



universität
wien

MAGISTERARBEIT

Titel der Magisterarbeit

„Nominal GDP versus Inflation Targeting: The Case of
Imperfect Credibility at the Zero Lower Bound”

Verfasst von

Michael Berger, Bakk.rer.soc.oec

angestrebter akademischer Grad

Magister der Sozial- und Wirtschaftswissenschaften
(Mag.rer.soc.oec.)

Wien, 2015

Studienkennzahl lt. Studienblatt:
Studienrichtung lt. Studienblatt:
Betreuerin / Betreuer

A 066 913
Magisterstudium Volkswirtschaftslehre
Univ.-Prof. Dipl.-Ing. Dr. Gerhard Sorger

Nominal GDP versus Inflation Targeting

The Case of Imperfect Credibility at the Zero Lower Bound

Michael Berger

Abstract

This thesis explores the potential gains for monetary policy if the central bank pursues a nominal-GDP target instead of an inflation target. In simple New Keynesian models with the nominal interest rate at the zero lower bound, a nominal-GDP target can typically generate welfare improvements. However, if the possibility of providing forward guidance is taken into account, the potential welfare gains diminish significantly. Moreover, if central banks operate under imperfect credibility, public expectations may not necessarily be in line with the policy makers' intentions. Changes in the policy framework may then exacerbate uncertainty among the public and even result in welfare losses. Thus, abolishing the current long-term strategic policy goal by adopting a nominal-GDP target is very risky. Implementing a nominal-GDP target in addition to an inflation target might reduce uncertainty and serve as a viable alternative to targeting inflation only.

Acknowledgements

I want to express my gratitude to Gerhard Sorger for supporting me throughout the process of writing this thesis and for helping me form a multitude of loose ideas into an interesting topic.

To all my friends I met throughout my time at the University of Vienna, I want to say how grateful I am for all the seemingly endless conversations and inspiring discussions we had and for sharing the struggle we faced in some of our courses. I could not have made it without you and things would have certainly been a lot less fun. I want to address a particularly loud shout-out to Christoph and Dominic, for their efforts in proof-reading, dissecting and/or butchering this thesis.

To my family, I stand in the deepest of gratitude for giving me the opportunity to pursue my wish to study economics in Vienna and for always being by my side.

But most importantly, I want to thank Katharina for her astonishing patience with my habit of constant complaining. For the larger part of my studies, her kind and wise words of encouragement helped me through the bleakest of times.

Contents

1	Introduction	1
2	Theoretical Background	4
2.1	Discretion versus Commitment	5
2.2	The Role of Central Bank Credibility	8
2.3	Forward Guidance	17
3	Monetary Policy at the Zero Lower Bound	20
3.1	Lessons from the Pre-Crisis Literature	20
3.2	Imperfect Credibility at the Zero Lower Bound	25
3.2.1	A New Keynesian Model	25
3.3	A Note on Forward Guidance at the Zero Lower Bound	35
4	Perspectives of a Nominal GDP as an Alternative Monetary Target	38
4.1	Nominal GDP Targeting at the Zero Lower Bound	39
4.2	The Practical Side: Implementing a Nominal GDP-Target	54
5	Conclusion	58
6	Appendix	63

1 Introduction

In the decade preceding the economic crisis of 2008, inflation targeting was the widely undisputed approach to central banking. First introduced by the central bank in New Zealand in 1990, with other central banks (e.g. Chile in 1991 and Sweden in 1993) following this example in subsequent years, a remarkable consensus how and to what aim monetary policy should be conducted was formed. When describing modern macroeconomics shortly before the crisis Snowdon & Vane (2005, p. 413) state that

"[...] it is now widely accepted that the primary long-run goal of monetary policy is to control inflation and create reasonable price stability."

Similarly, Blanchard, Dell'Ariccia & Mauro (2010) point out that in a nutshell for pre-crisis monetary policy there was one target, inflation, and instrument, namely the policy rate. However they acknowledge that this narrow view was more prominent in academia than by policy makers who were often more pragmatic. Intellectual support for strict inflation targeting was predominantly provided by the New Keynesian (NK) literature.¹ Although models employed by central banks are far more elaborate than canonical textbook models, the simple framework already serves to highlight potential benefits of targeting a particular level of inflation.

In the aftermath of the recent global economic crisis the widespread consensus on how to conduct monetary policy came into question, resulting in a variety of still ongoing debates among economic scholars. This thesis focuses on one particularly interesting branch of discussion, considering the introduction of a nominal GDP target (or nominal income target) as an alternative to an inflation target for central banks. While the idea of using a nominal GDP target for monetary policy is not particularly new and has already been proposed in the 1980s (see e.g. Bean (1983)) - well before the latest economic crisis - it has experienced a surge in interest lately. For instance, Woodford (2012) and Frankel (2013) stressed the potential benefits of targeting nominal GDP in recent articles. Such a far-reaching change in the monetary framework touches on several issues that need to be thoroughly addressed. First, there is the question if nominal GDP targeting can be considered a superior framework to inflation targeting. Unfortunately there is no empirical basis to answer this question as no central bank has ever officially adopted it

¹A comprehensive treatment on the theoretical foundations of the basic NK models used for monetary policy analysis is provided for example in the textbooks by Woodford (2003) and Galí (2008).

as its monetary framework. As a consequence, the analysis has to rely on theoretical models.

In this thesis, I will focus on the possibilities that a nominal-GDP target can offer in the current economic environment. With the Zero Lower Bound (ZLB) now posing a real obstacle to monetary policy the analysis of monetary policy against the background of the ZLB and the resulting model dynamics is a reasonable if not necessary step when comparing the two monetary regimes. In a recent working paper Billi (2014) uses a simple NK model for a comparison of nominal-GDP targeting and flexible inflation targeting subject to the ZLB. The analysis is carried out in a rather stylized model including neither capital nor costs associated with changes in the policy framework. It does however serve to highlight the key trade-offs policy makers are facing under these two targets in an intuitive fashion. Very much in the spirit of previous research in monetary policy, the analysis considers the cases of optimal commitment, optimal discretion and two policy rules with forward guidance, namely a Taylor rule and a nominal GDP level rule.

But this analysis does not take the effects of central bank credibility into account. As credibility plays a crucial role in the effectiveness of monetary policy incorporating credibility imperfections allows for a more in-depth exploration of monetary dynamics at the ZLB. Turning a blind eye to the costs associated with a regime change can be considered a shortcoming in this discussion. Bodenstein, Hebden & Nunes (2012) discuss the influence of imperfect credibility in an economy against the background of a ZLB. By applying the quasi-commitment approach proposed by Roberds (1987), Schaumburg & Tambalotti (2007) and Debortoli & Nunes (2010) in a simple NK model, they highlight that when the ZLB is binding, central bank credibility is critical for monetary policy, as a lack of credibility can no longer be offset by further decreases of the policy rate. Theoretical considerations aside, there remain the practical issues of the proper implementation of a new monetary policy framework.

Interpreting the results of Billi (2014) under the light of imperfect credibility, I find that moving away from an inflation target to a nominal-GDP target is not desirable in the current environment in particular if the possibility of forward guidance is accounted for. Nevertheless, adopting a nominal-GDP target in addition to a inflation target as proposed by Woodford (2013) shows promise, as the risk for central bank credibility is reduced, while most benefits of a nominal-GDP target remain intact. Further research is needed before definite conclusions can be drawn.

The thesis will begin with a discussion of the theoretical background of modern monetary policy that is needed for the analysis of the research topic. The discussion of the merits of commitment, in contrast to discretion will be addressed as well as the importance of central bank credibility. In the third section, the challenges of central banking at the ZLB will be discussed on the basis of recent articles towards this topic. The fourth section will consist of a review on recent research that has been carried out, tackling the issue whether or not a nominal GDP target would be preferable to an inflation target. Practical elements in regards of a change in monetary policy framework will also be addressed, as well as how an implementation of a nominal GDP target could be carried out in practice. In the concluding section, the findings from the preceding sections will be brought together in order to address the question of whether the adoption of a nominal GDP target could indeed be considered a favourable move.

2 Theoretical Background

The theoretical works that established inflation targeting as the main framework for monetary policy prior to the crisis, can be found in NK literature. The basic NK model has been the workhorse model for monetary policy analysis well before the crisis and still is in many central banks. Some features are drawn from the Real Business Cycle (RBC) models, such as the assumption of infinitely-lived representative households seeking to maximize lifetime utility from consumption and leisure, subject to their intertemporal budget constraint and large number of firms with access to some identical technology subject to random shocks. This Dynamic Stochastic General Equilibrium (DSGE) structure is then combined with assumptions deviating from the standard RBC framework. Key elements of NK models are *monopolistic competition*, the *presence of nominal rigidities* (i.e. firms cannot adjust their prices freely) and *short run non-neutrality of money*. Notably, these three features of NK models were already present in the NK literature of the late 1970s and 1980 that developed parallel to RBC models. However, emphasis there was on providing microfoundations for price stickiness and the resulting non-neutrality of money. The models used were often static or made use of reduced form equilibrium conditions. (Galí 2008, pp. 4ff)

In the canonical NK model with sticky prices à la Calvo as the only friction in the economy, Galí (2008) shows that policy makers do not face a meaningful tradeoff between stabilizing price and output, since at a fully stabilized price level, output is at its natural level, i.e. the output gap is zero. In this scenario, following a *strict inflation target* is the optimal choice of policy. In practice, central banks typically have to deal with considerable trade-offs especially in the short-run. The notion of strict inflation targeting thus plays virtually no role in actual monetary policy. Even central banks with an outspoken inflation target cannot simply focus on stabilizing inflation alone due to the consequences for output or employment. A more practical approach is to only partially accommodate monetary policies to inflationary pressure in the short run in order to circumvent instability in output and employment, but still pursue an inflation target in the medium and long run. This kind of policy accommodation is referred to as *flexible inflation targeting* (Galí 2008, p. 95).

Galí (2008, pp. 185f) points out that a key finding in the basic models of the NK literature is that the expectations of the private sector on the future development of the short-term interest rate, i.e. the central bank's policy instrument, are crucial for the transmission

of monetary policy. At any point in time, the expectations of future short-term interest rates and inflation determine aggregate demand and output, while current inflation is a function of current and expected levels of economic activity. In this sense, setting of the short-term interest rate is not the only determinant of aggregate output and inflation, since they also depend upon the anticipated path of this policy instrument. The effective management of private sector's expectations by the central bank is the driving force behind the success of monetary policy.

As a consequence, a policy target that is both easy to grasp and communicate is imperative in central banking. Overall the consensus for the last two decades was that commitment to stabilizing prices would offer exactly such a comprehensible way of policy conduct. Ergo, inflation should not only be kept stable, but also at a very low level, in most cases around 2 percent (Blanchard et al. 2010, p. 4).

2.1 Discretion versus Commitment

For the analysis of monetary policy in a NK model, it is useful to elaborate on the notion of *commitment* and *discretion*. Galí (2008, pp. 95ff) shows that in the presence of policy tradeoffs combined with the forward-looking nature of inflation, the best way of pursuing monetary policy for a central bank is fully committing to a state-contingent policy plan. Such a policy stance is referred to as full commitment or the *Ramsey plan*. Alternatively, the optimization problem could be approached sequentially, such that the central bank re-optimizes in each period. This is referred to as discretion. In this case the monetary authority makes policy decision in each period and does not commit to any actions for the future. Woodford (2003, p. 19) acknowledges that at first glance, discretionary policies would seem the more favourable choice, given that unexpected events affecting inflation and real activity constantly occur. Therefore it would only seem reasonable that the optimal level of interest rates at any given point in time, should depend on what has actually occurred. The level of policy rate should be determined only after unexpected shocks have been observed.

Thus it would seem justified to reduce the underlying dynamic optimization problem to a sequence of independent choices at each succession of decision dates. However, it is only valid to apply standard dynamic programming methods to optimally control systems, which evolve mechanically in response to the controller's action. With monetary

stabilization the problem is different, as the history of instrument settings is not the only determinant of the effects of the central bank's policy. Rather, the consequences of central bank actions also depend on the expectations the private sector has with respect to future monetary policy. At each point a decision is made in the case of discretionary (sequential) optimization, prior expectations are taken as given instead of something that is influenced by policy itself. For these reasons, the outcome of discretionary policy is only suboptimal. Under the hypothesis of rational expectations, the possibility to predict central bank behaviour determines the endogenous expectations of the private sector at earlier points in time. In this sense, private sector expectations can be formed to a certain extent by central banks, if commitment to new policy (or deviation from the old) can be convincingly communicated to the public. (Woodford 2003, p. 19)

The desirability of commitment in monetary policy follows from benefits due to the anticipation of the policy by the public. The expectations of the private sector ease the short-run trade-off of the central bank. This in turn can raise output above its natural level, potentially generating welfare improvements during a recession. As the public expects a gradual return of output to its natural level, the effect on inflation is on the other hand not as pronounced. In other words, if a central bank is able or willing to (credibly) commit to a policy plan, it can circumvent the inflation bias (i.e. the tendency to set discretionary policies in such a way that an overly ambitious output target is achieved by causing high inflation) inherent in discretionary policies.

Woodford (2003, pp. 15ff) stresses that central banking is in many ways about the management of expectations. The control of overnight interest rates in the interbank market for central-bank balances, for instance the federal funds rate in the U.S., would only imply that the costs of overnight borrowing would increase for this particular night. Therefore it would have only little effect on private sector consumption behaviour, even if the change would be of considerable size. In this sense, a change in the current level of the overnight interest rate would be by itself not very effective as a policy tool were it not for the shaping of private sector expectations. A change in the overnight interest rates has an impact on other financial-market prices such as long-term interest rates, exchange rates and equity prices which are all plausibly linked through arbitrage relations. Typically, central banks can directly influence these short-term interest rates and thereby indirectly influence other financial-market asset prices linked to it. Moreover, the current level of short-term interest rates is not the deciding factor in the pricing of long-term financial assets. The channel at work here are the expectations on the future path of short-term

interest rates over a longer time horizon, that mainly determine the prices of these other financial assets. Therefore the ability of a central bank to influence and form market expectations about the development of short-term interest rates like the overnight rate are crucial.

This also highlights the importance of clear communication to the public and clear decision making by the central bank. If market participants have more information on the intentions and actions of the central bank, the degree in which policy decisions influence market expectations will be greater. The better the expectations can be managed, the stronger the stabilization effect of monetary policy can be. Transparency of the actions of a central bank is insofar not only desirable from the perspective of democratic legitimacy of monetary institutions, but also from a practical point of view, with respect to the effectiveness of monetary policy. The public should have a clear understanding of the systematic way a central bank decides on the appropriate response to future developments. Otherwise the benefits of policy commitment cannot fully manifest. This does however not mean that a central bank would have to blindly follow a rule forever once it has been adopted, nor does it mean that it has to plan out the implications of the rule on every possible future development or economic disturbances. It would be enough for a forward-looking private sector to have no reason to assume that a central bank will behave in a systematically different way than its communicated framework would suggest. In other words, the central bank can be expected to behave in a predictable manner as long as its basic understanding of the economy does not change. If this understanding of the economy does in fact change - as would be the case in the face of scientific advances and improved knowledge - the framework or policy rule can be adapted. As long as changes in monetary policy are well justified and backed by new scientific insights, this will not curb the credibility of a central bank's ability and willingness to commit to certain policies in the future. (Woodford 2003, pp. 17f)

Schaumburg & Tambalotti (2007, p. 303) point out that economic planners operate under constraints that depend on their own current and future choices when dealing with rational and forward-looking agents. The effect that those choices have on current private behaviour, must therefore be internalized by optimal policy. As an example, Schaumburg & Tambalotti (2007) consider a central bank facing a trade-off between inflation and unemployment, where the current level of inflation is also dependent on expectations of future inflation levels. If the central bank in this case can credibly announce a future policy tightening that goes beyond the level needed to dampen the forecasted inflationary

pressure, it can lower the expectations on future inflation and hence ease today's trade-off. However, such an optimal policy that utilises the net marginal benefit of such an announcement to its full extent, is time-inconsistent. As soon as the promised recession takes effect, the announcement of policy tightening that helped to moderate expectations becomes regrettable. To avoid the recession, policy makers at the central bank would have to step back from the previous announcement. On the other hand, this would have a negative impact on the credibility of the central bank's ability (or willingness) to commit to their announced policies, which is an indispensable prerequisite for the feasibility of the optimal policy. This example serves to highlight the dilemma policy makers face: The conflict between the optimality of commitment to a policy plan and the ex post incentive to abandon it. Central banks can only utilise the potential benefits of commitment in full under the condition that the private sector is entirely convinced that policy makers will stick to their announced policy plans. However, there is no reason for the public to believe that a central bank will not deviate from the announced plans ex ante.

In the standard NK literature, the models are often set up along the lines of full commitment, full discretion or policy rules. In all cases individual choices follow a strict binary logic, as the public can either believe or not that the central bank follows an announced policy plan. This is also the case in the analysis of inflation and nominal-GDP targeting at the ZLB provided in Billi (2014). But the possibility of regime changes that cause policy deviations, has a considerable impact on private sector expectations and thus on the effects of the policy itself. Therefore incorporating the effects of central bank credibility in the policy analysis at the ZLB can provide valuable insights.

2.2 The Role of Central Bank Credibility

For monetary policy it is not only relevant whether or not a central bank is indeed *willing* to commit to a policy plan, but rather to what extent the public *believes* in this willingness, the issue of central bank credibility deserves some more in-depth treatment on its own. In the history of central banking, the topic of credibility and transparency is actually fairly young. Up until the 1990s and the subsequent rise of inflation targeting as the main paradigm in monetary policy, central banks were not keen on communicating their objectives or strategies with the public. In fact it was even considered to be more favourable for central banks to operate as a secretive institution and maintain a veil on their policy framework. As Mishkin (2004) points out, the basic idea behind this secretive

behaviour was to insulate central banks as far as possible from political influence so that central banks could not be exploited for political gains. As, for example, politicians could put pressure on a central bank to conduct excessively expansionary monetary policy to exhaust the trade-off between employment and inflation. Typically, the time horizon of governments - or politicians in general for that matter - is shorter than desirable from the perspective of monetary policy.

