

Working Paper

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Taylor Rule and Financial Instability

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Abstract:

This paper estimates an augmented/non-linear Taylor rule for the ECB and the Riksbank to include financial instability factors. The existence of nonlinearities will be explored and assessed through the estimation of a threshold regression model. The threshold model divides the sample in two distinct subsamples, each representative of a different regime. A composite indicator of systemic stress characterizes the two regimes into a low instability regime and a high instability regime. The results are quite clear. They show us that the classical Taylor rule performs well during Regime 1, or “normal administration times”; but it shows inherently weaknesses in describing the behavior of CBs during financial instability periods, when discretion may be necessary. Remarkably such a non-linear model is also successful in not crossing the ZLB.

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Introduction

The so-called Great Moderation period has been characterized by a low and stable inflation environment that has assured steady growth and stable economic cycles. These results have been achieved thanks to the two pillars of modern Central Banking: independence and credibility.

Pioneering works by Kydland and Prescott (1977)¹ and Barro and Gordon (1983)² have shown through repeated game theory models that reputation building is best when central banks (CBs) follow clear rules in setting their main instrument: interest rate. Predictability is key to build credibility. See Alesina and Stella (2011)³ for a review of the relevant literature.

These results have become widely accepted and led CB to start committing to policy targets and communicating to the public the rationale of their policy stance.

In a groundbreaking paper Taylor (1993)⁴ showed how a simple rule, which prescribes CBs to set the interest rate by targeting lagged inflation and the output gap, can be very effective in describing the behavior of the FED. From that day the Taylor Rule became a benchmark in monetary policy.

However, since the beginning of the financial crisis back in 2008, the Taylor rule and the target rate set by the FED have started to diverge. About the gap, during a recent speech the FED governor Janet Yellen said: “*Under normal circumstances, simple monetary policy rules, such as the one proposed by John Taylor, could help us decide when to raise the federal funds rate.*”, but “[.] *I would assert that simple rules are too simple and ignore important complexities of the current situation*”.⁵

Complexities may refer to different assumptions about the neutral real interest rate, market expectations, the zero lower bound for interest rates or, as I would like to prove in my work, to the increasing importance of financial shocks.

Economics is a subject in continuous development and relationships change or break up over time. In chapter 5 this work aims to deepen our knowledge of the economic variables monitored and targeted by the ECB since the inception of the common currency in 1999. In chapter 6 the same model will be applied to study the behavior of the Central Bank of Sweden, the Riksbank. As I will argue below, the analysis of the Riksbank is of particular interest because it was the only CB of an advanced economy who temporarily increased its rates in late 2010. The analysis will estimate

¹ Kydland, F. and E. Prescott (1977), “*Rules rather than discretion: The inconsistency of optimal plans*”, *Journal of Political Economy*, 85, 473-490.

² Barro and Gordon. 1983. Rules, discretion, and reputation in a model of monetary policy. *Journal of Monetary Economics* 12: 101-121.

³ Alesina, Alberto, Andrea Stella, “*The Politics of Monetary Policy.*” In *Handbook of Monetary Economics*, Ch. 8 1000-1054. Amsterdam: North Holland.

⁴ Taylor, John B., “*Discretion Versus Policy Rules in Practice,*” *Carnegie-Rochester Conference Series on Public Policy* 39: 195-214 (1993).

⁵ Speech of Janet L. Yellen At the “*The New Normal Monetary Policy,*” a research conference sponsored by the Federal Reserve Bank of San Francisco, San Francisco, California March 27, 2015 *Normalizing Monetary Policy: Prospects and Perspectives.*

an augmented Taylor rule to include financial instability factors. Furthermore, the existence of nonlinearities will be explored and assessed through the estimation of a threshold regression model.

The threshold model estimated in chapters 5 and 6 divides the sample in two distinct subsamples, each representative of a different regime. A composite indicator of systemic stress characterizes the two regimes into a low instability regime and a high instability regime. The results are quite clear. They show us that the classical Taylor rule performs well during Regime 1, or “normal administration times”; but it shows inherent weaknesses in describing the behavior of CBs during financial instability periods, when discretion may be necessary. Remarkably such a non-linear model is also successful in not crossing the ZLB. Below I will propose an augmented version of the Taylor Rule, which is able to fairly describe the behavior of the ECB and the Riksbank during the recent Financial crisis and the Sovereign debt crisis.

1 Literature review

1.1 The Taylor Rule

In the following, I will analyse the increasing importance and the developments of the Taylor Rule starting from Taylor's original proposal (1993). First of all I would like to point out that what is simply called the Taylor rule, has appeared in the literature with different assumptions. For example, the literature has proposed backward or forward looking Taylor Rules⁶, nonlinearities, interest rate smoothing regimes or just different weights for inflation and the output gap.

However the basic principles (i.e. inflation and output gap targeting) are unchanged from the original rule proposed by Taylor (1993)⁷ for the FED:

$$i_t = 2 + \pi + 0.5(\pi - 2) + 0.5Y$$

Where i_t is the federal fund rate, Y is the percentage deviation of real GDP from a target and π inflation in the last 4 quarters⁸. The above can be rewritten in general form to get the following:

$$i_t = \pi_t^* + r_t^* + \alpha(\pi_t - \pi_t^*) + \beta(y_t - \bar{y}_t)$$

Where r_t^* is the equilibrium neutral rate of interest, π_t^* is the target inflation rate, π_t is the observed inflation rate, $(y_t - \bar{y}_t)$ is the current period output gap.

