20	-	-
(1.3) Repo Rate		0.62* 0.34				-0.34 (0.23)						2.43*** (0.19)	0.03	-	-
(1.4) Repo Rate			-2.44*** (0.26)				-0.16 (0.34)					3.17*** (0.16)	0.52	-	-
(1.5) Repo Rate	0.84*** (0.34)			0.19 0.17				0.85*** (0.04)	-2.50** (1.03)			3.74*** (1.11)	0.97	-	-
(1.6) Repo Rate	1.00*** (0.27)				0.73*** (0.15)			0.90*** (0.03)	-3.04*** (1.02)			3.78** (0.89)	0.98	-	+++
(1.7) Repo Rate		3.73*** (0.74)				2.14*** (0.56)		0.92*** (0.04)	-4.02*** (1.33)			4.23*** (1.52)	0.97	+++	+++
(1.8) Repo Rate			0.65 (0.92)				-0.73 (0.74)	0.86*** (0.04)	-4.11*** (0.98)			3.35*** (1.03)	0.96	-	-
(1.9) Repo Rate	0.69** (0.29)			0.17 (0.22)				0.85*** (0.04)	-2.14** (1.09)	0.41 (0.45)	0.00 (0.29)	3.67*** (0.17)	0.97	-	-
(1.10) Repo Rate	1.02*** (0.33)				0.78** (0.38)			0.90*** (0.03)	-3.08*** (1.15)	-0.04 (0.54)	-0.06 (0.40)	3.86*** (1.28)	0.98	-	++
(1.11) Repo Rate		3.84*** (0.96)				1.48* (0.86)		0.93*** (0.03)	-4.39*** (1.58)	-0.71 (1.99)	1.71 (1.19)	4.28*** (1.66)	0.98	+++	+
(1.12) Repo Rate			1.90 (1.28)				-0.19 (0.89)	0.87*** (0.04)	-3.34*** (1.28)	-2.09 (1.81)	-1.39 (1.66)	3.29*** (1.03)	0.96	-	-

Table 7: Various Taylor-type Rules based on (forecast) data of the Swedish Riksbank

The regression estimations below correspond to $t+h=0=1=2$ (forecast) data of the Reserve Bank of New Zealand, published in their quarterly monetary policy reports and follow equations (27), (28) and (29), respectively. ***, ** and * indicate significance at 99%, 95% and 90% level for all parameters > 0 . +++, ++ and + indicate significance at the 99%, 95% and 90% level for the strict abidance of $\beta\pi(t+h) > 1$ (Taylor Principle) and $\beta\gamma(t+h) > 0$.

Regression Results New Zealand Q1/1990-Q2/2017																
Policy Interest Rate	Inflation Gap (t+0): $\beta\pi$	Inflation Gap (t+1): $\beta\pi$	Inflation Gap (t+2): $\beta\pi$	Output Gap (t+0): $\beta\gamma$ Bank Estimate	Output Gap (t+0): $\beta\gamma$ HP Filter	Output Gap (t+1): $\beta\gamma$ HP Filter	Output Gap (t+2): $\beta\gamma$ HP Filter	Smoothing Interest Rate (t-1), ρ	Financial Crisis Time Break	Δ Inflation Gap Policy (Post Crisis)	Δ Output Gap Policy (Post Crisis)	Constant	R ²	$\beta\pi(t+h) > 1$	$\beta\gamma(t+h) > 0$	
(2.1) OCR	0.78*** (0.11)			0.96*** (0.10)								4.47*** (0.14)	0.68	-	+++	
(2.2) OCR	0.87*** (0.18)				0.08 (0.09)							4.43*** (0.21)	0.25	-	-	
(2.3) OCR		1.89*** (0.31)				-0.15 (0.40)						3.99*** (0.21)	0.35	+++	-	
(2.4) OCR			2.60*** (0.66)				-0.24 (0.65)					3.69*** (0.31)	0.18	+++	-	
(2.5) OCR	0.25 (0.18)			0.65*** (0.17)				0.74*** (0.04)	-2.94*** (0.57)			5.87*** (0.97)	0.97	-	+++	
(2.6) OCR	0.06 (0.31)				0.82*** (0.15)			0.87*** (0.04)	-5.10*** (1.10)			6.83*** (1.87)	0.98	-	+++	
(2.7) OCR		0.17 (0.52)				3.46*** (0.56)		0.85*** (0.04)	-4.51*** (0.87)			6.49*** (1.48)	0.98	-	+++	
(2.8) OCR			0.41 (0.93)				4.13*** (0.78)	0.84*** (0.04)	-4.63*** (0.89)			6.51*** (1.40)	0.98	-	+++	
(2.9) OCR	0.67** (0.30)			0.70*** (0.19)				0.73*** (0.04)	-2.97*** (0.55)	-0.66*** (0.33)	-0.39 (0.32)	5.57*** (0.92)	0.97	-	+++	
(2.10) OCR	0.94 (0.67)				0.52** (0.22)			0.88*** (0.04)	-4.85*** (1.15)	-1.19* (0.71)	0.71** (0.32)	6.46*** (2.01)	0.98	-	++	
(2.11) OCR		2.16*** (0.60)				3.33*** (0.74)		0.49*** (0.04)	-2.90*** (0.57)	-2.35*** (0.61)	-1.24 (0.85)	5.18*** (0.97)	0.98	+	+++	
(2.12) OCR			3.30*** (1.15)				3.08 (2.00)	0.79*** (0.04)	-2.87*** (0.69)	-3.84*** (1.21)	0.05 (2.07)	5.23*** (1.03)	0.98	++	-	

Table 8: Various Taylor-type Rules based on (forecast) data of the Reserve Bank of New Zealand

The regression estimations below correspond to $t+h=0=1=2$ (forecast) data of the U.S. Federal Reserve Bank, published in their historical transcripts and follow equations (27), (28) and (29), respectively. ***, ** and * indicate significance at 99%, 95% and 90% level for all parameters > 0 . +++, ++ and + indicate significance at the 99%, 95% and 90% level for the strict abidance of $\beta_{\pi}(t+h) > 1$ (Taylor Principle) and $\beta_{\gamma}(t+h) > 0$.

Regression Results United States Q1/1990-Q2/2017															
Policy Interest Rate	Inflation Gap (t+0): β_{π}	Inflation Gap (t+1): β_{π}	Inflation Gap (t+2): β_{π}	Output Gap (t+0): β_{γ} Bank Estimate	Output Gap (t+0): β_{γ} HP Filter	Output Gap (t+1): β_{γ} HP Filter	Output Gap (t+2): β_{γ} HP Filter	Smoothing Interest Rate (t-1): ρ	Financial Crisis Time Break	Δ Inflation Gap Policy (Post Crisis)	Δ Output Gap Policy (Post Crisis)	Constant	R ²	$\beta_{\pi(t+h)} > 1$	$\beta_{\gamma(t+h)} > 0$
Fund Rate	2.27*** (0.23)			-0.05 (0.07)								2.13*** (0.19)	0.55	+++	-
Fund Rate	2.29*** (0.22)				-0.13 (0.08)							2.06*** (0.17)	0.57	+++	-
Fund Rate		3.01*** (0.18)				-0.45*** (0.16)						1.90*** (0.12)	0.77	+++	-
Fund Rate			n.a.				n.a.					n.a.	n.a.	n.a.	n.a.
Fund Rate	0.83 (0.93)			0.73*** (0.20)				0.91*** (0.03)	-2.67* (1.38)			2.00 (1.41)	0.97	-	+++
Fund Rate	0.85 (0.98)				0.84*** (0.24)			0.91*** (0.03)	-3.35*** (1.43)			3.28** (1.39)	0.97	-	+++
Fund Rate		2.47*** (0.85)				-0.32 (0.38)		0.84*** (0.04)	-1.43* (0.86)			2.38*** (0.78)	0.97	+	-
Fund Rate			n.a.				n.a.	n.a.	n.a.			n.a.	n.a.	n.a.	n.a.
Fund Rate	2.90** (1.20)			0.52** (0.23)				0.89*** (0.03)	-2.06* (1.18)	-3.31** (1.36)	0.18 (0.32)	1.16 (1.16)	0.98	-	++
Fund Rate	3.24*** (1.17)				0.75*** (0.26)			0.89*** (0.03)	-2.18** (1.09)	-3.75*** (1.35)	-0.06 (0.35)	1.84* (1.07)	0.98	+	+++
Fund Rate		3.46*** (1.05)				-0.81 (0.56)		0.83*** (0.04)	-1.42* (0.81)	-2.78** (1.24)	1.13 (0.73)	1.75** (0.76)	0.97	++	-
Fund Rate			n.a.				n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Table 9: Various Taylor-type Rules based on (forecast) data of the U.S. Fed

After evaluating the estimated Taylor-type Rule specifications in table 7, 8 and 9 in more detail, six important findings stand out in particular and are of utmost interest for both, practitioners and researchers, active in the field of monetary policies.

1. Firstly, the inflation coefficients ($\beta_{\pi(t+h)}$) are positive in all cases except for the classical, unadjusted 2-year forecast Taylor Rule variant for the Swedish Riksbank (-2.44 percentage points), which can partly be attributed to disturbances related to the financial crisis and European sovereign debt crisis. Moreover, most of the coefficients are reasonable in size, not different from unity, and mostly significantly different from zero. These results indicate that inflation deviations from target are indeed an important variable for explaining monetary policy behavior across all different policy jurisdictions and provide first evidence for a general monetary policy behavior consistent with the Taylor Principle.

When analyzing the classic Taylor Rule, based on realized and forecasted data in a first step, compelling evidence for monetary policy behavior highly consistent with the Taylor Principle can be found for both New Zealand and the U.S (estimation 2.3, 2.4, 3.3 and 3.4). The corresponding observations hold for both central banks at the 99% significance level. Contrarily, the inflation coefficient seems to be not in line with the Taylor Principle for Sweden if not accounted for a structural break in real interest equilibrium rates. However, when analyzing monetary policy behavior more deeply, it becomes obvious that an important distinction between monetary policy behavior pre- and post-financial crisis needs to be made.

More precisely, all estimations provide strong evidence that the ex ante inflation targeting central banks' forecasts under analysis are consistent with the Taylor Principle for the t+1 year forecast horizon, prior to the financial crisis 2007/2008. The results hold at the 99% significance level for Sweden, at the 95% significance level for the U.S. and at the 90% significance level for New Zealand. Moreover, the coefficient of New Zealand for the t+2 years forecasts horizons prior to the financial crisis seem to follow the Taylor Principle even more strictly. Monetary policy behavior for the t+2 year forecast horizon can be confirmed at the 95% significance level.. Moreover, the coefficient of the Swedish Riksbank for the t+2 year forecast horizon is not statistically different from unity.

In detail, central bank forecasts are highly consistent with the Taylor Principle in the case of the 1-year forecast of the Swedish Riksbank adjusted for a change in real interest rate equilibria- and/or a change in policy behavior post-crisis (estimation 1.7 and 1.11). In the case of New Zealand, the results indicate a clear obedience to the Taylor Principle for the classic Taylor Rules and for the Taylor Rule morphologies adjusted for changing policy behavior post-crisis (estimation 2.3, 2.4, 2.11 and 2.12). Lastly, estimations based on published forecast data of the U.S. seem to provide the strongest indications for constituent policy behavior with regards to the Taylor Principle. The Taylor Principle holds in all forecast cases for the U.S. and turns only insignificant when incorporating the possibility of a changing real interest equilibrium rate post-financial crisis, for the realized cases $t+0$. Nevertheless, the two parameters are not different from unity in these cases.

Post-financial crisis, the inflation parameters of New Zealand and the U.S. turn insignificant based on joint hypothesis tests of the respective inflation coefficients and the changing inflation policy coefficient, however stay significant for Sweden for the 1-year forecast horizon. This result statistically holds for all estimation for the U.S. and New Zealand based on forecast data, suggesting that the corresponding central banks do not necessarily adjust their interest rate policy instrument by more than one to one to changes in inflation forecasts after the financial crisis and, hence, might not hold on to the Taylor Principle in more recent times.

Intuitively, the empirical findings are reasonable and partly confirm the until recently believed, notable asymmetry in monetary policy implementations. In excessive expansion periods when inflation could potentially rise to undesirable levels, monetary authorities could increase their respective policy rate to any given level, which they deem to be necessary. In contrast, in periods marked as recessions, the policy rate adjustments were believed to be limited by the zero lower bound. As soon as the zero lower bound was reached, the short-term interest rate instrument potentially loses its power and cannot be further tuned down. In this case, economic stimulus needs to be provided by more unconventional, complementary monetary policies, for instance, QE and credit easing (CE). However, recently different central banks experiment with negative policy rates, for instance the Swedish Riksbank, as even large scale QE and CE programs seem not to provide sufficient expansionary stimulus in some economies.