Of course, this secretive approach came with several setbacks that led to its eventual overhaul. First, there is the blatant incompatibility with the core democratic principles. Although shielding central banks from political influence to avoid non-optimal opportunistic monetary policy seems desirable, it should still be possible to hold central banks accountable for their actions. A necessary prerequisite for this is that the public is aware of what the central bank is doing which in turn requires some sort of communication. Another critical aspect was that without communicating their objectives, central banks could not shape public expectations. When the NK literature of the 1990s shed light on the importance of the management of expectations, transparency and proper communication were identified as key determinants to the success of monetary policy and the veil over central bank objectives was lifted.

This shift in approaching central banking can also be observed in a study conducted by Blinder (1999) in which central bankers and economists were asked questions on the topics why credibility matters and how it can be built. For each question, respondents assigned points on a scale of 1 to 5, where 1 point signalled lowest importance and 5 points the highest importance. The question "How important is credibility to a central bank?" was answered with a mean of 4.83 by central bankers (with a standard deviation of 0.37). Economists seemed somewhat less enthusiastic, and not as unanimous with a mean response of 4.23 but with a higher standard deviation of 0.85. When asked about the why credibility was important, central bankers identified credibility to be most important in order to keep inflation low.

Woodford (2013) summarizes that the argument for commitment as the desirable approach to monetary policy conduct in the literature, mainly boils down to the idea that policy commitment helps to keep deviations of inflation from a definite and relatively low value for as short as possible. Central banks with an explicit inflation target (to which Woodford also counts the US Fed since January 2012) only commit to keep inflation near the target rate in the medium run. Or, put differently, that they try to return

actual inflation back to its target over the course of two or more years ahead. However, as pointed out before, central banks do not make policy decisions with their eyes solely on inflation. In most cases they follow the approach of flexible inflation targeting, wherein policy targets carry an explicit reference to other stabilisation goals that are pursued as well. A necessary prerequisite for these additional stabilisation goals is that they are consistent with the envisaged medium-run inflation target. Public confidence in the central bank's ability to reach its medium-term goals, depends crucially on these short-term policy measures. Therefore, it is important that the framework for near-term policy decisions is comprehensible and can also be expected to deliver a certain average inflation rate over time. If the near-term decision making is not properly communicated, there may be only little confidence in the central banks ability to achieve these goals, or more dramatically, this confidence could vanish in face of an unexpected shock. In other words, tattered credibility can critically impair a central bank's ability to conduct monetary policy in the short-run and consequently also in the medium to long-run.

Although clearly an important topic for theoretical research in monetary policy, central bank credibility is in many cases not explicitly addressed in the macroeconomic models used in research. Roberds (1987) provides a modelling framework where policy is set by a sequence of administrators, whose turnover is determined by random draws. This offers the possibility that the frequency of regime changes can be interpreted as a measure for credibility. Schaumburg & Tambalotti (2007) incorporate this framework into a simple NK model to address the issue of rules versus discretion in monetary policy. The background for their research is the problematic position of a central bank between the optimality of policy commitment and the ex-post incentives to deviate. The basic idea is to study the influence of uncertainty on monetary policy by granting agents the ability to doubt, and form their expectations accordingly. This is done by assuming that in each period a new central banker, j , might be called into office with an exogenous probability, α , replacing the predecessor. At the beginning of each new regime the newly appointed administration will renege on the promises of the predecessors and commit to a new - as of this period optimal - policy plan. The public is aware of possible regime changes and forms expectations such that doubts about the outstanding promises of the current administration are accounted for. Essentially, the modelled economy can be thought of as having access to a limited commitment technology, that is, policy makers can with certainty fulfil their own promises, but they cannot affect the policy set by their successors. Thus it is expected that the successors deviate from the existing policy plan and formulate their own policies independently of their predecessors behaviour. Given these

expectations, it is indeed optimal for new administrators to do so and then commit to this new policy plan over the course of their mandate. The resulting equilibrium and the supporting limited commitment technology are referred to as *quasi-commitment*. Put differently, quasi-commitment is a way of modelling a middle-ground between commitment and discretion. In fact, quasi-commitment coincides with full commitment or full discretion if α is set to 0 or 1 respectively. As a consequence, the quasi-commitment technology can neither improve on the full commitment solution of the planning problem nor can it yield worse results than full discretion.

Schaumburg & Tambalotti (2007, p. 304) interpret the probability of a regime change, α , as a measure of central bank credibility. In the model, the public bears in mind the possibility that the current policy plan might be abandoned. The degree to which the public doubts that the current policy plan will persist in the next period is reflected in the value for α . A higher value of α indicates a higher mismatch between the public's perception and the current policy plan and thus a lower central bank credibility. Hence, the relation between α and the credibility of the monetary regime is of an inverse nature, so α^{-1} - defined as the average length of the period between two re-optimizations - serves as a measure for the credibility attributed to the current regime. Moreover, following this notion of credibility, it is not an attribute of the optimal policy plan, but rather a quality of the central bank itself perceived by the public. This implies that different central banks can have different levels of credibility. However, quasi-commitment imposes a given level of credibility without explaining its origin, which one could argue to be a shortcoming in terms of modelling. This depends on the focus of the research though, and would only constitute a problem, if the premises of credibility were the subject of research.

Using a calibration to standard U.S. data (following Woodford (2003)) Schaumburg & Tambalotti (2007) illustrate the effect of credibility on the transmission mechanism of the model. The expected duration of the quasi-commitment regimes is set to two quarters and two years respectively, i.e. $\alpha^{-1} = 2$ and $\alpha^{-1} = 8$. For the regime-change shock, η_t , several kinds of impulse response functions (IRFs) are analysed, since the effect of a shock on the dynamics of the model is non-linear and the interaction with the linear structural shocks (a cost-push shock and a shock to the efficient interest rate) is non-trivial. The first type of IRFs can be described as *within regime* responses that highlight the dynamics of the system, if no re-optimization would occur over the observed period. In this sense, they are describing a scenario of a central bank regime that is in office for an

unexpectedly long time. The second type of IRF is conditioned on a specific realization of regime-change shocks. A third type of IRFs are the ex ante averages of all possible conditional IRFs integrated over the distribution of the corresponding re-optimization draws. This type can be seen as representative of the expected evolution of the system after an initial shock took place. The analysis of the dynamic responses is then done using a one standard deviation i.i.d. cost-push shock. In response, a central bank under discretion moves its policy instrument with the shock, thus bringing the economy back to its steady state immediately after the impact has faded. In the case of an i.i.d. impulse the economy is driven into a sharp recession by the attempt to combat the inflationary shock. Under commitment the central bank can take advantage of the possibilities offered by its influence on inflationary expectations - in this case lowering them - at the time of the shock. Using limited but persistent movement in the interest rate, the central bank can credibly promise a protracted mild recession and deflation. With an average regime duration of two years the dynamic response of a system under quasi-commitment lies very close to the one under full commitment. This suggests that relatively low levels of credibility are sufficient to produce outcomes that are close to being optimal. Even with an average regime duration of two quarters, the path of the economy is arguably close to the case of full commitment, but with a more pronounced recession and more painful disinflation.

Schaumburg & Tambalotti (2007) emphasize however, that the first type of IRFs is not very useful when describing the "typical" behaviour of a quasi-commitment economy since it only models one particular and atypically long monetary regime. This typical behaviour is better captured by the second type of IRFs with the dynamics following a seesaw pattern generated by the re-optimizations at the regime changes. Under quasi-commitment, the newly inaugurated central bankers deviate from the time-inconsistent plan of their predecessors and set the interest rate below average, thereby boosting both output and inflation. Following this re-optimization, the variables slowly converge back to their respective within regime steady states which coincides with the equilibrium of the economy, that would prevail if no further re-optimizations would take place. One should note however, that the steady state differs from the unconditional mean of the model, which Schaumburg & Tambalotti (2007) normalize to zero. The steady state however corresponds to the quasi-commitment response, conditional on no re-optimizations, with the same normalization as the second type IRFs. The steady state of interest then lies above average, whereas both output gap and inflation lie below, which can be interpreted as the price an unexpectedly long incumbent central bank has to pay for its credibility

deficits. With the last type of IRFs, the results of the average quasi-commitment responses are placed more or less in the middle of the full discretion and full commitment extrema. In this analysis the regime duration is set to two quarters. Given this short regime duration one could have expected the results to be closer to the discretion case than to full commitment at a first glance. This result is due to the non-linear effect of credibility on the transmission mechanism, so that even small gains in credibility can help to significantly increase the central bank's ability to influence public expectations and hence take advantage of most of the commitment benefits. Apart from the effect quasi-commitment takes on the dynamic policy response to exogenous shocks, another interesting observation is the effect of credibility on the average inflation bias. In the benchmark calibration of the model, average inflation has a range from zero under full commitment to around five percent under discretion. With a relatively low average regime duration for two quarters the bias is already cut by approximately half and declines further with increasing regime durations exhibiting a convex pattern. With an average regime duration for two and a half years, the bias lies around 0.5 percent. A similar pattern can be observed for the output though smaller in magnitude.

In the final step, Schaumburg & Tambalotti (2007) analyse the effect of quasi-commitment on welfare. Figure 1 depicts the minimum expected welfare loss originating from various quasi-commitment equilibria as a function of the average regime duration, i.e. credibility. The welfare loss is normalized such that it can be presented as relative to commitment and discretion. Welfare gained by optimal commitment is set to 1 and is found in the upper left corner of the figure, whereas welfare associated with full discretion is set to 0 and hence found in the lower right corner. Most of the welfare gains accrued by credibility appear at relatively low levels. For example, if central bankers are on average two quarters in office, the welfare loss due to the deviation from the optimal commitment path is reduced by 70 percent. With an average monetary authority regime duration of two and a half years, welfare loss is already reduced by 95 percent, which highlights the nonlinear nature of the effect of credibility, especially when measured in welfare terms. Moreover, these results are also robust to changes in the loss function and changes in the shock distribution. Additionally, when setting the relative weight on inflation in the central bank's objective function to 1, the considerable influence of the average inflation bias on the nonlinearity of the relationship between credibility and welfare is pronounced. In summary, Schaumburg & Tambalotti (2007) point out that in the benchmark calibration of their model, an economy where policy makers are able to commit on average for one year, would find its average inflation rate within a range of 1 percent around the

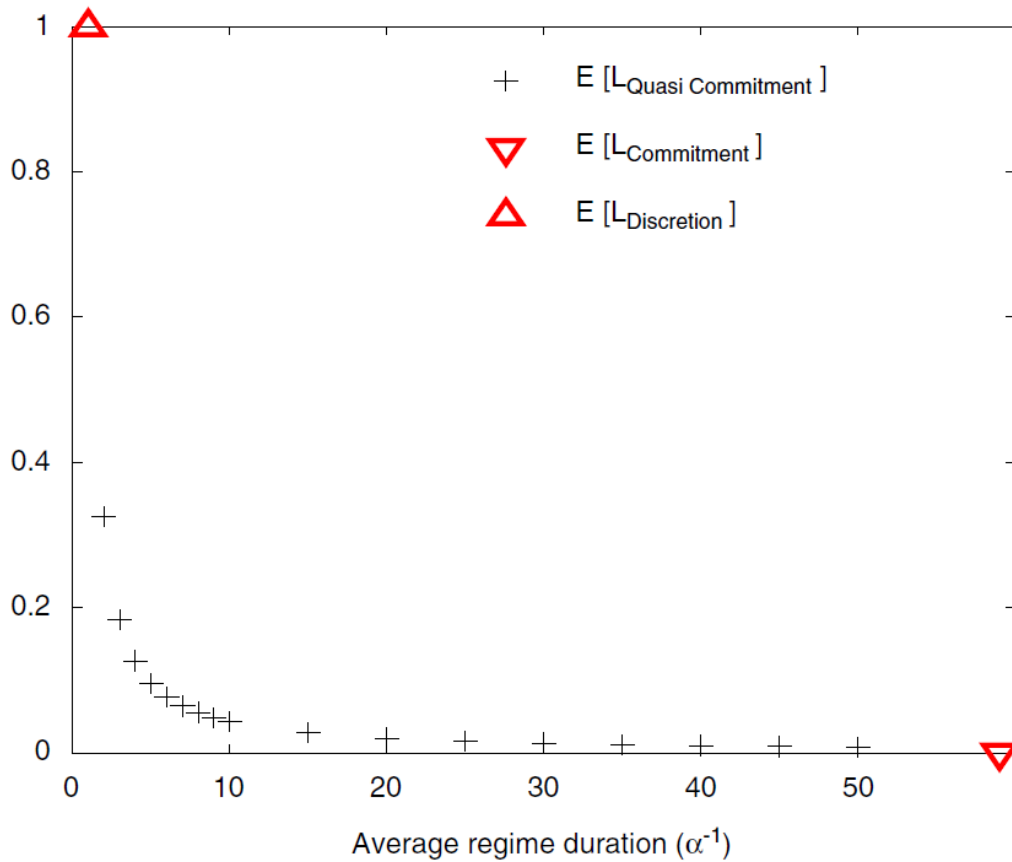


Figure 1: Welfare loss as a function of average regime duration. Source: Schaumburg and Tambalotti (2007, p. 319)

optimum. Thus, while standard deviations of the output gap and inflation are practically equal to those in the optimum, the welfare gains in contrast to a discretionary regime would be greater than 90 percent.

The results presented in Schaumburg & Tambalotti (2007) shed light on some interesting properties of credibility in central banking. If indeed most of the gains from commitment can be achieved at relatively low levels of credibility, it would suffice for central bankers to convince the public that they will honour their promises over a reasonable time horizon and not commit to a plan forever. However, it is worthwhile to point out that while offering a very intuitive picture of the dynamics behind credibility, policy conclusions should only be drawn from them with caution due to the simplistic nature of the model. The contribution lies first and foremost in the approach to modelling credibility itself,

offering a practical method to include credibility in monetary analysis based on DSGE models, that goes beyond the constraints of pure commitment and discretion paths. The framework proposed by Schaumburg & Tambalotti (2007) is only applicable within linear quadratic frameworks though. Debortoli & Nunes (2010) apply the quasi-commitment approach to a model of fiscal policy but in doing so develop the methodology further. The method they put forth is more efficient in the sense that it only relies on the solution of one fixed point problem. This is especially beneficial when dealing with endogenous state variables, which can be an interesting feature in commitment problems. As of now, articles using the quasi-commitment approach in their models typically incorporate these extensions.

In a recent article Dennis (2014) takes up the quasi-commitment approach to examine the behaviour of a central bank seeking to conduct optimal monetary policy under imperfect credibility while it is simultaneously harbouring doubts about its models. The main issue tackled is the relationship between the forward guidance offered by a central bank and the models it uses to forecast inflation and resource utilization. As mentioned before, central banks typically try to offer the public an outlook on future monetary policy to increase the policy's impact on current economic activity by influencing expectations. The term forward guidance typically refers to information provided on the future of the policy instrument itself. However, as Dennis (2014, p. 218) notes, the effectiveness of forward guidance is dependent on the central bank's credibility and on the potential of the models used for forecasting to be misspecified. Hence, the model used in the analysis features imperfect credibility via quasi-commitment, but at the same time also employs a robust control approach by Hansen & Sargent (2008). This allows policy makers to base monetary policy decisions on models while simultaneously voicing their concerns about the accuracy of the models. In trying to achieve robustness with regard to model misspecification, central banks formulate their policy against background of a potentially distorted approximating model in order to guard against the worst still tolerable misspecification. The effects of imperfect credibility and model uncertainty on optimal monetary policy are then examined in the model proposed by Smets & Wouters (2007).

The key finding is that credibility is a crucial property for a central bank, notwithstanding whether the model is known to be correct, or if doubts about the accuracy prevail. Although building on the quasi-commitment approach and at first glance appearing to be in line with the findings of Schaumburg & Tambalotti (2007), some notable differences

arise in the relationship between average regime duration and the welfare gains from commitment. In contrast to Schaumburg & Tambalotti (2007), the bulk of credibility gains is not generated at low levels of regime duration. For example, Dennis (2014, p. 225) notes that in order to reap around 95 percent of commitment gains requires around 25 quarters in his model, whereas a similar result requires only 10 quarters with Schaumburg & Tambalotti (2007). Therefore, short average regime durations fail to close the larger part of the gap between the commitment and discretionary policies. Hence even the experience of relatively small falls from perfect credibility can noticeably curb the effectiveness of monetary policy. Regarding the dynamic responses of the system, Dennis (2014) uses two different types of responses, both of which are also used in Schaumburg & Tambalotti (2007). First, the *within regime* responses, where a policy maker remains in office for all future periods and secondly the *expected* responses which take into account the regimes changes occur stochastically. Following Bodenstein et al. (2012), within regime responses can be seen as a form of forward guidance issued by the central bank, i.e. a state-contingent forecast subject to a particular shock and no regime change occurring in the future. Here, a main finding is that central banks facing imperfect credibility have an incentive to announce more drastic (in the sense that the implemented policy during the regime is tighter for a longer time than it would be under commitment) within regime responses to leverage credibility in order to stabilize inflation when confronted by a price-markup shock. The effects on within regime responses arising from the concerns about robustness are quantitatively less important, in relation to those of imperfect credibility. However, as far as the effect of robustness on policy responses to shocks goes, they are more important for central banks endowed with low levels of credibility. Although the desire for robustness helps to improve monetary policy at essentially all levels of credibility, it can prove particularly beneficial for central banks with very low credibility. As such, desire for robustness can in these cases constitute a viable substitute for credibility.