If the Taylor principle holds, such a policy rule has the ability to provide the nominal anchor for inflation expectations and to rule out multiple equilibria. The Taylor principle prescribes that nominal rates should increase more than proportionately with respect to inflation, that is: the inflation coefficient should be larger than 1, see for example: Woodford (2001)⁹.

Provided that CBs face a trade-off in the medium term between inflation and growth, the Taylor rule enjoys good welfare properties in standard neo-Keynesian models with symmetric quadratic loss function and it is generally robust to different specifications in different models¹⁰ (Taylor 1999). On top of that, Galí and Blanchard

⁶ Clarida, R., Gali, J., Gertler, M., December 1999. "The Science of Monetary Policy". Journal of Economic Literature 37(4), 1661-1707

⁷ Taylor, J. B. (1993). "Discretion versus policy rules in practice". Carnegie-Rochester Conference Series on Public Policy 39, pp 195-214.

⁸ Ivi, pp 202

⁹ Woodford, Michael. 2001. "The Taylor Rule and Optimal Monetary Policy." American Economic Review, 91(2): 232-237.

¹⁰ Taylor, J. B. (1999). "The robustness and efficiency of monetary policy rules as guidelines for

(2005) showed how inflation targeting stabilizes the output gap without CB facing a trade-off between the two objectives and they called it the “divine coincidence”¹¹. They also showed that in presence of real wage rigidities this property does not hold¹². Still the Taylor rule is a very desirable policy function since it has lower variances of output and inflation vis a vis other monetary policy rules and provides stability of rational expectations equilibria under sticky prices.¹³ Last but not the least, easiness of communication to the general public makes it a very good and widespread benchmark to evaluate the monetary stance of CBs. See again Taylor (1999) for further analysis of the rule’s properties¹⁴. Unfortunately it cannot be the golden rule and it has some drawbacks as well. First of all, its fitting properties refer to the past and in economics relations may break up with time (i.e. Philipps curve). Secondly, CBs do not respond to all the shocks, especially if they deem the latter to be only transitory (i.e. a short term increase in oil prices that impacts inflation). Thirdly, CBs take into account in their models more variables than expected/realized inflation and the output gap. Finally, the latter is very difficult to estimate and different methodologies are used (i.e. Okun’s law, real time vs revised data) with imperfect results¹⁵.

1.2 Forward Vs Backward looking Taylor rules

With reference to the rule’s structure, the main debate in the literature is between forward and backward looking Taylor Rules. The original rule (Taylor 1993) is a feedback rule, which targets backward variables (i.e. lagged inflation and output gap). Alternatively, in a seminal paper Clarida, Galì, Gertler (2000)¹⁶ used the GMM (Generalized Method of Moments) to estimate a forward-looking Taylor Rule. The authors pointed out that such a rule, by targeting future expected inflation and the output gap, resembles more the actual behavior of CBs. Why is it so? Because forward variables allow CBs to value other variables in estimating expectations. A key example are asset prices. Another rationale for choosing a forward looking rule is the fact that the transmission mechanism of monetary policy is inherently subject to lags and inertia, and it may pass time well before the monetary stimulus is channeled into the economy. Therefore CBs need to try to anticipate shocks and volatility.¹⁷ They also underline that if a combination of lagged inflation and output gap is a sufficient statistics to predict expected future inflation, then their forward looking Taylor rule collapses to the traditional Taylor rule, but in this case the original

interest rate setting by the European Central Bank”, Journal of Monetary Economics, 43, pp. 655–79.

¹¹ Olivier J. Blanchard & Jordi Galì, 2005. “*Real wage rigidities and the New Keynesian model*,” Proceedings, Board of Governors of the Federal Reserve System (U.S.)

¹² Ivi

¹³ Clarida, R., Galì, J., Gertler, M., December 1999. “*The Science of Monetary Policy*”, Journal of Economic Literature 37(4), 1661-1707

¹⁴ Taylor, J.B. (1999) “*The robustness and efficiency of monetary policy rules as guidelines for interest rate setting by the European Central Bank*”, Journal of Monetary Economics, 43, pp. 655–79.

¹⁵ Orphanides, A (2003): “*The quest for prosperity without inflation*”, Journal of Monetary Economics, no 50(3), pp 633–63.

¹⁶ Clarida, R., J. Galì, and M. Gertler (2000). “*Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory*.” Quarterly Journal of Economics 115, pp 147-180

¹⁷ Ivi - pp 151

coefficients should be interpreted with caution¹⁸.

Orphanides (2001) instead, points out that: "In some models, Taylor rules responding to several-quarters-ahead forecasts of inflation appear more promising for stabilization than rules focusing only on near-term conditions. However, this conclusion is not robust and is overturned once the potential unreliability of longer-term forecasts due to model misspecifications factored into the analysis".¹⁹ Therefore researchers may have to trade-off fitting properties with estimation errors.