Applying the aforementioned reasoning on the sample under analysis sheds some light on the empirical finding. Prior to the devastating financial crisis in 2007/2008, central banks primary monetary policy instrument, used for price- and output stabilization, were short-term discount interest rates (at least during the time span under analysis). The policy rates were sufficiently adjusted in accordance with the Taylor Principle and provided economic stability. However, as a direct response to the crisis, most central banks excessively cut their policy rates to, or close to the zero lower bound to stimulate the economy, thereby effectively reaching the limit of their policy instrument. For example, the U.S. federal fund rate nearly reached the zero interest floor in Q4/2008, where it stayed for almost seven years. Since 2008, further expansionary economic stimulus was provided by various large scale QE programs.²¹⁸ Even though the OCR did not effectively reach the zero lower bound in the case of New Zealand, a historical high cut could be observed. After the historical cut in OCR, the interest rate was left unchanged for almost five years. Sweden appeared to be the exception. The policy rate only shortly approached the zero interest rate floor before an increase was observed again. However, as a consequences of the European sovereign debt crisis the Swedish Riksbank lowered their policy rate once again. A remarkable observation is provided by the fact that the Swedish Riksbank recently crossed the zero lower bound and set negative short-term policy rates, complementary to large scale asset purchase programs. A potential reason why no statistically significant change in policy behavior could be observed in Sweden could be attributed to the fact that Sweden appears to not obey to the previously believed limitations of the zero lower bound on interest rates and further adjusted its policy rate instrument.

As observations for crossing the zero lower bound are momentarily rather limited, it represents a field of enormous interest for potential future research.

2. The output gap indicator is, as aforesaid, a measure of how far the economy is away from its potential productivity level and an important determination of potential inflation development. As previously stated, most economic models require the output gap parameter to be ≥ 0 for stabilizing monetary policy decisions.

²¹⁸ Fed (2013) - <https://www.federalreserve.gov/faqs/what-were-the-federal-reserves-large-scale-asset-purchases.htm> (accessed 29/10/2017)

For most specifications, the output gap parameter appears to be of reasonable magnitude and is either positive or not significantly different from zero. This first observation indicates that all central banks place some weight on output stabilization, or at the very least do not follow a potentially destabilizing monetary policy.

Especially noteworthy is the fact that the parameters are highly significant and are of relatively high magnitude for all estimation specifications in New Zealand, after incorporating the possibility of a changing real interest rate equilibrium (estimation 2.5 to 2.8) and changing policy behavior post-crisis (estimation 2.9 to 2.12), with the exception of the t+2 year forecasts estimation (regression 2.12). The statistical insignificance in this case mainly stems from the high, inherit forecast error. Furthermore, according to the estimation results for the Riksbank, monetary authorities in the Swedish jurisdiction seem to put some weight on output stabilization for the t+1 year forecast horizon, after adjusting the regressions for possible changing policy behavior and a change in real interest equilibrium rates post-crisis (estimations 1.5 to 1.12).

The observation of a positive output gap parameter confirms the flexible inflation targeting strategy of both central banks. As elaborated in section 2.4.1., the objectives of inflation targeting central banks can be well approximated by a standard quadratic intertemporal loss function, consisting of the sum of the expected, squared inflation gap and a relative weight times the expected squared output gap as the intermediate target variables (equation 18). In order to minimize the expected loss function some weight must be placed on the output gap next to the inflation gap under flexible inflation targeting.

Contrarily, the forward-looking variant estimations for the U.S. seem to not incorporate a high degree of output stabilization, as the coefficients appear to be all negative in size, not statistically different from zero. Nevertheless, post financial crisis a possible shift towards a forward-looking monetary policy that places more weight on output stabilization could potentially be the case. This hypothesis is partly supported by a large positive parameter for a change in output stabilization post-crisis (estimation 3.11) The statistical insignificance of the corresponding parameter stems mainly from the large, inherit standard error. Moreover, the realized output gap parameters at t+0 turn positive and significant at the 99% and 95% level after

incorporating the possibility of changing policy behavior and changing real interest equilibrium rates.

The results are highly interesting and partly confirm the past policy objective of the Fed. Prior to 2008, the Fed followed a price stability strategy and has been reluctant to explicitly acknowledge full employment as a separate policy goal. The Fed rather communicated that the state of full employment could best be reached by following a price stability strategy. The corresponding results, which indicate a high, significant inflation gap coefficient, strongly support the communicated statements. However, as of December 2012, the Fed's FOMC announced the new policy directive, namely its dual objective of price stability and full employment. Furthermore, equivalent language indications for the followed operational dual objective were identifiable since the FOMC's monetary policy report in September 2010.²¹⁹ An official shift towards a monetary policy which focusses on output stabilization next to price stability could grant some explanation for the high change in output gap parameter post-crisis. Moreover, the immanent high standard error could stem from the low variations in policy rates, once it hit the zero lower bound. The question, whether a shift in monetary policy from a price stability strategy towards a real dual objective is incorporated in the ex ante U.S. central bank forecasts could be the ground for further research once the policy rate reaches levels in excess of the zero interest rate floor and provides more variation for efficient statistical interferences.

3. Furthermore, as mentioned before, the results in table 7, 8 and 9 grant strong evidence for a change in policy behavior post-financial crisis 2007/2008 for the Reserve Bank of New Zealand and the U.S. Fed with regards to price stability. The estimated results indicate a large negative adjustment towards their general price stabilization policies in all specifications and are highly significant, mostly at the 1% significance level. The dynamic policy adjustment parameters range from -0.66 (estimation 2.9) to -3.84 (estimation 2.12) for New Zealand and from -2.78 (estimation 3.11) to -3.75 (estimation 3.9) for the U.S. Surprisingly, no change in price stabilization policy behavior is observed in the estimation results of the Swedish Riksbank.

²¹⁹ Thornton (2012). p. 117

As previously explained, this phenomenon could partly be attributed to the fact that the U.S. Fed reached the zero lower bound post-financial crisis, limiting the further adjustment potential of its interest rate policy instrument. Instead, the Fed had to rely on more unconventional monetary policy instruments, such as QE and CE. In the case of New Zealand, no sufficient variation in the policy rate could be observed after a dramatic cut post-crisis. The Swedish Riksbank only shortly hit the zero lower bound on their policy rate post-financial crisis. A fast recovery could be observed before the policy rate dropped once again due to the European sovereign debt crisis. As no sufficient expansionary stimulus, even after engaging into large scale QE programs, could be provided, the Riksbank decided to temporarily cross the zero lower bound. This decision could potentially be an indicator, why the Riksbank policy adjustments appeared to still be in line with the Taylor Principle, even after accounting for the financial and European sovereign debt crisis.

With regards to output stabilization, no statistically significant change in the output gap coefficient could be observed in any policy jurisdiction with regards to their interest rate policy instrument. Nevertheless, the change in output gap policy parameter after the financial crisis appears to be of relatively high magnitude in the t+1 forecast estimation of the Riksbank and of the Fed, indicating that both central banks placed some more weight on stabilizing output. The statistical insignificance effectively stems from the immanent high standard errors.

However, the presented results post-financial crisis have to be treated with cautions, as variations in the policy rates are rather limited for the case of the U.S. and New Zealand. Moreover, the presented results are solely concerned with interest rate instruments and do not take other policy instruments into account. As aforesaid, a higher emphasis on output stabilization does not seem to be unlikely for the U.S., especially after the official announcement of following a dual objective in 2012. On a more general level, a high degree of output stabilization would seem reasonable, especially in times of severe crisis.

4. All short-term policy rates are highly dominated by the previous level of interest rates. This is clearly indicated by the excessive smoothing parameters, ranging from 0.85 (regression 1.5 and 1.9) to 0.93 (regression 1.11) for Sweden, 0.73 (regression 2.9) to 0.88 (regression 2.10) for New Zealand and 0.83 (regression 3.11) to 0.91 (regression

3.5 and 3.6) for the U.S. Even though all smoothing parameters are statistically different from unity, they are very close to it.

The observed phenomenon of a high smoothing parameter could be seen as an indication for the fact that central banks are normally not be concerned with relative, temporary variations in inflation and output levels, but rather focus on so-called pure inflation, the sustained devaluation of money and its effect on the economy. Thus, variations to the interest rate instrument should only be conducted for non-temporary, larger deviations of inflation from the desired target level, not explicitly accounted for in the provided estimations. Moreover, as elaborated in section 2.3.1., central banks generally try to minimize the variability in policy rate changes, as frequent changes in the interest rate could significantly harm the credibility and accountability of central banks' initial policy announcements and could introduce unnecessary volatility into the economy. Lastly, for a long time horizon it was believed that the zero nominal interest rate floor effectively provides a limit of how much policy rates can be cut. This implies that further reductions of the policy rate in response to deflationary shocks cannot be absorbed by changes in policy rates. The policy rates effectively stay at the zero lower bound while other complementary actions have to be decided on. Consequently, the policy rates seem to imitate a significant smoothing character, while in reality they simply reached their adjustment potential.

5. The constants, which are proxies for the long- to medium-term real interest rate equilibria are nearly all highly, statistically significant at the 1% level as well as are reasonable in magnitude, with the exception of regression 3.5 and 3.9 conducted for the U.S. This, however, is mainly attributed to the large standard errors. Moreover, according to the regression estimations, New Zealand comprises the highest equilibrium real interest rates corresponding to values between 3.69 (regression 2.4) and 6.51 (regression 2.7). Contrarily, the U.S. comprises the lowest proxies for the long- to medium-term real interest equilibrium rates, ranging from 1.75 (estimation 3.11) to 3.28 (estimation 3.7). Lastly, the rates vary between 2.43 (regression 1.3) and 4.28 (equation 1.11) for Sweden. Moreover, estimations that have a constant with a higher magnitude contain noticeably higher standard errors.

6. The financial crisis time break dummy is, as expected, negative for all specifications and countries. Hence, all estimations provide a clear indication towards a structural break in real interest equilibrium rates post-crisis. The corresponding dummy variables are highly significant at the 1% level for almost every case and range from as little as -1.42 in regression 7.11 for the U.S to as much as -5.10 in estimation 6.6 for New Zealand. Thus, the presented results confirm the assumption of the structural break initially proposed in section 3.3.1.

Overall, the indicative results present various significant findings in the area of monetary policy research. Even though, short explanations for the respective findings are presented, each of them deserves further deep, individual research and lay the ground for avenues for further research.

3.4. Limitations, Assumptions and Avenues for Future Research

The following part is dedicated to a summary of limitations of the presented findings and suggest intriguing areas for further avenues for future research.

The empirical analysis provides first evidence of generally consistent ex ante central banks' forecasts with respect to the well-known Taylor Principle. However, it depends on a wide range of assumptions. In particular, the used proxies for the inflation and output gap could be subject to further analysis. For instance, the forecasted output gap is solely calculated by a HP filter approach with a quarterly smoothing term. However, most international monetary bodies rely on much more sophisticated structural methods. Thus, potential deviations between estimated output gaps used in the respective empirical analysis and estimated output gaps used by the decision-making bodies of central banks might be possible. Moreover, the inflation measurement component is a fundamental variable in the conduction of monetary policy and its evaluation. CPI was chosen as a proxy in the quantitative analysis due to the provided ex ante forecasts by inflation targeting central banks'. However, as monetary policy should mainly be concerned with pure inflation and not with relative, temporary price fluctuation, a more appropriate inflation policy measure for the inflation gap would be based on CPI less energy. A possible robustness check, of using other inflation and output gap indicators is intriguing and worth further exploring.

Furthermore, as the sample is fairly limited and comprises only a small number of inflation targeting central banks, no generalization should be made. It would be worth further exploring, whether the empirical results also hold for a larger sample of central banks. Moreover, the sample under analysis might incorporate some selection bias. All evaluated central banks are active in developed economies. Thus, the important question arises, whether a difference in policy behavior in emerging and developed policy jurisdictions can be observed.