In conclusion, credibility plays a pivotal role in central banking due to its deciding influence on the ability of central banks to manage public expectations. But building up credibility is anything but a simple task as it requires not only clear communication with the public, but also commitment to announced policy plans (at least to a certain extent). The reformulation of policy targets and plans thus bears a risk for credibility and consequently for the effective management of expectations. In view of the research question, whether following a nominal-GDP target could improve on inflation targeting, this risk concerning a regime change should be taken into account.

2.3 Forward Guidance

The topic of forward guidance has become a central issue in modern central banking. As mentioned before, the term refers to the act of a central bank issuing forecasts on the policy instrument to the public in order to effectively influence private sector expectations. Therefore, the use of forward guidance as a monetary policy tool is not new, though motivation and its scope have changed considerably in the course of the recent economic crisis (den Haan 2013). Additionally, forward guidance can play a crucial role when there are constraints on policy instruments. This will be an important issue at a later point, when the Zero Lower Bound on the policy rate is discussed in more detail.

Campbell, Evans, Fisher & Justiniano (2012) discuss the macroeconomic effects of forward guidance by the Federal Reserve. They argue that, when facing a large output gap and stable low inflation close to the target, further monetary measures are needed. With the short term interest rate close to zero, the Federal Open Market Committee (FOMC) finds itself devoid of its primary policy instrument. However, public announcements of central banks' intentions may serve as a substitute for lower interest when they are already close to zero. A similar point is made by Praet (2013, p. 28) who holds that there is evidence for the view that the way in which a central bank announces its decisions may be as important as the decision itself. Moreover, Campbell et al. (2012) make a very useful distinction in their article between two types of forward guidance. On one hand the so-called *Odyssean*² forward guidance, in which a central bank is publicly committed to take certain monetary actions in the future. On the other hand there is *Delphic*³ forward guidance, which consist of macroeconomic forecasts and likely or intended future monetary action based on the expected economic fundamentals and the central banks own policy goals.

In the Odyssean case, the central bank effectively ties its hands by committing to a particular monetary policy in the time to come. If the public deems this promise credible, this simply corresponds to a commitment plan. However, once a credible announcement has been put in place to improve today's macroeconomic performance, as sketched out before, the central bank can fall victim to the temptation of reneging on its promise when the time of actual implementation arrives. Withdrawing from promised monetary

²Odyssean refers to Odysseus, the hero of the famous Greek epos, who tied himself to the mast of his ship so as not to be lured by the Sirens' song

³Another reference to Greek mythology, namely to the Oracle of Delphi

policy would of course only come at severe costs for credibility, putting the effectiveness of future policy announcements at stake. This is not the case with Delphic forward guidance. Though also aiming at improving today's economic performance, this should mainly be achieved by trying to reduce uncertainty amongst the public. Arguably, the effect is weaker than in the Odyssean case as the absence of a binding commitment to a policy plan curbs the impact on private expectations. But this comes with the advantage that the reputation of the central bank is not at stake if it deviates from the indicated path. Of course, it must be noted that a classification whether a statement released by a central bank is Odyssean or Delphic in nature may not always be entirely clear, and one can easily imagine cases where borders are somewhat blurred.⁴

In an empirical context, Campbell et al. (2012) show that the FOMC has in the past often deliberately communicated their intended actions to macroeconomic developments. In fact, 80 percent of the FOMC's deviations from a simple interest rate rule were anticipated by market participants and forecasters. Moreover, surprises in the policy announcements by the FOMC tended to substantially influence Treasury bond rates, corporate borrowing rates as well as private macroeconomic forecasts. They also find that news of substantial monetary tightening in the past raised market interest rates, but meanwhile also raised inflation forecasts and lowered unemployment forecasts. The proposed explanation is that in some cases the public suspects some Delphic content in policy announcements that is not explicitly tied to economic fundamentals. Overall, it is concluded that difficulties in communication do not pose an insurmountable obstacle in providing Odyssean forward guidance for the FOMC. Given that other major central banks such as the European Central Bank (ECB) and the Bank of England have provided forward guidance in the past, it can be expected that the results hold for them as well. Another question that is addressed is related to the potential risk of Odyssean forward guidance to the Federal Reserve's mandate to maintain price-stability in case of unexpected economic recovery or a sudden rise in long-run inflation expectations. Using the estimated DSGE model of the Chicago Federal Reserve, the authors find this risk to be manageable if forward guidance is conditional on specific thresholds, the crossing of which would call for an increase in interest rates by the Federal Reserve. In the simulation, the threshold is reached if in the US economy either unemployment falls below 7 percent or medium-term expected inflation rises above 3 percent.

⁴In fact, Campbell et al. (2012) themselves open the paper by asking whether a certain statement issued by the FOMC in April 2012 should be regarded as Odyssean or Delphic

Providing forward guidance on the short-term interest rate may prove a viable tool for central banks when it comes to affecting public expectations. However, what seems desirable from a theoretical perspective need not necessarily entail the desired effects in practice. Solely providing Delphic forward guidance considerably reduces the risk to credibility, but this comes at the costs of a highly reduced impact on public expectations whereas Odyssean forward guidance makes reneging on past promises a very risky endeavour. Apart from this inherent risk, the effectiveness of Odyssean forward guidance can vary as well, depending on the way it is communicated by the central bank. The more explicit forward guidance is issued, the more powerful its impact will be. This could in fact be observed in the past few years. For instance, Williams (2014) points out that when the FOMC recently made its announcements more explicit, the effects on policy expectations turned out to be more pronounced.

3 Monetary Policy at the Zero Lower Bound

To the extent that for monetary policy price stability was considered to be the main mandate, the aftermath of the economic crisis of 2008 revealed the pitfalls of the previous consensus on monetary policy. Aiming at stable inflation at relatively low levels of around 2 percent, turned out to possess the relatively severe setback of limiting the vigour of monetary policy when facing an economic downturn. As a lower average inflation rate typically corresponds with a lower average nominal rate (Blanchard et al. 2010), the scope of cutting the short-term interest rate in reaction to adverse shocks is reduced as central banks typically refrain from setting the policy rate below zero, even if the policy rules would theoretically advise to do so. A boundary called the *Zero Lower Bound*. Of course, the possibility of hitting the ZLB⁵ and the entailed consequences have already been treated in the past following Japan's experience with near zero short-term interest rates in the 1990s (see e.g. Eggertsson & Woodford (2003)). The sudden change of the playing field for monetary policy owing to the recent economic crisis revived interest for research on this topic though.

3.1 Lessons from the Pre-Crisis Literature

Blanchard et al. (2010) point out that prior to the global economic crises of 2008 the liquidity traps of the Great Depression in the 1930s which combined deflation with low nominal interest rates, were considered to be a thing of the past and merely reflected policy errors which could now easily be avoided. The case of Japan in the 1990s, where deflation, near zero short-term nominal interest rates and a continuing slump reoccurred, showed that these economic phenomena were not ghosts of the past. Yet the Japanese experience was largely dismissed as a mere reflection of the unwillingness of the Japanese central bank to commit to future inflation and monetary growth. In fact, one key result from the research following Japan's economic adversity was that although the ZLB was indeed a problem that could occur in economies with sufficiently low inflation targets, the episodes at the ZLB would in general be infrequent in appearance and only be of short duration. However, most of this research was based on an economic environment resembling the economically calm period of the Great Moderation in the U.S. from the

⁵The notion of a zero boundary on short term interest rates is sometimes also referred to as a *liquidity trap*.

1980s to the 1990s (Williams 2014). Chung, Laforte, Reifschneider & Williams (2012) use a range of structural and statistical models to examine whether the threat posed by the possibility of hitting the ZLB had been underestimated in pre-crisis research. The findings highlight that a wide range of then employed macroeconomic forecasting models using postwar data from the U.S., generally found the probability of a prolonged ZLB-episode to be virtually non-existent. From this perspective, the events following the recent crisis can either be regarded as the manifestation of an extreme case of bad luck, or a warning that the models contained some severe misspecification that made bad outcomes more improbable than they actually are. In a recent working paper, Williams (2014) points out that when using data on the United States for the fifty years prior to the crisis, the probability of experiencing a downturn of such magnitude as in 2008, is less than one quarter of one percent, or put differently, one would expect such an downturn to occur once every 430 years. When using the variance in the data of the Great Moderation period, the probability is even lower with the probability of a comparable downturn around 0.003 percent or once every 33,000 years. Considering U.S. data for the much longer interval from 1871 to 2012 produces a different picture. Here, an economic downturn of this magnitude is not only possible but even probable, roughly occurring every thirteen years. Downsides of research with such long time data series are the issues of data availability and structural changes that might render data dating back so far into the past irrelevant for present topics.

Another point made by Williams (2014) is that in general empirical evidence on the severity and duration of ZLB episodes was very limited before the crisis. Thus, researchers had to rely on data artificially generated via stochastic simulations of macroeconomic models. While also depending on the details of the model specification and other assumptions, the size and the duration of the shock hitting the model economy are the two key features, that determine the simulated probability of hitting the ZLB and the resulting economic disturbances. Typically, the shock processes were estimated on the basis of historical data giving rise to the questions of which data should be used. As mentioned before, using postwar U.S. data as a basis for simulations makes considerable economic downturns much more improbable than they are. This in turn leads to an underestimation of the size of the shocks. But in addition, macroeconomic models often incorporate a great deal of correction to the mean, as is consistent with postwar U.S., leading to an additional underestimation of the duration of the shocks.

The main lessons that should be drawn from the experience of the past six years is that

the ZLB does indeed pose a serious obstacle for monetary policy conduct, both in terms of incidence and constraint on the effectiveness of future policy. Nevertheless, monetary policy is not powerless when an economy faces the ZLB. Eggertsson & Woodford (2003) emphasize that it is not the direct effect of a change in the level of overnight interest rates that is deciding for the effectiveness of monetary policy, but rather the management of the public's anticipation on the future path of short-term interest rates, which in turn determines the equilibrium long-term interest rate. Hence, when the policy instrument is facing its constraint and can no longer be fully utilised, the management of expectations becomes all the more important. Eggertsson & Woodford (2003) make a distinction between two kinds of scenarios involving the ZLB. The first case is when the natural rate of interest unexpectedly falls to a negative value making the ZLB on short-term interest rates binding. The other scenario is concerned with the case when the public expects short-term interest rates to fall to zero in the near future. For the first scenario Eggertsson & Woodford (2003) find that - given their inter-temporal model with rational expectations in the private sector - it is essential for a central bank to credibly promise to pursue inflationary policy even after the natural interest rate has returned to its natural level. The expectation of later inflation - when nominal interest rates are not expected to rise in order to counteract it - can stimulate current demand when investment and consumption decisions depend on real interest rate expectations in the future. Hence, the expectation that a central bank will keep nominal interest rates low, even beyond a point where it would have otherwise raised them, can stimulate spending when the ZLB is binding. Ergo, short-term interest rates should be kept "lower for longer" when the natural interest rate falls below zero.

For the latter scenario, there are two possible ways in which to proceed in terms of monetary policy. Either a central bank could try to "save its ammunition" for future emergencies, by taking a conservative stance and refrain from lowering the interest rate prematurely in which case the anticipation of a binding ZLB would cause tighter policies than actually justified by the current economic environment. Alternatively, the central bank could perform a "pre-emptive strike", and put policies in place that are more inflationary than might otherwise be preferred, in order to circumvent a future situation where a negative shock would cause the ZLB to be binding. Here, Eggertsson & Woodford (2003) find in their simulation that optimal policy involves driving the short-term nominal interest rate to zero, before the natural interest rate has itself become negative. A ZLB that is binding even before the natural interest rate has turned negative, shows that the price-level target is in fact higher than it would have been otherwise at the time

the shock to the natural interest rate takes effect. The result of following this optimal policy is that output gaps in the periods of negative natural interest rates turn out to be much less severe compared to the case where the shock had not been anticipated. In their model Eggertsson & Woodford (2003) build upon deterministic expectations. Adam & Billi (2006) study monetary policy in a similar NK set-up, but with forward-looking expectations. They find that the presence of a ZLB may require that short-term nominal interest rates are lowered more aggressively when reacting to shocks than would otherwise be suggested without the existence of a binding constraint. Moreover, the presence of shocks that could potentially cause a binding ZLB, also changes the optimal policy response to shocks that would be non-binding. This stems from a central bank's inability to affect the average real interest rate in any stationary equilibrium which in turn constitutes a global policy constraint.

All in all, the lessons that can be drawn from the pre-crisis literature, are that short-term interest rates should be cut aggressively when an economic downturn or deflation are impending. Once the short-term interest have been brought down, they should remain low even beyond the point where they would have otherwise been raised again. The expectation of short-term interest rates being held at a low level for a longer period causes longer-term yields to go down, thereby easing financial conditions. Thus, by aggressively cutting short-term interest rates and keeping them low, central banks should in theory be able to harvest the full potential of monetary stimulus. Moreover, research suggests that these monetary strategies should by themselves be sufficient in most cases to nearly offset the effects of the ZLB on the economy. (Williams 2014)

In the crisis of 2008, this is precisely how central banks reacted to the economic downturn. All the major central banks pursued these monetary strategies and drastically cut the short-term nominal interest rates. Figure 2 shows the development of the short-term interest rates of four major central banks. Immediately after the shock of the crisis occurred, the short-term rates were pushed to a level close to zero, where they remained relatively stable as the Great Recession continued. A striking feature of the graphs is that the ZLB episode is much longer in duration than previously proposed by the pre-crisis literature.

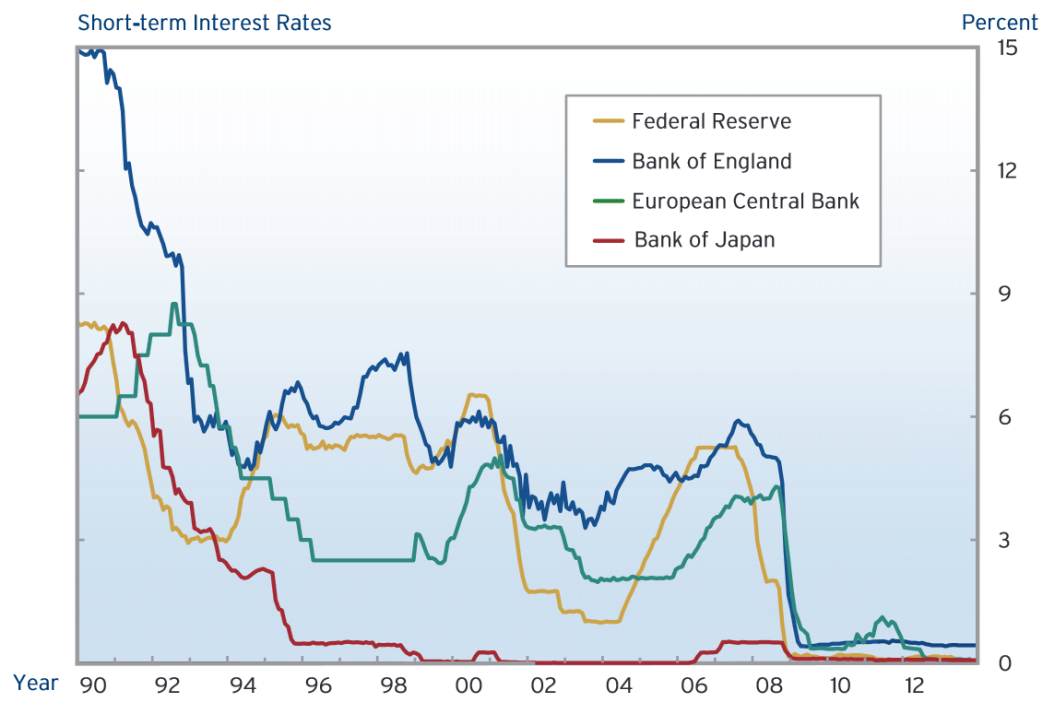


Figure 2: Development of the short-term nominal interest rates of the four major central banks over time. Source: Williams (2014, p. 2)

3.2 Imperfect Credibility at the Zero Lower Bound

Up to this point, the strategies for monetary policy at the ZLB presuppose that a central bank operates with virtually perfect credibility. With the policy instrument more or less tied to the ZLB, monetary stimulus can for the greater part only be gained through shaping private sector expectations. As sketched out in the previous section, it is not only relevant whether or not a central bank is willing to commit to a policy plan, but even more so whether or not the public puts faith in this willingness. Further problems arise after the economy has returned to its recovery path and the natural interest rate turns positive again. Keeping policy rates close to zero in this environment causes both output gap and inflation rate to overshoot in the future, resulting in welfare losses. A central bank in this situation could then submit to the temptation of abandoning its commitment and raising interest rates as to combat future inflation. If this is anticipated by the public, i.e. that it does not deem the promise of the central bank to commit to a path involving higher inflation credible, monetary policy at the ZLB would lose (at least part of) its effectiveness as providing forward guidance would become more challenging.