Another feature that has been incorporated in the model is interest rate smoothing. Adding another term – lagged interest rate- allows to better appreciate the smooth marginal changes that CBs implement to avoid shocks to the economy/financial markets and allowing a plain building of expectations. This feature is now widespread and the estimation of the smoothing parameter is usually significant. For an example see again Clarida, Galí, Gertler (2000), who found positive evidence for interest rate smoothing by the FED.²⁰

1.3 Non-linearities in the Taylor Rule

As evidenced in Taylor and Dravdakis (2006), non linearities may be a feature of: 1) non symmetric preferences of the CBs, 2) non linearities in the economy, 3) a combination of both.²¹ The authors study the behavior of the BoE (Bank of England) adopting a forward Taylor rule. They estimate different threshold models through GMM, and they find positive evidence for the BoE targeting a nonlinear Taylor rule. In particular, it reacts strongly to inflation when it is larger than 2,5%, while when inflation is below 2,5% the reaction of the BoE is very weak, with only a little positive coefficient for the output gap. Instead, Castro (2008)²² studied the presence of nonlinearities in the behavior of the FED, ECB and BoE. On top of that he tried to augment his forward looking Taylor rule with a financial instability indicator. I will discuss his results about the financial instability factor in section 2.2 (Augmented Taylor rule). His strategy relies on the estimation of a smooth transition model through the GMM. He found evidence of non-linearities for ECB and the BoE, which are inclined to massively target inflation only if it is above the target (asymmetric behavior)²³. On the other side he confirmed that the FED seems to follow a linear rule. Another interesting paper is Surico (2007)²⁴, where the author tested asymmetric preferences for the ECB and added a convex supply curve in the model. He found out that the ECB targets inflation symmetrically, however the output gap

¹⁸ Ibidem

¹⁹ Orphanides A. , (2007), "Taylor Rules" Board of Governors of the Federal Reserve System (U.S.) in its series Finance and Economics Discussion Series with number 2007-18

²⁰ Ivi - pp 152

²¹ Taylor, M.P. & Davradakis, E., 2006. *Interest rate setting and inflation targeting: evidence of a nonlinear Taylor rule for the United Kingdom*.

²² Castro, Vítor Manuel Alves (2008) *Are Central Banks following a linear or nonlinear (augmented) Taylor rule?* Working Paper. Coventry: University of Warwick, Department of Economics. Warwick economic research papers (No.872).

²³ Ivi, pp 31

²⁴ Surico P., (2007), "The monetary policy of the European Central Bank". *cScand. J. of Economics* 109(1), 115–135

and the nominal interest rate they are not. In fact the ECB reacts stronger to contractions and when the nominal interest rates are higher. Caveat: Also these results should be updated since they refer to the period before the financial crisis. For a deeper review of the literature on nonlinearities, see again Castro (2008).

1.4 Taylor Rule and the “Great Deviation”

Clarida, Galí, Gertler (2000)²⁵ analyse the pre-Volcker (i.e. pre 1979) and the post-Volcker period. They find out that the FED did not comply with the Taylor Principle in the pre-Volcker period, and this resulted in higher volatility of output and inflation. Instead, after the 1979, the FED started to comply with the Taylor principle. This policy led to the so-called Great moderation period.

But how has monetary policy performed during the recent crisis? As Williams (2014) effectively describes the CBs behavior: “*we are all inflation targeters now*”²⁶. However, the recent crisis put CBs around the world under pressure because what has been remarkably successful in anchoring inflation expectations so far has proved inadequate. Politicians started to use CBs as scapegoats²⁷ for the recession. A large number of academics pointed out that the crisis was due to the accumulation of imbalances caused by past (i.e. post 2001) deviation from the prescriptions of the Taylor rule – See Taylor (2009)²⁸. On the other side Bernanke (2010) defended the operate of the FED, pointing out financial innovation as the root of the housing boom²⁹. Lastly, other authors blamed simple inflation targeting for being inadequate³⁰, in light of the recent development in economics. But, what do facts tell us? The Taylor rule described very well the behavior of CBs at least until the recession of 2001³¹. There has been a very close fit between such a simple rule and the actual interest rate set by the FED, and this holds also for other CBs, ECB in primis. However this fit is far from being perfect and after the financial crisis of the 2008 the gap has widened even further.

²⁵ Clarida, R., J. Galí, and M. Gertler (2000). “Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory.” *Quarterly Journal of Economics* 115, pp 148

²⁶ Williams John C., (2014), “*Inflation targeting and the global financial crisis: successes and challenges*”, Federal Reserve Bank Of San Francisco, Conference on fourteen years of inflation targeting in South Africa and the challenge of a changing mandate.

²⁷ Alesina, Alberto, Andrea Stella, “*The Politics of Monetary Policy*.” In *Handbook of Monetary Economics*, Ch. 8 1000-1054. Amsterdam: North Holland. Pag 2

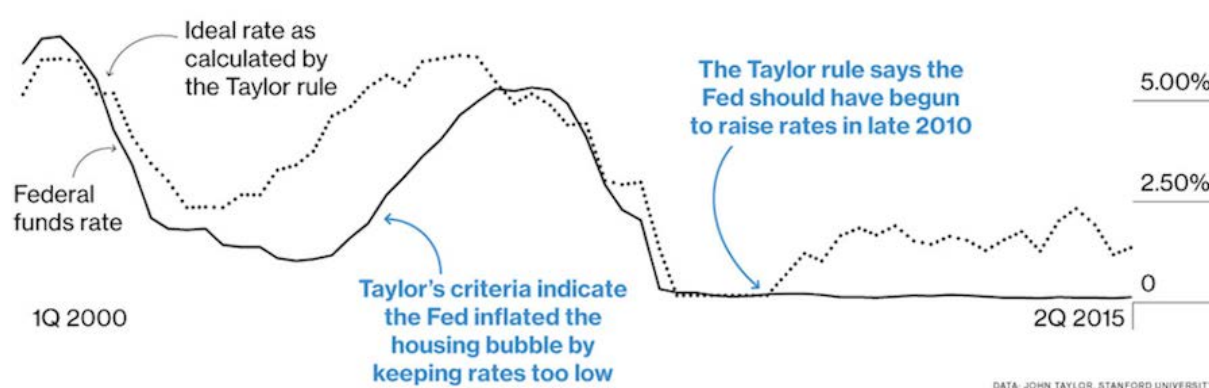
²⁸ Taylor J., 2009, “*The financial crisis and the policy responses, an empirical analysis of what went wrong*”, Rock Center Working Paper No. 30

²⁹ Bernanke, B (2010): “*Monetary policy and the housing bubble*”, speech given at the American Economic Association Annual Meeting, Atlanta, Georgia, 3 January.

