universität
wien

MASTERARBEIT

Titel der Masterarbeit

„Financial Stability and Monetary Policy of the European Central Bank“

verfasst von

Boris Kucera, BSc

angestrebter akademischer Grad

Master of Science (MSc)

Wien, 2016

Studienkennzahl lt. Studienblatt:	A 066 913
Studienrichtung lt. Studienblatt:	Masterstudium Volkswirtschaftslehre
Betreut von:	Univ.-Prof. Dipl.-Ing. Dr. Gerhard Sorger

Acknowledgment

I would like to express my deepest gratitude to my supervisor, Univ.-Prof. Dipl.-Ing. Dr. Gerhard Sorger, for all his patience and invaluable guidance throughout the completion of my Master's thesis. I would also like to thank Dr. Dipl.-Ing. Robert Kunst for all his help and insightful comments on the empirical part of my thesis.

Summary

Monetary policy of central banks has undergone a substantial transformation since its inception. The initial focus on liquidity and stability of the banking sector has shifted towards price stability and in some cases, resource utilization. Until recently it was widely held that price stability would ensure financial stability and output at the potential. However, the crash of 2008 clearly demonstrated otherwise. It is now being recognised that interest rate decisions of central banks, far from only having an impact on inflation and short-run output, affect risk-taking of financial institutions on both sides of their balance sheets. Empirical evidence supports this risk-taking channel hypothesis and suggests that prolonged periods of low interest rates encourage banks to take excessive risks, thus contributing to financial instability. With the use of a theoretical model I demonstrate that this impact of policy rates on bank risk-taking cannot be fully neutralised by a prudential regulator.

The empirical part of my thesis investigates the relationship between the policy rates of the European Central Bank (ECB) and a proxy for financial instability – the credit to GDP gap – which has a record as one of the best predictors of financial crises and which serves as the basis for setting the countercyclical capital buffers defined in the Basel III regulations. My results suggest that policy rates of the ECB do not cause changes in the credit to GDP gap, whilst changes in the credit to GDP gap seem to affect the interest rate behaviour of the ECB. As a result, monetary policy of the ECB can be described as purely reactionary to financial shocks.

To account for the impact of interest rates on risk-taking in the financial sector, I advocate a slightly modified version of inflation targeting, which would incorporate the so-called "finance-neutral" output gaps in the spirit of Borio et al. (2013). Finance-neutral output gaps provide a better measure of the underlying cyclical conditions in the wider economy and can therefore signal a need to tighten the monetary policy even if inflation remains close to the target. However, whilst monetary policy clearly matters for financial stability, prudential regulation ought to be the main safeguard against financial instability. Monetary policy should only assume a complementary role.

Zusammenfassung

Die Geldpolitik der Zentralbanken hat sich seit ihrem Entstehen deutlich geändert. Die ursprünglichen Aufgaben der Zentralbanken, die Liquidität und Stabilität des Bankensystems zu gewährleisten, wurden in den letzten Jahrzehnten in den Hintergrund gedrängt. Stattdessen hat sich die Geldpolitik in dieser Periode ausschließlich auf Inflation konzentriert. Das Argument dafür war die Vermutung, dass Preisstabilität auch für die Stabilität des Finanzsystems sorgen würde. Die Ereignisse von 2008 haben diese Vermutung eindeutig widerlegt. Heutzutage wird allgemein anerkannt, dass Geldpolitik eine starke Auswirkung auf die Risikoneigung im Finanzsektor hat. Die wachsende empirische Literatur zeigt, dass langfristig niedrige Zinsen Anreize für Banken schaffen, beträchtliches Risiko einzugehen. Dieses Verhalten führt letztendlich zu finanzwirtschaftlicher Instabilität. Mithilfe eines theoretischen Modells beweise ich, dass die Auswirkungen der Niedrigzinspolitik auf die Risikoneigung der Banken nicht völlig durch die Aufsichtsbehörde neutralisiert werden können.

Der empirische Teil meiner Masterarbeit erforscht die Beziehung zwischen der Zinspolitik der Europäischen Zentralbank (EZB) und einem Indikator finanzieller Instabilität – Kredit/BIP-Lücke. Diese Kredit/BIP-Lücke ist einer der besten prognostischen Barometer für Finanzkrisen und dient als Grundlage für den in Basel III festgelegten antizyklischen Kapitalpuffer. Meine Ergebnisse weisen darauf hin, dass die EZB Zinspolitik keine Auswirkung auf die Kredit/BIP-Lücke hat, jedoch stattdessen die Kredit/BIP-Lücke die Zinspolitik der EZB beeinflusst.

Um die Auswirkung der Zinsrate auf die Risikoneigung im Finanzsystem erkennbar zu machen, schlage ich die Einführung von „finance-neutral output gaps“ in den Entscheidungsprozess von Zentralbanken vor (Borio et al. (2013)). „Finance-neutral output gaps“ spiegeln die eigentlichen zyklischen Bedingungen in der Volkswirtschaft wider und können eine Verschärfung der Geldpolitik andeuten, auch wenn das Inflationsziel erreicht ist. Doch selbst wenn die Geldpolitik offensichtlich

für die finanzielle Stabilität von Bedeutung ist, sollte in erster Linie die prudentielle Aufsicht für die finanzielle Stabilität sorgen.

Table of contents

1. Introduction

1.1 Brief history of central banking – from Lender of Last Resort to Inflation Targeting

Central banking and monetary policy have undergone a substantial transformation since their inception. Initially, central banks were privately owned institutions, independent of the government. Historically, the Bank of England can be considered as the first central bank of the modern kind. The heyday of the Bank of England was during the gold standard period (1870-1914) and its main task was to maintain external balance, more specifically, to ensure gold convertibility at the prevailing exchange rate. The pound sterling was convertible to gold at a given exchange rate and any bank (be it domestic or foreign) holding notes and/or reserves at the Bank of England was entitled to have its notes/reserves converted to gold on demand. As a secondary and subordinate role, the Bank of England was providing liquidity for the smooth functioning of the banking system. To fulfil both of the objectives, the Bank of England used the discount rate as its main instrument. At this rate, commercial banks rediscounted the bills of exchange they purchased from their corporate customers. The main role of the Bank of England was thus the maintenance of the external balance, whilst serving as the lender of last resort for the banking sector by rediscounting commercial paper.

Similarly, the creation of the Federal Reserve Bank of the United States in 1907 was the result of periodically repeating bank runs, which were plaguing the free banking system in the 19th and early 20th century. The long title of the Federal Reserve Act was formulated as follows: "An Act to provide for the establishment of Federal Reserve banks, to furnish an elastic currency, to afford means of rediscounting commercial paper, to establish a more effective supervision of banking in the United States, and for other purposes" (Federal Reserve Act, 1913). Thus the main role of the Federal Reserve was to act as a lender of last resort to the banking sector, providing liquidity in times of need by rediscounting commercial paper. It is important to note that nowhere at this stage of development of central banking was a mention that central banks should be targeting any particular macroeconomic variable or interfere with the functioning of the real economy. Central banks were concerned solely with the proper functioning of the banking system and currency convertibility into gold.

The gold standard was replaced by the havoc of the interwar period, in which countries began to slowly suspend the currency convertibility and instead started focusing on the domestic objectives of inflation and employment. The countries that tried to restore the pre-war gold parity shortly after the war, such as Britain, experienced pronounced recessions as the restoration required significant interest rate increases. The US also stayed on the gold standard until 1934 and this unfortunate decision prevented the US from conducting expansionary monetary policy, which would have accommodated the stock market crash and the subsequent depression. Central banking entered unchartered waters during the interwar period. Central banks started using previously unknown tools, such as credit controls, regulation of foreign exchange and management of clearing agreements (Toniolo, 2010)

The post-war period was characterised by a system of fixed exchange rates agreed at the Bretton-Woods conference in 1944. In this monetary system currencies were pegged to the US dollar whilst the US dollar, in turn, was convertible to gold at $35 for a troy ounce. Financial globalisation in the form of the newly-created eurodollar market and excessive monetary expansion in the US (as a result of financing the war in Vietnam) rendered the system unsustainable. The Bretton-Woods system collapsed in 1973 when President Nixon of the US suspended the convertibility of the US dollar to gold. In the Bretton Woods era exchange rates acted as the nominal anchor that central banks had to preserve. To achieve the exchange rate peg, central banks engaged in many of the activities already known from the interwar and war periods – ceilings on loan growth and interest rates etc.

The next couple of years after the fall of the Bretton Woods system were characterised by oil shocks and the ensuing stagflation. The West briefly flirted with the then increasingly popular ideas of monetarists, who held that inflation was always and everywhere a monetary phenomenon. Monetarists accused central banks of being responsible for excessive money creation and the spiralling inflation. As a result, central bank in the US started targeting the monetary aggregate M2 (consisting of currency in circulation, sight and term deposits) in order to bring inflation down to the desired level. However, thanks to the accelerating pace of financial development and difficulty in determining the precise composition of monetary aggregates, the monetarist experiment was abandoned. Meanwhile, as the monetarist experiment in the US was unwinding, European countries established the Exchange Rate Mechanism (ERM) – a system of managed float of the exchange rate. The exchange rates were fixed vis-à-vis the European Currency Unit (ECU), however, they were allowed to fluctuate within certain bounds. More specifically, the currency fluctuations had to be contained within a margin of 2.5% on either side of the bilateral rates. The Italian lira, the Spanish peseta, the Portuguese escudo and the British pound sterling were allowed to fluctuate within ±6% of the bilateral rates.

1990s marked the beginning of a new monetary policy framework. Failures of Keynesian demand management during the Bretton-Woods era as well as the various shortcomings of monetarism to contain inflationary spirals, paved the way for a new nominal anchor – inflation - and a new policy framework - inflation targeting. Inflation targeting provided a viable alternative to monetarism. The gist of inflation targeting lies in constraining the rate of price growth of a selected basket of commodities. Based on the notion of a Phillips curve grounded in the New Keynesian model, a stabilisation of inflation around a given target was expected to close the output gap and cause the economy to operate close to its potential - expressed in the words of the chief IMF economist Olivier Blanchard, a “divine coincidence” (Blanchard & Galí, 2007). Inflation targeting, either in its strict (absolutely no deviation from target allowed) or flexible form (minor deviations from the target allowed if output significantly depressed), remains the dominant modus operandi of the majority of central banks around the world. The frameworks differ only to the extent to which central banks attach different weights to inflation and output deviations. Some central banks, like the Federal Reserve of the US, have a dual mandate in that they also attach a lot of importance to output deviations from the potential. Other central banks, like (supposedly) the European Central Bank

(ECB), adhere to strict inflation targeting. Although as has been demonstrated by the recent past, the distinction can become quite blurred and central banks often do whatever it takes to stabilise dire economic situation.

The lesson that the brief history of central banking provides is twofold. Firstly, it demonstrates that central banking has undergone substantial transformation from its inception. In their early days central banks kept a very close eye on developments in the banking, and in the wider financial sector. Targeting of macroeconomic variables meant a complete departure from the original role of central banks. Secondly, the current inflation targeting framework is a relatively new invention and definitely not something which is set in stone. It has evolved as a result of a trial-and-error approach and it is only natural that we continue to ask ourselves how we can improve on the current policy framework.

The main motivation of my Master thesis is to reconsider the interaction between monetary policy and financial stability. The thesis will try to answer several questions. Firstly, should central banks focus on financial stability in their conduct of monetary policy? If so, what should be the extent - should they try to deliberately lean against the wind, or let the things run their course and then clean up the subsequent mess? Last but not least, I empirically examine whether the European Central Bank has been responding to selected indicators of financial stress in its policy rate decisions.

1.2. Appraisal of inflation targeting

Inflation targeting has been the incumbent monetary policy regime since 1990 when New Zealand adopted it as the first country in the world. In the 25 years of its functioning it has achieved considerable success, yet, as some critics point out, it has become a victim of its own success. So much so that many critics now argue for a complete overhaul of the framework.

Inflation targeting has become the dominant policy regime for a reason. After the oil shocks of 1970s and early 1980s inflation was still relatively high at the beginning of 1990s. Experiments with exchange rate and monetary aggregate targeting failed to tame the stubbornly high inflation. In New Zealand, the country of origin of inflation targeting, inflation was running at close to 7% and interest rates were in excess of 10%. The situation was not much different elsewhere around the world. The credibility of central banks, or rather lack thereof, necessitated large hikes in the policy rates in order to induce disinflation. Inflation targeting was initiated with the aim of taming high and volatile inflation for good and all.

As a policy framework, inflation-targeting has numerous desirable properties. It provides a clear and easily measurable nominal anchor. Unlike data on output, data on prices of goods are available at a relatively high (most often monthly) frequency. The inflation target is transparent, easily understood by and communicated with the public. This facilitates the planning of the private sector in terms of wage negotiation and indexation of financial contracts. As a result, inflation expectations ought to become more firmly anchored, which prevents the emergence of persistent inflationary shocks and the wage-price spirals. The clearly stated objective also makes central banks more accountable for their actions and prevents them from falling prey to the time-inconsistency trap. Given all the apparent benefits of inflation targeting, how did the framework fare in the 25 years of its existence? Was it able to achieve its stated goals?

It must be said in the beginning that inflation targeting proved very successful in attaining its goals. It helped to firmly anchor inflation expectations in countries where inflation had been high and volatile for years. By anchoring expectations around the target inflation rate central banks significantly reduced the persistency of inflationary shocks of the past decades. Gillitzer and Simon (2015) show that since the beginning of inflation targeting in Australia in 1991, the impact of shocks to current-year inflation on long-term inflation expectations has been significantly diminished. The transitory nature of inflation shocks in the inflation targeting framework has also been confirmed by Stock and Watson (2007), who demonstrate that in the US the variance of the trend component of inflation decreased markedly in the mid-1980s and then decreased even further after 1990 whilst the variance of the transitory component (outside the Fed's remit) has remained largely unchanged. As a result, the share of inflation variability accounted for by transitory shocks has risen significantly.

Gillitzer and Simon (2015) confirm these results for the case of Australia. The switch to an inflation-targeting regime has left the variance of tradable inflation (reflecting outside influences) almost unaffected. On the other hand, the persistence (sum of model's autoregressive coefficients) and variance of non-tradable inflation (under the control of the central bank) have both declined significantly after the switch to inflation targeting. Authors also demonstrate that inflation targeting has resulted in a flattening of the Phillips curve. As a result, inflation seems to be much less responsive to unemployment/output gaps than in the previous decades. In the past any major deviation in the unemployment gap was quickly reflected in the behaviour of inflation. However, the recent pre-crisis experience has shown that even significant deviations in output gaps are consistent with inflation at the target level. The best example of this is the experience of countries on the periphery of the euro area. Although these countries were experiencing unprecedented property booms, their inflation figures remained very close to the target, thus significantly underestimating the large positive output gaps that these countries had. The last finding of Gillitzer's and Simon's empirical investigation concerns the extent of pass-through of import price inflation to consumer price inflation. They find that the magnitude and the speed of the pass-through have both declined significantly after the introduction of inflation targeting. Even though Gillitzer and Simon conduct their analysis with Australian data, they point out that their results apply to almost all countries using inflation targeting.