3.2.1 A New Keynesian Model

In the models of the pre-crisis monetary policy literature, the issue of imperfect credibility at the ZLB was, however, not formally addressed. Bodenstein et al. (2012) employ the modelling approach by Schaumburg & Tambalotti (2007) and Debortoli & Nunes (2010) and introduce a ZLB on the nominal short-term interest rates. In a standard NK model, the central bank can promise a state-contingent policy plan, but has the possibility to renege on its previous promises and re-optimize in the future. The model the authors use in their analysis consists of two building blocks: a private sector and a monetary authority. The model follows the typical NK assumptions. Households choose consumption, leisure, money and bond holdings subject to their respective budget constraints. Firms are monopolistic competitors and can set nominal prices. Price stickiness is modelled with staggered prices à la Calvo. The demand side of the economy is described by a dynamic IS equation given by the Euler equation of the representative household log-linearised around zero inflation

$$x_t = E_t x_{t+1} - \gamma(i_t - E_t \pi_{t+1}) + g_t \quad (1)$$

where x_t denotes the output gap, measured as the deviation of output from its natural level, π_t the inflation rate, i_t the nominal interest rate on one period non-contingent debt, which can be controlled by the monetary authority, $\gamma > 0$ describes the inter-temporal elasticity of substitution in consumption and g_t is a demand shock.⁶ The supply side of the economy is described by a forward-looking Phillips curve given by a log-linear approximation of the optimal price setting under sticky prices.

$$\pi_t = \kappa x_t + \beta E_t \pi_{t+1} + u_t \quad (2)$$

where $\beta \in (0, 1)$ is the subjective discount factor and u_t is a cost-push shock. The slope parameter of the Phillips curve

$$\kappa = \frac{(1-v)(1-v\beta)}{v} \frac{\gamma^{-1} + \omega}{1 + \omega\theta} > 0$$

is a function of the structural parameters with v being the probability of a firm being able to adjust its price. $\omega > 0$ gives the elasticity of a firm's real marginal cost with respect to its own output level and $\theta < 1$ is the elasticity of substitution of demand for the different goods produced by the monopolistic firms. The exogenous shocks are assumed to follow AR(1) stochastic processes described by

$$u_t = \rho_u u_{t-1} + \epsilon_{u,t},$$

$$g_t = \rho_g g_{t-1} + \epsilon_{g,t}$$

Expressing i_t as the deviation from the steady state interest rate associated with zero steady state inflation, the ZLB is given by

$$i_t \geq -r^* \quad (3)$$

where r^* is value of the nominal interest rate in the steady state. The level of the nominal interest rate is defined as $\tilde{i}_t = i_t + r^*$

Monetary policy is conducted in such a way that the central bank maximizes the quadratic

⁶Note that for comparability reasons with other models treated in this thesis, I deviate from the original notation.

form present discounted value of its period objective function

$$U_t = -\pi_t^2 - \lambda x_t^2 \quad (4)$$

subject to constraints (1) - (3) and where $\lambda = \frac{\kappa}{\theta}$. However in doing so, the central bank operates under imperfect credibility modelled via quasi-commitment technology as in Schaumburg & Tambalotti (2007). For each period, a realization of the random variable $X = \{C, R\}$ is drawn with a probability distribution of $p(C) = \eta$ and $p(R) = 1 - \eta$ for $\eta \in [0, 1]$. If in a period the event $\chi = C$ occurs, the central bank will stay committed to its previously announced policy path in contrast to $\chi = R$ where the central bank will renege on its promise and re-optimize. Thus, a policy plan for the future path of the nominal interest rate formulated in period t will still be in place in period $t + s$ with probability η^s . Again, the cases of $\eta = 1$ and $\eta = 0$ correspond to full commitment and full discretion respectively.⁷ The optimization problem of a central bank under imperfect credibility is then given by

$$V(u_t, g_t) = \max_{y_t, \pi_t, i_t} E_t \sum_{t=0}^{\infty} (\beta\eta)^t [-(\pi_t^2 + \lambda x_t^2) + \beta(1 - \eta)E_t V^R(u_{t+1}, g_{t+1})] \quad (5)$$

subject to

$$\begin{aligned} \pi_t &= \kappa x_t + \beta\eta E_t \pi_{t+1} + \beta(1 - \eta)E_t \pi_{t+1}^R + u_t, \\ x_t &= \eta E_t x_{t+1} + (1 - \eta)E_t x_{t+1}^R - \gamma[i_t - \eta E_t \pi_{t+1} - (1 - \eta)E_t \pi_{t+1}^R] + g_t, \\ i_t &\geq -r^*, \\ u_t &= \rho_u u_{t-1} + \epsilon_{u,t}, \\ g_t &= \rho_g g_{t-1} + \epsilon_{g,t} \end{aligned}$$

where variables carrying the superscript R are evaluated under re-optimization. Essentially, the objective function consists of two parts. The future paths where the central bank sticks to the current policy is mirrored in the first two terms. Owing to the possibility of policy re-optimization by the central bank in the future, they are discounted at the rate of $\beta\eta$. Promises can be replaced at any point in time with probability $1 - \eta$ by a new policy. The value that can be gained by the central bank by such re-optimizations is summarized in the function V^R . Lastly, the inclusion of expectation terms in the con-

⁷Bodenstein et al. (2012) do not treat these extreme cases in their article, since such an analysis of monetary policy at the ZLB in a fully stochastic environment for full commitment and discretion has already been conducted by e.g. Adam & Billi (2006).

straints captures the uncertainty created by the possibility of deviations from the current policy path in future periods. One should recall that in this framework monetary policy re-optimizations occur randomly and thus are not the results of endogenous decisions, that is, they do not depend on the state of the economy. In terms of modelling this serves as a simplification similar to Calvo pricing. However, the authors argue that this assumption need not necessarily be too far fetched as for example the members of the decision-making committee within a monetary authority can change over time. The degree of influence politicians or the financial industry have on a central bank may affect the tendency to renege on a previous policy path as well, although one might argue that this need not necessarily be completely detached from the state of the economy.

Bodenstein et al. (2012) solve the optimization problem of the central bank by applying the recursive formulation of Marcet & Marimon (2011). By rearranging the terms the problem can be expressed as

$$V(s_t) = \min_{(\sigma_t^1, \sigma_t^2)} \max_{y_t, \pi_t, i_t} h(x_t, \pi_t, i_t, \sigma_t^1, \sigma_t^2, s_t) + \beta[\eta E_t V(s_{t+1}) + (1 - \eta) E_t V^R(s_{t+1}^R)] \quad (6)$$

subject to

$$i_t \geq -r^*,$$

$$u_t = \rho_u u_{t-1} + \epsilon_{u,t}, \quad g_t = \rho_g g_{t-1} + \epsilon_{g,t}$$

$$\mu_{t+1}^1 = \sigma_t^1, \quad \mu_0^1 = 0, \quad \mu_{t+1}^2 = \sigma_t^2, \quad \mu_0^2 = 0,$$

where $s_t = (u_t, g_t, \mu_t^1, \mu_t^2)$ and $s_t^R = (u_t, g_t)$ describe the state of the dynamic system for the cases of policy plan commitment or re-optimization respectively. (σ_t^1, σ_t^2) denote the Lagrange multipliers associated with the behavioural constraints and

$$h(x_t, \pi_t, \sigma_t^1, \sigma_t^2, s_t) \equiv -\pi_t^2 - \lambda y_t^2 + \sigma_t^1 h_t^{PC} + \sigma_t^2 h_t^{IS} - I_\eta \mu_t^1 \pi_t + I_\eta \frac{1}{\beta} \mu_t^2 (x_t + \gamma \pi_t), \quad (7)$$

$$h_t^{IS} \equiv -x_t + (1 - \eta) E_t x_{t+1}^R - \gamma(i_t - (1 - \eta) E_t \pi_{t+1}^R) + g_t,$$

$$h_t^{PC} \equiv \pi_t - \kappa x_t - \beta(1 - \eta) E_t \pi_{t+1}^R - u_t$$

with I_η being an indicator function satisfying $I_\eta = 0$ for $\eta = 0$ and $I_\eta = 1$ otherwise. From Marcet & Marimon (2011) and Debortoli & Nunes (2010) it follows that optimal policy as well as the value functions are time invariant if the state space is enlarged to contain the lagged Lagrange multipliers (μ_t^1, μ_t^2) . The previous state-contingent promises are summarised in the multipliers where the case of non-binding promises corresponds

to the case of the multipliers being zero. Note that the multipliers are not physical state variables and that hence only commitment impedes the central bank from renegeing on their previous promises. This reflects the time-inconsistent nature of the problem. Resetting the Lagrange multipliers to zero is in fact optimal. In equilibrium this happens each time the central bank is able to do so.

Bodenstein et al. (2012) point out that the equilibrium under imperfect credibility satisfies three conditions. First, given $\{x_t^R, \pi_t^R\}_{t=0}^\infty$ and the value V^R , problem (5) is solved by the path $\{x_t, \pi_t, i_t\}_{t=0}^\infty$. This definition basically invokes optimality given the constraints of the problem. Second, the value function V^R is such that $V^R(u_t, g_t) = V(u_t, u_t, \mu_t^1 = 0, \mu_t^2 = 0)$ where V is defined by equation (6). In this way, the value of the re-optimization V^R is defined as the continuation value without binding promises, that is, that the lagged Lagrange multipliers are zero. Third, when denoting the optimal policy functions as $(x_t, \pi_t) = \psi(u_t, g_t, \mu_t^1, \mu_t^2)$, the pair (x_t^R, π_t^R) satisfies the condition $(x_t^R, \pi_t^R) = \psi(u_t, g_t, 0, 0)$. This requires the policy functions (x_t^R, π_t^R) the public expects to be implemented when re-optimizations occur to be consistent with the optimal policy functions that are implemented in absence of any promises that would need to be honoured. As both the value function V^R and the policy functions under re-optimization are not known, it follows that the solution of equation (6) is non-standard. Overall, since the model features the presence of an occasionally binding ZLB and the possibility of policy renouncements, global methods are required for the solution.

The model is then parametrized as in Adam & Billi (2006) and Woodford (2003) which allows for good comparisons. In the analysis, several values for probability of re-optimization, η , i.e. the level of credibility, are assumed as there is no empirical guidance on this matter. Bodenstein et al. (2012) do however point out that in analysis of publicly available communication by the U.S. Feder Reserve their model suggests a value for η in the neighbourhood of 0.5. An alternative notation the authors use for credibility is to express the expected duration of a promise as $\alpha = \frac{1}{1-\eta}$. The analysis shows the impulse response functions after the nominal interest rate is pushed to zero by a large and persistent contraction in aggregate demand in period 1. The results of the transition dynamics in response to a large negative demand shock are presented in figure 3. In the simulation, the shocks are initialized at $u_1 = 0$, $g_1 = -10$, and $(\epsilon_{u,t}, \epsilon_{g,t}) = 0 \forall t \geq 2$. The left column describes the case of the specific history with no policy re-optimizations ($\chi_t = C \forall t \geq 1$) for different levels of credibility ($\alpha = 2$, $\alpha = 4$ and full commitment) and no future re-optimizations. The graphs highlight the optimal promises of the central bank in period 1

with respect to the evolution of the nominal interest rate, the output gap and inflation. From the graphs it is evident that the lower the credibility of a central bank, the more extreme its promises on future policy turn out. This is reflected by the result that while a central bank with $\alpha = 4$ keeps the nominal interest rate at zero for six periods, a central bank with $\alpha = 2$ follows a policy path where the interest rate is kept at zero for the entire plotted horizon. As the private sector takes the possibility of future policy re-optimizations into account, a less credible central bank finds itself in a weaker position to influence private expectations. Thus, the less credible central bank extends its promise to keep interest rates low in order to get a better grip on private expectations. There is a downside to this type of policy, however, as these extreme promises may turn out to be rather costly for a central bank if there is no possibility to re-optimize policies in the future. As can be seen in the case for $\alpha = 2$, the low interest rate promotes a persistent boom at high levels of inflation. Optimally, policy makers at a central bank would equate the marginal benefits of a promise of low interest rates with the costs associated with actually delivering such a promise, that is, to refrain from policy re-optimizations. The reason promises tend to be more extreme when credibility is low, is that their fulfilment is unlikely thus making private expectations harder to influence. These findings stand in contrast to those of e.g. Adam & Billi (2006) and Eggertsson & Woodford (2003) insofar, as there policy makers under full commitment promise to keep interest rate at zero for a longer time compared to policy makers operating under full discretion. However, as Bodenstein et al. (2012) point out, this inference is only correct in a purely forward-looking model for these two extremes. In the case of imperfect credibility, the conditional announcement of keeping interest rates at zero for an extended period cannot be interpreted as a sign of high credibility.

Another interesting finding is the effect of policy re-optimization in specific periods. The middle column of figure 3 shows that while an economy is still in a recession, even a central bank with low credibility will not raise the interest from zero when reformulating its policy plan. This is shown for a central bank with $\alpha = 4$ and policy reformulation in periods 2 ($\chi_2 = R$ and $\chi_t = C \forall t \neq 2$) and 3 ($\chi_3 = R$ and $\chi_t = C \forall t \neq 3$). One should note that if a reformulation of the policy plan takes place in the middle of a recession, the incentive to let the interest rate remain low in later periods, is reduced as the effects of the shock fade. Another key finding is that commitment does indeed matter, even before the central bank has incentives to raise the interest rate again. In the graphs, this is reflected by the fact that although the interest rate remains unchanged, inflation and the output gap react immediately to the renouncement of the previous policy plan. The right

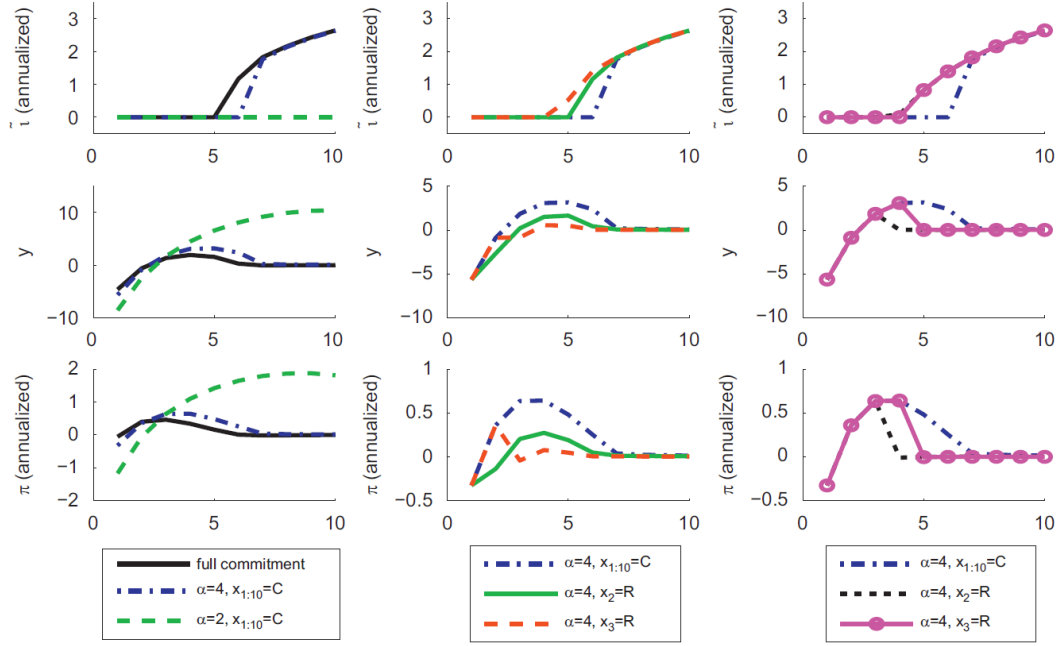


Figure 3: Transition dynamics in response to a negative and large demand shock causing the inflation rate to reach the ZLB. Source: Bodenstein et al. (2012, p. 140)

column depicts the cases where policy reformulation occurs at points in time, where the economy is already in the phase of recovery. In this case, the central bank immediately increases the interest rate when re-optimizing in this environment. The graphs show that in the case of re-optimization in periods 4 ($\chi_4 = R$ and $\chi_t = C \forall t \neq 4$) or 5 ($\chi_5 = R$ and $\chi_t = C \forall t \neq 5$) the previous policy plan with high inflation and a positive output gap is immediately brought down with both variables quickly approaching their target.⁸

In a next step Bodenstein et al. (2012) analyse the effect of different histories for χ_t , $\epsilon_{g,t}$ and $\epsilon_{u,t}$. In the first experiment, attention is put on histories with $g_1 = -10$, $\epsilon_{g,t} = 0 \forall t \geq 2$, $u_1 = 0$ and $\epsilon_{u,t} = 0 \forall t \geq 2$, while allowing for all possible histories of χ_t . In figure 4, the mean impulse response for the case of imperfect credibility are shown with $\alpha = 4$ in the left column and $\alpha = 2$ in the right column respectively, with the shaded areas around the mean being the impulse response functions between the 1st and the 99th percentiles. The impulse responses of a central bank operating under full commitment or full discretion are included in the figure as well. One can see that for the mean response

⁸Note that the legends for the two lower graphs in the right column are incorrectly specified and should read $x_4 = R$ and $x_5 = R$, respectively.

under imperfect credibility, the interest rate path is higher than in the case of either full discretion or full commitment, at least in the near term. Regardless of the higher interest rate, both inflation and the output gap overshoot in the case of imperfect credibility, as is the same under full commitment. Nevertheless the mean response under imperfect credibility is accompanied by considerable uncertainty as indicated by the shaded area in the graph.

Similar to the case of full discretion, the impulse response functions under imperfect credibility show that for histories with many re-optimizations, a recession need not necessarily be followed by a boom with high levels of inflation. Nevertheless, with central banks operating under imperfect credibility, the economy still performs better than under full discretion. Hence, keeping at least some degree of commitment (even with several policy reformulations) is still preferable to being known to not commit at all. Therefore, even central banks endowed with very low levels of credibility should not completely refrain from using forward guidance as a tool for monetary policy.

Bodenstein et al. (2012) also turn to an analysis of the time inconsistency problem and welfare gains from re-optimization. Although policy commitment can be especially beneficial when facing the ZLB, the time consistency problem is also exacerbated. In figure 5 the difference in welfare between staying committed to the previous policy plan in period T , $V_{T,\chi T=C}$ and policy reformulation in period T , $V_{T,\chi T=R}$ is shown across time for the two cases where the economy experienced a considerable negative demand shock ($g_1 = -10$) and where an economy is initialized at $g_1 = 0$. As a result of the time inconsistency problem, at any given point in time for a fixed level of credibility, a central bank can achieve higher utility if it chooses to re-optimize. As can be seen in figure 5, the welfare gains from deviating from the previous policy plan are significantly higher across all periods for an economy in a deep recession compared to the case of $g_1 = 0$. In fact, in the case of $g_1 = -10$ the central bank is most tempted to abandon its previous policy plan in period 3. Turning back to figure 3, it becomes apparent that this deviation from the policy plan would serve to circumvent the overshooting of inflation and the output gap and hence the resulting welfare losses. Therefore, when the central bank is able to implement new policies in this period, the economy can be stabilised more effectively compared to every other period.