³⁰ George Akerlof, Olivier Blanchard, David Romer and Joseph Stiglitz, May 2014 “*What have we learned?*”: Macroeconomic policy after the crisis” MIT Press, Pag 54

³¹ Hoffman B., Bogdanova B, (2012) “*Taylor rules and monetary policy: a global “Great Deviation”?*”, BIS Quarterly Review – September 2012

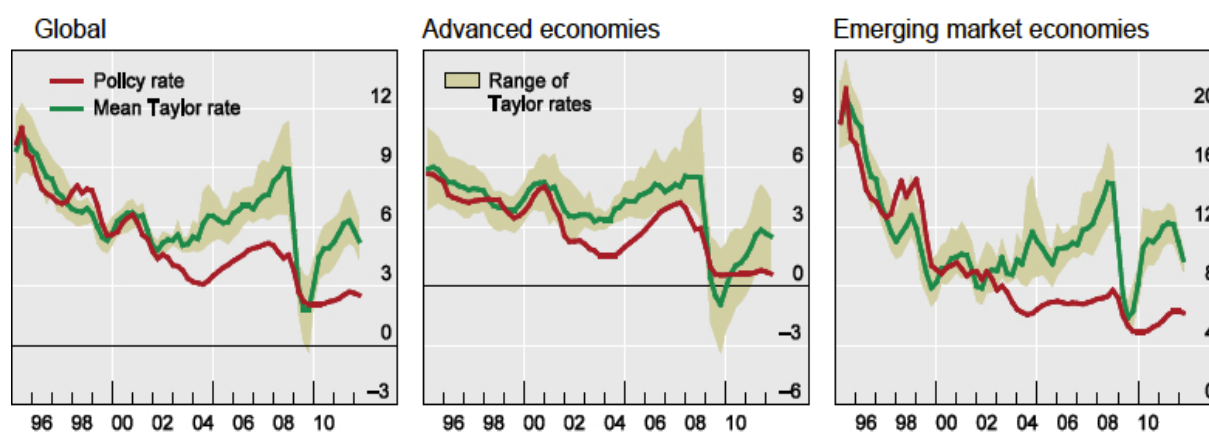
Figure 1: Taylor Rule vs Federal Funds Rate



Source: Bloomberg on John Taylor data³²

A reasonable candidate for the widening of the gap is the support of CBs to financial markets and the unconventional monetary policy that CBs around the world were pushed to implement when the zero lower bound (ZLB) for the interest rate was hit. Since the causes of every crisis differ, sometimes CBs need flexibility in fulfilling their mandate, as discretion is necessary in turbulent environments. After the burst of the financial crisis, widespread reforms empowered CBs with more responsibilities: from the adoption of Macro stability tools to supervision of the banking sector (ex SSM for the ECB). CBs are therefore in the privileged position to get information about financial instability factors in advance with respect to the average market agent. In chapter 2 I will point out why it could be important to include factors that take into account financial instability in the “classical” Taylor rule.

Figure 2: Taylor Rule vs policy rates in the world (1995-2012)



Source: See footnote 12

³² <http://www.bloomberg.com/news/articles/2015-07-23/yellen-fed-s-independence-under-attack-despite-economic-rebound>

1.5 Scope of Taylor rule

As seen before the FED behavior may be summarized by the Taylor rule. But what about other CBs? The ECB has a limited time series available (from 1999), and therefore consistent estimation was not possible until few years ago. Therefore for periods before the 1999, some authors studied whether the Bundesbank followed a Taylor rule, and the answer is positive : See Clausen and Meier (2003)³³.

A recent paper by Gerlach and Lewis (2010)³⁴ studies the behavior of the ECB up until 2009. The authors use a smooth transition model to test for changing weights in the estimated policy rule. Their results confirm that the ECB can be described through a Taylor rule, but, most importantly, they show that the ECB increased its weight for the output gap. This change happened after the beginning of the last financial crisis, as soon as the ZLB started to bind (consistently with what the literature on ZLB suggests).³⁵