Moreover, the presented empirical findings are all based on linear Taylor-type Rules, with the incorporated possibility of a structural change in the monetary policy behavior post financial crisis. However, various studies discovered evidence for nonlinear augmented Taylor-type Rules. For instance, Castro reported strong evidence for nonlinear augmented policy behavior for the ECB and the Bank of England.²²⁰ Rabanal presented empirical findings, which support dynamic shifts in Taylor-type Rule coefficients in the U.S. for economic expansion and recession cycles, even when accounted for different chairman preferences.²²¹ Furthermore, Kato und Nishiyama reported a more forceful monetary policy reaction in vicinity of the zero lower bound, indicating asymmetric, accelerated policy responses dependent on the state of the economy.²²² Lastly, Cukierman and Muscatelli validated non-linear Taylor-type Rules in the U.K. and U.S. They attributed the non-linearity to different business cycles as well as to the policy approach followed by different chairmen. In particular, they emphasized that inflation targeting policy regimes seem to have a convex Taylor rule reaction function whereas non-inflation targeting policy regimes tend to have a concave reaction function.²²³ As the initial empirical study of this thesis did not account for any of these reported phenomena, it would be of utmost interest to analyze whether inflation targeting central banks' forecast incorporate any of the previous reported findings.

Lastly, with the emergence of negative nominal interest rates in a variety of policy jurisdiction, a new research area arises, namely the conduction of monetary policy under negative nominal interest rates. However, as experiences of operating with policy rates under the zero lower bound are fairly limited so far, a detailed analysis is left for future research.

²²⁰ Castro (2010). p. 1

²²¹ Rabanal (2004). p. 16

²²² Kato and Nishiyama (2005). p. 118

²²³ Cukierman and Muscatelli (2008). p. 3-21

4. Concluding Remarks

The presented paper has examined the important question whether ex ante inflation targeting central banks' forecasts are internally consistent with the Taylor Principle, by empirically comparing quarterly published economic forecasts of selected central banks, namely the Swedish Riksbank, the Reserve Bank of New Zealand and the U.S. Fed to their respective policy rate developments. The debates discussed in this thesis range from theoretical models to practical policy implementations, which are fairly complex and partly controversial. Thus, a broad overview of important macroeconomic debates, ranging from monetary policy transmission channels and instrument problems to the well know Taylor-Rule and its morphologies up until recent discussions about policymaking under inflation targeting, has been provided.

Generally, the provided empirical results are reasonable in magnitude and seem to explain monetary policy behavior remarkably well. In detail, the elaborated quantitative findings indicate a strong consistency with the Taylor Principle before the financial crisis for the $t+1$ year forecast horizon for all central banks under analysis and for the $t+2$ years forecast horizon for the Reserve Bank of New Zealand. Furthermore, the $t+2$ years ex ante forecast for the Swedish Riksbank appears to be not different from unity. After the financial crisis, the corresponding ex ante central banks' forecasts seem to not comply with the Taylor Principle anymore, with the exception of the monetary policy forecasts of the Swedish Riksbank. This observation indicates a significant shift in policy behavior of the U.S. Fed and Reserve Bank of New Zealand, which is statistically confirmed by the dynamic policy coefficients, mostly at the 1% significance level. For the U.S., this observed shift in policy was partly attributed to the vicinity of the zero lower bound, which limited the further use of the policy instrument as well as to the observable occurrence of excessive, unconventional monetary policy actions, such as the QE programs, started in 2008. The Swedish Riksbank crossed the zero lower bound on interest rates in 2015. Eliminating the previous believed limits on how far interest rates can be reduced, the Swedish Riksbank ex ante forecasts seem to comply with the Taylor Principle even post-financial and European sovereign debt crisis.

Along with the elaborated findings of a general consistency with the Taylor Principle pre- financial crisis and a change in monetary policy behavior post-financial crisis, several more findings have been presented. Firstly, several studies so far have assumed a constant long-run equilibrium real interest rate. However, the quantitative findings indicate a sharp

decline in real interest equilibrium rates post-financial crisis. Thus, using the same constant real equilibrium rate before and after the financial crisis would result in misleading findings. Future studies should at least analyze the existence of a structural break in long-run real equilibrium rates. Furthermore, only limited output stabilization behavior could be observed in the ex ante forecast estimations for New Zealand and Sweden and no direct, statistically significant output stabilization behavior could be observed in the forecast estimation for the U.S. However, this empirical finding can largely be attributed to large imminent standard errors. Moreover, the results partly indicate a higher but not statistically significant focus on output stabilization post-financial crisis for the U.S. The observed phenomenon is economically reasonable as the U.S. Fed is officially conducting monetary policy under a dual objective since 2012. Finally, all estimations of the smoothing parameter seem to be extremely high, indicating a significant policy rate inertia, which has also been extensively reported in past literature.

In conclusion, the primary objective of granting sufficient evidence for all central banks under analysis that ex ante central banks' inflation targeting forecasts, indeed, are consistent with the ubiquitous Taylor Principle, is accomplished, prior to the financial crisis. The immersion of the financial crisis, on the other hand, has shown that even monetary policy rule relationships and economic assumptions which were taken for granted alter dramatically, in times of severe economic crisis when nominal interest rates approach the zero-lower bound.

Finally, with the occurrence of negative nominal interest rates in a variety of policy jurisdictions, the Taylor Principle might be complied with again even with policy rates at or below the previously believed limit of the zero lower bound. All in all, only time will tell...

IV. Appendix

IV.I. The Various Channels of Monetary Policy Transmission

As previously argued, in conventional times, most modern monetary authorities typically implement monetary policies by directly setting the interest rate on central bank reserves, thereby implicitly treating money as an endogenous variable. The monetary policy objective is then transmitted into the real economy.²²⁴ As economic interactions within an open economy are fairly complex, monetary policy actions affect real economic variables through various intermediate channels and are typically characterized by long, variable and uncertain time lags. In the context of neoclassical channels, monetary policy decisions are transmitted by affecting investment, consumption and international trade.²²⁵ Non-neoclassical transmission channels primarily arise due to private market imperfections or government interferences in credit markets.²²⁶

According to the traditional Keynesian perspective, a contractionary monetary policy ($M \downarrow$) induced increase in short-term nominal interest rates ($i \uparrow$) would lead to a decrease in aggregate demand and total output ($Y \downarrow$) by increasing financing costs. As a result, total investment spending ($I \downarrow$) of both firms and private households would be lowered.²²⁷

$$M \downarrow (\uparrow) \rightarrow i \uparrow (\downarrow) \rightarrow I \downarrow (\uparrow) \rightarrow Y \downarrow (\uparrow) \quad (4)$$

Unanticipated shocks in interest rates, however, do not only have a short-term effect on real economic variables, due to the rigidity of the wage-price system, but also can affect long-term interest rates by forming expectations about future interest rate changes incorporated in the yield curve. According to the basic rational expectations theory of the term structure, the implied forward interest rates incorporated in the yield curve are equal to the corresponding anticipated spot rates. Deviations from the rational expectation theory result mainly from the liquidity preference of market participants who will require a risk premium for longer-term financial assets. Hence, by affecting expectations about the future,

²²⁴ Arestis and Sawyer (2003), p. 2

²²⁵ Boivin Kiley and Mishkin (2010), p. 6

²²⁶ Boivin Kiley and Mishkin (2010), p. 15

²²⁷ Mishkin (1995), p. 4

unanticipated policy actions can ultimately affect the real interest rate over the time horizon in which expectations are adjusted.²²⁸

Indeed, standard neoclassical economic models of investment indicate that the classic user cost of capital plays a central role for the demand for capital and is a key determinant for the consumption of investment goods, residential housing and consumer durables.²²⁹ The user cost of capital adjusted by the marginal tax rate (u_c) can be written as:

$$u_c = p_c [(1 - \pi) * (i - \pi^*) - (\tau_c^* - \pi^*)] \quad (5)$$

where

p_c is the relative price of new capital,

i is the nominal interest rate,

π^* is the expected inflation rate,

τ_c^* is the real rate of capital appreciation..²³⁰

Normally, both firms and private households base their investment decision on long-term interest rates rather than short-term nominal ones. However, dynamic-stochastic-general equilibrium (DSGE) models link investments to a sequence of expected short-term interest rates by incorporating a dynamic intertemporal optimality condition. Thus, DSGE models provide a link between short- and long-term interest rate based on some variation of the expectation hypothesis of the term structure.²³¹

Another theory supporting the investment transmission channel, which can also be linked to the user cost of capital approach, is Tobin's q theory. Tobin's q is defined as the market value of a firm divided by the current replacement costs of its assets. Put simply, a high Tobin's q indicates that current replacement costs of the assets held by the firm are relatively low in comparison to the market value of the firm, making it attractive to raise capital by issuing shares to finance additional investments.²³² *Ceteris paribus*, when monetary authorities lower interest rates, bonds become less attractive relative to stocks, which results in an increase in demand for stocks. Due to the resulting increase in stock

²²⁸ Cox, Ingersoll and Ross (1985), p. 385

²²⁹ Jorgenson (1963). p. 250

²³⁰ Boivin Kiley and Mishkin (2010), p. 8

²³¹ Boivin Kiley and Mishkin (2010), p. 9

²³² Mishkin (2001), p. 2 - *For a formal derivation how Tobin's q can be exactly related to the user cost of capital theory, as for example in the dynamic adjustment cost approach, please refer to Hayashi (1982).*

prices, Tobin's q increases and firms are able to raise capital for investments with fewer shares required to be issued. This in turn can increase the number of profitable investment projects companies pursue and stimulate total aggregated output through a higher amount of investments.²³³

Meanwhile, the life-cycle hypothesis of consumption defines wealth and income as key determinants of consumer spending and therefore identifies another transmission channel. *Ceteris paribus*, if stock prices rise after a loosening monetary policy, private households' total wealth increases. An increase in wealth of households will then affect consumer spending and stimulate total output.²³⁴

In open economies with flexible exchange rates, policy induced changes in short-term nominal interest rate additionally affect real economic variables through the exchange rate channel, due to the effects of interest parity in combination with price rigidity. If the domestic nominal interest rate increases above the level of its foreign counterpart, domestic monetary deposits become more valuable relative to other currency deposits, which leads to an increase in demand and to a corresponding currency appreciation under the assumption of perfect capital mobility.²³⁵ Simultaneously, as prices are assumed to be sticky, a change in nominal interest rate affects real exchange rates in the short run and impacts export and import behaviors of an economy. Therefore, an increase in the interest rate would ultimately result in a temporary decrease in net exports and lower total output, until the return of the exchange rate to its previous real base line path.²³⁶

In addition to traditional neoclassical transmission channels, the credit channel theory indicates that the effect of monetary policies on interest rates is amplified by endogenous variations in the external finance premium, which can be described as the difference between external and internal financing options. The linkage, between the external financing option and the monetary policy action that impacts loan demand and supply, is primarily described by the balance sheet channel and the bank lending channel.²³⁷

The theoretical prediction that a borrower's finance premium depends on its financial position gives rise to the balance sheet channel of monetary policy transmission. *Ceteris paribus*, a stronger net wealth position should result in more attractive credit terms. As

²³³ Mishkin (2001). p. 2

²³⁴ Ireland (2005), p. 4 - *The life-cycle theory of consumption was originally introduced by Modigliani, Ando and Brunberg (1963) in their paper: "The life cycle hypothesis of saving: Aggregate implications and tests"*

²³⁵ Mishkin (1995). p.5

²³⁶ Taylor (1995), p. 17

²³⁷ Bernanke, Gertler (1995), p. 28

monetary policy induced changes in nominal interest rates not only impact the market interest rate but also affect the net financial position of firms, in both a direct and indirect way, additional monetary transmission channels have been identified.²³⁸ For instance, a tightening monetary policy and a corresponding increase in interest rates directly affect the balance sheet of the borrowers due to increasing interest expenses resulting from outstanding short-term or floating-rate debt instruments. This in turn leads to a reduction of net cash flow and weakens the financial positions of the borrower. Furthermore, as previously explained, a tightening monetary policy is associated with a decline in asset prices and therefore reduces the net value of borrowers' collateral as well as their corresponding creditworthiness. This, among others, gives rise to adverse selection and moral hazard problems. Consequently, a tightening monetary policy amplifies the increase in total funding costs of firms above the level explainable by the changes in market interest rates and, therefore, further lowers their total loan demand for investments.²³⁹ Moreover, tightening monetary policy might also affect firms indirectly through reduced spending of their downstream customers, causing further declines in revenues.²⁴⁰

A contractionary monetary policy might also negatively affect the loan supply of banks and impact the corresponding bank-dependent borrowers by decreasing the core deposit funding of bank loans. This mechanism is known as the bank lending channel.²⁴¹

A further implication of the credit channels is that a decrease in total loan supply will impose a larger effect on smaller firms, as they are highly dependent on the supply of bank loans due to their inability of raising capital through debt or equity capital markets.²⁴²

To conclude, a policy induced, unexpected change in short-term interest rates does not only impact investments and total output through traditional neoclassic transmission channels, but also affects firms' investment behavior through non-neoclassical credit channels, which amplify the magnitude of monetary policy effects. The impact of non-neoclassical transmission channels, however, seems to asymmetrically influence the investment behavior of firms, depending on their size.²⁴³ Moreover, as the exact magnitude and time effect of monetary policy effects are uncertain, it is hardly possible to predict the precise effect of any transmission channel on the economy and general price levels.