To summarize, the analysis in a simple NK framework shows that credibility and the possibility of a policy renouncement by the central bank have a crucial influence on

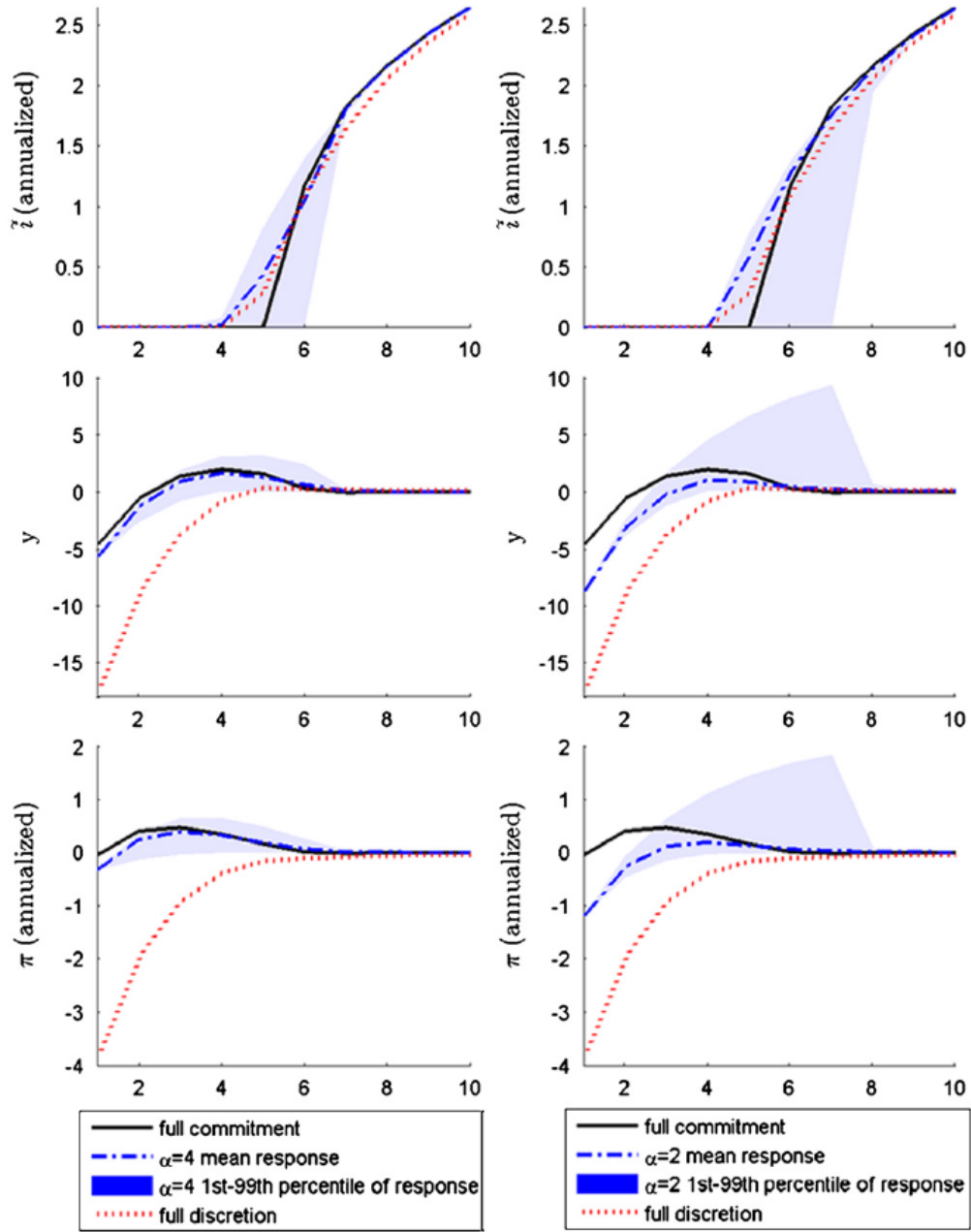


Figure 4: Distribution of the impulse response functions of the transition dynamics in response to a negative and large demand shock causing the interest rate to reach the ZLB with uncertainty to the history of re-optimization only. Source: Bodenstein et al. (2012, p. 142)

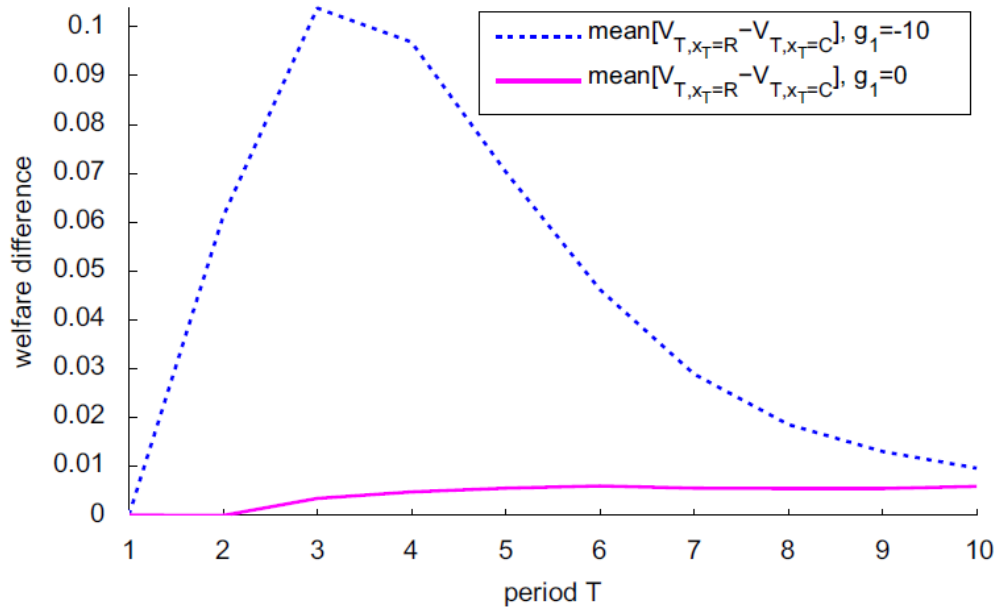


Figure 5: Mean expectation in period T of the gains in discounted welfare by a re-optimization in period T for central banks with $\alpha = 4$. Source: Bodenstein et al. (2012, p. 144)

the effectiveness of monetary policy. In reality central banks do not operate under full commitment but still typically enjoy some degree of credibility. Thus, the analysis of the monetary policy dynamics under imperfect credibility offer some valuable and intuitive insights. When facing an impending economic downturn and potential deflation, it may not only suffice for a central bank to cut the interest rate aggressively when operating under low credibility. Rather, the announcement by the central bank may need to be extreme in the sense that it must be communicated that interest rates will remain near zero for a relatively long time. Moreover, the simulation suggests that it does not only matter whether or not a central bank decides to re-optimize its policy plan, but even more on the exact timing of the re-optimization. This is also reflected by the possible welfare gains of policy reformulation presented in figure 5. The potential gains in welfare are also a potential candidate for an explanation of the intense political pressure on the Federal Reserve over the course of 2010 and 2011, as Bodenstein et al. (2012) point out. In fear of future inflation, financial commentators as well as politicians have repeatedly urged the Federal Reserve to raise the nominal interest rate. Going so far as to openly call for a replacement of the Federal Reserve's dual mandate by an explicit inflation target in order to affect tighter monetary policy. Although imperfections in credibility can pose considerable barriers to the effectiveness of monetary policy, it is clear that even at low levels of credibility the policy tool of providing forward guidance on the interest rate should not be ditched by central banks.

3.3 A Note on Forward Guidance at the Zero Lower Bound

Revisiting the discussion of forward guidance in the previous section, it is necessary to add a few comments on the nature of forward guidance when a central bank is operating at the ZLB under imperfect credibility. This applies in particular to the way in which forward guidance is communicated to the public. Given that deficits in credibility force a central bank to formulate more extreme policy plans than under perfect credibility, this holds for the means of communication as well. As a consequence, providing only Delphic forward guidance will not make do if credibility is low. The same goes for weak Odyssean forward guidance in the sense that no explicit time frame is set but rather only vague formulations like e.g. "in the near future". This, however, does make future deviations from the promised policy path all the riskier. As Williams (2014) notes, the U.S. FOMC did try to communicate that policy rates would be kept low throughout the recession and the early stages of recovery. However, in 2008 it was only announced

that policy rates would be kept low in the near future without specifying an explicit time-horizon. Although forward guidance was provided, widespread public opinion was that a policy tightening was to be expected in the near future. This was mirrored by the expectations from financial markets and surveys of economists from the beginning of 2009 to mid-2011, which consistently predicted that the federal funds rate would take off from the ZLB within a year in the future.

Despite the efforts of the FOMC to communicate the need for loose monetary policy over a longer horizon, due to the severity of the recession, the public's conviction that rates would be raised in the near future persisted. The FOMC then turned to more explicit and forceful forward guidance to counteract the excessively tight expectations. Announcements then included explicitly mentioning points in time up until which short-term interest rates could be expected to remain low. For instance, it was announced in August 2011 that the low levels of the federal funds rate would be warranted at least through mid-2013. This announcement did have a strong impact on the expectations of the financial market, causing an immediate 10 basis point drop in the two-year Treasury yield and a decline in longer-term yields greater than 20 basis points. When the FOMC's quantitative forward guidance was extended further in September 2012 to last until mid-2015, it had again significant effects on public expectations on yields. In December 2012 the forward guidance based on explicit dates was replaced by forward guidance based on the state of the economy, where for example the FOMC would keep the funds rate near zero unless expected inflation would exceed 2.5 percent or the unemployment rate fall below 6.5 percent. Moreover, in January 2012 the FOMC started publishing forecasts of the federal funds rate for the next few years along with those of GDP, unemployment and inflation - which too can be expected to have some impact on the public's expectations. (Williams 2014)

Related to this is a point made by Sims (2010), in that as of now most central banks in developed countries have convincingly positioned themselves as defenders of low and stable inflation in the eyes of the public. Yet this reputation was built up over decades, with central banks taking many efforts to deliver on their promises. However, when the presence of a binding ZLB necessitates future expansionary monetary policy such a reputation of being fierce inflation-fighters can prove quite problematic for central banks. In this case, convincingly communicating a temporary commitment to loose monetary policy and higher inflation can become a serious obstacle. This could serve as an explanation for the situation the FOMC found itself in between 2009 and 2011 where

public expectations persistently foresaw rising interest rates in the immediate future. Additionally, the experience of the FOMC in the recent past shows that it does not only matter *what* kind of forward guidance is communicated, but even more importantly *how* it is communicated. Overall, quantitative forward guidance turned out to be a highly effective policy tool for bringing public expectations about inflation in line with the policy makers' intentions. As a consequence, a necessary pre-requisite for any policy framework is that it should allow for ample possibilities to provide quantitative forward guidance in order to ensure effective management of expectations.

4 Perspectives of a Nominal GDP as an Alternative Monetary Target

Having established a theoretical foundation for the dynamics of monetary policy against the background of the ZLB, the main questions behind this thesis can now be addressed. In this section, the possibilities offered by the adoption of a nominal GDP target as an alternative framework for monetary policy will be discussed. In particular, focus will be on an economic environment characterized by a binding ZLB and imperfect central bank credibility. As mentioned before, this idea is not new per se, but has experienced somewhat of a renaissance recently, though under different circumstances. Frankel (2013) argues that adopting a nominal GDP target could deliver monetary stimulus and thus help to promote higher growth in the U.S., Japan and Europe whilst providing a credible nominal anchor. Therefore, following an inflation target can pave the way for several policy fallacies due to its lack of robustness with respect to supply and terms-of-trade shocks. An example would be the case of the ECB in July 2008 which - while the economy was entering a deep recession - raised interest rates in response to a spike in global oil prices in order to combat consumer-price inflation. As argued by Frankel (2013), this could have been avoided if the ECB had followed a nominal-GDP target. Furthermore, inflation targeting was again a target of criticism in September 2008, when it became clear that central banks that relied strongly on inflation targeting did not put enough attention to the build-up of asset bubbles.

Studies comparing an inflation target to a nominal-GDP target for an economy facing the ZLB in a NK framework are fairly rare though. Moreover, the issue of imperfect credibility is not addressed in the models of these studies at all. Two recent studies provide such a comparison. In a recent working paper Billi (2014) compares the performance as measured in the deviation in welfare from the Ramsey plan of an inflation target to a nominal-GDP target under discretionary policy. Additionally, he also compares the performance of a Taylor-type rule and a nominal-GDP level rule with both rules being capable of providing forward guidance. The modelling framework is a simple NK model of the monetary transmission mechanism. The second article is also a recent working paper by Honkapohja & Mitra (2014) who examine the global dynamics of a nominal-GDP, a price level and an inflation target in a model under infinite-horizon learning. The agents in this framework are only able to obtain imperfect information, but can adapt their expectations on policy by learning. For the purpose of this thesis, the article

by Billi (2014) is of more interest as its modelling approach closely follows the articles discussing imperfect credibility summarized in the previous section. As the same modelling framework is applied, the findings of the previous section can be translated to the theoretical findings of Billi (2014).

Apart from the theoretical perspective how the performance of a nominal-GDP target compares to that of an inflation target, there exist some practical issues that should be taken into consideration. For instance, data on nominal GDP is typically only available with substantial lags, whereas data on inflation is more readily available. Since the substitution of the long-term strategic goal would constitute a major shift in the monetary policy framework, it is also important how exactly a nominal-GDP target is introduced.

4.1 Nominal GDP Targeting at the Zero Lower Bound

Billi (2014) offers a comparison between nominal-GDP level targeting and inflation targeting in an economy subject to the ZLB within a simple NK model. The analysis in this stylized model allows for the key trade-offs faced by policy makers to be highlighted in a very intuitive fashion. However, in this modelling framework, neither the costs associated with a monetary policy regime change - in particular uncertainty faced by households and firms about the occurrence of a regime change - nor the broader issue of imperfect credibility are taken into account. Again, the IS curve describing the expenditure decisions of the representative household is given by

$$x_t = E_t x_{t+1} - \gamma(i_t - E_t \pi_{t+1} - r_t^n) \quad (8)$$

where E_t describes the expectations operator conditional on the information available at time t . The measure for real economic activity or the real GDP gap is denoted by x_t while π_t is inflation rate, i.e. the change in the log-price level ($\pi_t = p_t - p_{t-1}$). $i_t \geq 0$ denotes the short-term nominal interest rate, r_t^n is a natural interest rate shock summarizing all shocks that can cause a variation in the real interest rate under flexible prices, and $\gamma > 0$ denotes the interest elasticity of real aggregate demand, describing the intertemporal substitution in household spending.

The optimal price-setting behaviour under staggered prices à la Calvo is described by

$$\pi_t = \kappa x_t + \beta E_t \pi_{t+1} + u_t \quad (9)$$

where $\beta \in (0, 1)$ is the discount factor of the representative household and u_t denotes a mark-up shock. The slope parameter κ is again a function of the structural parameters given by⁹

$$\kappa = \frac{(1-v)(1-v\beta)}{v} \frac{\gamma^{-1} + \omega}{1 + \omega\theta} > 0$$

with $v \in (0, 1)$ describing the share of randomly picked firms unable to adjust their prices in a period. $\omega > 0$ denotes the elasticity of the real marginal costs of a firm with respect to its own output level and $\theta > 1$ is the price elasticity of substitution of demand for the different goods produced by the firms under monopolistic competition. Moreover, the exogenous shocks follow AR(1) stochastic processes given by

$$u_t = \rho_u u_{t-1} + \sigma_{eu} \epsilon_{u,t},$$

$$r_t^n = (1 - \rho_r) r_{ss} + \rho_r r_{t-1}^n + \sigma_{er} \epsilon_{r,t}$$

where $\rho_j \in (-1, 1)$ for $j = r, u$ denote the first-order autocorrelation parameters. r_{ss} denotes the steady-state real interest rate with $r_{ss} = \frac{1}{\beta-1}$, such that $r_{ss} \in (0, \infty)$. The innovations buffeting the economy are given by $\sigma_{ej} \epsilon_{j,t}$, with the properties of being independent across time and cross-sectionally and normally distributed with mean zero and the standard deviations $\sigma_{ej} > 0$ for $j = r, u$.

A key element of the model is the range of monetary policy frameworks considered with the nominal short-term interest rate or policy rate being constrained by the ZLB. The optimal commitment policy determined at time zero, i.e. the Ramsey plan, serves as the benchmark case, to which the performance of the optimal discretionary policies and the simple policy rules is compared to. For the Ramsey plan, the objective function of the policy coincides with the social welfare function given by

$$\min_{(\pi_t, x_t, i_t \geq 0)_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t [\pi_t^2 + \lambda x_t^2] \quad (10)$$

⁹Note, that for clarity reasons I deviate from the notation used in Billi (2014), as the use of some variables differs widely throughout the articles discussed in this thesis.

where the weight assigned to the stabilization of real GDP relative to inflation is denoted by λ . The utility function can be approximated around zero inflation, allowing for λ to be determined in terms of the structure of the model economy. In this case, it holds that $\lambda = \frac{\kappa}{\theta}$. As the objective function includes the cost of steady-state inflation, it is a reasonable choice for the benchmark criterion. Welfare loss caused by inflation in period t consists of two parts

$$E_0[\pi_t^2] = \pi^{*2} + E_0[(\pi_t - \pi^*)^2]$$

where on the right side, the first term describes the welfare loss caused by steady-state inflation, and the second term the loss caused by the variability of inflation. In order to correctly evaluate monetary policy in the presence of the ZLB, both parts are necessary. In particular, dropping the first term would imply strictly increasing welfare in π^* , as higher values of the inflation target are associated with a lower incidence of a binding ZLB.