Anchoring of inflation expectations, flattening of Phillips curve and the slower pass-through of inflation imply significant changes for the future conduct of monetary policy. Inflation, at least in the way it is defined now – as the rate of change in the Consumer Price Index (CPI), has decoupled from domestic cyclical conditions. Its relationship with output fluctuations has been severely weakened in the past decades and its failure to raise warning flags in the case of euro area periphery necessitate the search for a better indicator of the underlying cyclical conditions. If the economy is booming, the overheating is more likely to be reflected by wage pressures or asset price increases than by the headline inflation. Potential solutions include targeting the change in unit labour costs instead of the

CPI change or the inclusion of asset prices in the inflation measure. Another solution could be an explicit dual mandate as in the case of the Federal Reserve, whereby central banks stabilize output as well as inflation. Given the presence of the zero lower bound and the continued slack in the economy, many economists turn to even more radical proposals than inflation targeting with a different measure of inflation or the dual mandate. Some economists are keen to dismiss inflation targeting in favour of nominal GDP growth targeting. Others, such as Kevin Sheedy of the London School of Economics, argue for an even more radical proposal in the form of a nominal GDP target in levels (Sheedy, 2014). Unlike nominal GDP growth targeting, targeting the level of nominal GDP would require that past deviations from the target be corrected in the future. The attractiveness of the nominal GDP target lies in its ability to stabilise the debt-to-GDP ratio. Since financial contracts are written in nominal terms, a nominal GDP target would ensure that, on aggregate, debtors would be able to fulfil their obligations. Whilst nominal GDP targeting seems like a feasible option, I will propose a different solution in the "Policy Implications" part of my thesis, which is consistent with the current inflation-targeting framework.

All in all, inflation targeting was very successful in bringing about what it set out to do – anchor inflation expectations and prevent wage-price spirals of the previous decades. However, the above analysis of the current inflation targeting framework serves to demonstrate that price stability, due to firmly anchored inflation expectations and flattened Phillips curve, is not sufficient to guarantee either financial stability or equilibrium output. If anything, inflation targeting based on changes in the CPI has actually been detrimental to financial stability by lulling the policymakers into a false sense of security whilst imbalances were building up. The experience of the pre-crisis years calls for an extended policy horizon such that policy can be tightened, even if headline inflation remains on target, provided that signs of financial imbalances are emerging. Equally, there may be room for easing even if inflation exceeds the target provided that the inflation shocks causing the above-target inflation are imported and that output is significantly depressed. Ultimately however, there is no need for a change in the mandate of central banks since financial stability risks can be expressed in terms of their impact on price stability and output. The bottom line is that stabilisation of the economy around the inflation target is simply not enough to guarantee financial stability and equilibrium output.

To conclude the section, I have a look at the inflation-targeting performance of the European central bank. The ECB builds on its Bundesbank legacy in that it is very inflation averse and its sole objective, unlike in the case of the Federal Reserve in the US, is the price stability alone. This price stability is formally defined as inflation rate close to, but below 2%.

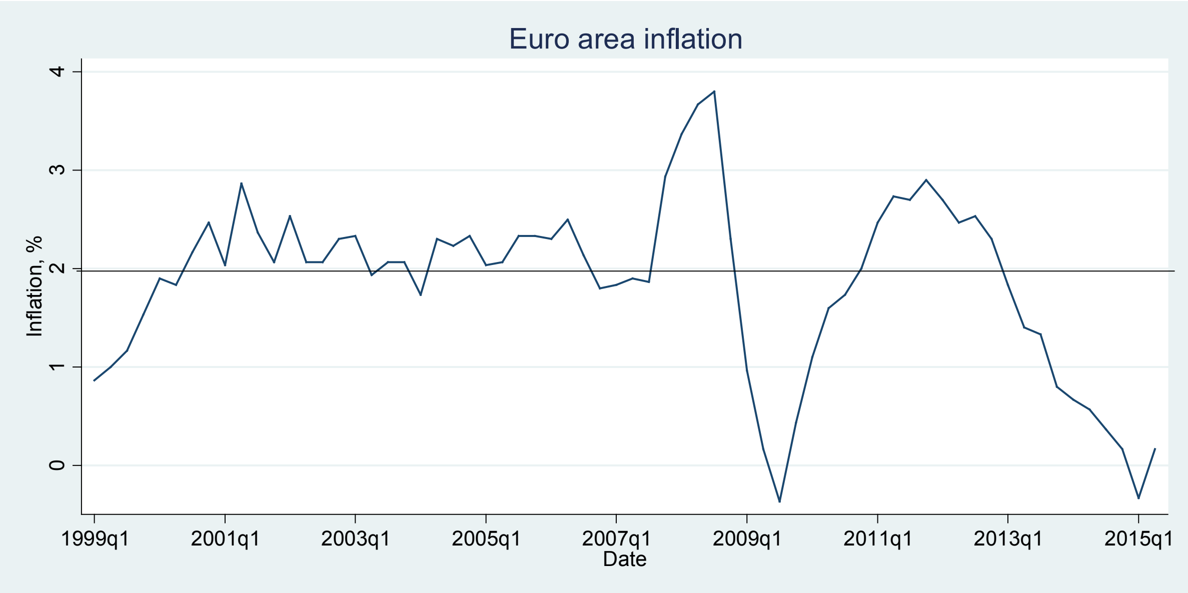

Figure 1: Euro area inflation versus the ECB target

As can be seen from Figure 1 above, the inflation-targeting performance of the ECB has been very mixed. The inflation rate, calculated as the rate of change in the Harmonised Index of Consumer Prices (at a quarterly frequency), was fluctuating around the 2% target only up to around the third quarter of 2007. After that the ECB has been consistently failing to hit the target rate of 2%. Thus it seems the ECB has only partially fulfilled its objective.

1.3. Risk-taking channel of monetary policy reconsidered

Despite the success of the inflation-targeting regime in attaining low and stable inflation and in firmly anchoring inflation expectations, it has been widely criticised in the post-crisis period. The main line of argument is that inflation-targeting helped mask financial instability developing in the system. It soon became apparent that achieving the inflation target does not automatically close the output gap, nor does it ensure financial stability, as was often assumed prior to the crisis. More specifically, central banks disregarded what is commonly referred to as the “risk-taking channel of monetary policy”.

Risk-taking channel of monetary policy describes “the impact of changes in policy rates on either risk perceptions or risk-tolerance and hence on the degree of risk in the portfolios, on the pricing of assets, and on the price and non-price terms of the extension of funding” (Borio & Zhu, 2012). The literature identifies three ways in which the risk-taking channel of monetary policy is manifesting itself. Firstly, changes in interest rates affect valuations, incomes and cash flows, which in turn affect the perceptions and pricing of risk (balance sheet effect). Secondly, changes in interest rates may drive a significant wedge between market rates and target rates of return of institutional investors. Pension funds or insurance companies may struggle to achieve the required rate of return using conservative investment strategies and may need to switch to riskier asset classes (search for yield effect). Thirdly, central banks' firm commitment towards a specific strategy – such as the resolution of Mario Draghi to do whatever it takes to save the euro in June 2012 – may reduce uncertainty about the future and thus compress risk premia (transparency effect). Following paragraphs will explain in much more detail each of the aforementioned effects.

Low interest rates boost not only asset and collateral values, but also profits and incomes, which in turn can reduce risk perceptions and/or increase risk tolerance (Borio & Zhu, 2012). The reason for this is that for a given expected cash flow, a lower discount/interest rate implies a higher present value of the cash flow. The mechanism is very similar to the famous financial accelerator model of (Bernanke, et al., 1999), which describes the link between the real economy and financial markets. The mechanism of the financial accelerator is as follows: in order to finance investment, firms can either use retained earnings (internal finance), or borrow the required funds from either banks or debt and equity markets (external finance). The difference in the cost of external versus internal finance is called the external finance premium. Owing to the asymmetric information between borrowers and lenders, borrowers are required to post collateral against the borrowed funds. As a result, the ability of firms to borrow depends on the value of the collateral or, more specifically, on the market value of their net worth. A fall in the policy rate boosts asset prices and these elevated asset prices in turn improve the balance sheets of firms and their net worth. This has a positive impact on firm investment and aggregate economic activity. The increased activity is translated into further increases in asset prices, collateral value and firm net worth, which lower the estimated probabilities of default[1]. The financial accelerator thus describes a feedback loop between policy rates, asset prices and aggregate economic conditions whereby seemingly small shocks to policy rates can result in relatively large changes in aggregate economic activity, which in turn impacts the estimated probabilities of default and risk perceptions more generally.

The empirical evidence on the impact of policy rates on risk perceptions and risk tolerance, while still relatively scant, has been growing in size in the aftermath of the financial crisis. Jimenéz et al. (2014) use micro data of the Spanish Credit Register over the period 1984-2006 to examine the interaction between the stance of the monetary policy and the riskiness of bank assets. Given that the monetary policy in Spain was essentially "determined in Frankfurt" by the decisions of the German Bundesbank (during the fixed exchange rate system of the ERM period) and of the ECB (post-1999), exogeneity of the monetary policy stance is ensured. In other words, authors use the German overnight rate as an instrument for the Spanish overnight rate, thus ruling out reverse causality and omitted variable bias. The authors find that lower interest rates prior to the origination of the loans induced more lending to borrowers with questionable or no credit history at all. Moreover, banks also granted more loans with a higher hazard rate (default probability normalized per time). However, lower interest rates implied lower default probability for the loans already granted - exactly as is predicted by the theory. Hence in the short-run, lower interest rates reduce credit risk but in the medium term they are likely

[1] Probability of default is usually estimated using regression techniques, logistic regression being the major one

to increase it. The main contribution of the paper is the finding that not only did the volume of loans to risky borrowers increase with low interest rates (predicted by the financial accelerator), the ex-ante default probability of these loans increased as well, implying that banks may assume more credit risk when monetary policy remains loose for a prolonged period of time. Jimenez et al. also demonstrate that the increase in risk appetite is not the same across the distribution – small banks and banks with ample liquidity undergo more credit risk when interest rates are low.

A very similar study of the effects of monetary policy on bank risk-taking was conducted by (Ioannidou, et al., 2015). They study the impact of the federal funds rate on the risk taking of Bolivian banks. The reason for choosing Bolivia was simple – Bolivian Peso was pegged to the US dollar and it had a completely dollarized banking system in the period 1999-2003. Given that the fed funds target rate was outside of Banco Central de Bolivia's remit, monetary policy is exogenous and authors can estimate the causal impact of low interest rates on bank risk-taking and risk-pricing. Moreover, the business cycles of Bolivia and US were not correlated so changes in monetary policy can be considered truly exogenous. Similar to the conclusion of Jimenez et al., authors find that expansionary monetary policy in the US increased the risk appetite of Bolivian banks - a decrease in the fed funds rate prior to loan origination raised the estimated default probability on individual bank loans. Furthermore, a decrease in the fed funds rate raised the probability of observing loans to borrowers with a subprime credit rating or loans to riskier borrowers. However, the most surprising finding of Ioannidou et al. was the fact that loan spreads (i.e. difference in the interest rate charged to risky versus safe borrowers) did not increase in the probability of default, indicating that Bolivian banks were not pricing in the extra risk they underwent. Similar to Jimenez et al., authors find that more liquid banks tended to undergo more credit risk than their less liquid counterparts.

Unlike previous studies, Altunbas et al. (2014) do not constrain their analysis to one country only. They examine the effects of low interest rates on the expected default frequency (EDF) of 643 exchange listed banks from the US and the EU. More specifically, they relate the EDF to the interest rate gap (proxy for monetary policy stance defined as the difference between the actual nominal short-term interest rate and that generated by a Taylor rule with interest smoothing) and to a set of controls accounting for bank-specific characteristics (size, liquidity, lending portfolio etc.), macroeconomic conditions (GDP, housing and equity prices, yield curve) and institutional characteristics (competition, regulation etc.). The EDF is a forward-looking indicator of credit risk and it is often used by investors, central banks and regulators to assess the health of financial institutions. In all specifications that the authors run the coefficient on the interest rate gap has the expected negative sign and it is very strongly significant. They also conduct various robustness checks with different definitions of credit risk yet the main findings hold – protracted periods of low interest rates are associated with increases in the expected default frequency, a proxy for credit risk.

Previous studies focused mainly on the impact of low interest rates on asset and collateral values, which in turn influence the risk perceptions and pricing by financial institutions. Low interest rates might also impact risk-taking of financial institutions through the so-called "search for yield" (Rajan, 2006). Institutional investors and bank asset managers are expected to achieve a certain nominal yield/return for their clients. This means that institutional investors and asset managers often shift from low-risk, low-yield government bonds and invest into much riskier, high-yielding assets such as corporate and emerging market bonds, but also commodities and hedge funds. This issue is also evident in the current low interest rate environment. The OECD has recently issued a warning for pension funds over excessive search for yield, arguing that they are increasing their probabilities of going bankrupt in the case of a sudden credit crunch/liquidity freeze. Taking US as an example, the 96 largest public pension funds that manage $2.9 trillion in total assets have increased their exposure to risky assets from around 3% in 2001, to around 15% in 2013 (OECD, 2015). Besides regulatory or institutional factors, the search for yield may also reflect investor psychology. It could be that the lower interest rates simply reflect a decline in inflation expectations, thus leaving the real return unchanged. However, even if this is the case, asset managers might still be tempted to aim for higher nominal returns and "search for yield".

Last but not least, monetary policy can have a significant impact on risk-taking of financial institutions through the so-called “transparency effect” (Borio & Zhu, 2012). If central banks follow an asymmetric interest rate policy whereby they do not actively lean against the wind during the boom period but ease aggressively during busts, they encourage moral hazard and reckless risk-taking in the financial sector. The term “Greenspan put”, named after Alan Greenspan, the former Chairman of the Federal Reserve, has been coined to describe such a policy. Greenspan himself (Greenspan, 2002) argued that the Federal Reserve cannot prevent, or even recognize, asset price booms and that the only thing the Fed can do is to mitigate the effects of a bubble burst by lowering interest rates. Diamond and Rajan (2012) present a theoretical model which suggests that the financial crisis of 2007-2009 may actually be closely related to the actions of the Federal Reserve in the run-up to the crisis. By convincing market participants that interest rates would remain very low after the dot-com bubble burst and by promising to clean up the mess in case of another asset price deflation the Fed might have played a crucial role in the levering up of the financial system.