Taylor (2000)³⁶ focuses on Emerging Market (EM) economies. Generally speaking, for EM, a simple rule composed by the Taylor rule plus a factor accounting for the exchange rate does a good job in describing the monetary policy. Obviously there are some peculiarities due to the missing of developed financial markets, for example the short term interest rate (the main policy instrument in the developed economies) should be substituted with monetary aggregates measures³⁷. Because as Taylor states: *"In a situation of a high inflation rate, the real interest rate is hard to measure, and risk premia can be high and variable. Also in a high growth emerging economy, the equilibrium real interest rate may be difficult to determine and measure. With an interest rate rule, uncertainty about the equilibrium real interest rate translates into policy errors"*³⁸. Further difficulties arise for EM since they may need to control the exchange rate to dampen excessive fluctuations. Still, a floating exchange rate allows them to fine tune their monetary policy to the needs of the domestic market. By doing so, they do not import inflation from the country to which they are pegged.³⁹ China is an EM economy that was able to assure stable inflation and high growth. Girardin, Lunven and Ma (2014)⁴⁰ study whether the CB of China follows a Taylor rule in its policy settings. Using a bayesian statistical model they find out that *"the PBC has engaged in a regime that looks a lot like informal flexible inflation targeting, with a weight on inflation similar to levels seen in other major economies (with a long-term coefficient higher than unity)"*⁴¹. Nonetheless the PBC differs from CBs of developed economies for its large weight on the output gap, a peculiarity of EM

³³ Clausen J., Meier C.P., (2003), *"Did the Bundesbank follow a Taylor Rule? An analysis based on real-time data"* Kiel Institute for the World Economy - Kiel Working Papers, number 1180

³⁴ Gerlach, S., Lewis, J. (2010). *"The Zero Lower Bound, ECB Interest Rate Policy and the Financial Crisis."* De Nederlandsche Bank Working Paper No. 254.

³⁵ Ivi, pp 22

³⁶ Taylor J., 2000, *"Using Monetary Policy Rules in Emerging Market Economies"*, Stanford University, Working paper, December 2000

³⁷ Ivi, pp 4

³⁸ Ibidem

³⁹ Ivi pp 15

⁴⁰ Girardin E., Lunven S., Ma G. (2014) *"Inflation and China's monetary policy reaction function 2002-2013"*, BIS : Globalisation, inflation and monetary policy in Asia and the Pacific, 2014, vol. 77, pp 159-170 from Bank for International Settlements

⁴¹ Ivi, pp 2

economies⁴²

Other interesting results refer to Switzerland. Feld P. Lars and Köhler A. Ekkehard (2015)⁴³ give another contribution to the large literature trying to explain the so-called “Swiss interest rate anomaly”⁴⁴ (lower long-term return of Swiss assets). The main hypothesis is that Switzerland is a kind of interest-rate Island, and the Swiss Franc is considered a safe-haven currency that appreciates Vis a Vis the other currencies every time an adverse shock happens. The recent stark appreciation of the Swiss Franc Vis a Vis the Euro and the introduction of a floor by the Swiss CB lowered the interest rate bonus to insignificant levels. The authors were able to prove a regime switch by the Swiss CB after it ended to target a floor exchange rate vis a vis the EURO, such that the Interest rate bonus has now risen again to normal level (in anticipation of another systemic shock)⁴⁵.

1.6 Econometric issues

Several econometric issues have arisen over time. First of all, the unreliability of real-time estimates for the output gap. Orphanides (2001) published an influential paper, where he prompted the importance to use real-time data for consistent estimation of the Taylor rule ⁴⁶. The reason is that CBs use real-time forward looking variables, therefore they cannot be studied consistently by using ex-post revised data. Another issue regards the estimation of the real-long term interest rate. Orphanides and Williams (2002)⁴⁷ show that even small errors in computing an estimate of the real interest rate may impair the results. Therefore, they suggest an alternative estimation model that does not rely upon the real interest rate. Sometimes the Taylor rule is deemed to be a spurious regression, when normally it is assumed that the time series of both inflation and the output gap are stationary. If it is a spurious regression and these assumptions do not hold, the validity of the coefficient estimates is impaired; see Osterholm (2005)⁴⁸. Lastly, I would like to briefly cite Cochrane (2011)⁴⁹, who critiques the determinacy of multi-equilibria in the neo-Keynesian model empowered with a Taylor rule. Basically Cochrane suggests that the Taylor rule relies upon unrealistic assumptions which imply that the government must stand willing to rule out explosive paths if the CB is to follow such a rule.⁵⁰

⁴² Ivi, pp 8

⁴³ Feld P. Lars and Köhler A. Ekkehard (2015) “*Is Switzerland an Interest Rate Island after all? Time Series and Non-Linear Switching Regime Evidence*” CESIFO WORKING PAPER NO. 5628

⁴⁴ Ivi, pp 2

⁴⁵ Ivi, pp 22

⁴⁶ Orphanides, A. (2001), “*Monetary policy rules based on real-time data*”, The American Economic Review, Vol. 91, No. 4, pp. 964-985

⁴⁷ Orphanides, A., Williams, J.C., (2002) “*Robust Monetary Policy Rules with Unknown Natural Rates*” Brookings Papers on Economic Activity 2:2002, 63-145.

⁴⁸ Osterholm p., (2005), “*The Taylor rule, A spurious regression?*”, Bulletin of Economic Research 57:3, 2005, 0307–3378

⁴⁹ Cochrane J., (2011), “*Determinacy and Identification with Taylor Rules*” Journal of Political Economy, Vol. 119, No. 3 (June 2011), pp. 565-615