Next, Billi (2014) considers optimal discretionary policies, where the monetary authority does not commit to the Ramsey plan, but seeks to re-optimize monetary policy in each period. The first of the two monetary policy frameworks considered is inflation targeting under discretion, where the policy maker's objective function takes the form:

$$\min_{(\pi_t, x_t, i_t \geq 0)_{t=0}^{\infty}} E_t \sum_{j=0}^{\infty} \beta^j [(\pi_{t+j} - \pi^*)^2 + \lambda^d (x_{t+j} - x^*)^2] \quad (11)$$

Where λ^d denotes the weight that is assigned to the stabilization of real GDP relative to inflation. With a weight equal to zero, that is, where no attention is paid to stabilizing real GDP, the central bank would operate under *strict inflation targeting*. In contrast, with a positive weight, the central bank would follow a *flexible inflation target*. The inflation target pursued by the monetary authority is indicated by $\pi^* \geq 0$ and the resulting target for the real GDP gap by x^* . Billi (2014) notes that the inflation target has a considerable impact on the development of the economy. For example, raising the inflation target can limit the incidence of hitting the ZLB. On the contrary, if the inflation target is set below a certain critical value, it can be the case that the economy is pushed into a deflationary spiral by a negative shock with all the entailed negative consequences for welfare. Thus, by raising the inflation target above this critical threshold, it can be ensured that the economy returns to a stable equilibrium in the aftermath of a bad shock rather than falling into a deflationary trap.

The second framework for monetary policy that is considered is a nominal-GDP level target where the objective function of the policy maker takes the form

$$\min_{(y_t, i_t \geq 0)_{t=0}^{\infty}} E_t \sum_{j=0}^{\infty} \beta^j (y_{t+j} - \bar{y}_{t+j})^2 \quad (12)$$

where the nominal GDP is denoted by y_t with $y_t = p_t + x_t$. The corresponding target for the nominal GDP gap is denoted by $\bar{y}_t$, which is assumed to increase at the deterministic rate $\bar{p}_t + x^*$. Here, $\bar{p}_t$ is the corresponding price level target increasing at the rate π^* such that $\bar{p}_t = \bar{p}_{t-1} + \pi^*$. Again, raising the inflation target would help to prevent the economy from falling into a deflationary trap, but Billi (2014) notes that the scope for this prevention is limited due to the anchoring effect of the nominal GDP level target.

Apart from the optimal discretionary policies, Billi (2014) compares the performance of two simple policy rules that offer the possibility of providing forward guidance. Forward guidance in this case involves adjustments to the setting of the central banks policy instrument, i.e. the policy rate. The first rule to be considered is a version of the Taylor rule subject to the ZLB constraint described by

$$i_t = \max[0, \phi_{\pi}(\pi_t - \pi^*) + \phi_x(x_t - x^*) + (1 - \phi_i)i^* + \phi_i i_{t-1}^u] \quad (13)$$

where ϕ_{π} and ϕ_x denote the positive response coefficients on the inflation gap and the real GDP gap, respectively. i^* is the equilibrium nominal policy rate with $i_* = r_{ss} + \pi^*$. Moreover, forward guidance on the nominal interest rate, or smoothing in the behaviour of the interest rate, is also incorporated in this Taylor type rule, reflected by a positive value of the coefficient ϕ_i . The unconstrained policy rate, that is, the policy rate set by the central bank in absence of the ZLB, is denoted by i_{t-1}^u .¹⁰ Hence, the policy rate remains below its equilibrium value following a ZLB episode. This implies that the central bank tries to make up for the monetary stimulus lost by the existence of a binding ZLB, even if the central bank is not providing forward guidance on nominal GDP.

The second policy rule is a nominal GDP level rule with a ZLB constraint given by

¹⁰In this model, i_{t-1}^u is an observable variable as it is a function of observable variables only. Billi (2014) notes that in reality the equilibrium real interest rate and the GDP are not observable, making the implementation of policy challenging.

$$i_t = \max[0, \phi_y(y_t - \bar{y}_t) + (1 - \phi_i)i^* + \phi_i i_{t-1}^u] \quad (14)$$

where ϕ_y denotes the coefficient on the nominal GDP gap and ϕ_i denotes the smoothing coefficient. Setting ϕ_i corresponds to the case where the central bank issues forward guidance on the nominal GDP level, only in order to make up for the lost monetary stimulus due to the binding ZLB. If a positive value is assigned to ϕ_i , the central bank makes use of forward guidance on both the nominal GDP level as well as the policy rate. Note that as the nominal GDP level rule provides forward guidance, even in the absence of smoothing, the scope for smoothing the nominal policy rate is limited.

In equilibrium, the central bank chooses its policy based on the response function $y(s_t)$ and the state vector s_t with the corresponding expectations function taking the form

$$E_t y_{t+1}(s_t) = \int y(s_{t+1}) f(\epsilon_{t+1}) d(\epsilon_{t+1})$$

where $f(\cdot)$ is a probability density function of future innovations affecting the economy. In the model, the ZLB becomes an occasionally-binding constraint among the endogenous variables due to the uncertainties about the future of the economy. In this setting, a stochastic rational expectations equilibrium is then given by the response function $y(s_t)$ and the corresponding expectations function $E_t y_{t+1}(s_t)$ which satisfy the set of equilibrium conditions. For the simple policy rules, the model is closed by the rule itself whereas for the Ramsey plan and the optimal discretionary policies the corresponding First Order Conditions have to be derived. Then, by applying a numerical procedure as in Billi (2011), which takes the ZLB and uncertainty about the future of the economy into account, the model can be solved. Applying a solution procedure that accounts for the ZLB and uncertainties is crucial insofar as the mere possibility of hitting the ZLB suffices to create expectations of GDP falling below potential and inflation below target.

For the policy evaluation, the model is calibrated to U.S. data where the baseline is very similar to the one used in Billi (2011) if price indexation is set to zero. Since the likelihood of the occurrence of a ZLB episode depends on the variance in the real-rate shock, the robustness of the findings can be checked by considering a range of values for the shock variance. The baseline calibration is shown in table 1 with a period defined as one quarter.

Definition	Parameter	Numerical value
Discount factor	β	0.99
Interest elasticity of aggregate demand	γ	6.25
Share of firms keeping prices fixed	ν	0.66
Price elasticity of demand	θ	7.66
Elasticity of a firm's marginal cost	ω	0.47
Slope of aggregate supply curve	κ	0.024
Weight on real GDP gap (Ramsey plan)	λ	0.003
Steady-state real interest rate	r_{ss}	1.00 percent
Standard deviation of real-rate shock	σ_r	0.75 percent
Standard deviation of mark-up shock	σ_u	0.10 percent
AR(1) parameter of real-rate shock	ρ_r	0.80
AR(1) parameter of mark-up shock	ρ_u	0.00

Table 1: Baseline calibration of the model in Billi (2014)

In the first step of evaluating the performance of the optimal discretionary policies, the optimal values for the inflation target π^* and the weight assigned to the stabilization of real GDP relative to inflation λ^d have to be set. In the flexible inflation targeting regime, optimal value for λ^d used in the analysis is at 0.001. This weight is notably smaller than the corresponding weight λ in the case of full commitment of 0.003. This stems from the fact that the lack of commitment causes a stabilization bias and the central bank is forced to put more emphasis on stabilizing inflation compared to the Ramsey plan in order to reduce this bias. Moreover, in terms of welfare, flexible inflation targeting is found to be preferable to strict inflation targeting. Therefore the latter is not treated in more detail in the analysis. Using the optimal value for λ^d the critical value for the inflation target π^* is 1.8 percent annually. As noted before, if the inflation target is set below this critical value, a stable equilibrium to which the economy reverts in reaction to a negative shock is not ensured. In such a deflationary trap, the representative household would suffer infinite welfare loss, as inflation and real GDP variability are unboundedly large. Additionally, welfare losses relative to the Ramsey plan are minimized at the critical value of the inflation target. The welfare loss at the critical value under optimal flexible inflation targeting amounts to 0.79 percent of permanent consumption.

The adoption of a nominal GDP level target is an alternative way to circumvent the case of the economy falling into a deflationary trap and hence infinite welfare loss. Following a nominal-GDP target would keep inflation firmly anchored even if the inflation target is set to zero. However, an inflation target slightly above zero can improve welfare. In

the model, the optimal value for the inflation target with nominal-GDP level targeting is 0.2 percent annually, with a welfare loss amounting to about 0.08 percent of permanent consumption. Compared to the optimal flexible inflation target, the nominal-GDP level target therefore yields substantially more favourable results in terms of welfare.

The advantage of a nominal-GDP level targeting regime during a ZLB episode lies within the fact that it allows inflation to temporarily overshoot its target which can help to kick-start the economy, resulting in a speedier recovery. The main mechanism at work here is that this surge in prices offers firms incentives to expand their production thus boosting output. These features of a nominal-GDP level target are prominent features of the Ramsey plan as well, whereas a policy maker under discretion will not venture to push inflation above target causing economic recovery to be much slower. The evolution of the economy under the respective monetary policy regimes in a ZLB episode is shown in figure 6. Depicted are the expected paths of the model economy following a 2 standard deviation negative real-rate shock using optimal discretionary policies, i.e. using optimal weights and the respective optimal inflation targets that minimize welfare loss relative to the Ramsey plan, which is also included in the figure. The top panel shows the path of the nominal policy rate over time. As the economy recovers, the policy rate is gradually brought back to its corresponding equilibrium level under all policy regimes. Under the Ramsey plan, the nominal policy rate is kept the lowest resulting in prolonged monetary stimulus that pushes real GDP above its potential and inflation above its target, which is depicted in the middle and bottom panel, respectively. This is also true in the case of nominal-GDP level targeting, although the policy rate takes higher values in all periods compared to the Ramsey plan. This results on the one hand in a less pronounced overshooting of the inflation gap and, on the other hand, prevents real GDP from overshooting altogether. As under flexible inflation targeting the policy rate takes the highest values in all periods compared to the other regimes in order to prevent an overshooting of the inflation rate, real GDP stays below its equilibrium level for longer than under a nominal-GDP level target or the Ramsey plan. Hence, flexible inflation targeting is much less effective in stabilizing the economy than nominal-GDP level targeting in the model economy.

The performance of the two discretionary policy regimes is summarized in table 2. The table reports the expected frequency and the expected duration of ZLB episodes as well as the welfare loss relative to the Ramsey plan. Following the Ramsey plan, the nominal policy rate is expected to hit the ZLB in about 13 percent of the time with an

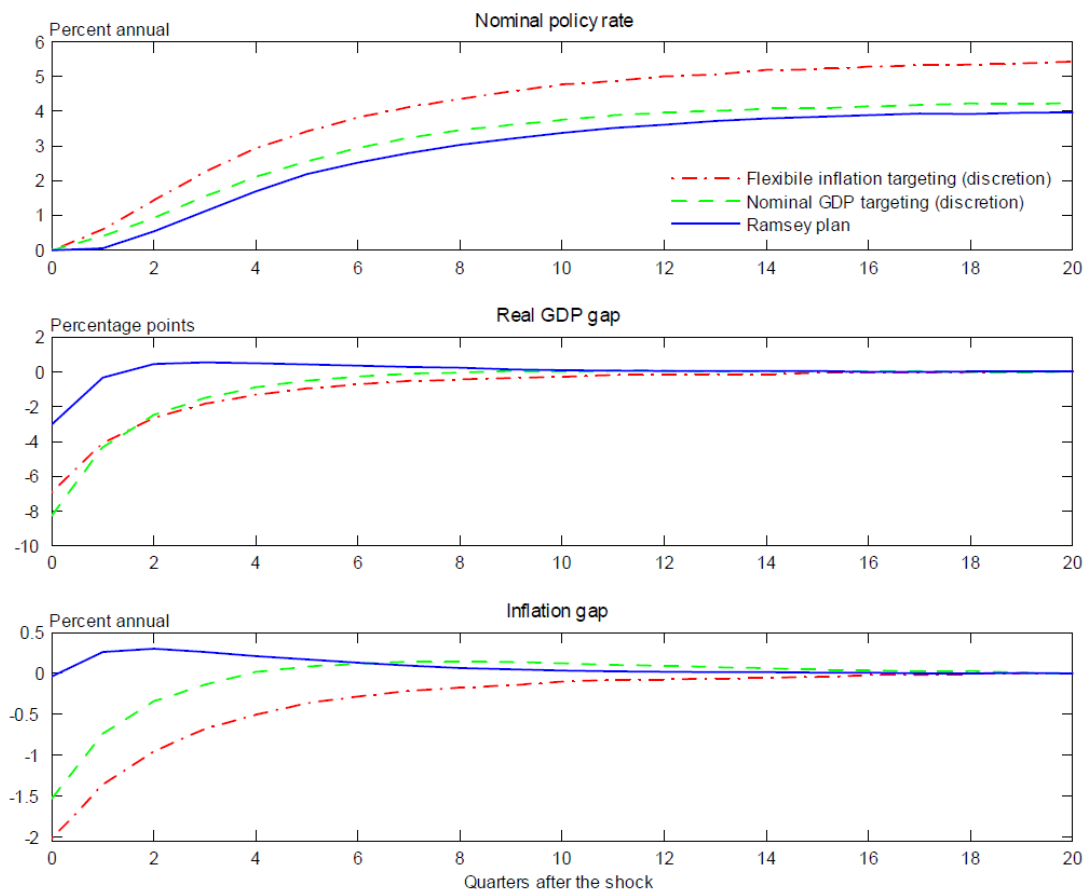


Figure 6: ZLB episode with optimal discretionary policies. Shown is the expected path after a 2 standard deviation negative real-rate shock using optimal weights and targets. Source: Billi (2014, p. 29)

Policy framework ^a	Inflation			Welfare loss relative to Ramsey ^e				
	target ^b	ZLB episodes		steady state		variability		Tot.
		freq. ^c	duration ^d	π	x	π	x	
Discretion								
Flexible inflation targeting	1.8	10	2	0.20	0.00	0.49	0.10	0.79
Nominal GDP targeting	0.2	13	2	0.00	0.00	0.04	0.04	0.08
Ramsey plan	0	13	3					

a. If flexible inflation targeting, optimal weight $\lambda^d = 0.001$

b. Percent annual

c. Expected percent of time at the ZLB

d. Expected number of consecutive quarters at the ZLB

e. Permanent consumption loss (percentage points)

Table 2: Performance of optimal discretionary policies. Source: Billi (2014, p. 26)

expected duration of 3 consecutive quarters. Similarly, for the nominal-GDP level target, the incidence of hitting the ZLB lies at 13 percent as well but with a shorter expected duration of only 2 quarters. The lowest chance of hitting the ZLB is observed under the flexible inflation targeting regime where the ZLB is expected to be binding in 10 percent of the time. This lower incidence is due to the higher inflation target, which is however associated with higher costs of steady-state inflation. The welfare loss relative to the Ramsey plan due to steady-state inflation under flexible inflation targeting amounts up to 0.2 percent of permanent consumption, with an additional loss of 0.49 percent and 0.1 percent of permanent consumption owing to inflation and real GDP variability, respectively. In total, the the sum of the welfare losses under flexible inflation targeting is 0.79 percent of permanent consumption. In contrast, under a nominal-GDP level targeting regime there is no welfare loss due to steady-state inflation. With the welfare loss caused by the variability of inflation and real GDP both amounting to 0.4 percent of permanent consumption, the total welfare loss relative to the Ramsey plan is only 0.8 percent of permanent consumption. In conclusion, under optimal discretion a nominal-GDP level target outperforms a flexible inflation target to a considerable extent.

In the case of simple policy rules that allow for forward guidance, the case is no longer

as clear cut as under discretion though. Two types of simple policy rules are considered, namely a Taylor type rule and a nominal-GDP level rule. Both types of policy rules incorporate the possibility of forward guidance, however, a key feature of the nominal-GDP level rule is that the central bank can offer forward guidance on both the policy rate as well as nominal GDP whereas under the Taylor type rule, forward guidance can only be given on the policy rate. In the first step of the evaluation of the policy rules' performance, the optimal values - optimal in the sense that the welfare loss relative to the Ramsey plan is minimized - for the smoothing coefficients are numerically determined. In the model, the smoothing coefficient in the Taylor rule provides the greatest marginal effect on welfare. In the nominal-GDP level rule, the marginal effect of the smoothing coefficient is much less pronounced. Owing to the fact that the scope for smoothing is greater in the Taylor type rule, as the nominal-GDP level rule provides forward policy guidance even in the absence of smoothing. As a result, Billi (2014) finds the optimal value for each rule coefficient to be practically equal to 1 in this model. Using the optimal coefficient, it can be shown that forward guidance on the policy rate offers a considerable anchoring effect. Figure 7 highlights three cases in which the monetary authority issues forward guidance on the policy rate, nominal GDP or on both. In each case with the coefficients being at their optimal level. With forward guidance on nominal GDP only, welfare loss is minimized at an inflation target of 0.2 annually, with the corresponding welfare loss being 0.12 percent of permanent consumption. By issuing forward guidance on the policy rate, the central bank is able to anchor inflation more firmly, with the inflation target falling down to zero and corresponding welfare loss of 0.02 percent of permanent consumption. The best result can be achieved by providing forward guidance on both policy rate and nominal GDP, although the welfare gains accrued by the inclusion of forward guidance on nominal GDP are only marginal.