²³⁸ Bernanke and Gertler (1995), p. 36

²³⁹ Boivin Kiley and Mishkin (2010), p. 20

²⁴⁰ Bernanke and Gertler (1995), p. 36

²⁴¹ Kirshan, Opiela (2000), p. 122

²⁴² Mishkin (1996), p. 9

²⁴³ Mishkin (1996), p. 10

IV.II. Empirical Analysis – Realized Macroeconomic Indicators

CPI			
Correlation Matrix	Sweden	New Zealand	United States
Sweden	1,00		
New Zealand	0,62	1,00	
United States	0,17	0,22	1,00

Table 10: CPI correlation matrix

GDP Growth			
Correlation Matrix	Sweden	New Zealand	United States
Sweden	1,00		
New Zealand	0,26	1,00	
United States	0,24	0,41	1,00

Table 11: GDP correlation matrix

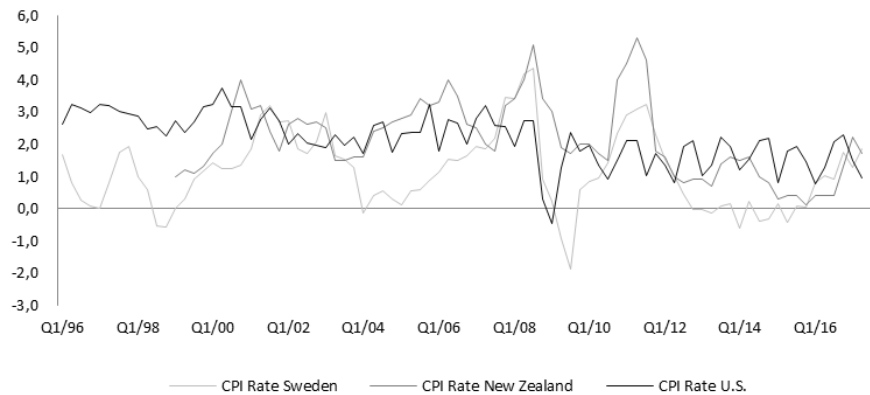


Figure 4: CPI development in Sweden, New Zealand and the U.S.



Figure 5: GDP development in Sweden, New Zealand and the U.S.

IV.III. Empirical Analysis – Potential Output Forecasts ²⁴⁴

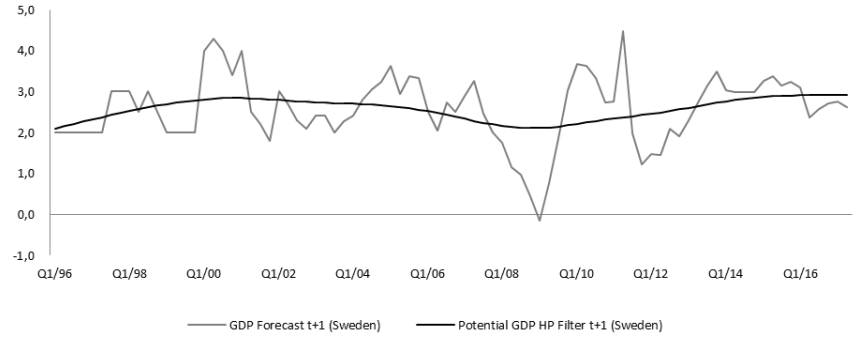


Figure 6: Potential output estimate t+1 (Sweden)

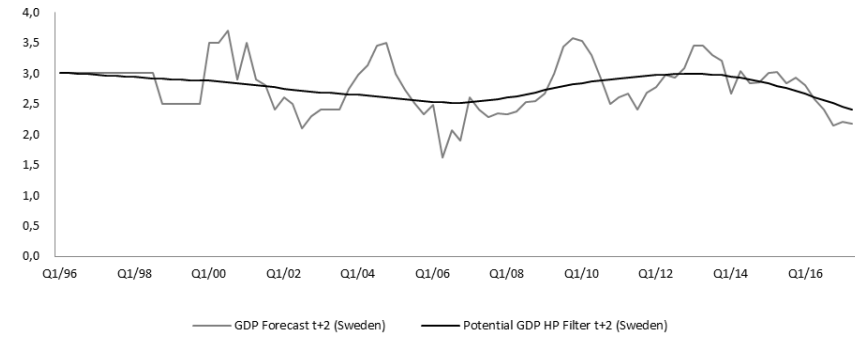


Figure 7: Potential output estimate t+2 (Sweden)

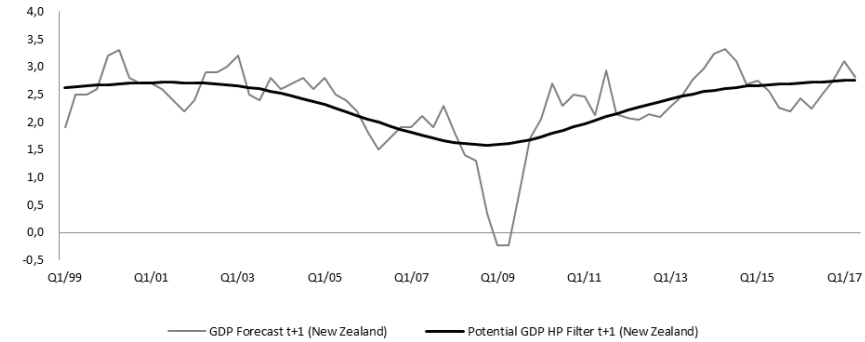


Figure 8: Potential output estimate t+1 (New Zealand)

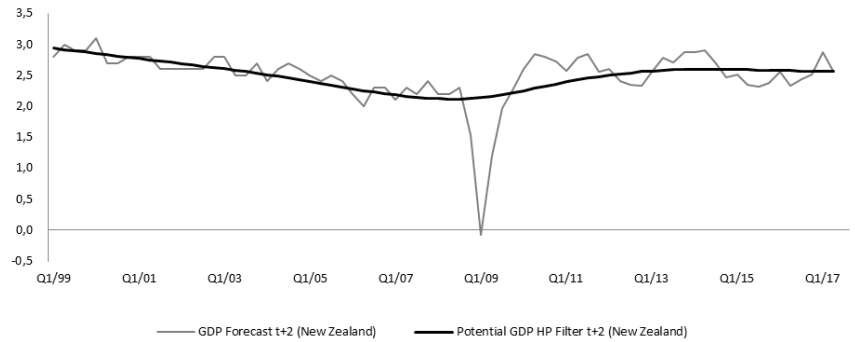


Figure 9: Potential output estimate t+2 (New Zealand)

²⁴⁴ Based on HP-Filter estimate with smoothing parameter $\tau = 1600$

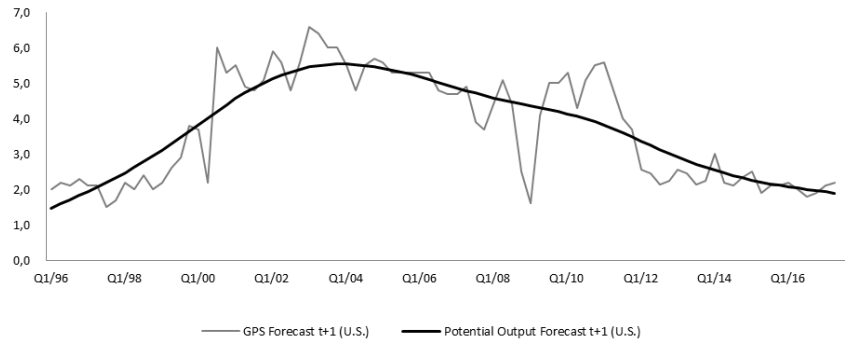


Figure 10: Potential output estimate t+1 (U.S.)

IV.IV. Empirical Analysis – Comparison of Realized and Forecasted CPI

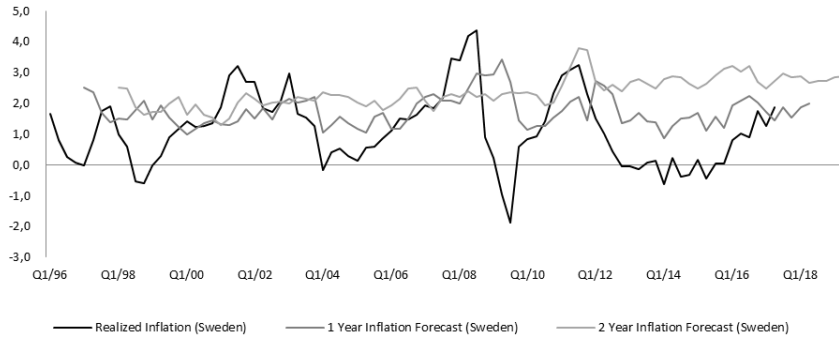


Figure 11: Comparison of realized and forecasted CPI (Sweden)

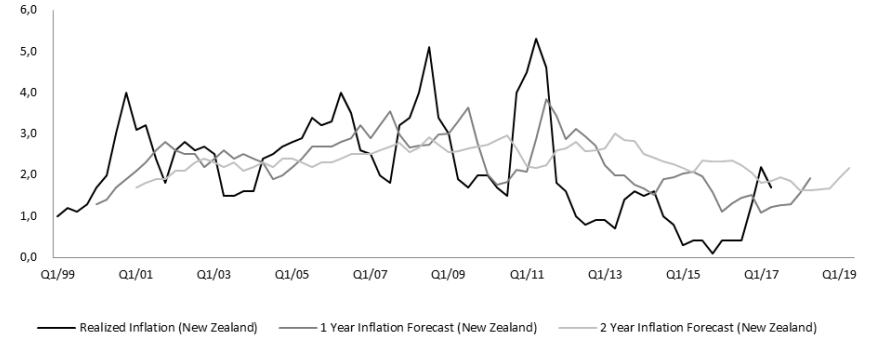


Figure 12: Comparison of realized and forecasted CPI (New Zealand)

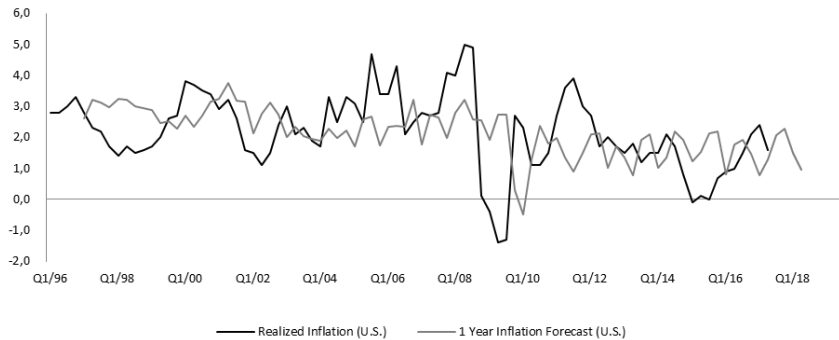


Figure 13: Comparison of realized and forecasted CPI (U.S.)