One more point regarding the risk-taking channel of monetary policy is worth emphasizing. The importance of monetary policy for financial stability has probably increased substantially in the past decades with the transformation of the financial system from an indirect/intermediary based to a direct/market based system. The transfer of a large part of financial sector activity to the regulation-exempt shadow banking system (money market mutual funds, structured investment vehicles etc.) meant that it is harder to react to precarious developments in the financial system. Since interest rates are essentially the price of leverage which affects the funding costs of all agents in the economy, even those in the shadow banking system, monetary policy can reach all of the cracks in the system that regulation cannot (Stein, 2013).

All in all, expanding literature suggests that much more attention should be paid to the risk-taking channel in the setting of monetary policy. Protracted periods of low interest rates have been shown to increase bank credit risk and the pricing, or rather non-pricing, of this risk. Low interest rates also motivate the search for yield, which may result in excessive risk-taking of institutional investors. Asymmetric monetary policy with low interest rates during booms and even lower interest rates during busts may induce substantial moral hazard and thus contribute to excessive leverage of the banking system and to investment into highly illiquid assets. Hence monetary policy can have a large impact on financial instability. Through the financial accelerator effect this financial instability can quickly turn into large instability of the real economy, which in turn further exacerbates financial instability in a self-propagating vicious circle.

2. Theoretical model

The previous section provided descriptive arguments as to why central banks should care about financial stability. The main reason is that central banks' main instrument – the short-term interest rate (Main Refinancing Rate in the Euro area, Federal Funds Rate in the US) – affects banks' decisions to take on debt and take excessive risk. The question now is the following: in the presence of the risk-taking channel of monetary policy, is it not sufficient to have a regulator setting risk-based capital requirements, which would neutralize the impact of monetary policy on banks' risk taking? In other words, is the prudential policy not sufficient to offset the impact of monetary policy on banks' risk taking? This question will be examined with the use of a theoretical model similar in spirit to Agur and Demertzis (2015). The model presented will depart from the model of Agur and Demertzis (2015) due to obvious mistakes made in the original, Working Paper version. Nevertheless, the paper provides a nice framework for thinking about the interaction between the central bank, the regulator and the commercial bank and as a result, I follow the structure of the paper whilst correcting for the mistakes made in the derivation of the results.

2.1. The bank's problem

The authors present a relatively simple, yet informative, single period (i.e. static), partial equilibrium model of the interaction between the rate-setting central bank, representative commercial bank, and a regulator. The authors start with the formulation of the bank problem. The bank's balance sheet consists of debt, d, and internal capital, c. The management and owners of the bank are assumed to be the same and their objective is the maximization of the expected profit. Internal capital comes from either retained past earnings or inside equity of bank owners. Apart from debt and capital, authors define several other variables:

x = risk profile chosen by the bank
r = bank funding rate
R(x) = gross rate of return on the bank's risky project
p(x, d) = probability of bank surviving/not defaulting, which is a function of the bańk s ris k profile and its leverage d

The bank′ s expected profit is:

$$\boldsymbol{E[\pi] = p(x, d) * [R(x) * (d + c) - r * d]} \qquad \textbf{(1)}$$

which is essentially the probability of bank survival times the net return conditional on survival. Authors also assume the following features:

1. Probability of survival is equal to 1 provided bank takes on no debt
2. Probability of survival is equal to 1 provided the bank takes no risk
3. Maximum risk is normalized to certain default
4. The probability of default rises exponentially in the risk and leverage taken by the bank. In mathematical terms: $\frac{\partial p(x,d)}{\partial x} < 0,\ \frac{\partial^2 p(x,d)}{\partial x^2} < 0, \frac{\partial p(x,d)}{\partial d} < 0,\ \frac{\partial^2 p(x,d)}{\partial d^2} < 0$
5. Marginal return to risk is positive but diminishing, i.e. $\frac{dR(x)}{dx} > 0,\ \frac{d^2 R(x)}{dx^2} < 0$
6. A marginal amount of asset risk and leverage yields higher expected return than no risk or debt. Combined with the fact that maximum risk is normalized to certain default, this implies only interior solutions.
7. The bank's funding rate is the same as the risk-free rate. The non-existence of risk premium on the bank's funding implies an existence of deposit insurance.

The banks optimizes over its choice of leverage and risk-profile to maximize its expected profits, i.e.

$$\boldsymbol{max\ E[\pi] = p(x, d) * [R(x) * (d + c) - r * d]\ w.r.t\ x\ and\ d} \qquad \textbf{(2)}$$

2.1.1. Optimal risk profile

First let us have a look at the optimal risk profile - x^*- of the bank. To simply the analysis, let's assume that the leverage (d), capital (c) and the interest rate (r) are all exogenous. Taking the first derivative of the bank's profit function with respect to the risk-profile, x, yields:

$$p_x'(x,d)[R(x)(d+c)-rd]+p(x,d)R'(x)(d+c)=0$$

or,

$$\frac{\boldsymbol{rd}}{\boldsymbol{d+c}}=\boldsymbol{R}(\boldsymbol{x})+\frac{\boldsymbol{p}(\boldsymbol{x},\boldsymbol{d})}{\boldsymbol{p}_{\boldsymbol{x}}'(\boldsymbol{x},\boldsymbol{d})}\boldsymbol{R}'(\boldsymbol{x}) \qquad \textbf{(3)}$$

Under the assumptions on the probability of survival declining concavely with risk ($p_x'(x,d)<0$) and the positive but diminishing marginal returns to risk ($R'(x)>0$ and $R''(x)<0$), conducting a bit more algebra would show that the right-hand side of the equation above is monotonically increasing in x, i.e. $\frac{dRHS}{dx}>0$. This means that the term on the left-hand side of the equation $\frac{rd}{d+c}$ essentially determines the level of risk-taking the bank undertakes. This implies that:

- $\frac{\partial x^*}{\partial c}<0$: an increase in bank capital decreases the risk taken by the bank
- $\frac{\partial x^*}{\partial r}>0$: an increase in the interest rate increases the risk taken by the bank
- $\frac{\partial x^*}{\partial d}>0$: an increase in leverage increases bank risk-taking

The logic of the first implication is quite clear – the higher the capitalization of a bank, the more it has at stake. As a result, increases in bank capital reduce incentives to take risk. The second implication represents the so-called profit effect of monetary policy. An increase in the policy rate increases the bank's funding costs. This increase in funding costs is translated into lower profitability and thus lower charter value. Provided that the bank has implicit or explicit bailout guarantees, it has less to lose from a risky strategy – the upside can restore its profitability whilst the downside is capped by the bank's limited liability. Thus the bank has an incentive to gamble in the presence of a profit effect. The third implication shows that as the bank leverage increases, the bank will increase the riskiness of its asset portfolio. Conditional on survival, i.e. $p(x,d) > 0$, this increase in leverage and subsequent increase in optimum risk-taking boost the bank's return on capital.

2.1.2. Optimal amount of leverage

Now let us have a look at the optimal amount of leverage - d^*- of the bank. To again simplify the analysis, let's assume that this time the level of risk (x), capital (c) and the interest rate (r) are all exogenous. The first partial derivative of the bank's profit function with respect to leverage, d, yields:

$$p'_d(x,d)[R(x)(d+c) - rd] + p(x,d)[R(x) - r] = 0$$

Or,

$$\boldsymbol{d}^* = \frac{\boldsymbol{p}(x,\boldsymbol{d})}{|\boldsymbol{p}'_{\boldsymbol{d}}(x,\boldsymbol{d})|} - \frac{\boldsymbol{cR}(x)}{\boldsymbol{R}(x) - \boldsymbol{r}} \qquad \textbf{(4)}$$

From equation (4) we can infer that:

- $\frac{\partial d^*}{\partial r} < 0$: the optimum level of debt decreases with the policy rate.
- $\frac{\partial d^*}{\partial c} < 0$: the optimum level of debt decreases with bank capital.
- the sign of $\frac{\partial d^*}{\partial x}$ is uncertain and depends on the functional form of $R(x)$ and on the size of r.

A higher policy rate r increases the price of leverage and as a result, the bank will take on less debt. This negative effect of interest rates on bank debt is referred to as the leverage effect of monetary policy. Increase in bank capital c reduces the optimum amount of leverage since the bank would lose more of its money if it went bust.

2.1.3. Putting it all together – the risk-taking channel of monetary policy

As was demonstrated by the bank's optimization problem, interest rates affect the bank's decision-making on both sides of its balance sheet – a higher policy rate encourages bank risk-taking on the asset side through the so-called profit effect, whilst it discourages risk-taking on the liability side through the so-called leverage effect. The overall impact of policy rates on bank risk-taking – the so-called risk-taking channel of monetary policy, is composed of these two countervailing effects. Since the profit effect and leverage effect act in opposing ways, the overall impact of policy rates on bank risk-taking is a priori uncertain. Whether changes in policy rates increase or decrease bank risk-taking depends crucially on the relative strength of the profit and leverage channels. If the leverage effect is stronger than the profit effect, as was probably the case in the run-up to the crisis, lower interest rates can increase bank risk-taking on the liability side due to lower borrowing costs. If the profit effect is stronger than the leverage effect, as was likely the case in the immediate aftermath of the financial crash, lower interest rates can actually decrease bank risk-taking since banks' profitability is maintained and they do not have to gamble for resurrection. At the same time, since banks are trying to de-lever in the immediate aftermath of a crash, low interest rates are unlikely to stimulate much additional borrowing.

The analysis above has major implications for the “leaning against the wind” strategy – the success of tight monetary policy in reducing bank risk-taking depends crucially on the state of the credit cycle. Given that the credit cycle is in its early stages and leverage effect outweighs the profit effect, higher interest rates might actually reduce bank risk-taking. However, if the credit cycle nears its end the profit effect is likely to outweigh the leverage effect, a rate hike might significantly decrease the charter value of banks and thus encourage “gambling for resurrection”. Hence timing is the key in “leaning against the wind”.

However, the success of the “leaning against the wind” strategy depends not only on the correct timing. One policy measure which could radically lower the size of the profit channel and thus make rate hikes much more effective in reducing bank risk-taking is the abandonment of the implicit bailout guarantees that banks have. Implicit bailout guarantees encourage banks to behave recklessly since profits are privatized whereas losses are socialised. Of course the question remains whether large and systemically important banks could be allowed to fail given the interconnectedness of the financial system and its importance for the real economy. However, in the very least it must be creditors who are forced to pick-up the largest portion of the bill (bail in), taxpayer involvement ought to be the very last resort.

2.2. Interaction with the regulator – leverage effect

The analysis above dealt with the impact of policy rates on bank risk-taking and provided some insights for the "leaning against the wind strategy". However, it is important to ask whether the impact of interest rates on bank risk-taking cannot simply be neutralised by prudential policies of a regulator. Agur and Demertzis model the interaction of the central bank, regulator and the representative commercial bank to show that a regulator is almost never able to fully neutralize the impact of interest rates on bank risk-taking.

The regulator is maximising a utility function

$$\Omega(p(\bar{x}, d), d)$$

which consists of the financial stability term $(p(\bar{x}, d)$, i.e. the probability of bank survival, and of bank leverage, d. To make the analysis easier, I am assuming the bank's risk profile on the asset side of its balance sheet is fixed $(\bar{x})$. Hence I model the regulator's response to interest rate changes in the presence of the leverage effect only.

The regulator faces a trade-off. On one hand, she cares about financial stability – she wants to maximise the probability of survival for the bank. On the other hand, she does not want to constrain credit provision in the economy. As a result, her utility function is increasing in the probability of bank survival as well as in the amount of leverage. In mathematical terms, $\Omega'_p > 0$ and $\Omega'_d > 0$. However, the two goals are countervailing – large debt negatively impacts the probability of survival. Hence the regulator maximizes her utility subject to the possibilities constraint to find an optimal mix of financial stability and credit provision. The regulator in the model is equipped with a simple tool, a leverage cap $\overline{d}$, with which it can control the amount of bank debt. This tool is very similar to the leverage ratio in Basel III regulations and was used explicitly in Basel I. While being a simple tool, it facilitates the analysis and allows for clear-cut analytical results. The sequence of moves in the model is as follows: first, the central bank moves and sets the interest rate. The regulator then responds to this exogenous rate change and adjusts the leverage cap. Finally, given the interest rate, the leverage cap and the risk profile of its assets, the bank decides how much debt it wants to take.

To model the regulator's optimization problem, we note that she has convex indifference curves since she cares both about financial stability and credit provision and the marginal benefit of additional financial stability/credit provision decreases the more financial stability/credit provided there is. The possibilities frontier faced by the regulator reflects the assumption on the concave decline of the probability of survival in debt made in bank's optimization problem.

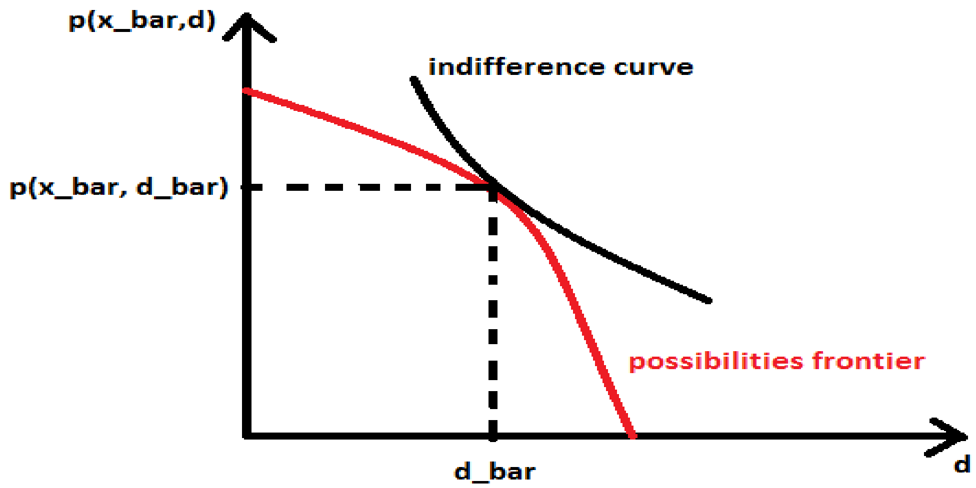

Figure 2: Optimization of the regulator

Figure 2 depicts the maximization problem of the regulator – the optimum mix of financial stability and credit provision occurs where the indifference curve of the regulator is tangential to the possibilities frontier. What is important to emphasize is that the regulator in the model is granted full flexibility, i.e. he can change the leverage cap as soon as the monetary authority makes its decision on the interest rate. However, in reality the regulator adjusts her policies only very infrequently and definitely at much lower frequency than monetary authority. Therefore, any results derived in the following analysis are likely to apply even more strongly in the real world where monetary policy is adjusted at a much higher frequency than the regulatory one.