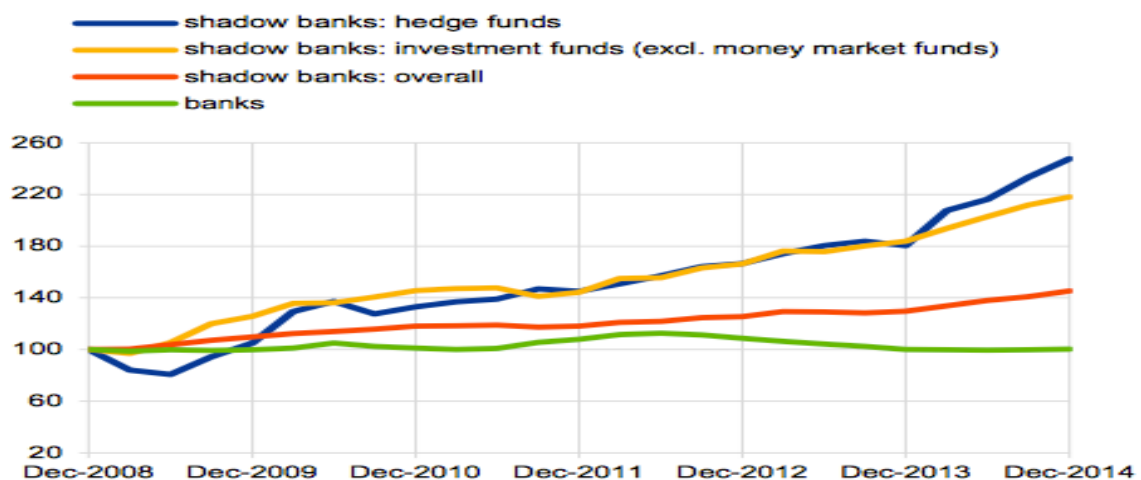
⁵⁰ Ivi, pp 567

2 The importance of the financial sector

Why may financial shocks be important for the implementation of monetary policy? Simply because the size of the financial sector has been growing steadily, up to a point that academics have started to call it the “financialization of the world economy”. *“Financialization transforms the functioning of the economic system at both the macro and micro levels. Its principal impacts are (1) to elevate the significance of the financial sector relative to the real sector; (2) transfer income from the real sector to the financial sector; and (3) contribute to increased income inequality and wage stagnation”* (Palley 2007)⁵¹

It is important to remind that the actual size of the financial sector is underestimated by the official statistics. Starting in the 80', in order to increase the profitability of the banking sector, the activities related to credit intermediation, the liquidity and maturity transformation were taken out of the regulated banking system to create the so-called shadow banking system, upon which the banking system relies for funding. Since funding in these markets is mainly short term (Repos), it is particularly susceptible to runs and lack of liquidity⁵²-i.e. financial instability-.

Figure 3: Growth in EU shadow banking assets since 2008 (Rebased: 100)



Source: See footnote 52

The spillovers of the financial sector to the real economy are significant. Firstly, and most importantly, non-functioning financial markets impair the transmission mechanism of monetary policy. The increasing and concrete risk for the real economy to be vulnerable to financial shocks, for example due to losses of the

⁵¹ Palley Thomas I., November 2007, Financialization: “What it is and Why it Matters”. Working paper series. Number 153. Gordon Hall

⁵² ECB, (2012) Shadow Banking in the Euro Area, an overview. April 2012, Occasional paper series, NO 133

banking system, may impair the credit cycle and the long-lasting spilling of debt-deflation cause prolonged recession. These macroeconomic concerns are compounded by worries about income distribution: *"the era of financialization has witnessed a disconnection of wages from productivity growth, raising serious concerns regarding wage stagnation and widening income and wealth inequality"* (Mishel et al., 2007)⁵³. Income inequality seriously damages internal demand since the loss of disposable income impairs the level of current expenditures and investments by households.

Yet CBs are affected by a dilemma. There is no consensus on which financial variables to tackle and when, leaving apart the suitability of such interventions in the markets. Should CBs increase the interest rate when returns in financial markets exceed the normal average? How to define the normal average? How is it possible to recognize bubbles ex ante? Picking the bubble or helping the rebound of confidence in the aftermath? However as Cecchetti (2000) rationally observes in a widely cited paper: *"Our response is that the difficulties associated with measuring asset price misalignments are not substantially different from those of estimating theoretical constructs such potential GDP or the equilibrium real interest rate"* ⁵⁴

CBs should be concerned with "bad" volatility, that is they should be able to recognize exogenous shocks, not related to asset fundamentals, that impacts the net worth of households and companies. This has been proved to be the most important channel through which financial shocks impact the real economy. The existence of a kind of "financial acceleration factor" has been already showed in 1999 by Bernanke et al.⁵⁵. They show how positive changes in the balance sheet of firms/households lead to a multiplier effect due to a larger collateral available in the economy for borrowers. Another source of "bad" volatility or non-motivated exuberance is financial deregulation when it isn't supported by a regulatory safety net⁵⁶.

Financial literature itself provides us with mixed results about the ability of markets to self-regulate themselves: Starting from Arrow and Debreu's (1954)⁵⁷ and (Brainard and Tobin, 1977) -q.theory-, both support the view that increased volume of trading augments liquidity and reduces the impact of small random shocks⁵⁸, while on the other side the rational expectations theory (Flood and Garber, 1980)⁵⁹, and

⁵³ Mishel, L., J. Bernstein, and S. Allegreto. 2007. *"The State of Working America 2006/2007"* Ithaca, NY: Cornell University Press.

⁵⁴ Cecchetti, Stephen, Hans Genberg, John Lipsky, and Sushil Wadhvani (2000). "Asset Prices and Central Bank Policy". Geneva Report on the World Economy 2. CEPR and ICMB. Pag 1

⁵⁵ Ben Bernanke & Mark Gertler, 1999. "Monetary policy and asset price volatility," Proceedings, Federal Reserve Bank of Kansas City, pages 77-128

⁵⁶ Bernanke, B.S., and M. Gertler, "Monetary Policy and Price Volatility," NBER Working Paper 7559, February 2000.