IV.V. Empirical Analysis – Comparison of Realized and Forecasted GDP Growth

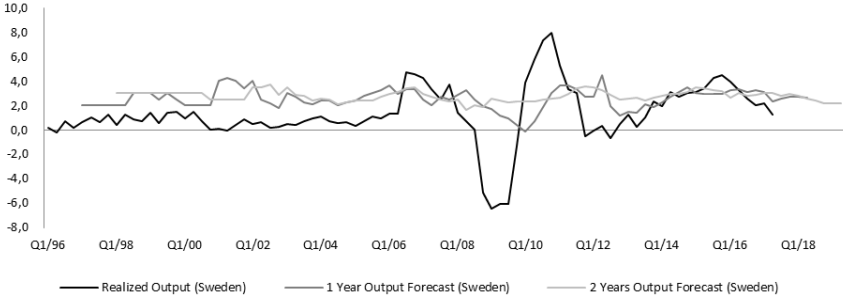


Figure 14: Comparison of realized and forecasted GDP growth (Sweden)

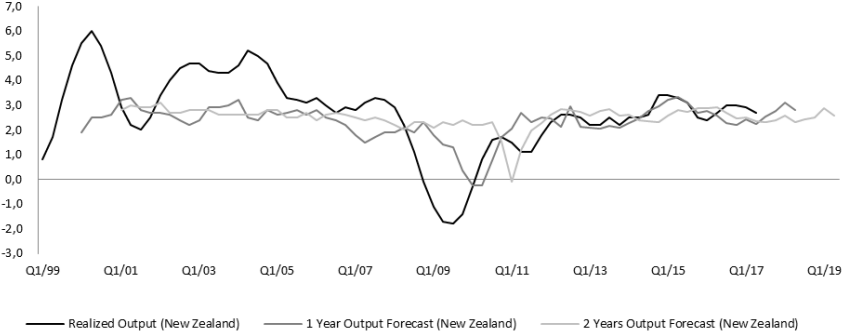


Figure 15: Comparison of realized and forecasted GDP growth (New Zealand)

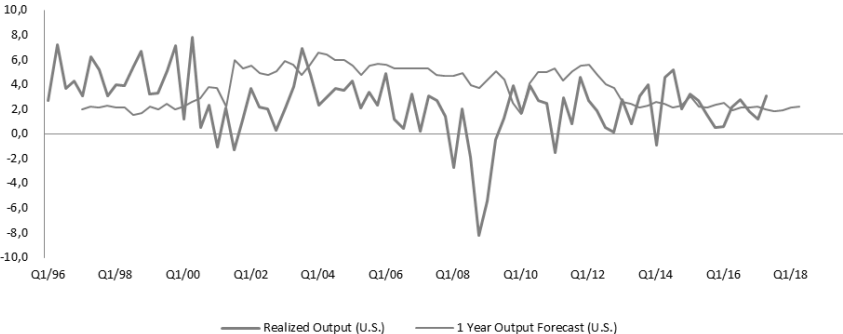


Figure 16: Comparison realized and forecasted GDP growth (U.S.)

IV.VI. Empirical Analysis – T.R. (Taylor’s Suggested and Estimated Parameters)²⁴⁵

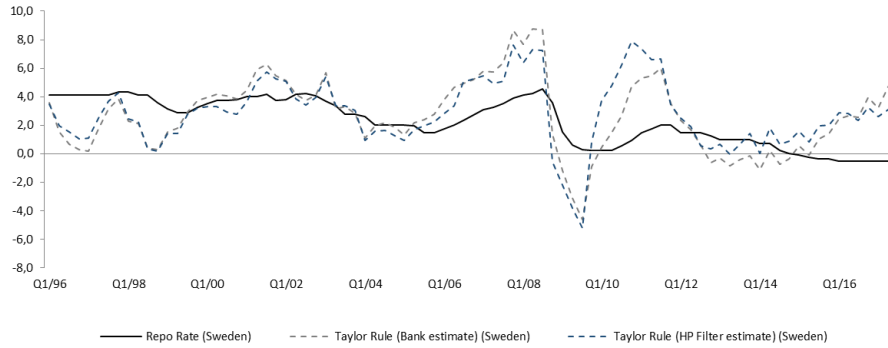


Figure 17: Classic Taylor Rule (Sweden)

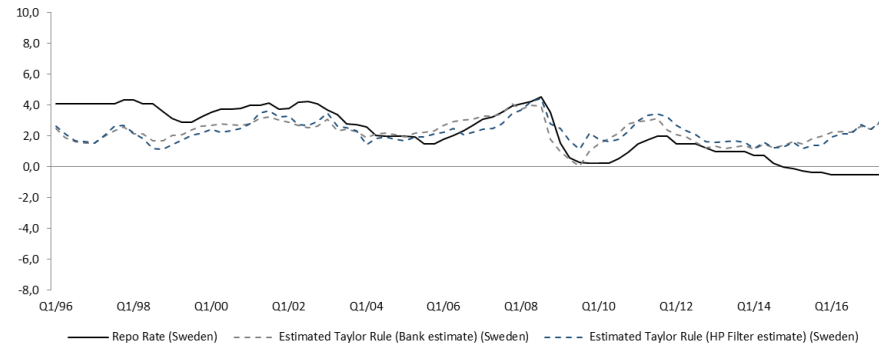


Figure 18: Estimated Taylor Rule (Sweden)

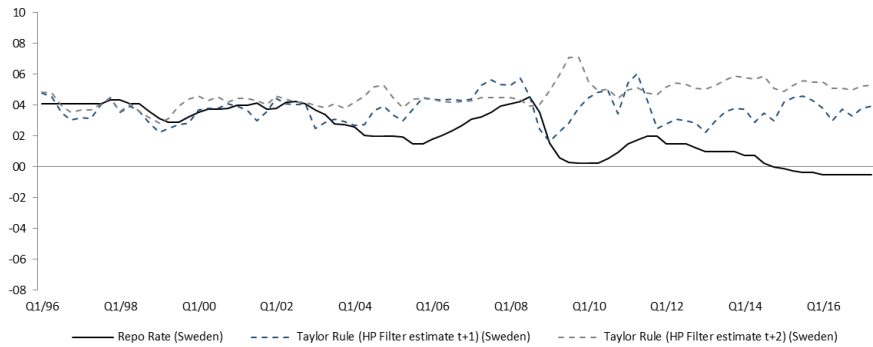


Figure 19: Classic Taylor Rule based on forecast data (Sweden)

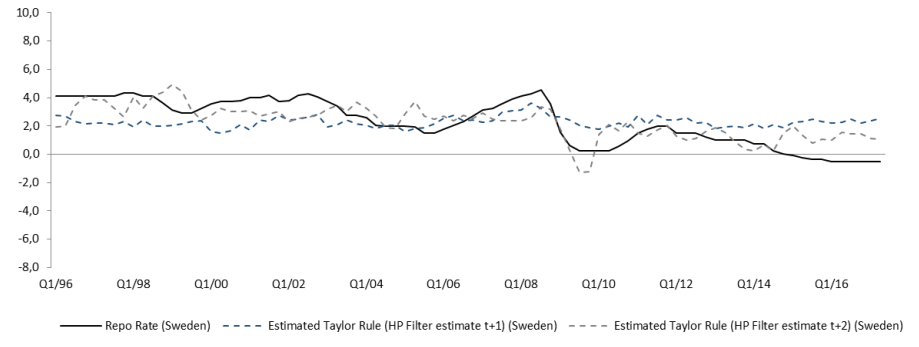


Figure 20: Estimated Taylor Rule based on forecast data (Sweden)

²⁴⁵ Based on Taylor’s initially proposed reaction function: $i_t = r^* + \pi_t + \beta_\pi (\pi_t - \pi^*) + \beta_y (y_t - y^*) + \varepsilon_t^i$; Taylor’s suggested parameters amount to 0.5

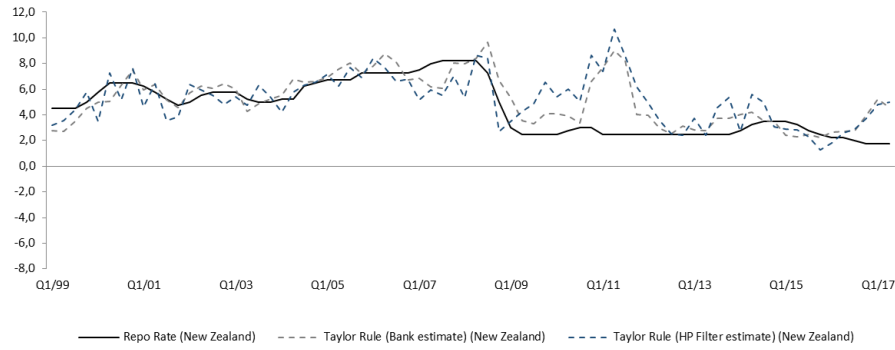


Figure 21: Classic Taylor Rule (New Zealand)

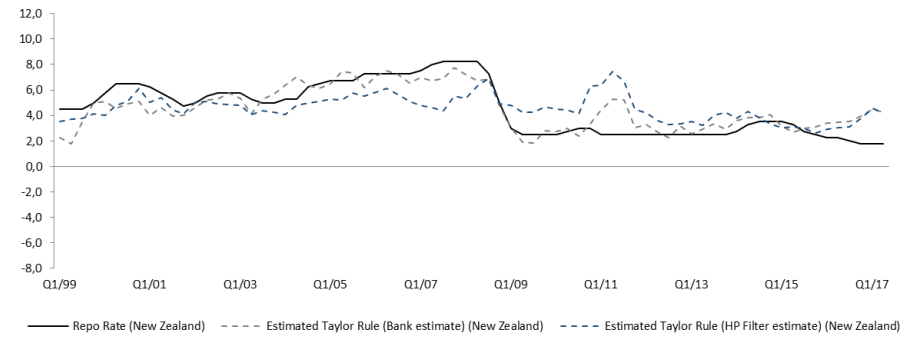


Figure 22: Estimated Taylor Rule (New Zealand)

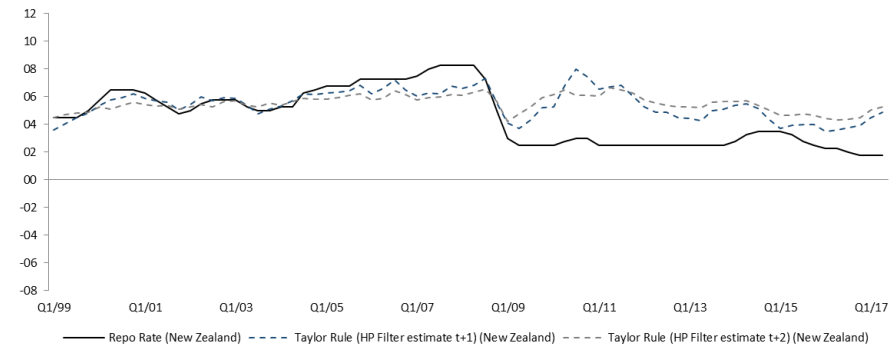


Figure 23: Classic Taylor Rule based on forecast data (New Zealand)

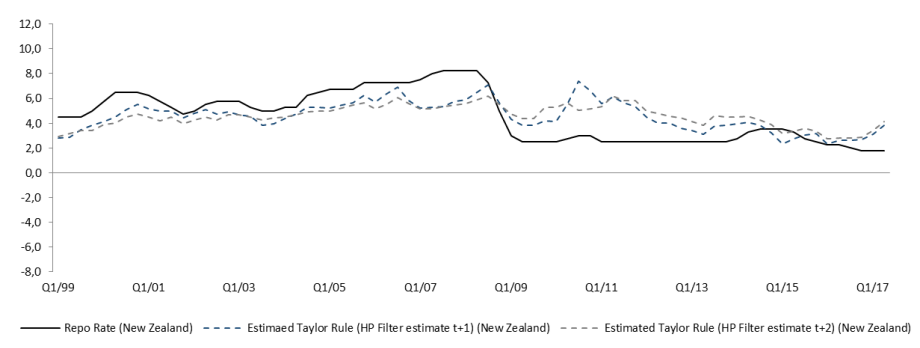


Figure 24: Estimated Taylor Rule based on forecast data (New Zealand)

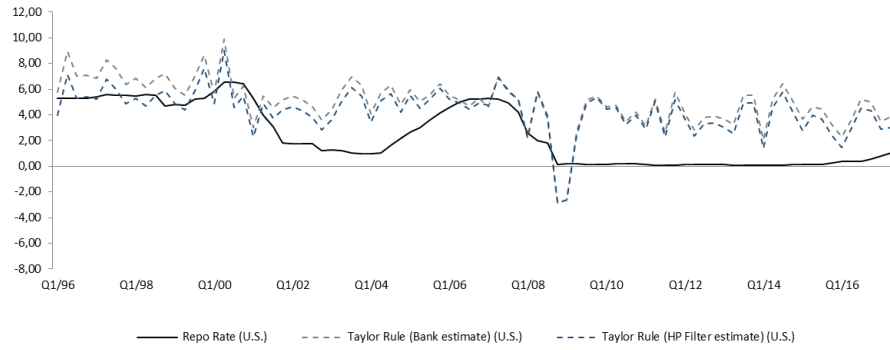


Figure 25: Classic Taylor Rule (U.S.)

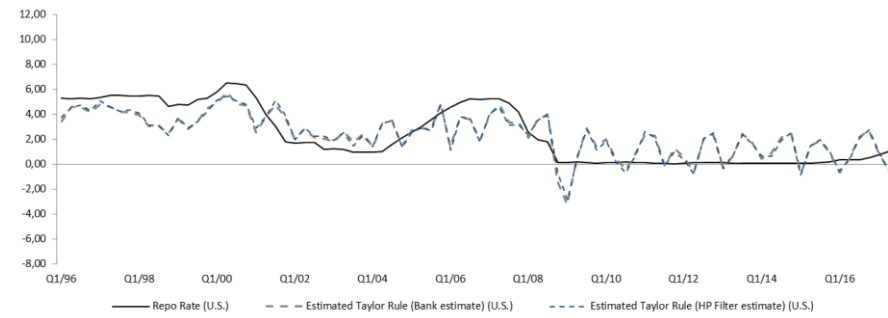


Figure 26: Estimated Taylor Rule (U.S.)