2.2.1. Interest rate impact on regulator's optimization

Changes in the interest rate affect the regulator's whole operating space – any interest rate change will have an impact on the possibilities frontier of the regulator and thus on his ability to uphold financial stability without curtailing significantly the provision of credit. The possibilities frontier of the regulator changes with every rate decision of the central bank and can be expressed mathematically as:

$$\frac{\partial}{\partial r}\left[\frac{\partial p(\bar{x},d)}{\partial(d)}\right] = \frac{\partial^2 p(\bar{x},d)}{\partial d^2}\frac{\partial d}{\partial r} \qquad \textbf{(5)}$$

(-) * (-)

The signs below the equation, obtained in the previous parts of the model, indicate that the overall change in the slope of the possibilities frontier as a result of changes in the interest rate, whilst holding the risk profile constant at $\bar{x}$, is always positive. The fact that $\frac{\partial}{\partial r}\left[\frac{\partial p(\bar{x},d)}{\partial(d)}\right] > 0$ means that a rate cut will decrease the slope of the possibilities frontier, i.e. make it pivot inwards, and a rate hike will increase make the possibilities frontier pivot outwards. The effect of a rate cut in the presence of the leverage effect is illustrated in Figure 3. Given that there is no change in the regulator's preferences, a rate cut will move the new optimum inwards, where the new possibilities frontier is tangential to the lower indifference curve of the regulator. As is clear from Figure 3, the rate cut causes a fall in the leverage cap set by the regulator from $\bar{d}$ to $\bar{d}_1$, which means that the regulator tries to offset the expansionary monetary policy. However, even when the regulator tightens there is still a decrease in the probability of bank's survival from $p(\bar{x},\bar{d})$ to $p(\bar{x},\bar{d}_1)$. As a result, the increased bank risk-taking induced by the lower rate is not fully offset by a tighter prudential policy and financial stability diminishes despite the regulatory tightening.

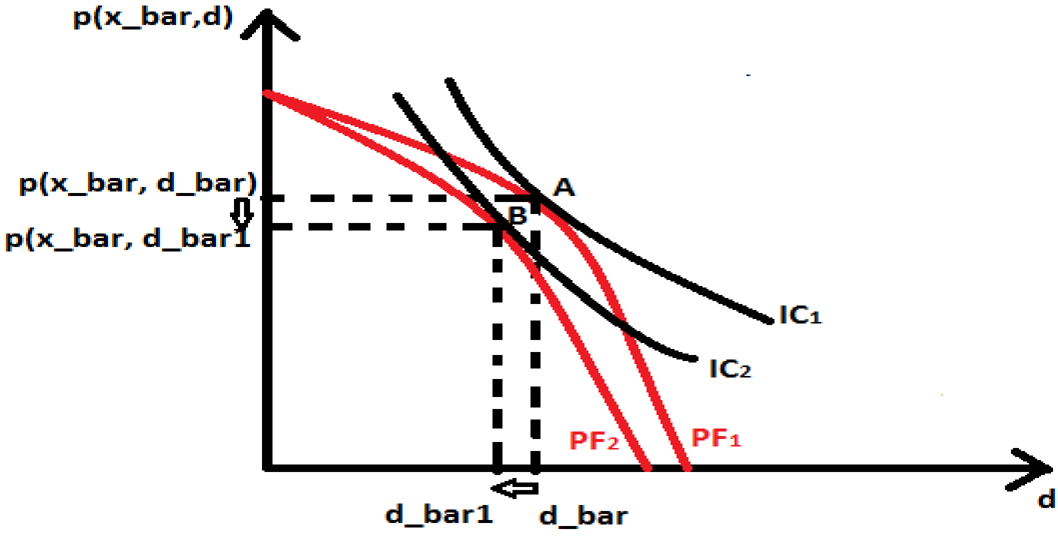

Figure 3: Impact of a rate cut

Considering a rate hike in the presence of the leverage effect, the regulator's trade-off is unambiguously better. Figure 4 depicts the regulator's response after a rate hike – the possibilities frontier pivots outwards, where it is tangential with a higher indifference curve. This implies that the regulator increases the leverage cap from $\bar{d}$ to $\overline{d}_1$, thus offsetting the contractionary monetary policy, whilst the probability of bank survival also increases from $p(\bar{x},\bar{d})$ to $p(\bar{x},\overline{d}_1)$. The simple model thus suggests that leaning against the wind and raising interest rates in times of a strong leverage effect can actually enhance financial stability, even if the regulator increases the leverage cap. It is very likely that in the run-up to the crisis the leverage effect was particularly strong and the analysis conducted above was a correct representation of the pre-2008 reality. Given the low interest rate environment and insufficient regulation in place during this period, monetary policy likely imposed a significant negative externality which was not neutralised by the regulators.

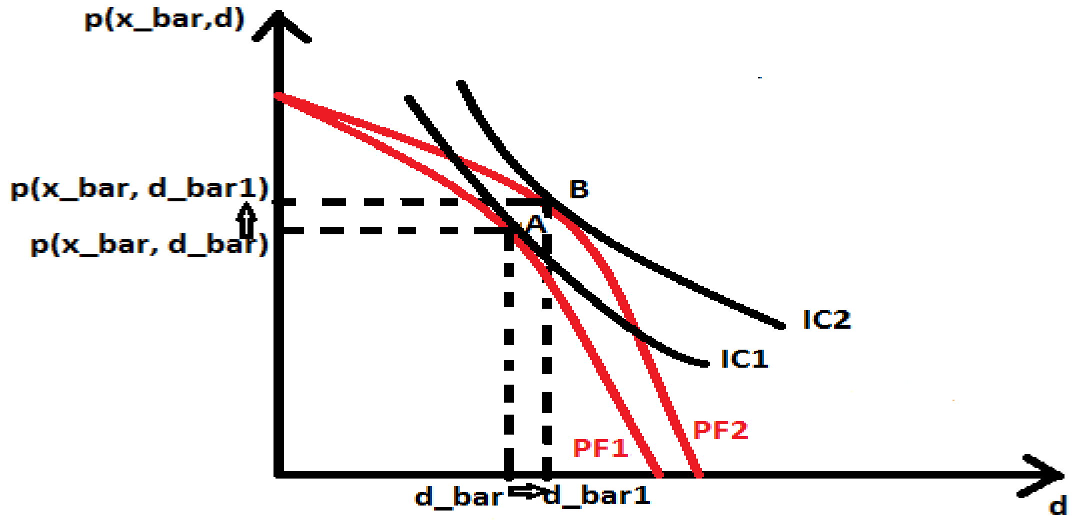

Figure 4: Impact of a rate hike

It is not necessary to investigate whether the commercial bank will actually choose $d^* = \overline{d}_1$ or $d^* < \overline{d}_1$. What is important is that $\overline{d}_1$ will be the maximum level of leverage and $p(\bar{x}, \overline{d}_1)$ the minimum level of financial stability guaranteed regardless of the commercial bank's decision for d^*.

2.3. Policy implications

The theoretical model served to demonstrate a couple of very important points relevant for the conduct of monetary policy. The impact of interest rates on bank risk-taking (the risk-taking channel of monetary policy) depends crucially on the relative size of the profit and leverage effects. The relative size of the two effects depends, in turn, on the state of the financial cycle. In the early stages of the financial cycle the leverage effect is likely to be greater than the profit effect and low interest rates are likely to decrease financial stability by encouraging more leverage (pre-2008 era). In the later stage of the financial cycle when banks are trying to recover from a crash, the profit effect is likely to be stronger than the leverage effect and low interest rates act to maintain bank profitability, thus decreasing risk-taking incentives on the asset side and increasing financial stability (post-2008 era).

Crucially, the effect of monetary policy on bank risk-taking cannot be fully neutralized by the actions of a regulator. Monetary policy choices affect the whole optimization problem of a regulator and her prudential policies never leave financial stability unchanged. This happens despite the fact that the regulator knows the bank's optimization problem and acts before the representative bank chooses leverage given its asset risk profile.

In conclusion, the model, whilst clearly being a considerable simplification, provides valuable insights for the conduct and coordination of monetary and prudential policies in the real world.

3. Empirical analysis

My empirical analysis examines the monetary policy of the ECB since its inception. The aim is to examine the mutual relationship between the policy rate (the main refinancing rate) and the extent of financial instability, as proxied by the credit to GDP gap. Based on monetary policy frameworks employed by central banks around the globe, whereby only the real variables (i.e. output and inflation) are relevant for policy decision, the causality is hypothesised to go from interest rates to financial instability. However, it is equally interesting to examine whether the ECB has actually been responding, be it consciously or unconsciously, in its interest rate decisions to signs of financial instability. In statistical terminology, I assume that both the policy rate and indicators of financial instability are endogenous variables, with causality going in both directions so that there is a feedback between the two variables.

As a proxy for financial instability, I choose the credit to GDP gap (credgdp). The reasons for choosing this proxy are several. Firstly, it is publicly available at the ECB Statistical Data Warehouse and the calculations of this metric for individual euro area countries go back as far as 1997. Credit to GDP gap, calculated as the deviation of credit to GDP from its historical norms (calculated using the Hodrick-Prescott filter), is used by many central banks and regulators as the main proxy for financial instability (Borio & Lowe, 2004). I take this for granted and do not further examine the prediction power of this variable in detecting financial crises using noise-to-signal ratios etc. The suitability of the credit to GDP gap as a predictor of future crises is also recognised by the Basel Committee on

Banking Supervision, which established in its most recent set of regulations - Basel III - the obligation for banks to set their counter-cyclical capital buffers based on the national credit to GDP gap. Although the credit to GDP gap figures are published only at the individual countries' level, I construct an aggregate variable by weighting the credit to GDP gaps in individual countries by their countries' real GDP share of the Euro area GDP.

The remaining variables used in my framework are the standard ones used in the Taylor Rule analysis – the output gap defined as the deviation of real GDP from its potential (calculated using the Hodrick-Prescott filter, HP filter thereafter), the inflation gap defined as the deviation of inflation from the ECB target of 2% and the main refinancing rate/policy rate of the ECB. All the variables used to derive the gap measure were obtained from the ECB Statistical Data Warehouse for the period 1999q1 – 2015q2 and I conduct the analysis with data at quarterly frequency. The gap measures are used to make a rough approximation of the stance of the ECB's monetary policy since its inception. While the use of the HP filter to estimate the gap measures is not without shortcomings, the use of HP filters is a standard practice in the profession and it is undoubtedly sufficient for my purpose.

One word of caution regarding my financial instability variable (credgdp) – it does not capture precisely the risk-taking channel emphasized by the theoretical literature and mentioned in the previous parts of my thesis. Literature emphasizes the role that prolonged periods of low interest rates play in fuelling bank debt/leverage and portfolio riskiness. However, data on bank leverage and portfolio riskiness going back to 1999 (the start of my sample) are almost impossible to obtain. Most publicly available data, such as the Consolidated Banking data published on the ECB Statistical data warehouse, do not cover the pre-crisis period. The earliest observation on bank leverage ratios comes from the end of 2007. As a result, the massive build-up of bank debt (mainly very short-term debt) is missed out by the data. Even if data on bank leverage ratios include the pre-crisis period, such as those published by the OECD, they are recorded at an annual frequency, rather than the quarterly one. Similarly, data on changes in credit standards on loans granted to households and corporations suffer from the same shortcoming as bank leverage data – the earliest observation is from 2003. Some studies, such as Altunbas et al. (2014), relate the expected default frequency of European and US banks to interest rate gaps, measured as the observed policy rate minus the rate implied by a Taylor rule with interest rate smoothing. Once again, although the expected default frequency of European banks is listed among variables available at the ECB Statistical data warehouse, the actual data is nowhere to be found. Furthermore, many indicators of idiosyncratic and systemic risk in the banking sector have been developed only after the crash of 2008, and even if some existed prior to the crash, they were not accessible for the wider public. Data availability and accessibility thus pose the greatest problem for the empirical investigation of the risk-taking channel.

However, despite not being the first choice, credit to GDP gap (credgdp) still bears much relevant information. As was mentioned previously, credit to GDP gap was demonstrated to be the best timely indicator of financial market turmoil and it forms the basis for the setting of countercyclical capital buffers according to the latest Basel III regulation. Based on economic theory, I expect this measure of financial (in)stability to be quite sensitive to the interest rate policy of the ECB, thus providing me with a link between monetary policy and financial (in)stability in the wider economy.

3.1. Univariate properties of the data

The first step in the analysis is to consider the univariate time-series properties of the data. I first look at the time series graph of each of the series and then examine the partial autocorrelation function in order to check how many lags are non-zero. I then estimate an autoregressive model of order p (where p = number of non-zero lags) for every variable, which is necessary to conduct the augmented Dickey-Fuller test to test for the presence of unit root. Table 1 below demonstrates the results from the Augmented Dickey Fuller tests.

Variable	Variable definition	Number of non-zero lags	ADF Test statistic	5% critical value	Process
Infgap	*Inflation(t) - ECB Inflation target of 2%*	2	-3.455	-2.92	STATIONARY
Outgap	*Real GDP(t) - Potential real GDP*	2	-3.628	-2.92	STATIONARY
Mrr (trend)	*Main refinancing rate on fixed rate tenders*	3	-3.04	-3.49	NONSTATIONARY
Credgdp	*Credit(t)/GDP(t) - Credit/GDP historical norm*	2	-0.95	-2.92	NONSTATIONARY

Table 1: Results from the ADF test

We can see that only the output and inflation gaps are stationary, the remaining variables are nonstationary. This has some important implications for our empirical analysis.

3.2. Was monetary policy of the ECB "too loose"?

There are two ways in which we can judge whether the monetary policy of the ECB was "too loose" or not. We can compare the actual observed policy rates of the ECB with the rates implied by some sort of benchmark model. Secondly, since the ECB had a two-pillar strategy for the conduct of monetary policy in its early years – with second pillar being the target growth rate of a M3 money aggregate – we can look at the behaviour of the M3 aggregate versus its reference growth rate of 4.5%. Any major deviation from the reference rate should be a sign of inflationary pressures looming in the future given the well-established stability of money demand in the euro area.