The expected evolution of the model economy in a ZLB episode following a 2 standard deviation negative real-rate shock is shown in figure 8. Forward guidance in both cases, that is, on the policy rate and nominal GDP, creates a surge in inflation. By pushing it temporarily above target, faster recovery is promoted. With forward guidance on the policy rate, the nominal policy rate is kept at a lower level compared to forward guidance on nominal GDP only while it is gradually reverting to its equilibrium level. This prolonged and more forceful monetary stimulus created by forward guidance on the policy rate causes both inflation and the real GDP gap to overshoot, thus promoting a speedier recovery of the economy. With forward guidance on nominal-GDP only, the amount of monetary stimulus is considerably smaller, resulting in a more pronounced

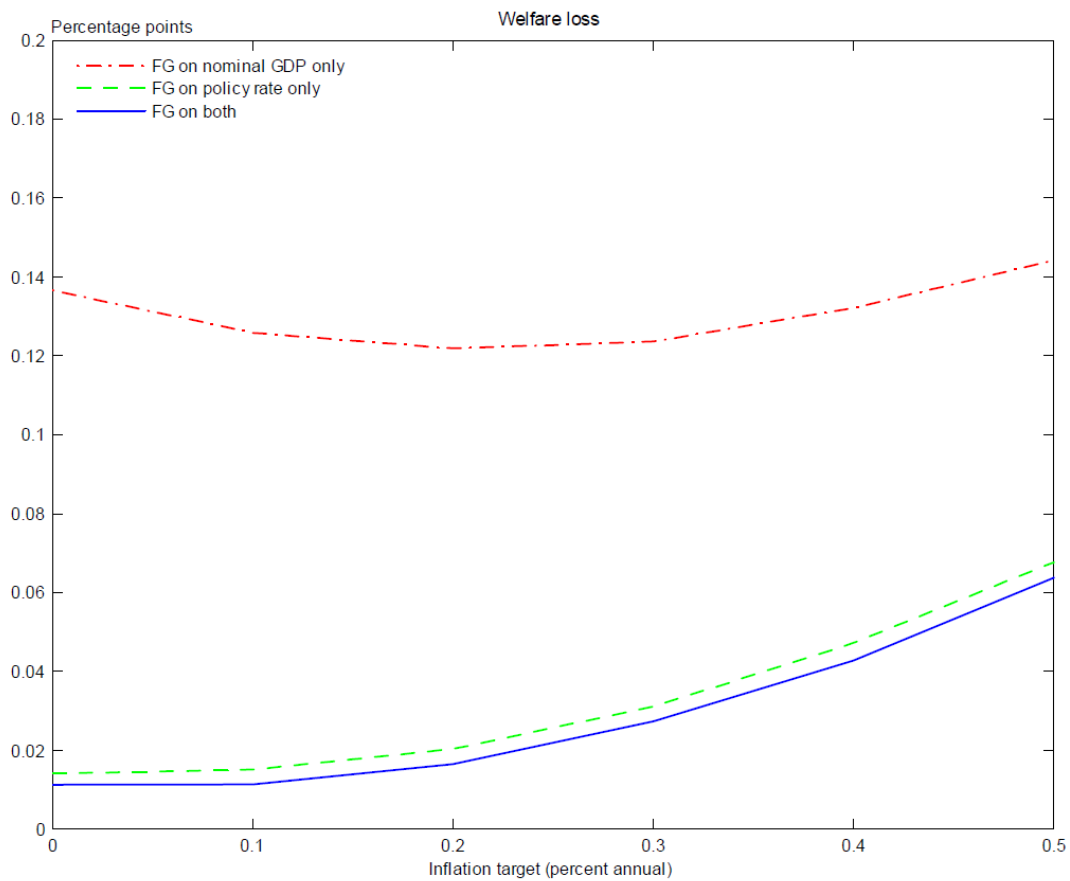


Figure 7: Anchoring effect of forward guidance in simple policy rules with optimal coefficients. Welfare loss is measured as permanent consumption loss relative to the Ramsey Plan. Source: Billi (2014, p. 31)

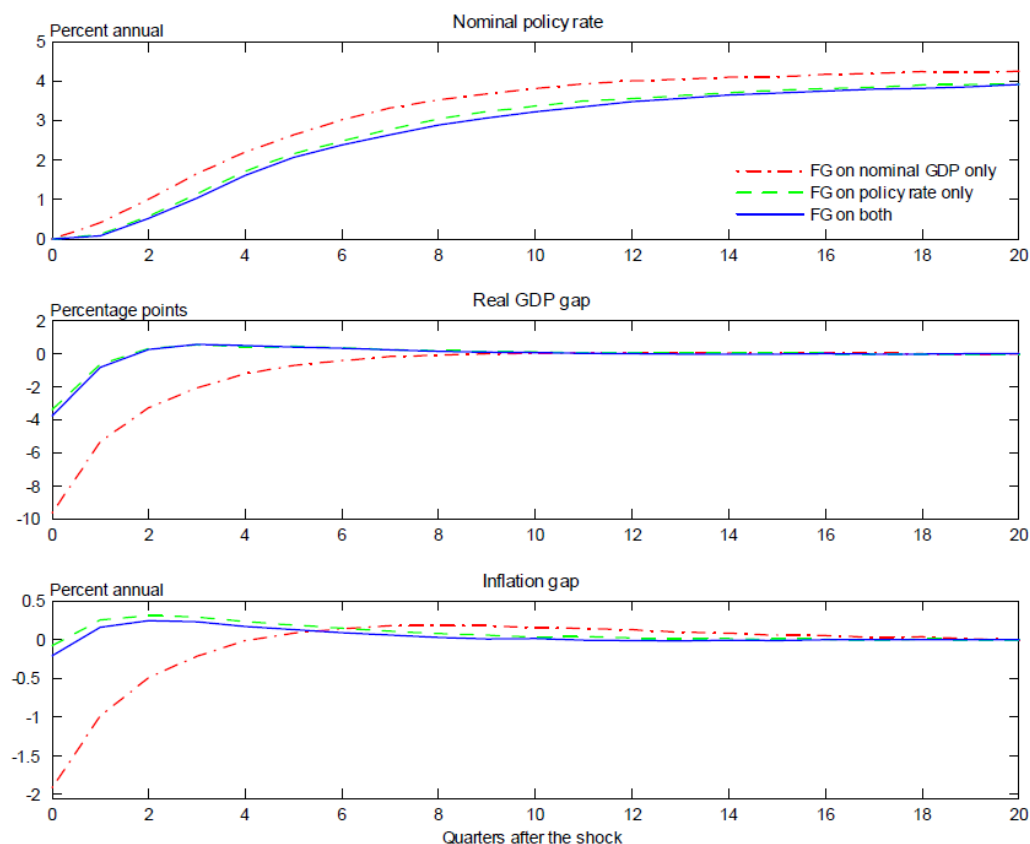


Figure 8: ZLB episode under simple policy rules with forward guidance. Shown is the expected path after a 2 standard deviation negative real-rate shock using the optimal inflation target and coefficients. Source: Billi (2014, p. 32)

recession and a slower recovery. It is also important to note, that the evolution of the model economy with forward guidance on both the policy rate and nominal GDP, closely resembles that of the economy under forward guidance on the policy rate only.

Table 3 presents a summary of the performance of the the simple policy rules with optimal inflation targets and coefficients that minimize the welfare loss relative to the Ramsey plan. Comparing forward guidance on the policy rate with forward guidance on nominal GDP, it can be seen that the former is associated with a lower inflation target, as well as lower welfare loss due to inflation and real GDP variability. However, the lower inflation target causes a higher incidence of ZLB episodes with a longer expected duration. This is also the case if forward guidance is issued on both the policy rate and nominal GDP,

	Inflation			Welfare loss relative to Ramsey ^g				
	target ^d	ZLB episodes		steady state		variability		Tot.
		freq. ^e	duration ^f	π	x	π	x	
Forward guidance	π^*							
on nominal GDP only ^a	0.2	9	2	0.00	0.00	0.07	0.05	0.12
on policy rate only ^b	0.0	10	3	0.00	0.00	0.02	0.00	0.02
on both ^c	0.0	11	4	0.00	0.00	0.01	0.00	0.01

a. Rule (7) with $\phi_i = 0$ and $\phi_y = 1$

b. Rule (6) with $\phi_i = 1$, $\phi_\pi = 1$ and $\phi_x = 1$

c. Rule (7) with $\phi_i = 1$ and $\phi_y = 1$

d. Percent annual

e. Expected percent of time at the ZLB

f. Expected number of consecutive quarters at the ZLB

g. Permanent consumption loss (percentage points)

Table 3: Performance of optimal simple policy rules with forward guidance. Source: Billi (2014, p. 27)

where expected incidence and duration of ZLB episodes are highest. Overall, the welfare loss associated with forward guidance on nominal GDP only sums up to 0.12 percent of permanent consumption, whereas with forward guidance on the policy rate only welfare loss sums up to only 0.02 percent of permanent consumption. As expected, incorporating forward guidance on both yields the best results with regard to minimizing welfare loss. Nevertheless, it can only slightly improve on the outcome of forward guidance on the policy rate alone, with welfare loss relative to the Ramsey plan summing up to 0.01 percent. Thus, if the possibility of forward guidance is considered, both targets perform roughly the same.

As the anchoring effect of forward guidance depends on the shock calibration as well as the monetary policy framework, in the final step of the policy evaluation Billi (2014) offers two robustness checks. First, since a higher shock variance entails a higher likelihood of ZLB episodes, the variance in the real-rate shock has a potentially strong impact on the anchoring effect of forward guidance. Substantially increasing the standard deviation

from its baseline value of 0.75 to 1 percent results the welfare loss associated with a monetary policy regime with forward guidance on nominal GDP to rise considerably from 0.12 to 0.45 percent of permanent consumption. In fact, this effect is owing to an increase in both the variability of inflation and real GDP. In the case of forward guidance on either the policy rate alone or on both nominal GDP and the policy rate, no noticeable change in welfare can be observed when the standard deviation of the real-rate shock is increased. Thus, in contrast to forward guidance on nominal GDP, the anchoring effect of forward guidance on the policy rate is very robust to uncertainty about the evolution of the economy. The second robustness check tackles the issue that with forward guidance on nominal GDP, the central bank's reaction in the model economy to prices and real economic activity has the same intensity. For this, Billi (2014) introduces a price level rule that allows for a more flexible approach, such that the central bank can react with different intensities. Using the flexible price target rule with optimal coefficients, the welfare loss relative to the Ramsey plan lies again around 0.01 percent of permanent consumption. Therefore, the analysis is robust to the consideration of a price level rule as well.

Overall, Billi (2014) concludes that for a plausible calibration to U.S. data, the inflation target outperforms a nominal-GDP target in his stylized model. This is due to the possibility of providing forward guidance directly on the policy rate, rather than indirectly on the level of nominal GDP the central bank seeks to attain. Moreover, forward guidance on policy rates firmly anchors inflation. This effectively eliminates one of the major setbacks of an inflation target under discretion in the form of the economy's proneness to fall into a deflationary trap if the inflation target is set too low. Lastly, the performance of monetary policy with forward guidance solely on nominal GDP is severely curbed in the face of high uncertainty towards future developments of the economy. Thus, Billi (2014) concludes that contrary to some recent proposals, inflation targeting should not be abandoned. Regardless, he acknowledges that central banks could adopt a nominal GDP target, with forward guidance on both policy rates and nominal GDP though he holds that this would imply nothing short of a fundamental change in the current monetary policy framework of the major central banks. Since his analysis does not take any potential costs entailed by a regime change into account (e.g. the uncertainty faced by households and firms), he hypothesizes that accounting for these costs would provide even further incentives to give guidance directly on policy rates in order to anchor the economy more firmly.

These conclusion are however not entirely incontestable, especially not in the form presented by Billi (2014). To conclude that the nominal-GDP target is in fact 'outperformed' by the inflation target remains somewhat of a stretch, as this argument only holds if one excludes the possibility of the nominal-GDP target rule to provide forward guidance simultaneously on policy rates and nominal-GDP. Taking this into consideration, it is strictly speaking the nominal-GDP target that outperforms the inflation target, albeit only by a small margin. The analysis mainly serves to highlight the importance and the potential of forward guidance that causes both targets to perform roughly the same. The more reasonable conclusion to take from this model, would be that the benefits from the introduction of a nominal-GDP target instead of an inflation target would be small at best, if they manifest at all. This point is touched in the second argument by Billi (2014), that the implementation of a nominal-GDP target would be a major shift in the way monetary policy is conducted. Again, the conclusion that potential costs of a shift in monetary policy caused by uncertainty of households and firms provide stronger incentives to give forward guidance directly on policy rates is not truly an argument against the adoption of a nominal-GDP target per se. This form of forward guidance can also be provided under a nominal-GDP target. But as elaborated in the previous chapters, such overhaul of the way monetary policy is conducted, is clearly an issue of central bank credibility. Recalling the argument made by Sims (2010), central banks have built up a reputation as fierce inflation-fighters over the last decades. A sudden announcement of the adoption of a nominal-GDP target - which typically entails higher inflation - instead of an inflation target might not seem credible to the public. Additionally, since an overshooting of the inflation rate causes welfare losses in a normal economic environment, the public might anticipate that a central bank will abandon the nominal-GDP target again, as soon as the additional monetary stimulus has brought the economy back on its recovery-track. Of course, if the public expects the central bank's new policy framework to be only temporarily, it is unlikely that these expectations would then be in line with the intentions of the central bank. Not only might the benefits of a nominal-GDP target then fail to manifest, but future monetary policies could then become even harder to implement if the central bank's credibility is harmed. Any deviation in the policy plans comes with a certain risk for a central bank's reputation. In that sense, whether a nominal-GDP target should be adopted, is not the sole question that needs to be asked here. The question of *how* such a target is introduced is of equal importance.

4.2 The Practical Side: Implementing a Nominal GDP-Target

In this thesis, I focus on two proposals on how the implementation of a nominal-GDP target could be approached. While the proposal by Frankel (2013) is calling for the replacement of the inflation target, Woodford (2013) argues in favour of the adoption of a nominal-GDP target, in addition to the inflation target. Insofar, the second proposal can also be viewed as a way of 'fine-tuning' inflation targeting rather than abandoning it completely.

In its essence, the proposal of Frankel (2013) is a plan for a two step phase-in of a nominal-GDP target that would allow central banks to remain committed to inflation around 2 percent. He notes that in an economy like Europe in 2013, on the edge between recovery and recession, a 4-5 percent target for nominal-GDP growth in the coming year would correspond to an inflation target of 4 percent. However, aiming towards inflation rates of 4 percent remains an idea many central bankers are averse to (regardless whether it is the entailed consequence of a nominal-GDP target or a higher explicit inflation target), as they are reluctant to abandon a target that has succeeded in keeping inflation expectations firmly anchored for many years. Furthermore, many central bankers worry that even if this increase in inflation were explicitly temporary, there might be permanent damage to the credibility of the nominal anchor. Though Frankel argues, commitment to the 2 percent target can be maintained by a two step implementation of a nominal-GDP target. In the first step, central banks should begin by omitting the public projections for near-term inflation and real growth, but at the same time keeping the longer-run projections and inflation-setting where they are. Moreover, central banks should add a longer-run projection for nominal-GDP growth that should be around 4-4.5 percent for the U.S., corresponding to a long-run real growth rate of 2-2.5 percent which is the same as in the current setting. In the second step, the projections for nominal-GDP growth over the coming three years should be added which should be above 4 percent for the U.S., UK and the Eurozone (Frankel (2013) suggests 5 percent in the first year, going up to 5.5 percent afterwards), while the projections for the longer-run should be maintained at 4-4.5 percent. This move would trigger speculations on how exactly the nominal-GDP growth breaks down between real growth and inflation. The idea is that a nominal-GDP target would then ensure that either the real GDP growth rate increases, or, if this is not the case, that the real interest rate falls, which would help to boost demand. In the long run, nominal-GDP growth would revert back to an annual rate of 4-4.5 percent with real growth returning to its potential and inflation back to its target. Thus, by

substituting the Taylor rule by a nominal-GDP target at one- or two-year horizons, the long-term inflation target could be kept intact, while in the short-run more monetary stimulus could be accrued. But as Gerlach (2013) points out, that for the inflation to remain stable in the medium run, it is essential that the central bank has good grasp of what path of real GDP is feasible. Unfortunately this information is not easy to obtain. In the aftermath of the recent economic crisis nominal GDP has fallen below trend in many economies. Following a nominal GDP target would then require central banks to take measures in order to stimulate the economy. But the financial bubble preceding the crisis has evidently boosted nominal GDP above its sustainable growth path. Moreover, as the literature on growth following a financial crisis suggests, real GDP will grow at a lower rate than would otherwise be the case. The extent of both effects remains unclear. Hence, he concludes that determining a plausible nominal GDP target path is particularly difficult for a central bank in the aftermath of a financial bubble. While it is likely that nominal GDP currently lies below potential in many economies, by how much this is the case remains guesswork. Setting the nominal GDP target path too high then carries the risk of an inflation above the usual 2 percent target.