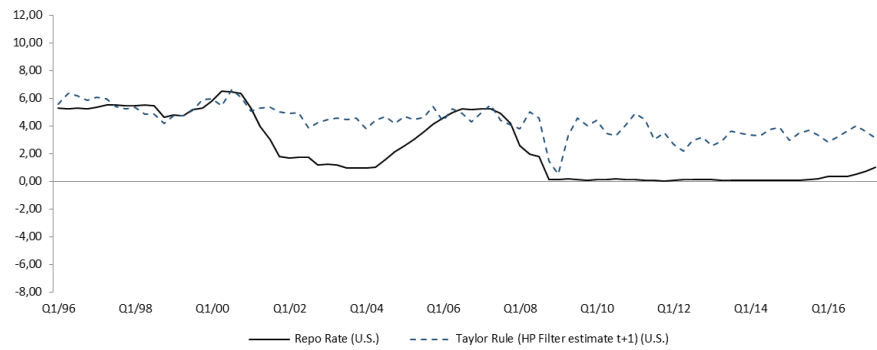


Figure 27: Classic Taylor Rule based on forecast data (U.S.)

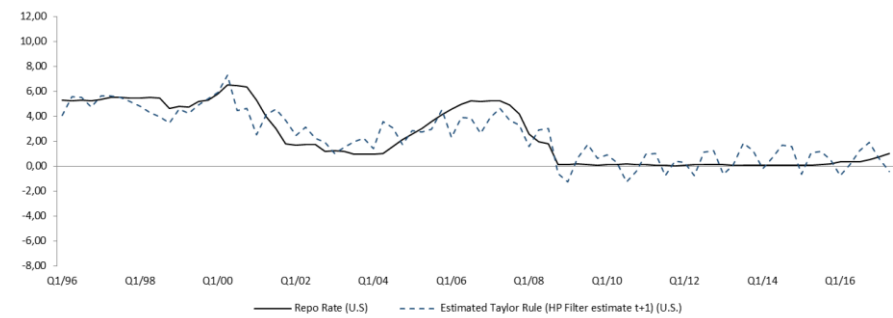


Figure 28: Estimated Taylor Rule based on forecast data (U.S.)

IV.VII. Empirical Analysis – T.R. inclusive Interest Rate Smoothing and Time Break ²⁴⁶

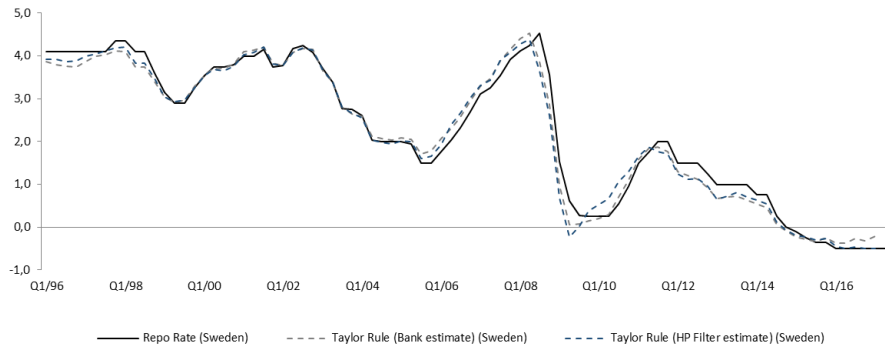


Figure 29: T.R. incl. interest rate smoothing and time break (Sweden)

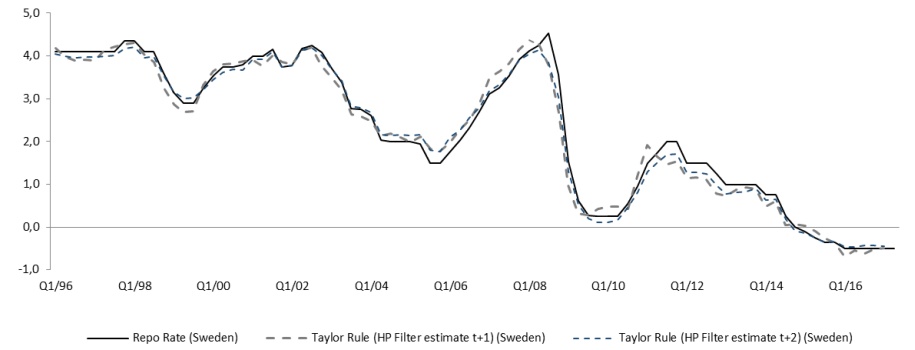


Figure 30: T.R. incl. interest rate smoothing and time break based on forecast data (Sweden)

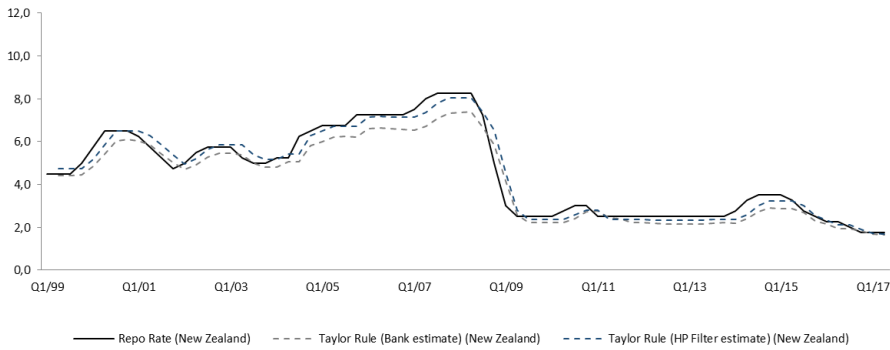


Figure 31: T.R. incl. interest rate smoothing and time break (New Zealand)

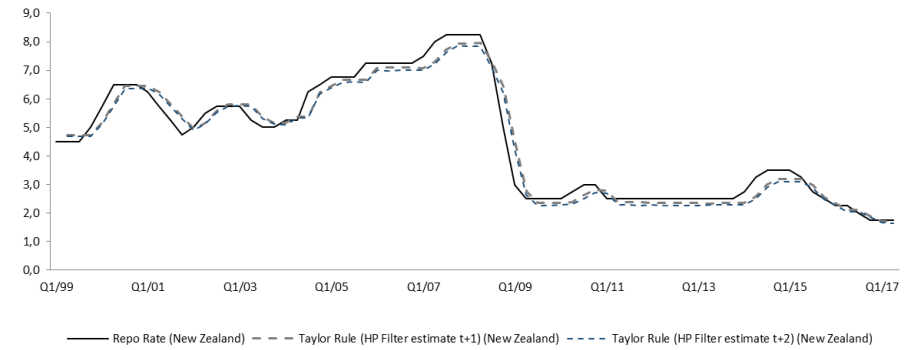


Figure 32: T.R. incl. interest rate smoothing and time break based on forecast data (New Zealand)

²⁴⁶ Based on following Taylor-type Rule specification: $i_t = (1 - \rho) * (r^* + \pi_{t+h} + \beta_\pi * E_t(\pi_{t+h} - \pi^*) + \beta_y * E_t(y_{t+h} - y^*) + \delta_{time\ break}) + \rho * i_{t-1} + E_t(\varepsilon_{t+h}^i)$

(New Zealand)

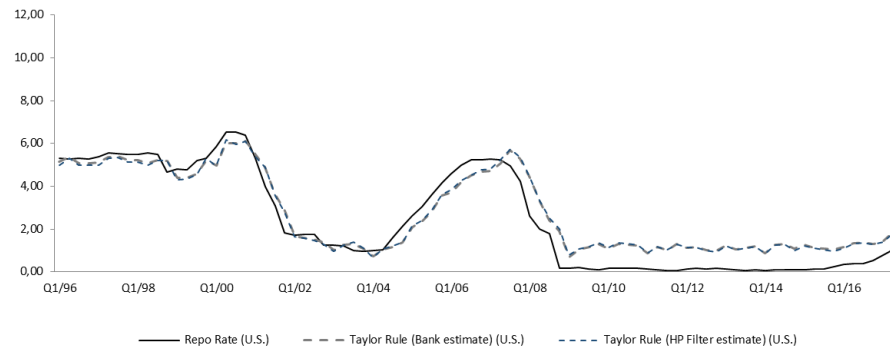


Figure 33: T.R. incl. interest rate smoothing and time break (U.S.)

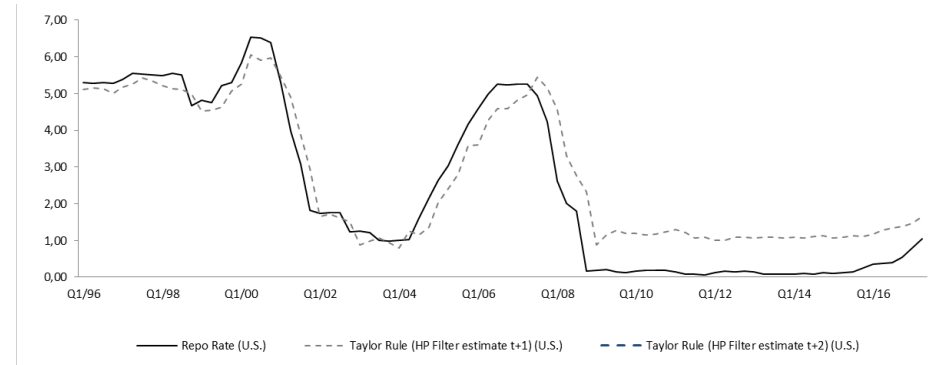


Figure 34: T.R. incl. interest rate smoothing and time break based on forecast data (U.S.)

IV.VIII. Empirical Analysis – T.R. inclusive Dynamic Policy Behavior ²⁴⁷

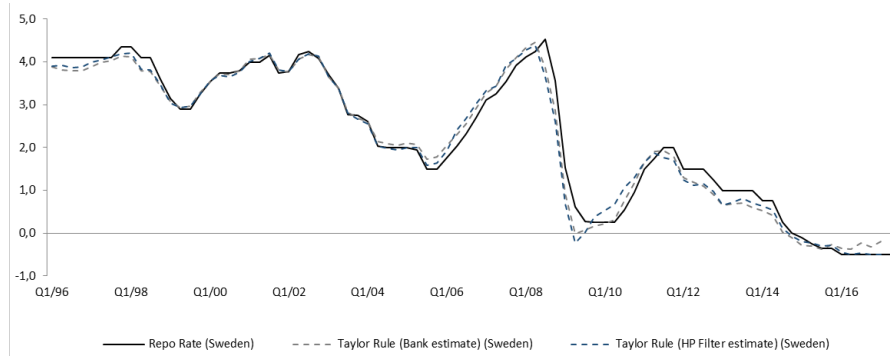


Figure 35: T.R. incl. dynamic policy behavior (Sweden)

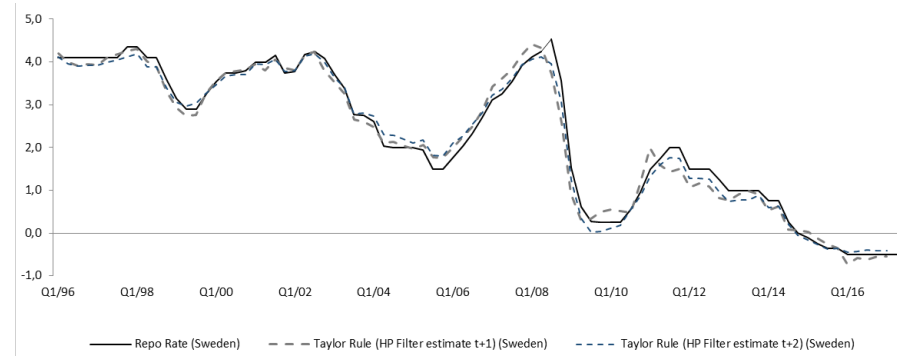


Figure 36: T.R. incl. dynamic policy behavior based on forecast data (Sweden.)