To compare the policy rates of the ECB to benchmark model rates is not an easy task. The practice in the literature has been to compare the observed policy rates with rates implied by versions of the Taylor rule. I shall proceed in a similar way. The simplest version of the Taylor rule as suggested by its father, John Taylor (Taylor, 1999), relates the current policy rate to the current inflation and output gaps:

$$\boldsymbol{MRR_t = a_0 + a_1 INFGAP_t + a_2 OUTGAP_t + u_t} \qquad \textbf{(6)}$$

Simple Taylor rules, such as the one above, have been under severe criticism from many authors. Many economists emphasize various methodological shortcomings of Taylor rules′ estimation – gap measures are very difficult to estimate and are usually not available at the time of interest rate decision, the rule is too simplistic to describe the complex behaviour of a central bank, the rule could be forward or backward-looking, or combination of both etc. I acknowledge the various shortcomings of describing central bank behaviour with such a simple rule. However, since my task is not to find the most robust policy rule but to examine the link between policy rates of the ECB and financial instability (as proxied by credit to GDP gap), I will use the simple Taylor rule as a very rough guide to assessing the extent of “looseness” of the ECB′ s monetary policy.

The main empirical difficulty in obtaining consistent estimates from the Taylor rule is the nonstationarity of the policy rate (mrr). The regression in (6) does not “balance” - the main refinancing rate is a nonstationary variable (confirmed by the ADF test) and as such cannot be expressed in terms of two stationary variables (output and inflation gaps). Estimation using the OLS would yield coefficients not converging to any well-defined population parameter. Many studies, such as Clarida et al. (2000), find that interest rate series are, indeed, non-stationary. However, they claim that stationarity of interest rates is a reasonable assumption, both on theoretical and empirical (persistence of interest rate series and low power of unit root tests) grounds. Given that the ECB was established only in 1999, it is reasonable to assume that in the long-run interest rates would be stationary. Moreover, as I noted before, the aim of my thesis is not to obtain consistent coefficient estimates of a robust monetary policy rule but to examine the link between the stance of monetary policy and financial instability. In order to do that, I need a rough measure of the stance of monetary policy.

Central banks have a preference for smooth interest rate adjustments since volatile interest rates may be harmful to the economy. As a result, standard Taylor rule is amended in the following way so as to account for the smoothing preference:

$$\boldsymbol{MRR_t^{smooth} = (1-\lambda)\widehat{MRR}_t + \lambda MRR_{t-1} + u_t} \qquad \textbf{(7)}$$

where $\widehat{MRR}_t$ is the estimated value of the main refinancing rate from the simple Taylor rule (equation (6)) and parameter λ reflects the degree of interest rate smoothing. Backward-looking estimation of the smoothing parameter λ usually yields a value between 0.6 – 0.9 (Clarida, et al., 2000). I use λ = 0.8 which can be seen as the middle ground, whilst also being consistent with empirical evidence for the ECB (Pinkwart, 2013). The smoothed predicted policy rate is compared to the actual observed policy rate of the ECB in Figure 5.

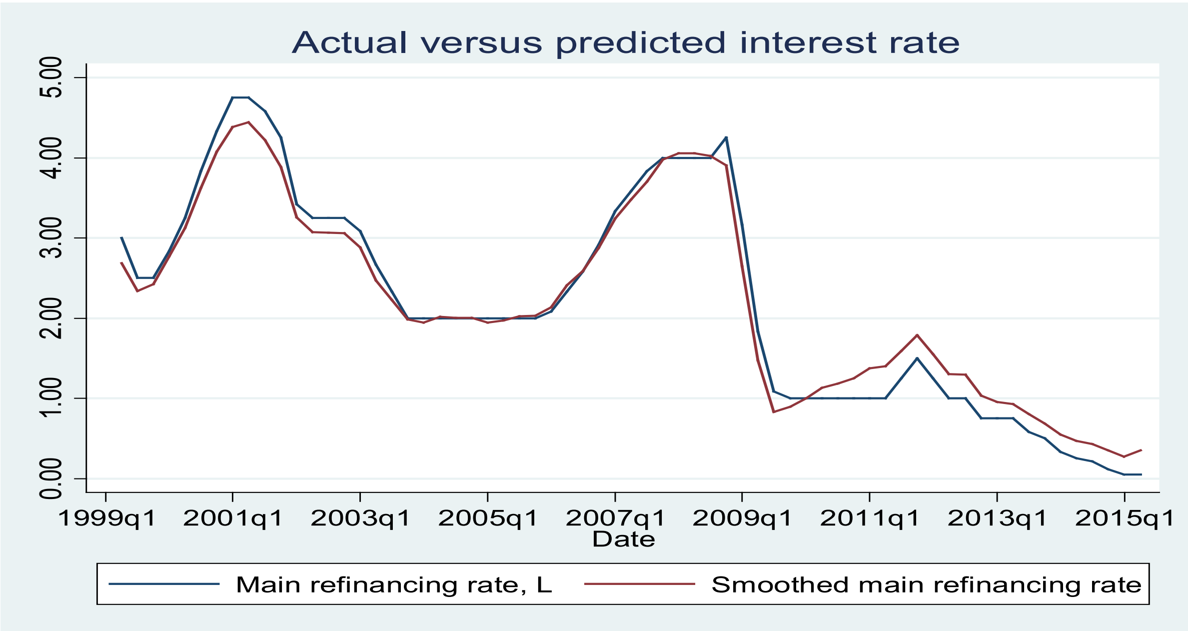

Figure 5: Actual versus predicted Taylor rates

As is evident from Figure 5, the predicted main refinancing rate from the smoothed Taylor rule tracks the actual interest rate quite closely. There do not seem to be any major deviations between the actual rate and the rate predicted by the smoothed Taylor rule. Figure 6 provides a closer look – it plots the interest rate gap, defined as the policy rate of the ECB minus the smoothed Taylor rule rate, against time. The plot confirms that there are indeed no major deviations between the two rates.

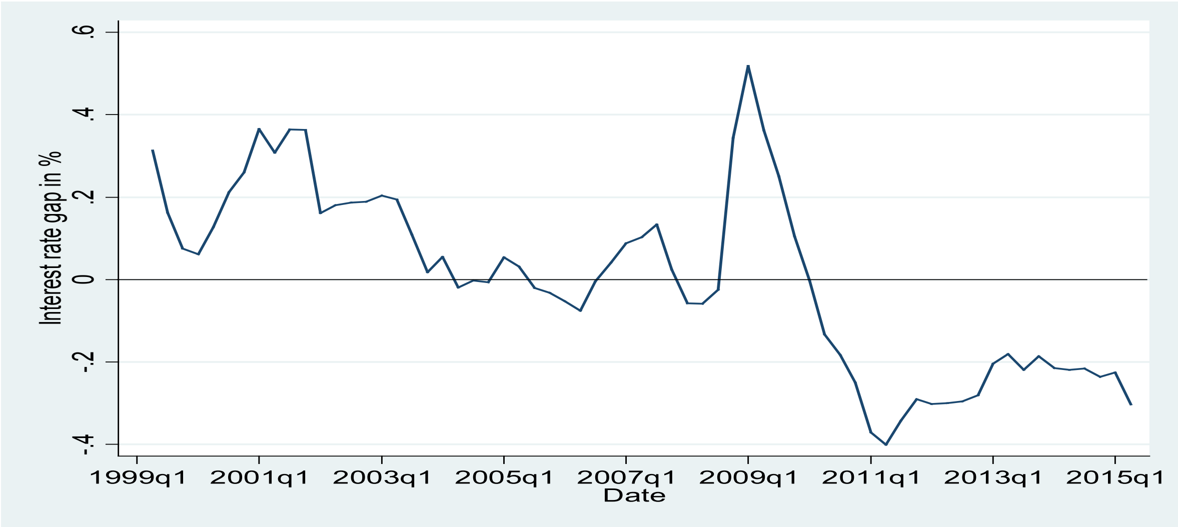

Figure 6: Interest gap = Actual rate - Taylor rule predicted

My estimation might yield inconsistent parameter estimates due to non-stationarity of the policy rate and, as a result, any far-reaching conclusions on the appropriateness of my Taylor rule with preference for smoothing ought to be avoided. However, two points are worth highlighting. Firstly, the implied rate from the Taylor rule seems to be tracking the actual policy rate of the ECB quite well. Hence a simple contemporaneous Taylor rule with interest rate smoothing (with λ = 0.8) seems to provide a good in-sample fit for the actual behavior of the ECB in the past. Secondly, there do not seem to be any persistent deviations between the actual rate and the Taylor rule implied rate. Again, I would like to avoid any precise quantification of the interest rate gap throughout the time. However, it is very unlikely that the monetary policy of the ECB has been systematically expansionary or "too loose" in the run-up to the crisis based on interest rate behaviour.

To provide a quick check, I also look at the behavior of the euro area monetary aggregate M3 defined as the sum of currency in circulation, overnight deposits, deposits with agreed maturity of up to 2 years, deposits redeemable at notice of up to three months, repurchase agreements, money market shares/units and debt securities with a maturity of up to 2 years. The reference value for the growth of the M3 aggregate has been set at 4.5% by the ECB and significant deviations from this target can be perceived, ceteris paribus, as potential signs of future inflationary pressures.

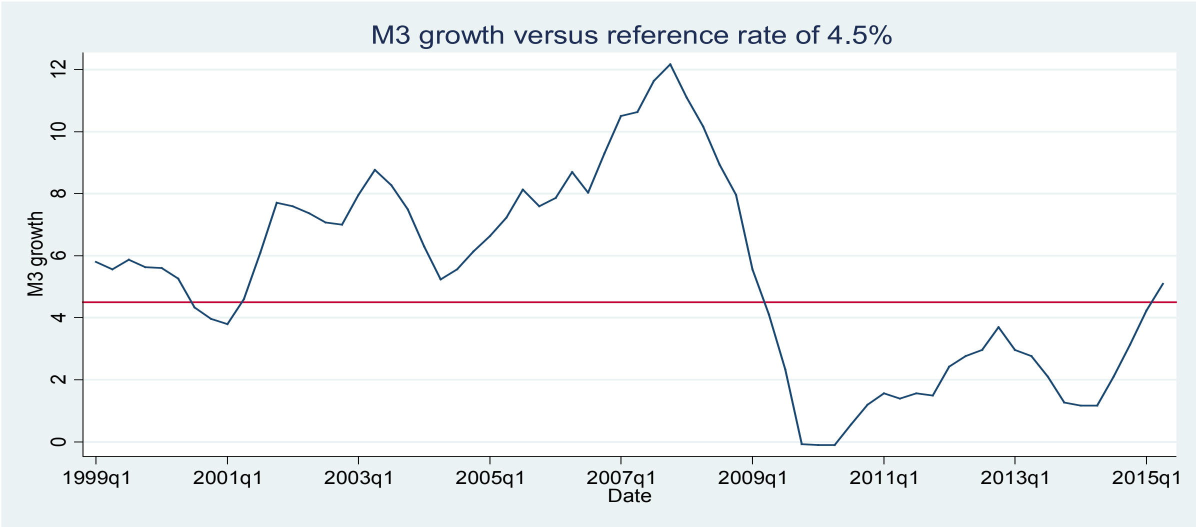

Figure 7: Growth rate of the M3 aggregate

Figure 7 shows that the growth of the M3 aggregate has been systemically exceeding the reference growth rate of 4.5% in the run-up to the crisis. This indicates that the monetary policy of the ECB was indeed quite expansionary, even if this loose policy was not reflected in the behavior of inflation. This leads me back to the point I already made in the appraisal of the inflation targeting framework. Since inflation targeting lead to a very strong anchoring of expectations and the flattening of the Phillips curve, behavior of inflation no longer reflected the underlying cyclical conditions of the economy. In light of these facts the recent dismissal by the ECB of the second pillar seems absurd. Had more attention been paid to the rapid growth of M3 in the run-up to the crisis, the ECB could have reassessed its monetary policy and mitigate the impact of the crash.

3.3. Relationship between policy rates and proxies of financial instability

The main objective of my analysis is to investigate the cointegrating, or in other words, long-run causal relationship between the main refinancing rate of the ECB and the aforementioned proxy for financial instability – credit to GDP gap. I want to test if such a relationship exists and if so, to examine the way in which the causality is going - is the main refinancing rate causing changes in the credit to GDP gap (risk-taking channel)? Or is the credit to GDP gap causing the move in the main refinancing rate of the ECB? Or, perhaps even more likely, is there evidence of some sort of reinforcing behavior? Figure 8 shows the time series plot of the main refinancing rate of the ECB and of the credit to GDP gap. At the first sight, the series do not seem to share a common stochastic trend. Two other features stand out. Firstly, the series seem to be strongly positively correlated and this suspicion is indeed confirmed. The correlation coefficient between the main refinancing rate and the credit to GDP gap is 0.7517 and it is very statistically significant. Secondly, there is a break in both series. Therefore, the results of tests conducted over the whole sample period might be significantly affected by these breaks. I do not test for a structural break; however, I do divide my sample into two subsamples of different length. The dividing point is the collapse of the investment bank Lehman Brothers in September 2008. I conduct the Johansen test for 3 samples – the whole sample going from 1999q1 – 2015q2, the first subsample from 1999q1 – 2008q3 and the second subsample going from 2008q4 – 2015q2.