The proposal by Woodford (2013) can be seen as a variation of the above proposal that also calls for the adoption of a nominal GDP level path as a near-term criterion for monetary policy. Frankel (2013) notes that this variation would deal with the problem that some central bankers fear that under the current economic conditions, no reliable quantitative target at a one- to two-year horizon for either consumer price index or nominal GDP can be delivered. In this case, central banks provide forward guidance by announcing to keep policy rates low as long as nominal GDP remains below the estimated path of potential GDP. The adoption of a nominal-GDP level target would introduce history-dependence into the policy commitment of a central bank, in the sense that a central bank would commit to make up for any deviation from the target path of nominal GDP due to the loss of aggregate expenditure caused by the binding ZLB. This could be achieved by temporarily aiming for higher nominal GDP growth rates in the near term, helping to put the economy back on the nominal GDP trend path it would have followed, were it not for the disturbances. As Woodford (2013) holds, this differs from the purely forward-looking approach common to inflation targeting. In this approach, normal stabilisation objectives will be followed as soon as the ZLB is no longer binding. However, this causes expectations on future policy to become fairly contractionary. This has two reasons. On one hand, the public expects nominal growth to be insufficient for an indeterminate period when the ZLB is binding. On the other

hand, the public also expects that the central bank will not let the nominal growth rate exceed its normal rate when the ZLB is no longer binding. Moreover, as argued in Woodford (2008), such a history-dependent targeting procedure should incorporate an error-correction commitment. Under such a commitment, a central bank that misses a nominal growth target due to its mistakes in setting the policy instrument, can be expected to take actions in order to compensate the lost growth as soon as mistakes are realized. When anticipated, the expectation of such an error-correction could reduce the size of the deviation caused by the flawed setting of the policy instrument. This, in turn, would of course help to stabilize economic outcomes given the limitations in the real-time availability of information for the central bank needed to accurately set the policy rate.

Furthermore Woodford (2013) too argues that the adoption of a nominal-GDP path is not at all incompatible with following an inflation target in the medium-run. Even more so, that commitment to a nominal-GDP level path could add to a more complete description of how commitment to an inflation target is carried out in practice. This argument is mainly based on Woodford's view that an inflation target by itself does not offer enough information on how near-term policy decisions are actually made. A nominal-GDP level path could then serve as a clear near-term target criterion with two distinct benefits. For one, it is a criterion not referring to inflation alone, and additionally, when following this path, it can be expected that the desired medium- to long-run inflation rate is achieved. Woodford (2013) considers this approach to be much less of a departure from existing policy commitments of flexible inflation targeting compared to the form of forward guidance now applied by the U.S. FOMC. There, policy decisions are explicitly tied to an unemployment rate threshold. In fact, he argues, that this inclusion of a numerical threshold on unemployment poses a greater risk for the Fed's commitment to its medium-run inflation target than would be the case under the adoption of a nominal-GDP level path. This is because these thresholds must always represent two things: a departure from previous policies, and a new policy approach that differs from what the central bank wants the public to anticipate about policy in the future once the economic environment has normalized again. In that sense, such temporary thresholds can neither serve as a criterion to determine whether or not past policy decisions (e.g. bringing the policy rate close to zero) were appropriate under the FOMC's initial policy approach nor is it a criterion the FOMC can be expected to base future policy decisions on in a normal economic environment. A nominal-GDP level path in contrast could be chosen in such a way that it would describe a path that is consistent with the previous policy goals and also achieve the medium-run inflation target of the central bank under normal economic

circumstances.

From a practical point of view, the second proposal seems more promising as no considerable deviations from current monetary policy conduct would be necessary. As shown in e.g. Billi (2014), the inclusion of forward guidance on nominal GDP can theoretically improve on the performance of forward guidance on policy rates alone. However, data availability is a critical weak spot of using nominal GDP as a target, as data from national accounts is only available with considerable lags and frequently revised (Gerlach 2013). How well the economy performed compared to a envisaged nominal-GDP target, can only be assessed after several months have passed. Relying on forecasts for policy decisions too can be problematic, especially if sudden and unexpected shocks occur. Hence, how well the inclusion of an additional nominal-GDP target performs will to some extent also depend on the quality of the forecasts.

5 Conclusion

In this thesis I address the issue whether or not the adoption of a nominal-GDP target instead of an inflation target would be a preferable move under the current economic circumstances. However, evidence on this topic is inconclusive. Although recent theoretical works like Billi (2014) and Honkapohja & Mitra (2014) find that a nominal-GDP target can indeed yield favourable results during a ZLB episode, neither study takes the issue of central bank credibility into account. Moreover, Billi (2014) finds that the benefits of adopting a nominal-GDP target are relatively small in size if the possibility of forward guidance is taken into consideration. Recalling that imperfect credibility can significantly reduce the potency of monetary policy - in particular in presence of the ZLB - it remains questionable if these benefits of a nominal-GDP target would manifest at all. Worse yet, if the overhaul of the monetary policy approach would in fact cause worse outcomes if the credibility of the central bank is battered. As shown in Dennis (2014), even small falls in credibility can have a substantial impact on the effectiveness of monetary policy. Consequently, more research in this area is needed to adequately address this issue. For instance, incorporating the quasi-commitment approach used in Bodenstein et al. (2012) into the model employed in Billi (2014), to investigate the effects of imperfect credibility on the different monetary policy regimes, would be an interesting starting-point for further research. But this will take time and it is unlikely that a satisfactory answer to this question can be found fast enough, such that policy conclusions can be drawn that would help to overcome the current economic slump at a greater pace.

Yet there is a viable alternative, as a nominal-GDP target and an inflation target are not necessarily mutually exclusive. The adoption of an additional nominal-GDP target - especially for the short-run - while retaining the medium-run inflation target, does indeed carry some promising prospects. This is particularly true if the possibility of granting forward guidance is taken into consideration, which can drastically improve on the effectiveness of monetary policy in general. In the recent past the issue of forward guidance has received its fair amount of attention. Most notably in the prominent case of the U.S. Fed struggling with exceedingly tight public expectations on monetary policy. The main lesson is that the way monetary policy is communicated is critical. As Bodenstein et al. (2012) highlight, when the ZLB is a binding constraint lower levels of credibility force central banks into announcing increasingly extreme monetary policy plans in order to leverage all the credibility available to them. More explicit and forceful Odyssean

forward guidance also can be seen as an attempt by a central bank to throw as much weight as possible behind its policy announcement in terms of credibility. Hence, it must be acknowledged that such forceful forms of forward guidance can only be used if one is willing to take certain risks with respect to the effectiveness of future monetary policy. The fact that a central bank has to rely on such forceful forms of forward guidance, can be interpreted as a sign of having to operate under imperfect credibility. In this light, the reluctance of central bankers to adopt a new monetary policy framework in the form of a nominal-GDP level rule is to some extent understandable as the risk for the credibility of future monetary policy could be even greater. Nevertheless, the incorporation of explicit thresholds on inflation and unemployment into monetary policy decisions by the FED, is in itself already somewhat of a deviation from the previous approach of flexible inflation targeting. Incorporating a nominal-GDP target into the broad framework of flexible inflation targeting as proposed by Woodford (2013), might indeed not be such a stretch policy-wise after all. By providing a clearer setting of how monetary policy decisions are made in the short-run, this could be a viable alternative to the use of very explicit forward guidance with a threshold on unemployment. Under a short-term nominal-GDP target, the option of using forward guidance is still available, and the medium-term inflation target can also be left intact. Therefore, two major benefits of a flexible inflation targeting regime can be maintained, while more monetary stimulus during an economic downturn could be accrued. Taking into account the experience of the past six years, it is evident that a ZLB episode is much more likely than pre-crisis literature suggested. From this point of view, the adoption of an additional short-term nominal-GDP target seems a favourable move - though to the same extent that this is a theoretical issue, it is a practical issue as well. With most announcements in monetary policy, the way a nominal-GDP target is implemented and *how* this is communicated is a delicate issue. Even in this case, the problems of correctly specifying the nominal-GDP target path remain. But as the medium term inflation target remains more firmly anchored than in the case of a target replacement, the risk of a painful overshoot of the inflation rate is substantially reduced.

References

- Adam, K. & Billi, R. M. (2006), ‘Optimal Monetary Policy under Commitment with a Zero Bound on Nominal Interest Rates’, *Journal of Money, Credit, and Banking* **38**(7), 1877–1905.
- Bean, C. R. (1983), ‘Targeting Nominal Income: An Appraisal’, *The Economic Journal* **93**, 806–819.
- Billi, R. M. (2011), ‘Optimal Inflation for the US Economy’, *American Economic Journal: Macroeconomics* **3**, 29–52.
- Billi, R. M. (2014), ‘Nominal GDP Targeting and the Zero Lower Bound: Should We Abandon Inflation Targeting?’, *Sveriges Riksbank Working Paper Series* (270).
- Blanchard, O., Dell’Ariccia, G. & Mauro, P. (2010), ‘Rethinking Macroeconomic Policy’, *International Monetary Fund*.
- Blinder, A. S. (1999), ‘Central Bank Credibility: Why do we care? How do we build it?’, *NBER Working Paper Series* (No. 7161).
- Bodenstein, M., Hebden, J. & Nunes, R. (2012), ‘Imperfect credibility and the zero lower bound’, *Journal of Monetary Economics* **59**, 135–149.
- Campbell, J., Evans, C., Fisher, J. & Justiniano, A. (2012), ‘Macroeconomic Effects of Federal Reserve Forward Guidance’, *Brookings Papers on Economic Activity* pp. 1–80.
- Chung, H., Laforte, J., Reifschneider, D. & Williams, J. (2012), ‘Have We Underestimated the Probability of Hitting the Zero Lower Bound?’, *Journal of Money, Credit and Banking* **44**, 47–82.
- Debortoli, D. & Nunes, R. (2010), ‘Fiscal policy under loose commitment’, *Journal of Economic Theory* **145**(3), 1005–1032.
- den Haan, W. (2013), Introduction, *in* W. den Haan, ed., ‘Forward Guidance: Perspect-

- ives from Central Bankers, Scholars and Market Participants’, Centre for Economic Policy Research, pp. 1–21.
- Dennis, R. (2014), ‘Imperfect credibility and robust monetary policy’, *Journal of Economic Dynamics & Control* **44**, 218–234.
- Eggertsson, G. & Woodford, M. (2003), ‘The Zero Bound on Interest Rates and Optimal Monetary Policy’.
- Frankel, J. (2013), Nominal-GDP-targets, without losing the Inflation Anchor, *in* R. Baldwin & L. Reichlin, eds, ‘Is inflation Targeting Dead? Central Banking After the Crisis’, Centre for Economic Policy Research, pp. 90–94.
- Galí, J. (2008), *Monetary Policy, Inflation and the Business Cycle: An Introduction to the New Keynesian Framework*, Princeton University Press.
- Gerlach, S. (2013), Is inflation targeting passé?, *in* R. Baldwin & L. Reichlin, eds, ‘Is inflation Targeting Dead? Central Banking After the Crisis’, Centre for Economic Policy Research, pp. 37–43.
- Hansen, L. & Sargent, T. (2008), *Robustness*, Princeton University Press.
- Honkapohja, S. & Mitra, K. (2014), ‘Targeting Nominal GDP or Prices: Guidance and Expectation Dynamics’, *Bank of Finland Research Discussion Papers* **4**.
- Marcet, A. & Marimon, R. (2011), ‘Recursive Contracts’, *EUI Working Paper* .
- Mishkin, F. S. (2004), ‘Can Central Bank Transparency Go Too Far?’, *NBER Working Paper Series* (No. 10829).
- Praet, P. (2013), Forward guidance and the ECB, *in* ‘Forward Guidance: Perspectives Central Bankers, Scholars and Market Participants’, Centre for Economic Policy Research, pp. 25–34.
- Roberds, W. (1987), ‘Models of policy under stochastic replanning’, *International Monetary Review* **27**, 731–755.

- Schaumburg, E. & Tambalotti, A. (2007), ‘An Investigation of the Gains from Commitment in Monetary Policy’, *Journal of Monetary Economics* **54**, 302–324.
- Sims, C. (2010), ‘Commentary on Policy at the Zero Lower Bound’, *International Journal of Central Banking* **6**(1), 205–213.
- Smets, F. & Wouters, R. (2007), ‘Shocks and frictions in US business cycles: a Bayesian DSGE approach’, *American Economic Review* **54**, 302–324.
- Snowdon, B. & Vane, H. R. (2005), *Modern Macroeconomics: Its Origins, Development and Current State*, Edward Elgar Publishing.
- Williams, J. (2014), ‘Monetary Policy at the Zero Lower Bound: Putting Theory into Practice’, *Hutchins Center Working Papers* .
- Woodford, M. (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press.
- Woodford, M. (2008), ‘How Important is Money in the conduct of Monetary Policy?’, *Journal of Money, Credit and Banking* **40**, 1561–1598.
- Woodford, M. (2012), ‘Methods of Policy Accommodation at the Interest-Rate Lower Bound’.
- Woodford, M. (2013), Inflation Targeting: Fix it, don’t scrap it!, *in* R. Baldwin & L. Reichlin, eds, ‘Is inflation Targeting Dead? Central Banking After the Crisis’, Centre for Economic Policy Research, pp. 74–89.

6 Appendix

German Abstract

Diese Arbeit untersucht die potentiellen Vorteile, die durch die Einführung eines nominalen BIP-Ziels anstelle eines Inflationsziels lukriert werden können. In einfachen Neuk Keynesianischen Modellen, in denen sich die Wirtschaft in einer Liquiditätsfalle befindet, kann ein nominales BIP-Ziel Wohlfahrtsgewinne erzielen. Wird jedoch die Nutzung von sogenannter "Forward Guidance" durch die Zentralbanken in Betracht gezogen, werden die potentiellen Wohlfahrtsgewinnen beträchtlich reduziert. Handeln Zentralbanken darüber hinaus unter unvollkommener Glaubwürdigkeit, kann es zu Diskrepanzen zwischen der Erwartungshaltung des privaten Sektors und den Intentionen der Zentralbanken kommen. Ein Wechsel eines Hauptbestandteils der Geldpolitik kann dann die Unsicherheiten im privaten Sektor verschärfen und dadurch sogar in Wohlfahrtsverlusten resultieren. Ein Umsturz des langfristigen geldpolitischen Zieles durch die Einführung eines nominalen BIP-Ziels birgt also beträchtliches Risiko. Die komplementäre Implementierung eines nominalen BIP-Ziels zusätzlich zu dem bestehenden Inflationsziel könnte dieses Risiko reduzieren und stellt damit eine interessante Alternative zu einem alleinigen Inflationsziel dar.

CURRICULUM VITAE

Personal Data

DATE OF BIRTH 25 November 1988
NATIONALITY Austrian
EMAIL mic.berger88@gmail.com

Education

10/2012 - Now Mag.rer.soc.oec. (MSc equivalent) in ECONOMICS (research oriented)
Department of Economics, University of Vienna, Austria

10/2009 - 06/2012 Bakk.rer.soc.oec. (BSc equivalent) in ECONOMICS
Department of Economics, University of Vienna, Austria
Thesis I: “Die Auswirkungen von Privatisierungen auf die wirtschaftliche und soziale Entwicklung von Entwicklungsländern [The impact of privatizations on the economic and social development of developing countries]”
Supervisor: Karin Mayr
Thesis II: “On value theory in Friedrich Freiherr von Wieser’s ‘Theorie der Gesellschaftlichen Wirtschaft’ (‘Social Economics’), his methodological approach and its logical implications”
Supervisor: Karl Milford

Work Experience

10/2014 - 01/2015 Teaching Assistant at UNIVERSITY OF VIENNA
Department of Economics
Assisting Assistant Professor Melis Kartal in proctoring exams and grading homework exercises for her undergraduate lecture on *Introductory Macroeconomics*.

08/2012 - 11/2014 Research Assistant at INSTITUTE FOR ADVANCED STUDIES, Vienna
HealthEcon Group
Assisting in and conducting research projects dealing with topics in health economics, in particular health service provision in primary care

10/2013 - 01/2014 Teaching Assistant at UNIVERSITY OF VIENNA
Department of Economics
Organizing a self-organized lecture entitled *Europe: Economic and Political Perspectives* for undergraduate economics students by independently choosing topics and inviting corresponding researchers; grading essays.

Languages

GERMAN Mother tongue.

ENGLISH Proficient user.

FRENCH Independent user, 5 years of schooling.

Computer Skills

MS-OFFICE	Proficient user, self-taught, everyday use.
L ^A T _E X	Independent user, self-taught, everyday use.
STATA	Independent user, self-taught and applications covered in MSc economics programme.
MATLAB	Independent user, self-taught and applications covered in MSc economics programme.
EViews	Basic user, introductory applications covered in BSc and MSc economics programmes.

Further Activities

2012 - 2015	Co-author of various issues of <i>Der Rote Börsenkrach</i> , a paper for economics students at the University of Vienna.
-------------	--

Publications

RESEARCH REPORTS	Czypionka, T., Ulinski, S., Berger, M.: <i>Best Point of Service: Konzeption und Ansätze zur Bestimmung [Best Point of Service: Conception and Approaches for Identification]</i>. IHS Research Report, October 2013. Czypionka, T., Ulinski, S., Berger, M.: <i>Skaleneffekte intermediärer Versorgungsformen [Economies of Scale in Intermediate Care]</i>. IHS Research Report, March 2013. Czypionka, T., Müllbacher, S., Berger, M., Platzer J.: <i>Kooperationen in der ambulanten Versorgung [Cooperation in Ambulatory Care]</i>. IHS Research Report, September 2012.
PUBLICATIONS	Czypionka, T., Berger, M.: <i>Zum Nutzen von Diagnosekodierungen in sterreich. [On the Benefits of Diagnosis Codes in Austria.]</i> Health System Watch IV/2014. Czypionka, T., Röhring G., Ulinski S., Berger, M.: <i>Ambulatory Sensitive Care Conditions: Einflussmöglichkeiten und Ansätze zur Reduktion - Internationale Evidenz. [Ambulatory Sensitive Care Conditions: Influence Possibilities and Approaches for Reduction - International Evidence.]</i> Health System Watch II/2014. Czypionka, T., Sigl, C., Berger, M., Kronemann, F., Reiss, M.: <i>Qualitätsmanagement im ambulanten Bereich - Teil 2 [Quality Management in the Outpatient Sector]</i>. Health System Watch, I-B/2014.
PRESENTATIONS	Czypionka, T., Berger, M.: <i>Ambulante Versorgung zu Randzeiten Internationale Beispiele [Out-of-Hours Care - International Examples]</i>. Medizin und Management, Vienna, 12.10.2012