⁵⁷ Arrow K., Debreu G. (1954), "Existence of an equilibrium for a competitive economy". *Econometrica* - 1954- 22(3) pp 265-280

⁵⁸ Brainard W., Tobin J.(1977) "Asset Markets and the Cost of Capital", in *Economic Progress, Private Values and Public Policy: Essays in Honor of William Fellner*, Richard Nelson and Bela Balassa eds. Amsterdam, North Holland, pp. 235-62

⁵⁹ Flood R., Garber P., (1980), "Market fundamentals versus Price level Bubbles: The first tests". *Journal of Political Economy*, 1980, pp 745-770

Blanchard Watson (1983)⁶⁰, acknowledges that it is rational to participate in bubbles if there are expectations of rising prices. The only widely accepted fact is that liquidity helps fostering market efficiency. It promotes fair prices since sell and buy sides continuously meet and arbitrage opportunities are ruled out.

This argument is a hot topic, and the last CB in order of time to support asset prices with liquidity injections has been the Central bank of China, starting from July 2015. The implicit goal was to avoid the burst of bubbles. China's situation is very peculiar, with the economist pointing out already in April *"First, valuations are beginning to look stretched and, in some cases, plainly absurd. Chi Next, China's small-cap board, has a trailing price-earnings (PE) ratio of 90, more than double that of internet stocks at the peak of America's dotcom bubble in 2000. Second, leverage has soared over the course of the rally."*⁶¹

2.1 Monetary stance and assets yield

Most of the literature has focused on the correlations between the monetary stance and the performance of different asset classes. While there are mixed results between accommodative monetary policy and commodity prices/equity bubbles, almost unambiguous results show how too low interest rates for a prolonged period fuel credit booms, easy lending and consequently bubbles in the real estate markets, see Taylor et al (2012)⁶² and IMF (2012)⁶³. Instead Bordo (2012) proved that deviations from Taylor rule positively impacts also equity and commodities prices⁶⁴, while Kahn (2010) again finds positive effects on real estate prices, but for other asset classes its econometric analysis provides either wrong signs with respect to what theory should suggest, or no statistically significant effects at all⁶⁵. Moreover, prolonged period of low interest rate stimulates appetite for risk in search of higher yields in the investment universe.

Inconsistency in cause-effect between too low interest rate and booming asset prices signals that there may be a scope to study if those supposed deviations are in reality the result of missing variables not accounted for by the "classical" Taylor rule.

⁶⁰ Blanchard, Olivier and Mark Watson (1983), *"Bubbles, rational expectations and financial markets,"* National Bureau of Economic Research, NBER Working Papers 945.

⁶¹ <http://www.economist.com/blogs/freeexchange/2015/04/china-booming-stockmarket>

⁶² Taylor J., 2009, *"The financial crisis and the policy responses, an empirical analysis of what went wrong"*, Rock Center Working Paper No. 30

⁶³ Giovanni Dell'Ariccia G., Igan D., Laeven L., and Tong H., with Bas Bakker and Jérôme Vandenbussche, June 2012, *"Policies for Macroeconomic Stability: How to Deal with Credit Booms"*, IMF Staff Discussion Note

⁶⁴ Michael Bordo and John Landon Lane, 2012, *"Does Expansionary Monetary Policy Cause Asset Price Booms: Some Historical and Empirical Evidence."* Central Bank of Chile Conference "Macroeconomic and Financial Stability: Challenges for Monetary Policy" NBER.

⁶⁵ George A. Kahn, (2010) *"Taylor Rule Deviations and Financial Imbalances"*, Federal Reserve Bank of Kansas City., Economic Review.

While including exchange rate control hasn't been significant (Taylor 2001)⁶⁶, Bauducco et al. (IMF 2007) used a neo-Keynesian model enriched with a financial system to show that if a central bank incorporates also credit risk in its policy function, it allows the economy to return faster to the trend after a crash in credit markets⁶⁷. On the other side Williams (2014) suggests it could be appropriate for CBs to start targeting different price levels measures, and hypothetically a measure may also include asset prices⁶⁸. What really is missing in the literature is an updated explorative and counterfactual approach that relies on the estimation of an augmented Taylor rule to find out if CBs target other variables, even if they do not state to do so.

2.2 Augmented Taylor rule

The rationale for including asset prices/yields is their importance as forward looking variables. They can help predict future inflation and output gap, as Stock and Watson (2003)⁶⁹ show. There are only few papers that try to estimate an augmented Taylor rule. The most recent one is a minor one. Albulescu, Goyeau and Pépin (2013)⁷⁰ find out that financial instability factors account for the 54% of explained variance for ECB policy settings. However this paper does not take into account non-linear and forward looking variables (ex realized volatility vs implicit volatility). A more comprehensive study is Castro (2008)⁷¹, who also takes into account non-linearities. The author found evidence that the ECB targeted financial instability, while the FED and BoE seem to target only inflation and the output gap. Castro's methodology was to build an index to identify financial instability conditions in diverse markets and used is as a regressor. However this result goes back to the 2008, and need to be updated to incorporate all the new information about the unconventional interventions during the financial crisis. Here is where my work aims to contribute to the literature.

⁶⁶ Taylor, J. (2001). The role of the exchange rate in monetary-policy rules. *The American Economic Review*, 91(2):263-267.