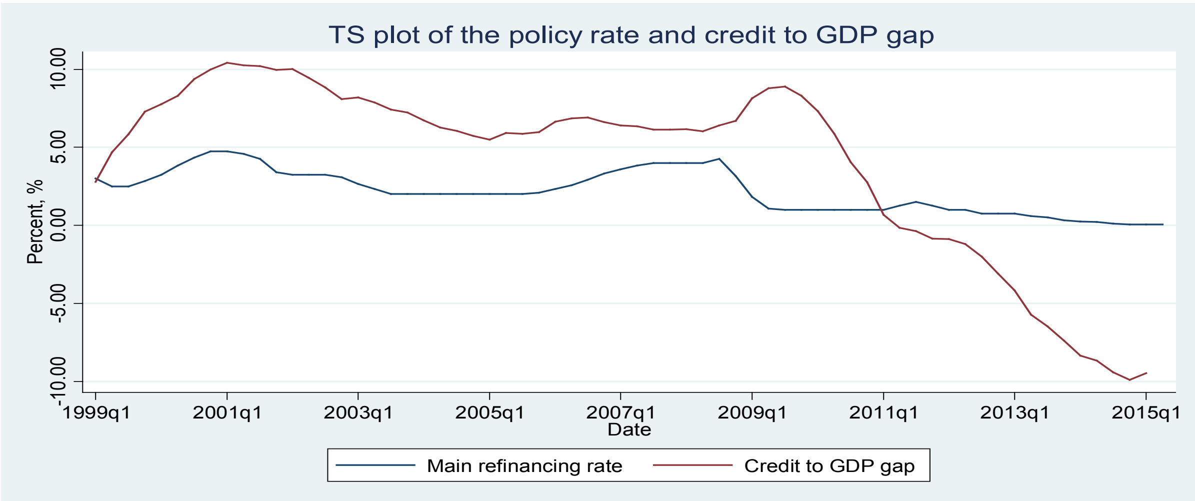

Figure 8: Time series plots - MRR and CREDGDP

I start the analysis by considering a simple vector autoregressive model (VAR thereafter) of the main refinancing rate and the credit to GDP gap. A VAR model of order p can be written as:

$$\boldsymbol{Y_t = \delta + \Gamma_1 Y_{t-1} + \cdots + \Gamma_p Y_{t-p} + \varepsilon_t} \quad \textbf{(8)}$$

where, in my case, Y_t = (mrr credgdp) and ε_t is a white noise process. Specifying the right number of lags is crucial for subsequent estimation steps. Once the order of the VAR model is correctly specified and provided that the model does not display any residual autocorrelation with p number of lags, the Johansen test of cointegration can be conducted from the vector error correction (VEC) representation of the VAR model. The VEC model can be expressed as follows:

$$\Delta \boldsymbol{Y_t} = \boldsymbol{\delta} + \boldsymbol{\Gamma_1 \Delta Y_{t-1}} + \cdots + \boldsymbol{\Gamma_{p-1} \Delta Y_{t-p+1}} + \boldsymbol{\pi Y_{t-1}} + \boldsymbol{\eta_t} \qquad \textbf{(9)}$$

where ΔY_t is k×1 vector of first differenced *mrr* and *credgdp*, Γ_i is a k×p matrix of coefficients and η_t is a white noise process. The Johansen procedure involves testing hypothesis about the rank of the long-run matrix π – all the terms in equation (9) are first-differenced and thus stationary, with the possible exception of πY_{t-1}. If πY_{t-1} is stationary, then the whole system described in equation (9) is stationary and this happens if and only if the matrix π is of reduced rank. In this case, since my VAR model consists of only two variables, the main refinancing rate and the credit to GDP gap (both I(1)), the system in equation (9) will be stationary if the rank of matrix π is equal to 1. The Johansen test is very sensitive to the number of lags used and as a result, it is vital to ensure that the underlying VAR model is correctly specified.

Starting with lag specification, some information criteria, such as the Hannan-Quinn and Schwarz's Bayesian information criteria, suggest a VAR model with two lags while others, such as the Akaike information criteria, suggest a model with three lags. I estimate both models and find that the VAR model with two lags suffers from autocorrelation in the residuals. As a result, I estimate the VAR model with three lags and test for residual autocorrelation. For the model with 3 lags I cannot reject the null hypothesis that there is no residual autocorrelation in the errors of the model. VAR (3) thus serves as the model from which I will derive the VEC representation and this VEC model will in turn serve as the basis for the Johansen test of cointegration between the main refinancing rate and the credit to GDP gap.

Since the VAR model seems to be correctly specified with 3 lags, the VEC model will contain two lagged difference terms:

$$\Delta \boldsymbol{Y_t} = \boldsymbol{\delta} + \boldsymbol{\Gamma_1 \Delta Y_{t-1}} + \boldsymbol{\Gamma_2 \Delta Y_{t-2}} + \boldsymbol{\pi Y_{t-1}} + \boldsymbol{\epsilon_t} \qquad \textbf{(10)}$$

The Johansen procedure, as mentioned previously, will test hypotheses about the rank of the matrix π. Provided that the rank of the matrix π is equal to 1, the term πY_{t-1} is stationary and there is a long-run equilibrium relationship between the main refinancing rate of the ECB and the credit to GDP gap. Johansen test is sensitive not only to the number of lags of the underlying VEC model, but also to the trend specification – it must be specified whether there are any trends in the levels of the data and in the cointegrating relationship itself. Given that over the whole sample there do not seem to be any clear time trends in the levels of either *mrr* or *credgdp*, I choose the specification "trend(rconstant)". This specification rules out any linear time trends in the levels of the data and allows the cointegrating equation to be stationary around a constant mean. Figure 9 displays the result of the Johansen test for the VEC(2) model specified in equation (10). The Johansen test cannot reject the null hypothesis that the rank of matrix π is equal to 0, in other words, the Johansen test cannot reject the hypothesis that the main refinancing rate and credit to GDP gap are not cointegrated.

Johansen tests for cointegration

Trend: rconstant — Number of obs = 62

Sample: 1999q4 - 2015q1 — Lags = 3

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	8	-31.037894	.	13.5055*	19.96
1	12	-25.782683	0.15593	2.9951	9.42
2	14	-24.285124	0.04716		

Figure 9: Johansen test - VEC (2) model

Even if the Johansen test suggests that the policy rate of the ECB and the credit to GDP gap are not cointegrated over the whole sample, this result could be affected to a large extent by the structural break in the series. Therefore, I also check whether the two variables are cointegrated prior to and after the fall of Lehman Brothers in autumn 2008.

The results of the Johansen test examining the period prior to the fall of Lehman Brothers are displayed in Figure 10. Once again, the Johansen test cannot reject the null hypothesis that *mrr and*

Johansen tests for cointegration
Trend: rconstant — Number of obs = 36
Sample: 1999q4 - 2008q3 — Lags = 3

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	8	2.9888028	.	14.0282*	19.96
1	12	8.9533249	0.28206	2.0991	9.42
2	14	10.002892	0.05664		

Figure 10: Johansen test for the subsample before the fall of Lehman Brothers

credgdp are not cointegrated. Figure 11 presents the results of the Johansen test for the subsample starting after the fall of Lehman Brothers. Since both the policy rate and the credit to GDP gap seem to display a downward linear trend in the post-2008 period, I modify the trend specification from trend(rconstant) to trend(constant), which allows linear trends in the levels of data and also allows the cointegrating equation to be trend stationary. The Johansen test suggests that there is indeed a

Johansen tests for cointegration
Trend: constant — Number of obs = 26
Sample: 2008q4 - 2015q1 — Lags = 3

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	10	-12.567206	.	43.9499	15.41
1	13	7.5659301	0.78748	3.6836*	3.76
2	14	9.4077499	0.13210		

Figure 11: Johansen test for the subsample after the fall of Lehman Brothers

cointegrating, or long-run equilibrium, relationship between the policy rate of the ECB and the credit to GDP gap in the aftermath of the financial market collapse in late 2008. Given that the Johansen test indicates a cointegrating relationship, I proceed to estimate a VEC (2) model. The estimation procedure will decompose the matrix π into the product of vectors α and β, i.e. $\pi = \alpha' \beta$, where β represents the long run/cointegrating relationship (static) between the policy rate and the credit to GDP gap and α represents the speed of adjustment to this long-run equilibrium (SR dynamics). Figure 12 displays the estimated cointegrating vector β of the VEC (2) model: $\hat{\beta}$ = (1   -0.07667).

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
mrr	1	.	.	.	.	.
credgdp	-.07667	.0105939	-7.24	0.000	-.0974338	-.0559063
_cons	-1.357262	.	.	.	.	.

Figure 12: Cointegrating vector β = (1   -0.07667)

The estimation results suggest that the linear combination *mrr – 0.07667*credgdp* is stationary and that it is strongly significant as well. Figure 13 displays the estimation result for the speed of adjustment vector $\hat{\alpha}$ = (-0.3329   0.3757). The negative coefficient of -0.3329 on the first element of the adjustment vector implies that whenever the main refinancing rate is above its long-run equilibrium relationship with the credit to GDP gap, it reverts back to restore the equilibrium. This adjustment is, moreover, strongly statistically significant. The positive coefficient of 0.3756 on the second element of the adjustment vector implies that whenever the main refinancing rate is above its long-run equilibrium relationship with the credit to GDP gap, the credit to GDP increases to restore the equilibrium. However, this adjustment is no longer statistically significant. As a result, it seems that whilst the main refinancing rate adjusts back to the equilibrium relationship with the credit to GDP gap, the credit to GDP gap does not adjust back to the equilibrium. This implies that the credit to GDP gap is weakly exogenous and the main refinancing rate simply reacts to changes in the credit to GDP gap.

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
D_mrr						
_ce1						
L1.	-.3329134	.0508481	-6.55	0.000	-.4325738	-.233253
D_credgdp						
_ce1						
L1.	.3756735	.2007565	1.87	0.061	-.0178021	.7691491

Figure 13: Speed of adjustment vector

However, the results presented above should be taken with much caution. The Johansen test is known to perform quite badly in small samples and given that my subsample after the fall of Lehman Brothers contains only 25 observations, the test results are unlikely to be very reliable. This suspicion is confirmed by looking at the plot of the error correction term from the cointegrating equation against time (Figure 14).

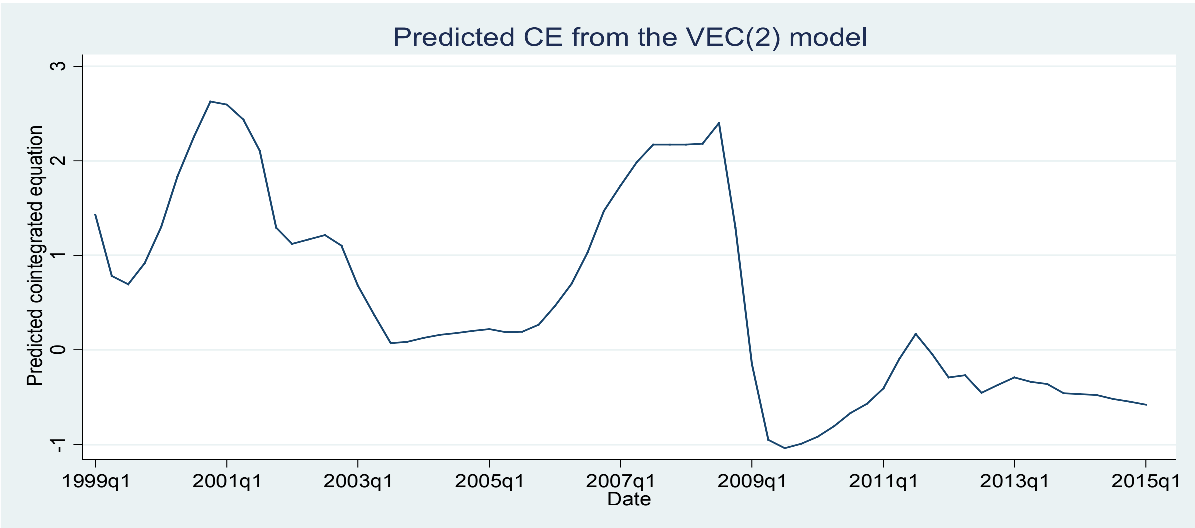

Figure 14: Predicted error correction term from the VEC(2) model

The error correction term should be a stationary and strongly autocorrelated process provided that the model is correctly specified. This is certainly not the case – the series wanders quite widely and does no converge to any constant mean. All in all, there does not seem to be any cointegrating relationship between the main refinancing rate and the credit to GDP gap, neither in the whole sample, nor in the two subsamples.

However, the fact that there is no cointegrating relationship between the main refinancing rate and the credit to GDP gap does not mean that these two variables do not explain one another. I estimate a VAR model with the main refinancing rate and the three gap measures: output gap, inflation gap and credit to GDP gap. The information criteria suggest a VAR model with 3 lags and the subsequent test of residual autocorrelation does not detect any misspecification. To test the explanatory power of the variables, I employ the Granger causality test, which involves testing linear restrictions on the parameters of a VAR model. Given that two variables in my VAR(3) model are non-stationary (both *mrr* and *credgdp* are I(1)), the Wald test statistic does not follow the usual asymptotic chi-square distribution under the null hypothesis and thus the results of the Granger causality test would be invalid. To correct for nonstationarity of the policy rate and the credit to GDP gap, I use the Toda-Yamamoto procedure which ensure that the Wald test statistic is asymptotically chi square distributed. In the first step, Toda-Yamamoto procedure involves determining the maximum order of integration of all non-stationary variables. In my case, since both the credit to GDP gap and the main refinancing rate are integrated of order 1, the maximum order of integration is equal to 1. In the second stage, the Toda-Yamamoto procedure involves estimating a VAR (p+m) model, where p corresponds to the number of lags determined by the information criteria and m corresponds to the maximum order of integration of all my variables. However, the m-th lag is to be treated as exogenous in the Toda-Yamamoto procedure. Therefore, I estimate the VAR(3) with the fourth lag of *mrr, infgap, outgap* and *credgdp* added as exogenous variables. The Wald test of linear restrictions on the parameters of this model should yield statistics which are chi-square distributed.

Results of the Granger-causality test, based on the Toda-Yamamoto procedure, are displayed in Figure 15 and show some interesting results. The credit to GDP gap granger-causes the main refinancing rate, however, the main refinancing rate does not granger-cause the credit to GDP gap. This implies that the credit to GDP gap is strongly exogenous in explaining the main refinancing rate.

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
mrr	infgap	5.1595	3	0.160
mrr	outgap	19.719	3	0.000
mrr	credgdp	14.358	3	0.002
mrr	ALL	34.029	9	0.000
infgap	mrr	.66122	3	0.882
infgap	outgap	13.551	3	0.004
infgap	credgdp	1.653	3	0.647
infgap	ALL	21.322	9	0.011
outgap	mrr	18.119	3	0.000
outgap	infgap	11.47	3	0.009
outgap	credgdp	2.0818	3	0.556
outgap	ALL	40.451	9	0.000
credgdp	mrr	3.5685	3	0.312
credgdp	infgap	.30077	3	0.960
credgdp	outgap	2.2354	3	0.525
credgdp	ALL	14.788	9	0.097

Figure 15: Granger causality test after a VAR (3+1) model

Given this exogeneity of the credit to GDP gap, I use the four-dimensional VAR(4) model to obtain an in-sample prediction of the main refinancing rate. As done previously, I assume that the ECB has a preference for interest rate smoothing:

$$\boldsymbol{MRR_t^{smooth} = (1-\lambda)\widehat{MRR}_t + \lambda MRR_{t-1} + u_t} \qquad \textbf{(11)}$$

where $\widehat{MRR}_t$ is the predicted rate from the VAR(4) model and $\lambda = 0.8$ as assumed previously.

Figures 16 shows the actual observed main refinancing rate of the ECB and the smoothed main refinancing rate based on the four-dimensional VAR(4) model. The smoothed main refinancing rate based on the four-dimensional VAR(4) model seems to be tracking the actual main refinancing rate of the ECB almost perfectly. The Augmented Dickey-Fuller test on the residuals of the four-dimensional VAR(4) model presented in Figure 17 suggests that they are stationary and this holds even after adjusting the critical values based on Phillips & Ouliaris (1990) – hence the four-dimensional VAR(4) model is correctly specified.