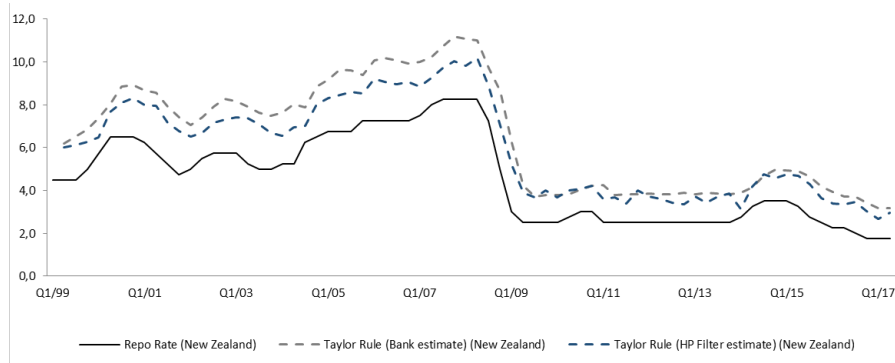


Figure 37: T.R. incl. dynamic policy behavior (New Zealand)

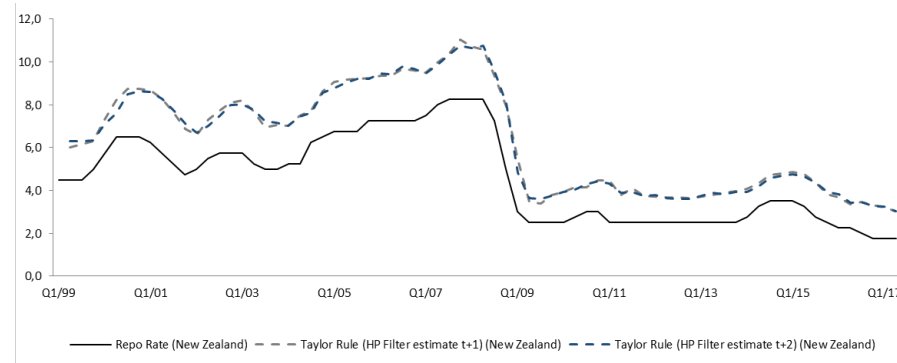


Figure 38: T.R. incl. dynamic policy behavior based on forecast data (New Zealand)

²⁴⁷ Based on following Taylor-type Rule specification: $i_t = (1 - \rho) * (r^* + \pi_{t+h} + \beta_\pi * E_t(\pi_{t+h} - \pi^*) + \beta_y * E_t(y_{t+h} - y^*)) + \delta_{time\ break} + \delta_{\pi\ (post\ financial\ crisis)} * E_t(\pi_{t+h} - \pi^*) + \delta_{\gamma\ (post\ financial\ crisis)} * E_t(y_{t+h} - y^*) + \rho * i_{t-1} + E_t(\varepsilon_{t+h}^i)$

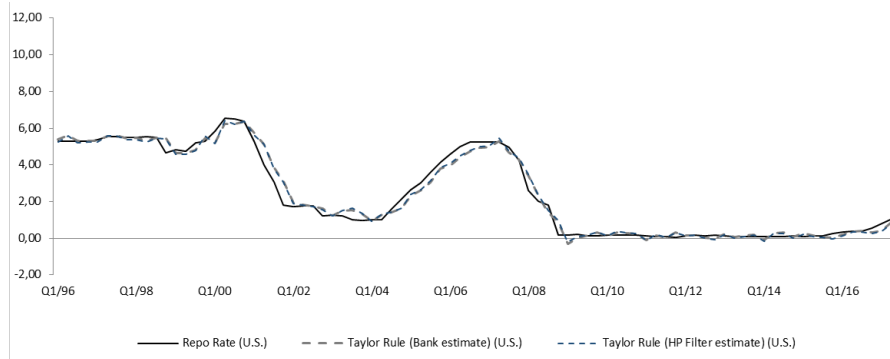


Figure 39: T.R. incl. dynamic policy behavior (U.S.)

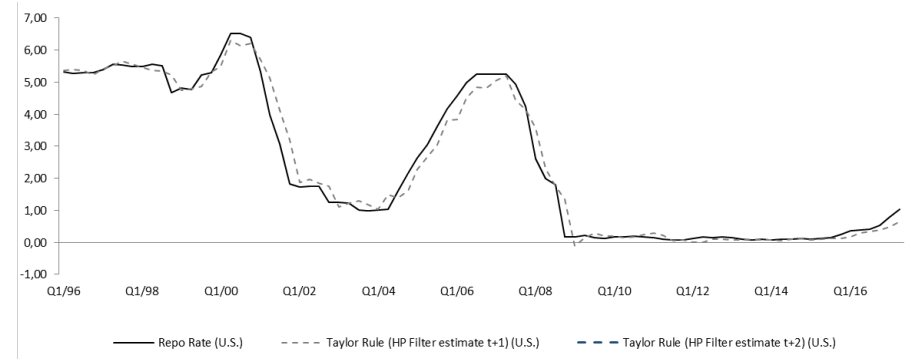


Figure 40: T.R. incl. dynamic policy behavior based on forecast data (U.S.)

V. References

- *Books*

Adam Smith (1811): “The Works of Adam Smith, LL.D. in five Volumes.” 3rd Edition. London and Edinburgh.

Cagan (1995): “Monetarism.” *Money*. Palgrave.

Brandl (2016): “Money, Banking, Financial Markets and Institutions.” Boston.

Bryant, Hooper and Mann (1993): “Evaluating Policy Regimes: New Research in Empirical Macroeconomics.” Washington D.C.

Darity (2008): “International Encyclopedia of Social Sciences.” 2nd Edition, Washington D.C.

Freeman (1970): “The Counter-revolution in Monetary Theory.” London.

Fellner (1976): “Towards a Reconstruction of Macroeconomics; Problems of Theory and Policy.” *American Enterprise Institute*.

Haberler (1980). “Notes on Rational and Irrational Expectations.” *American Enterprise Institute*.

Keynes (1950): “A Treatise on Money – Volume II. The Applied Theory of Money.” *Macmillan and Co.* 3. Edition (Original publication 1930). London.

Keynes (1923): “A tract on monetary reform.” London.

Wicksell (2013): “Interest and Prices.” (Original publication 1898). New York.

Mahadeva, Lavan and Sterne (2012): “Monetary policy frameworks in a global context.” Routledge.

Santomero, Viotti and Vredin (2001): “Challenges for Central Banking.” New York.

Serletis (2007): “The Demand for Money: Theoretical and Empirical Approaches.” New York.

- ***(Journal) articles***

Angeriz and Arestis (2008): “Assessing Inflation Targeting Through Intervention Analysis.” *Oxford Economic Papers*. Vol. 60. No. 2. p. 293-317.

Arestis and Sawyer (2006): “The nature and role of monetary policy when money is endogenous.” *Cambridge Journal of Economics*. Vol. 30. No. 6. p. 847-860.

Ball and Sheridan (2004): “Does inflation targeting matter.” *The inflation-targeting debate*. University of Chicago Press. Vol. 1. p. 249-282.

Barro (1986): “Developments in the Theory of Rules Versus Discretion.” *The Economic Journal*. Vol. 96. p. 23-37.

Barro and Gordon (1983): “Rules, Discretion and Reputation in a Model of Monetary Policy.” *Journal of Monetary Economics*. Vol. 12. p. 101-121.

Bernanke and Woodford (2004): “The Inflation Targeting Debate.” *University of Chicago Press*. p. 1-10.

Bernanke (2003): “A Perspective on Inflation Targeting.” *Business Economics*. Vol. 38. No. 3. p. 7-21.

Bernanke, Laubach, Mishkin and Posen (1999): “Inflation Targeting: Lessons from the International Experience.” *Princeton University Press*.

Bernanke and Mishkin (1997): “Inflation Targeting: A new Framework for Monetary Policy?” *National bureau of economic research*. No. 2518

Bernanke and Gertler (1995): “Inside the Black Box: The Credit Channel of Monetary Policy Transmission.” *The Journal of Economic Perspectives*. Vol. 9, No. 4.

Blinder (2010): “Quantitative Easing: Entrance and Exit Strategies.” *Federal Reserve Bank of St. Louis*. Vol. 96. No. 2. p. 465-480.

Byrne, Fazio and Fiess (2012): “Interest Rate Co-movements, Global Factors and the Lond End of the Term Spread.” *Journal of Banking and Finance*. Vol. 36. No. 1. p. 183-192.

Carstrom and Fuerst (1995): “Interest rate rules vs. money growth rules – A welfare comparison in a cash-in-advanced economy.” *Journal of Monetary Economics*. Vol. 36. p. 247-266.

Cecchetti and Stephen (1995): “Distinguishing theories of the monetary transmission mechanism.” *Review-Federal Reserve Bank of Saint Louis*, Vol. 7.

Chevapatrakul, Kim and Mizen (2009): “The Taylor Principle and Monetary Policy Approaching a Zero Bound on Nominal Rates: Quantile Regression Results for the United States and Japan.” *Journal of Money, Credit and Banking*. Vol. 41. No. 8. p. 1705-1723.

Clarida, Gali and Gertler (1998): “Monetary Policy Rules in Practice: Some International Evidence”. *European Economic Review*. Vol. 42. p. 1033-1067.

Cox, Ingersoll and Ross (1985): “A Theory of the Term Structure of Interest Rates.” *Econometrica*, Vol. 53 No. 2. p. 385-407.

Crowe (2010): “Testing the transparency benefits of inflation targeting: Evidence from private sector forecasts.” *Journal of Monetary Economics*. Vol. 57. No. 2. p. 226-232.

Crowe and Meade (2008): “Central bank independence and transparency: Evolution and effectiveness.” *European Journal of Political Economy*. Vol. 24. No. 4. p.763-777.

Cukierman and Muscatelli (2008): “Nonlinear Taylor Rules and Asymmetric Preferences in Central Banking: Evidence from the United Kingdom and the United States.” *The B.E. Journal of Macroeconomics*. Vol. 8. No. 1. p.

Davig and Leeper (2007): "Generalizing the Taylor Principle". *The American Economic Review*. Vol. 97. No. 3

Dwyer Jr. (1993): "Rules and discretion in monetary policy." *Review-Federal Reserve Bank of Saint Louis*. Vol. 3. No. 3. p. 607-635.

Ehrmann, Eiiiffinger and Fratzscher (2012): "The Role of Central Bank Transparency for Guiding Private Sector Forecasts." *The Scandinavian Journal of Economics*. Vol. 114. No. 3. p. 1018-1052.

Fendel, Frenkel and Rülke: "Ex-Ante Taylor rules – Newly discovered evidence from the G7 countries". *Journal of Macroeconomics*. Vol. 33. No.2. p. 224-232.

Fischer (1988): "Rules versus Discretion in Monetary Policy." *National bureau of economic research*. No. 2518

Freeman (1968): "The role of monetary policy." *The American economic review*. Vol. 58 No. 1. p. 1-17.

Fujiwara (2005): "Is the Central Bank's Publication of Economic Forecasts Influential?" *Economic Letters*. Vol. 89. p. 255-261

Geraats (2002): "Central Bank Transparency." *The economic journal*. No. 483

Giannoni and Woodford (2004): "Optimal Inflation-Targeting Rules." University of Chicago Press. p. 94-173.

Goodhart (2006): "Monetary Trasmission Lags and the Formulation of Policy Decision on Interest Rates." *Federal Reserve Bank of St. Louis Economic Review*. p. 165-181.

Greenspan (2004): "Risk and uncertainty in monetary policy". *American Economic Review*. Vol. 94. p. 33-40.

Greenspan (2002): "Chairman's Remakrs." *Federal Reserve Bank of St. Lous Review*. V. 84. p. 928-956.

Gürkaynak, Levin and Swanson (2010): “Does inflation targeting anchor long-run inflation expectations? Evidence from the U.S., U.K. and Sweden.” *Journal of the European Economic Association*. Vol. 8. No. 6. p. 1208-1242.

Henderson and McKibbin (1993): “A comparison of some basic monetary policy regimes for open economies: Implications of different degrees of instrument adjustment and wage persistence”. *Carnegie-Rochester Conference Series on Public Policy*. Vol. 39. p. 221-317.

Honkapohja and Mitra (2003): “Performance of Inflation Targeting Based On Constant Interest Rate Projections.” *Journal of Economic Dynamics and Control*. Vol. 29.

No. 11. p. 1867-1892

Jorgenson and Dale (1963): “Papers and Proceedings of the Seventy-Fifth Annual Meeting of the American Economic Association.” *The American Economic Review*. Vol. 53. No. 2.

Joyce, Miles, Scott and Vayanos,(2012): “Quantitative easing and unconventional monetary policy – an introduction.” *The Economic Journal*. Vol. 122. p. 271-288.

Judd and Rudebusch (1998): “Taylor Rules and the Fed: 1970-1997”. *Federal Reserve Bank of San Francisco Economic Review*. Vol. 3. p. 3-16.