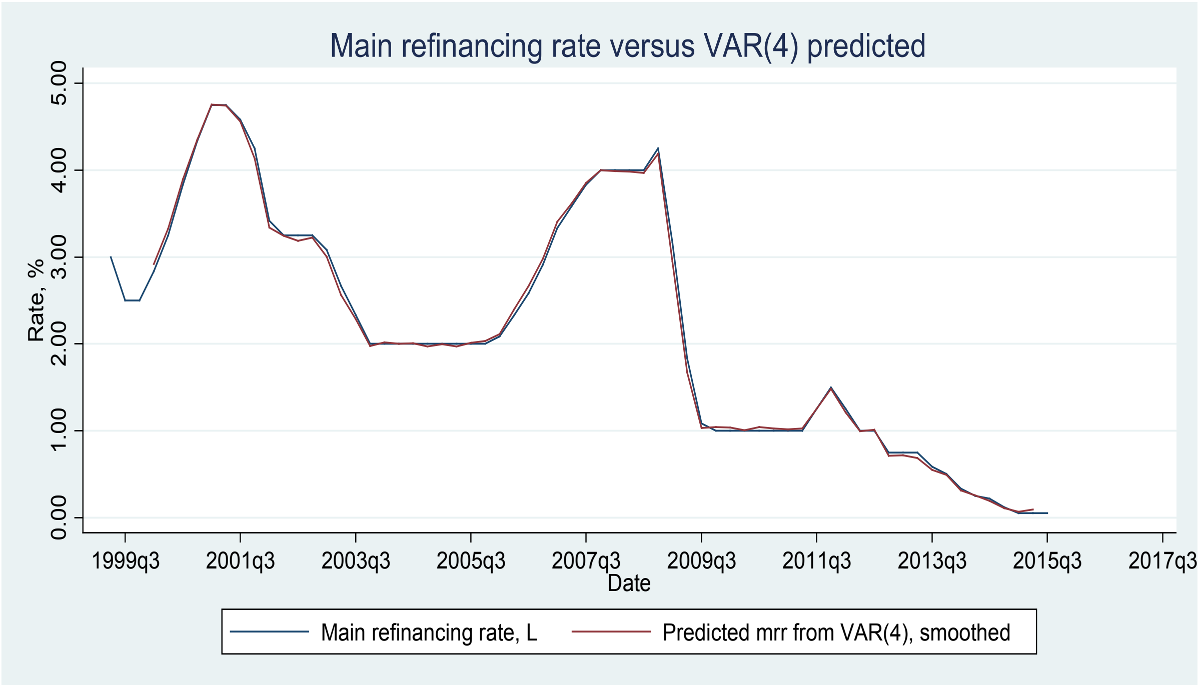

Figure 16: Actual versus predicted smoothed policy rates based on VAR(4) model

.

Dickey-Fuller test for unit root   Number of obs   =   61

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-7.644	-3.565	-2.921	-2.596

MacKinnon approximate p-value for Z(t) = 0.0000

Figure 17: ADF test on the VAR(4) residuals

To sum up, my empirical investigation has led me to reach a few conclusions. Judging by the behaviour of the policy rate versus the benchmark Taylor rate, monetary policy of the ECB was most likely not "excessively loose" in the period before the financial crisis. Even though the precision of the estimated coefficients from the proposed Taylor rule can be questioned, a large deviation of the observed policy rates of the ECB from rule predicted rates seems very unlikely. However, growth of the M3 aggregate was systematically above the reference growth rate of 4.5% and thus by this measure monetary policy of the ECB was indeed too expansionary in the run-up to the crisis. Secondly, there seems to be no equilibrium relationship between the policy rate of the ECB and the credit to GDP gap. However, as demonstrated by the Granger causality tests, credit to GDP does help to explain the behaviour of the policy rate whilst the converse does not apply. Therefore, credit to GDP can be considered exogenous in predicting the policy rate and the policy rate thus seems to respond only passively to developments in the credit to GDP gap.

The results of my empirical investigation are likely to be affected by the imperfect measure of financial instability. However, with the ever-growing pressure on financial institutions to provide quality data and with the ongoing developments in the field of financial stability indicators, future research will hopefully shed more light on the relationship between policy rates and financial instability.

4. Policy implications

To summarise the story so far: the role of central banks and their conduct of monetary policy have evolved significantly in the past 100 years. The initial roles of ensuring the smooth functioning of the banking system and standing in the back as the lender of last resort have been replaced by management of the economy through the targeting of macroeconomic variables. This transformation was not a pre-determined process but rather the result of a trial and error approach reflecting the most pressing problems facing economies at the time. Inflation shocks of the 1970s and 1980s seemed to suggest that taming the stubbornly high inflation was the holy grail of macroeconomic policymaking and this conjecture has been supported by the theoretical New Keynesian model at the time, which predicted that stabilising inflation would also automatically close the output gap – the notion of “divine coincidence”. Inflation targeting has indeed proved successful in attaining its goals – it firmly anchored inflation expectations around the target level and thus prevented the wage-price spiral of previous decades. However, this anchoring of the inflation expectations has resulted in the flattening of the Phillips curve, which meant that deviations of unemployment from the natural rate were no longer reflected in the behaviour of inflation and inflation became an unreliable predictor of the business cycle. Precisely the fact that inflation had remained close to the target level, thus failing to signal substantial positive output gaps, meant that policymakers were blind to the development of unsustainable credit and real estate booms (euro area periphery as the best example of this). Furthermore, there is now a clear and growing body of evidence demonstrating that loose monetary policy, far from only affecting inflation and short-term output, had a significant positive impact on risk-taking of the banking system and on the way it was pricing this additional credit risk. Loose monetary policy in the run-up to the crisis also resulted in the "search for yield", whereby institutional investors, such as insurance companies and pension funds, shifted to riskier asset classes (emerging market bonds, corporate junk bonds etc.) to achieve a certain nominal return target. Last but not least, the obvious asymmetry in the conduct of monetary policy prior to the crisis resulted in significant moral hazard of the financial sector which invested in very illiquid assets and levered up to maximise the return on equity. Furthermore, as was demonstrated by the theoretical model, prudential policies taking the form of risk-based capital requirements cannot fully neutralize the impact of monetary policy on bank risk-taking.

As a result of the risk-taking channel of monetary policy and of the way in which financial instability interacts with the real economy in a vicious circle, central bankers ought to consider the wider repercussions of the monetary policy. As argued by Woodford (2012), the question is no longer if monetary policy should respond to changes in the extent of financial stability – as was seen in the previous parts, the response of monetary policy to financial stability can be justified on both theoretical and empirical grounds. The hardest question is about how this could be done in practice and what the implications for the conduct of monetary policy are.

Before proceeding the with various suggestions about the way in which financial stability considerations could be addressed in the conduct of monetary policy, I must emphasize a point already highlighted by the theoretical model of Agur and Demertzis (Agur & Demertzis, 2015). Potential success of monetary policy in reducing financial instability is all about the correct timing. Many economists engaging in the current debate about the effect of policy rates on financial stability do not make this distinction. It takes no genius to recognise that raising policy rates when the system is saddled with significant leverage and nears the end of a credit cycle would only exacerbate financial instability. A rate hike under these circumstances would increase the real debt burden of agents in the economy by depressing nominal incomes and raising the servicing costs of the existing debt. However, monetary policy can be successful in improving financial stability if the policy rates of the central bank are adjusted to prevent the build-up of debt in the first place. Hence the correct timing to use policy rates to lean against the wind is early on in the leverage cycle, exactly as predicted in the theoretical model. Surprisingly, many economists fail to recognise this non-linear behaviour.

Many economists, most notably John Williams of the San Francisco Federal Reserve and Lars Svensson of the Swedish Riksbank, warn against abandoning inflation targeting and putting too much focus on financial stability. They argue that the benefits of such a strategy are questionable, while the costs are significant. Svensson (2014) argues that the decision of the Swedish Riksbank in 2010 to lean against the wind and raise the policy rate in order to reduce the high debt to income ratio (DTI) of Swedish households has been counterproductive. He runs a counterfactual experiment with the DSGE model currently used by the Riksbank to show that unemployment might have been 1.2% lower and the inflation close to the target of 2% had the rates been kept unchanged at the 0.25%. Moreover, his simulations suggest that the debt to income ratio of the Swedish households might have been lower by about 3% if the rates had remained at 0.25%. The reason, Svensson argues, is that nominal income is much more sensitive to changes in policy rates than the nominal debt, which is quite sticky - the average mortgage duration is about seven years and little of this debt is actually amortized every year. In the light of his simulations, Svensson is firmly convinced that leaning against the wind brings too much pain in terms of lower inflation and higher unemployment, while having a negligible impact on the debt to income ratio. While I share Svensson's scepticism about leaning against the wind in the particular case of Sweden in 2010, where higher rates might have actually been detrimental to financial stability, I do not share his negative views on leaning against the wind under all circumstances. I feel that Professor Svensson completely disregards the timing aspect of the pre-emptive policy. If a central bank leans against the wind early on in the leverage cycle, when the level of debt in the system is still relatively low, it can be successful. Obviously, leaning against the wind and hiking policy rates when the system is saddled with excessive debt (in the case of Swedish households the DTI ratio was staggering 170% in 2010) is equivalent to trying to prick a bubble. However, raising policy rates when the debt levels in the system are still relatively low yet growing might be successful in preventing the boom-bust cycles plaguing developed economies for the last 20 years.

John Williams of the San Francisco Fed has similar arguments against the use of interest rate policies to affect financial stability (Williams, 2014). Williams highlights the experience of two central banks that were using policy rates to impact the extent of financial stability. Not only the Swedish Riksbank but also the Norwegian Norges Bank set policy rates higher than what would be justified by the behaviour of inflation and output alone. Williams shows a chart of long-run inflation expectations in 4 countries - the US, the Eurozone, Sweden and Norway. In the US and in the Eurozone, where central banks adhered more to the price stability mandate, long-run inflation expectations were more firmly anchored at the target rate than the long-run inflation expectations in Sweden and Norway, where central banks used monetary policy to improve financial stability. Using monetary policy to affect financial stability can thus threaten the price stability mandate, unmoor inflation expectations and undermine the credibility of central banks. Now that the costs of high inflation of the 1970s and 1980s are long forgotten, it might be tempting to underestimate the large negative consequences of unmoored inflation expectations and undermined central bank credibility. Williams also points out that the current state of the literature on the impact of interest rates on financial stability is not sufficient to make precise policy recommendations.

It is important to acknowledge the points raised by Svensson and Williams. Inflation targeting has achieved a lot and it would be inappropriate to simply discard the framework. Firmly anchored inflation expectations and central bank credibility must be maintained. However, firmly anchored inflation expectations also lead to the flattening of the Phillips curve, which implies that inflation is no longer indicative of output deviations from the trend. Indeed, stable inflation and unsustainable output have been the norm prior to the crisis of 2007. How can we solve this puzzle? How can we maintain the benefits of firmly anchored inflation expectations while being able to detect financial imbalances and unsustainable output gaps? In the following paragraphs I would like to propose a solution which I find the most appealing.

4.1. Finance-neutral output gap

My proposed solution is to preserve inflation targeting but to modify the framework in order to reflect the changed nature of the relationship between inflation and output. More specifically, I would like to suggest that the ECB incorporates the so-called financial cycles (Borio, 2012) in its estimates of the euro area output gap. The financial cycle, as defined by Borio (2012),"denotes self-reinforcing interactions between perceptions of value and risk, attitudes towards risk and financing constraints, which translate into booms followed by busts." These booms and busts have, in turn, a significant impact on real economic activity. Financial cycles have several features. Firstly, they can be described most parsimoniously by the joint behaviour of credit and property prices. As Borio points out, there are other ways to describe the financial cycle; however, the combination of credit and property prices seems to be the most parsimonious way. In more analytical terms, credit and property prices form "the smallest set of variables needed to replicate adequately the mutually reinforcing interaction between financing constraints (credit) and perceptions of value and risks (property prices)." Secondly, financial cycles have a much lower frequency than the traditional business cycles and much greater wavelength. Drehmann et al. (2012) estimate that the average length of the financial cycle in a sample of 7 industrialised countries since the 1960s has been around 16 years, which is significantly longer than the length of a traditional business cycle (1 to 8 years).

Thirdly, the peaks of the financial cycle correspond with systemic banking crisis and, as a result, its behaviour can signal potential financial distress with a good lead in real time. Fourthly, the length and amplitude of the financial cycle is policy-dependant. Countries with deregulated financial markets, strict inflation-targeting central bank and open economy are likely to suffer more severe financial cycles.

However, what is most important for my analysis is the fact that the incorporation of financial cycles has been shown to improve the measurement of the output gap in real time. Figure 18 demonstrates the output gap estimates of the IMF and OECD, the traditional estimate based on the Hodrick-Prescott filter and the finance-neutral output gap which incorporates the financial cycle in the output gap measurement – the so-called finance neutral output gap (Borio, et al., 2013)

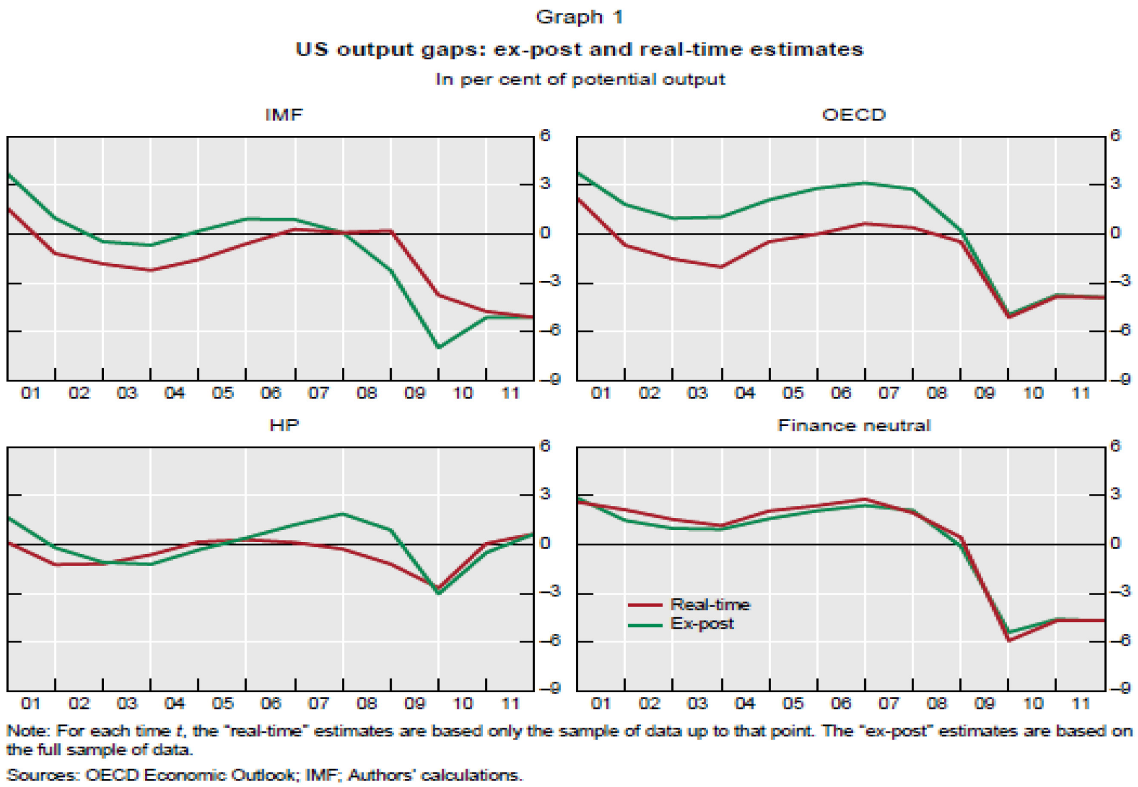

Figure 18: Estimated output gaps, Source: Borio et al. (2013)

A few features stand out. Firstly, in the boom period leading up to the crisis, the traditional measures of output gaps all indicated an output below, or at the very best, close to the potential. Some of the estimates got revised ex-post; nevertheless, their performance in the real time was rather poor. In stark contrast to these estimates was the finance-neutral output gap estimate which signalled significant positive output gaps leading up to the crisis. Even more striking is the performance of the finance-neutral output gap estimate in real time – ex-post revision resulted in only a very minor adjustment of the output gap measure.

Borio et al. (2013) proceed with their analysis further and examine the implications of finance-neutral output gaps on the cyclically-adjusted budget balances and policy rates of central banks in the US and in the UK. In the case of financial balances authors show that whilst the unadjusted budget balance was positive (i.e. budget surplus) in both in the US and the UK, the cyclical adjustments based on the finance neutral output gap yielded negative budget balances (i.e. budget deficits). Authors thus conclude that the fiscal positions of both the US and the UK were considerably weaker than the headline figures suggested. Similarly, Borio et al. also look the behaviour of the policy rates in the US and in the UK suggested by the standard version of the Taylor rule under different measures of the output gap. Authors use the canonical Taylor rule of the form

$$\boldsymbol{i_t = r^* + \pi^* + 1.5 * INFGAP_t + 0.5 * OUTGAP_t} \quad \textbf{(12)}$$

where r^* and π^* are both set equal to 2 and the weights on the inflation and output gaps are taken from the original paper by Taylor (1999). In any case, the precise values are irrelevant since it is the relative behaviour of the policy rate under different estimates of the output gap which is of interest. Figure 19 shows the actual behaviour of the policy rate versus the predicted ones based on different measure of the output gap.

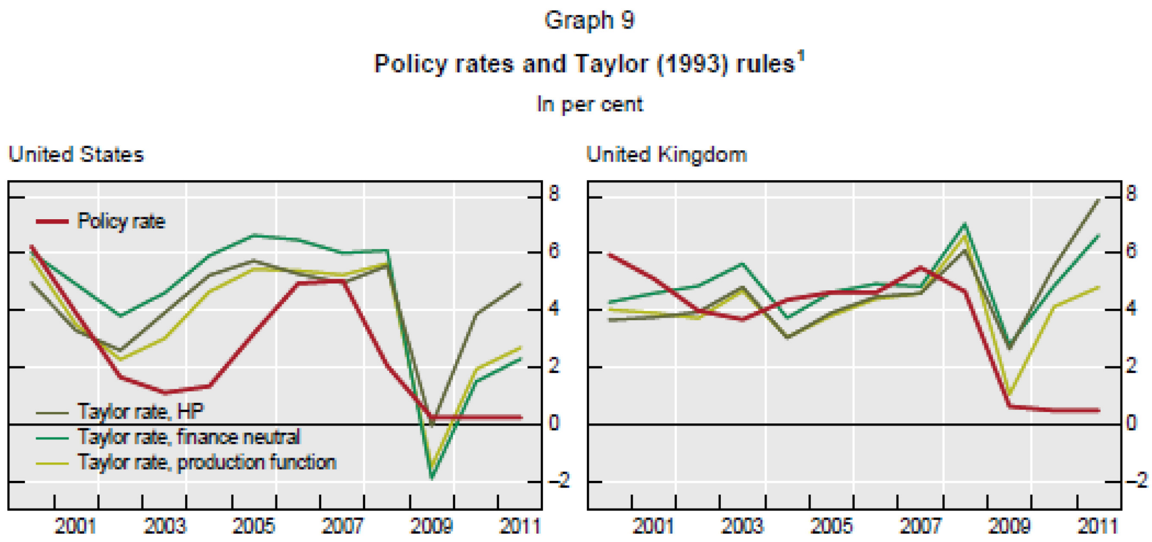

Figure 19: The policy rate with different measures of output gap, Source: Borio et al. (2013)

Relative to rules with other measures of the output gap, the Taylor rule based on the finance-neutral output gap would have implied an interest rate of around 1% higher on average in the US and around 0.7% higher on average in the UK during the boom period. While the results should be taken with a pinch of salt, the crucial point the authors are making is the fact that finance-neutral output gaps can provide a more refined measure of the underlying state of the economy compared with other methods. Furthermore, the finance-neutral measure of the output gap seems to be very reliable in real time. Therefore, by using the finance-neutral output gap the ECB could increase its chances of achieving sustainable price stability over the medium term. Stabilised inflation at the target level would no longer bring the added doubt of potentially devastating financial imbalances. By slightly adjusting the inflation-targeting regime to account for financial cycles, the ECB would be able to retain the benefits of firmly anchored inflation expectations without fears of financial imbalances.

Despite having said all of the above, I must emphasize that my firm conviction is that monetary policy should not become overburdened with too much focus on financial instability. Prudential policies (micro and macro) should be the first line of defence in preventing and resolving financial imbalances in the system and monetary policy should only assume a complementary role along with fiscal policy. Micro and macroprudential policy can be applied with much greater precision and, as opposed to leaning against the wind, without too many side-effects on the real economy. The points raised by critics of the leaning against the wind strategy are valid. It is true that interest rates are quite a crude instrument to affect financial conditions since they affect all agents in the economy in the same way regardless of the distribution of risks in the system. On the other hand, this universal reach of the policy rates might also be perceived as an advantage in the age of rising shadow banking (money market mutual funds, special investment vehicles etc.) since regulation simply cannot reach all of the cracks of the system (Stein (2013)). Too much attention paid to financial stability could also result in highly volatile interest rates, which would go directly against the wish of central banks to smooth interest rates in order to facilitate long-term planning in the real economy. Experience of the Swedish Riksbank and Norwegian Norges Bank also suggest that too much emphasis on financial stability can unmoor inflation expectations and cause substantial pain in the terms of higher unemployment.

However, theoretical models and empirical evidence send a clear message: stance of the monetary policy can have a significant impact on risk-taking and subsequently financial stability. This financial instability can be, in turn, quickly transmitted to the real economy. Furthermore, it is likely that this impact of policy rates on financial instability cannot be fully neutralised by regulatory policies. Therefore, central bankers should always bear in mind that every policy rate decision that they take can have quite wide repercussions in the financial system. The effectiveness of monetary policy in leaning against the wind depends crucially on the timing – a rate hike to prevent the build-up of imbalances is most effective early on in the leverage cycle. Any attempts to lean against the wind close to the peaks of the credit cycle (experience of Sweden) are likely to be counterproductive. Given that monetary policy matters for financial stability and given the failure of inflation-targeting to deliver on this front, a reform of the policy regime is required. To make the most of the apparent benefits of inflation targeting, the framework should remain in place but it should be modified in order to better reflect underlying output developments. The finance-neutral output gaps of Borio et al. seem to be a suitable, whilst still quite minor, amendment to the existing framework.

5. Conclusion

My thesis was motivated by the urge to raise awareness about the impact of low policy rates on instability in the financial sector, which can subsequently inflict substantial pain to the real economy. I find that this topic does not get the attention it deserves. The first part of the thesis dealt with the history of central banking and tried to convey the point that financial concerns were once at the forefront of central bank policymaking, price stability and resource utilization have not been even remotely alluded to. The pre-crisis consensus was that central banks should be only be concerned with price stability and in some cases with resource utilization to a smaller extent. The belief that financial stability would automatically follow from price stability proved to be flawed.

The theoretical model presented in part 2 of the thesis demonstrated that monetary policy can have significant impact on risk-taking of the banking sector and that this impact cannot be fully neutralised by prudential regulation. The theoretical model also provided clues as to when should be the strategy of leaning against the wind employed. Part 3 of the thesis presented empirical work on the relationship between the monetary policy of the ECB and a proxy for financial instability – the credit to GDP gap in the euro area. Whilst no cointegrating, or long-run equilibrium relationship was found, there is evidence that the credit to GDP gap has been causing changes to the policy rate of the ECB whilst no causality going in the other direction was detected. This suggests that the ECB has been reactive to financial instability and did not actively try to lean against the wind. Part 4 of the thesis provided an overview of the current policy debate about the role of monetary policy in helping to promote financial stability and also provided some suggestions as to how could inflation-targeting framework of the ECB be adjusted in order to account for the risk-taking channel.

Much more research needs to be undertaken in order to provide definite answers to the questions posed by this thesis. However, with the rapidly increasing interest in the relationship between monetary policy and financial stability even among mainstream economists, I am hopeful that monetary policy of the future will be more stabilising than ever before.

Bibliography

Act, F. R., 1913. *"An Act To provide for the establishment of Federal reserve banks, to furnish an elastic currency, to afford means of rediscounting commercial paper, to establish a more effective supervision of banking in the United States, and for other purposes,".* Vol. XXXVIII ed. Washington, DC: The Statues at Large of the United States .

Agur, I. & Demertzis, M., 2015. Will Macroprudential Policy Counteract Monetary Policy's Effects on Financial Stability?. *IMF Working Paper No. 283.*

Altunbas, Y., Gambacorta, L. & Marques-Ibanez, D., 2014. Does Monetary Policy Affect Bank Risk?. *International Journal of Central Banking,* March, 10(1), pp. 95-136.

Bernanke, B., Gertler, M. & Gilchrist, S., 1999. The Financial Accelerator in a Quantitative Business Cycle Framework. *Handbook of Macroeconomics,* 1(C), pp. 1341-1393.

Blanchard, O. & Galí, J., 2007. Real Wage Rigidities and the New Keynesian Model. *Journal of Money, Credit and Banking,* 39(s1), pp. 35-65.

Borio, C., 2012. The Financial Cycle and Macroeconomics: What Have We Learnt?. *BIS Working Paper No. 395.*

Borio, C., Disyatat, P. & Mikael, J., 2013. Rethinking Potential Output : Embedding Information About the Financial Cycle. *BIS Working Paper No. 404.*

Borio, C. & Lowe, P., 2004. Securing sustainable price stability: should credit come back from the wilderness?. *Bank for International Settlements Working Paper No.157.*

Borio, C. & Zhu, H., 2012. Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism?. *Journal of Financial Stability,* 8(4), pp. 236-251.

Clarida, R., Galí, J. & Gertler, M., 2000. Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory. *Quarterly Journal of Economics,* 115(1), pp. 147-180.

Diamond, D. & Rajan, R., 2012. Illiquid Banks, Financial Stability, and Interest Rate Policy. *Journal of Political Economy,* 120(3), pp. 552-591.

Drehmann, M., Borio, C. & Tsatsaronis, K., 2012. Characterising the Financial Cycle: Don't Lose Sight of the Medium Term!. *BIS Working Paper No. 380.*

Gillitzer, C. & Simon, J., 2015. Inflation Targeting: A Victim of Its Own Success. *International Journal of Central Banking,* 11(s1), pp. 259-287.

Greenspan, A., 2002. *Issues for Monetary Policy.* Economic Club of New York, New York City, s.n.

Ioannidou, V., Ongena, S. & Peydró, J.-L., 2015. Monetary Policy, Risk-Taking, and Pricing: Evidence from a Quasi-Natural Experiment. *Review of Finance,* 19(1), pp. 95-144.

Jimenéz, G., Ongena, S., Peydró, J.-L. & Saurina, J., 2014. Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?. *Econometrica,* March, 82(2), pp. 463-505.

OECD, 2015. *OECD Business and Finance Outlook 2015,* Paris: OECD Publishing.

Phillips, P. & Ouliaris, S., 1990. Asymptotic Properties of Residual Based Tests for Cointegration. *Econometrica,* 58(1), pp. 165-193.

Pinkwart, N., 2013. Quantifying the European Central Bank's Interest Rate Smoothing Behaviour. *The Manchester School,* 81(4), pp. 470-492.

Rajan, R., 2006. Has Finance Made the World Riskier?. *European Financial Management,* 12(4), pp. 499-533.

Sheedy, K., 2014. Debt and Incomplete Financial Markets: A Case for Nominal GDP Targeting. *Brookings Papers on Economic Activity,* pp. 301-73.

Stein, J., 2013. *Overheating in Credit Markets: Origins, Measurement, and Policy Responses.* St Louis, A Research Symposium sponsored by the Federal Reserve Bank of St. Louis.

Stock, J. & Watson, M., 2007. Why Has U.S. Inflation Become Harder to Forecast?. *Journal of Money, Credit and Banking,* 39(s1), pp. 3-33.

Svensson, L., 2014. Inflation Targeting and Leaning against the Wind. *International Journal of Central Banking,* 10(2), pp. 103-114.

Taylor, J., 1999. A Historical Analysis of Monetary Policy Rules. In: *Monetary Policy Rules.* s.l.:National Bureau of Economic Research, pp. 319-348.

Toniolo, G., 2010. *What is a Useful Central Bank? Lessons from the Interwar Years.* Oslo, Norges Bank Symposium “What is a Useful Central Bank?”.

Williams, J., 2014. Financial Stability and Monetary Policy: Happy Marriage or Untenable Union?. *Presentation to the Deutsche Bundesbank Conference.*

Woodford, M., 2012. Inflation Targeting and Financial Stability. *NBER Working Paper No. 17967.*

List of Figures and Tables