Kato and Nishiyama (2005): “Optimal monetary policy when interest rates are bound at zero.” *Journal of Economic Dynamics and Control*. Vol. 29. No.1. p. 97-133

King (2005): “Monetary Policy: Practice Ahead of Theory (Mais Lecture 2005).” *Forelesning ved the Cass Business School*.

King (1997): “The Inflation Target five years on – Speech by Meryll King.” *Bank of England*.

Kishan and Opiela (2000): “Bank Size, Bank Capital, and the Bank Lending Channel.” *Journal of Money, Credit and Banking*. Vol. 32. No. 1. p. 121-141

Kuttner and Posen. (2004): "The Difficulty of Discerning What's Too Tight: Taylor Rules and Japanese Monetary Policy." *North American Journal of Economics and Finance*. Vol. 15. p. 53-74

Kydland and Prescott (1977): "The inconsistency of Optimal Plans." *Journal of Political Economy*. Vol. 85. No. 3. p. 473-492.

Leiderman and Svensson (1995): "Inflation Targets." *London: Centre for Economic Research*.

Leitemo (2003): "Targeting inflation by constant-interest-rate forecasts." *Journal of Money, Credit, and Banking*. Vol. 54. No. 4. p. 609-626.

Levin, Natalucci and Piger (2004): "The Macroeconomic Effects of Inflation Targeting." *Federal Reserve Bank of St. Louis Review*. Vol. 86. p. 51-80.

Lin and Ye (2007): "Does Inflation Targeting Really Make a Difference? Evaluating the Treatment Effect of Inflation Targeting in Seven Industrial Countries." *Journal of Development Economics*. Vol. 89. No. 1. p. 118-123.

Lomax (2005). "Inflation Targeting in Practice: Models, Forecasts and Hunches." *Bank of England Quarterly Bulletin*.

Lowe and Ellis (1998). "The Smoothing of Official Interest Rates, *Proceedings of a Conference*. p. 286- 312.

Lucas (1980): "Two illustrations of the quantity theory of money." *The American Economic Review*. Vol. 70. No. 5. p. 1005-1014

Martin and Milas (2004): "Monetary Policy: Inflation Targeting in Practice." *Economica*. Vol. 71. No. 282. p. 209-221.

Melecký, Palenzuela and Söderström (2008): "Inflation Target Transparency and the Macroeconomy." *World Bank*

Mishkin (2001): "The transmission mechanism and the role of asset prices in monetary policy". *National bureau of economic research*. No. w8617.

- Mishkin (2001b): "Inflation targeting". *National bureau of economic research*.
- Mishkin and Posen (1997): "Inflation Targeting: Lessons from four countries." *National Bureau of Economic Research*. No. 6126
- Mishkin (1996): "The Channels of Monetary Transmission: Lessons for Monetary Policy." *National bureau of economic research*. No. w5464
- Mishkin (1995): "Symposium on the Monetary Transmission Mechanism." *The Journal of economic perspective*. Vol. 9. No. 4. p. 3-10.
- Murray, Papell and Rzhetsky (2015): "Markov switching and the Taylor Principle." *Macroeconomic Dynamics*. Vol. 19. No. 4. p. 913-930.
- Nelson (2001): "UK Monetary Policy 1972-1997: A Guide Using Taylor Rules." *Bank of England Report*.
- Orphanides (2003): "Historical monetary policy analysis and the Taylor rule". *Journal of monetary economics*. Vol. 50. No. 5. p. 983-1022.
- Orphanides (2001): "Monetary policy rules based on real-time data." *American Economic Review*. Vol. 1. p. 964-985
- Poole and William (1970): "Optimal choice of monetary policy instruments in a simple stochastic macro model." *The Quarterly Journal of Economics*, Vol. 84 No 2. p. 197-216.
- Roger (2009): "Inflation Targeting at 20: Achievements and Challenges". *International Monetary Fund*. E31.
- Roger (2010): "Inflation Targeting Turns 20." *Finance and Development*. Vol. 47. P. 46-49
- Rudebusch (2002): "Term Structure Evidence on Interest Rate Smoothing and Monetary Policy Inertia." *Journal of Monetary Economics*. Vol. 11. p. 1161-1187.
- Rudebusch and Svensson (1999): "Policy rules for inflation targeting." *Monetary policy rules*. *University of Chicago Press*. p. 203-262.

Rudebusch (1995): "Federal Reserve interest rate targeting, rational expectations, and the term structure." *Journal of Monetary Economics*. Vol. 35. p. 245-274.

Sack and Wiedland (2000). "Interest-Rate Smoothing and Optimal Monetary Policy: A Review of Recent Empirical Evidence." *Journal of Economics and Business*. Vol. 52. No. 1. p. 205-228

Sauer and Sturm (2007): "Using Taylor Rules to Understand European Central Bank Monetary Policy". *German Economic Review*. Vol. 8. No. 3. p. 375-398.

Svensson (2008): "Transparency under Flexible Inflation Targeting: Experiences and Challenges." *Sveriges Riksbank*.

Svensson and Woodfort (2004): "Implementing Optimal Policy through Inflation-Forecast Targeting." *University of Chicago Press*.

Svensson (2003): "The Inflation Forecast and the Loss Function." *Princeton University & Stockholm University*.

Svensson (2002): "Inflation targeting: Should it be modeled as an instrument rule or a targeting rule?" *European Economic Review*. Vol. 46. No. 4. p. 771-780.

Svensson (2000): "Open- Economy Inflation Targeting." *Journal of international economics*. Vol. 50. No. 1. p. 155-183

Svensson (1998): "Inflation targeting as a monetary policy rule." *Journal of monetary economics*. Vol. 43. No.3. p. 607-654

Svensson (1997): "Inflation targeting in an open economy: Strict or flexible inflation targeting." *Reserve Bank of New Zealand*. No. G97/8.

Taylor (2012): "Monetary Policy Rules Work and Discretion Doesn't: A Tale of Two Eras." *Journal of Money, Credit and Banking*. Vol. 44. No. 6.

Taylor (2010): "Simple and robust rules for monetary policy". *National Bureau of Economic Research*. No. w15908.

Taylor and Davradakis (2006): “Interest Rate Settings and Inflation Targeting: Evidence of a Nonlinear Taylor Rule for the United Kingdom.” *Studies in Nonlinear Dynamics & Econometrics*. Vol. 10. No. 4.

Taylor (1999): “A Historical Analysis of Monetary Policy Rules”. *Monetary policy rules*. University of Chicago Press. p. 319-348.

Taylor (1999): “The robustness and efficiency of monetary policy rules as guidelines for interest rate setting by the European Central Bank.” *The Journal of Monetary Economics*. Vol. 43. No. 3. p. 655-579.

Taylor (1995): “The Monetary Transmission Mechanism: An Empirical Framework.” *The Journal of Economic Perspectives*, Vol. 9, No 4. p. 11-26.

Taylor (1993): “Discretion versus Policy Rules in Practice.” *Center for Economic Policy Research*.

Taylor (1983): “Comments – Rules, Discretion and Reputation in a Model of Monetary Policy’ by Robert J. Barro and David B. Gordon.” *Journal of Monetary Economics*. Vol. 12.

Thornton (2012): “The Dual Mandate: Has the Fed Changed Its Objective?” *Federal Reserve Bank of St. Louis*. Vol. 94. No. 2. p. 117-133.

Woodford (2001): “The Taylor Rule and Optimal Monetary Policy”. *American Economic Review, Papers and Proceedings*. Vol- 91. No. 2. p. 232-237

- **Articles in books**

Batini and Haldane (1999): “Forward-Looking Rules for Monetary Policy”. in Taylor, ed., *Monetary Policy Rules*. University of Chicago Press. p. 157-202.

Batini and Laxton (2007): “Under What Conditions Can Inflation Targeting Be Adopted? The Experience of Emerging Markets” in Mishkin, Hebbel (eds). *Monetary Policy under Inflation. Central Banking, Analysis and Economic Policies*. Vol. 11. p. 467-507.

Clarida and Gerler (1997): “How the Bundesbank conducts monetary policy.” In: *Reducing inflation: Motivation and strategy*. University of Chicago Press. p. 363-412.

Goodhart (1997): “Why do the Monetary Authorities Smooth Interest Rates?”. Chapter 8. in S. Collignon, ed., *European Monetary Policy*. London. p. 119-174

Ireland (2005): “The Monetary Transmission Mechanism.” in: *The New Palgrave Dictionary of Economics, 2nd Edition*. Hampshire.

Mishkin and Hebbel (2007): “Does inflation targeting make a difference?” in Mishkin, Hebbel (eds). *Monetary Policy under Inflation. Central Banking, Analysis and Economic Policies*. Vol. 11. p. 291-372.

- ***Working papers***

Alichi, Chen, Clinton, Freedman, Johnson, Kamenik and Laxton (2009): “Inflation targeting under imperfect policy credibility.” IMF Workingpaper

Barro (1984): “Rules versus Discretion.” *National Bureau of Economic Research*.

Beck and Wieland (2008): “Central Bank Misperceptions and the Role of Money in Interest Rate Rules.”

Berg, Jansson and Vredin, (2004): “How useful are simple rules for monetary policy? The Swedish experience.” *Sveriges Riksbank Working Paper Series*. No. 169.

Billi (2012): “Output Gaps and Robust Monetary Policy Rules.” *Sveriges Riksbank Working Paper Series*. No. 260.

Boivin (2005): “Has US monetary policy changed? Evidence from drifting coefficients and real-time data.”. *National Bureau of Economic Research*. No. w11314

Castro (2008): “Are Central Banks following a linear or nonlinear (augmented) Taylor Rule?”. *NIFE*. WP19/2008.

Faust and Leeper (2005): “Forecasts and inflation reports: An evaluation.” *Federal Reserve Board, Washington DC*.

Goodhart (2005): “The Interest Rate Conditioning Assumption.”

Hannsgen (2004): “The Transmission Mechanism of Monetary Policy: A critical Review.”

International Monetary Fund (2017): “Negative Interest Rate Policies – Initial Experiences and Assessments.” *IMF Staff Report*.

Mishkin (2004). “Can Central Bank Transparency Go Too Far?” *National Bureau of Economic Research*. No. w10829.

Petersen (2007): “Does the Federal Reserve Follow a Non-Linear Taylor Rule?” *Economic Working Paper – University of Connecticut*.

Pétursson (2004): “The Effects of Inflation Targeting on Macroeconomic Performances.” *Central Bank of Iceland Working Paper*. No. 23.

Rabanal (2004): “Monetary Policy Rules and the U.S. Business Cycle: Evidence and Implications.” *International Monetary Fund*. Paper No. WP/04/164.

Setterfield (2013): “Using Interest Rates as the Instrument of Monetary Policy: Beware Real Effects, Positive Feedbacks, and Discontinuities.”

Svensson (2010): “Inflation Targeting.” *National Bureau of Economic Research*. No. 16653.

Thornton (2004): “Testing the Expectations Hypothesis: Some new evidence for Japan.” *Bank of Japan, Institute for Monetary and Economic Studies*, Discussion Paper No. 2004-E-3, February

- ***Accessed Websites, Press Releases and Monetary Policy Reports***

Bank of Canada (2017): <http://www.bankofcanada.ca/rates/indicators/key-variables/inflation-control-target/>. (Accessed 22/10/2017).

McDermott (2017): “Explaining Inflation”, <https://www.rbnz.govt.nz/monetary-policy/inflation>. (Accessed 22/10/2017).

Fed (2013) - <https://www.federalreserve.gov/faqs/what-were-the-federal-reserves-large-scale-asset-purchases.htm>. (Accessed 29/10/2017).

FRED (2017) - <https://fred.stlouisfed.org/series/FEDFUNDS> (Accessed 23/10/2017).

Reserve Bank of New Zealand (2017) - <https://www.rbnz.govt.nz/monetary-policy/about-monetary-policy/what-is-the-official-cash-rate> (Accessed 23/10/2017).

Sveriges Riksbank (2015): “Monetary Policy Report Q1/2015.”

Sveriges Riksbank (2017) - <http://www.riksbank.se/en/Interest-and-exchange-rates/Explanation-of-the-series/Riksbank-interest-rates/> (Accessed 23/10/2017).

Sveriges Riksbank (1993): “The Riksbank’s Target For Monetary Policy.” *Press Release*. No. 5.

VI. Affirmation in Lieu of Oath

Last Name: _____

First Name: _____

Date of Birth: _____

Place of Birth: _____

I swear that I have written this thesis on my own and with no other help than the literature and other supportive material listed in the appendix. Citations of sentences and parts of sentences are declared as such, while other imitations are clearly marked and linked to original sources with regard to extent and intention of the statements made. This thesis has never been handed in to any examination authority before and it is also not yet published.

Date

Place

Signature