⁶⁷ Bauducco S., Bulir A., Cihak M., January 2008, Taylor Rule under financial instability, IMF Working paper

⁶⁸ Williams John C., (2014), "Inflation targeting anf the global financial crisis: successes and challenges", Federal Reserve Bank Of San Francisco, Conference on fourteen years of inflation targeting in South Africa and the challenge of a changing mandate, p5

⁶⁹ Stock, J.H., Watson M.W., (2003). "Forecasting Output and Inflation: The role of Asset Prices". *Journal of Economic Literature*, 41 (September): 788-829

⁷⁰ Albulescu C., Goyeau D., Pépin D. (2013) "Financial Instability and ECB monetary policy". *Economics Bulletin*, Vol. 33 No 1, pp. 388-400

⁷¹ Castro, Vítor Manuel Alves (2008) *Are Central Banks following a linear or nonlinear (augmented) Taylor rule?* Working Paper. Coventry: University of Warwick, Department of Economics. Warwick economic research papers (No.872).

3 The ECB

Differently from the FED, the ECB has a single mandate. The Treaty on the Functioning of the European Union declares price stability as the primary objective of the Eurosystem. "Price stability shall be defined as a year-on-year increase in the Harmonized Index of Consumer Prices (HICP) for the euro area of below 2%. Price stability is to be maintained over the medium term"⁷²

The ECB follows a two-pillar framework:

1. Economic analysis : Short term focus on the real activity and the interplay between supply and demand
2. Monetary analysis: Medium term cross-check of implications of monetary policy. Recognition of the principle that inflation is in the end a monetary phenomenon.

However ECB recognized financial stability as a key factor for the transmission process of monetary policy to the economy, and has started its unconventional monetary policies in (2014) with the justification that:

*"From the viewpoint of the main prevailing risks for financial stability, a lack of ECB monetary policy action would have been detrimental not only to the maintenance of price stability, but also to the safeguarding of financial stability in the euro area. Not taking additional action could have triggered a further reduction of inflation expectations with a direct impact on real interest rates, thus leading to an unwarranted tightening of financial conditions and ultimately lower nominal growth. [...] In addition, rising asset prices improve the net worth of firms and households, enhancing borrowers' creditworthiness [...] this will support banks' essential financial intermediation function for the real economy"*⁷³

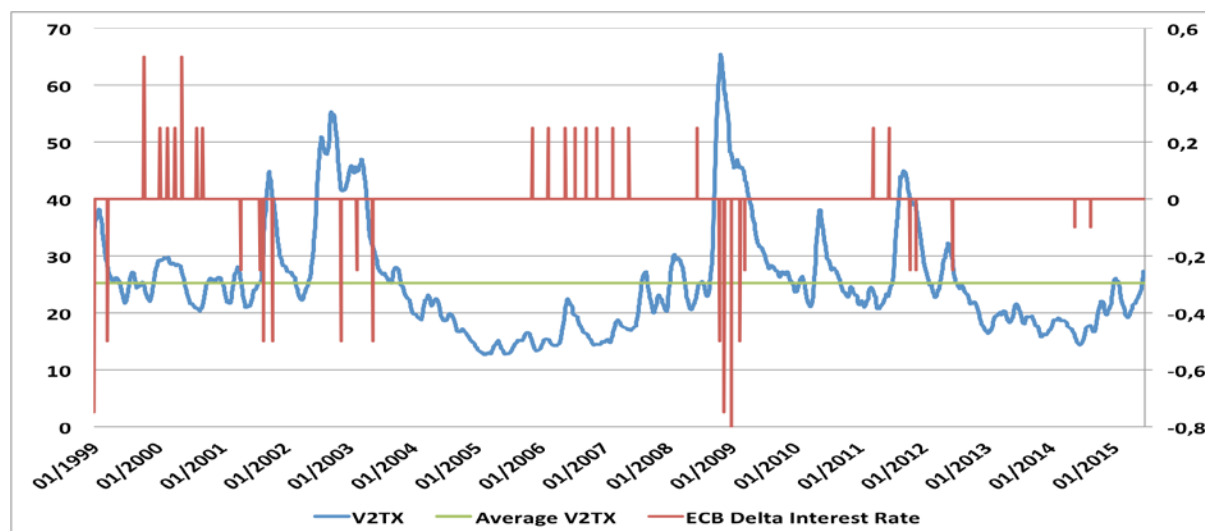
If we take a look to the following graph we see how stark volatility in European equity markets is followed by decisions of the ECB to lower the interest rate. In red (secondary axis) the delta ECB interest rate (only decisions to lower or rise the deposit facility are showed), while in blue (primary axis) we have the V2TX, that is the implied volatility of the EURO STOXX 50, an index that tracks the performance of the 50 most capitalized eurozone stocks. The V2TX is the European counterpart of the VIX, the so called "financial fear factor", and it tells us something more about market sentiments than the simple volatility. What the VIX (and the V2TX) measures is market expectation of near term volatility conveyed by stock index options, and therefore it provides us with an expectation of what market practitioners believe volatility will be. Obviously correlation does not imply causation but it is worth to

⁷² Governing Council of the ECB, 1998

⁷³ ECB, May 2015 Financial Stability Report

deepen the analysis since from the graph below we see that peaks of volatility almost always preceded decision of the ECB to lower the deposit rate and vice versa. Daily values of V2TX are a simple moving monthly average of the V2TX, to reflect the fact that CBs may show some inertia before deciding to intervene.

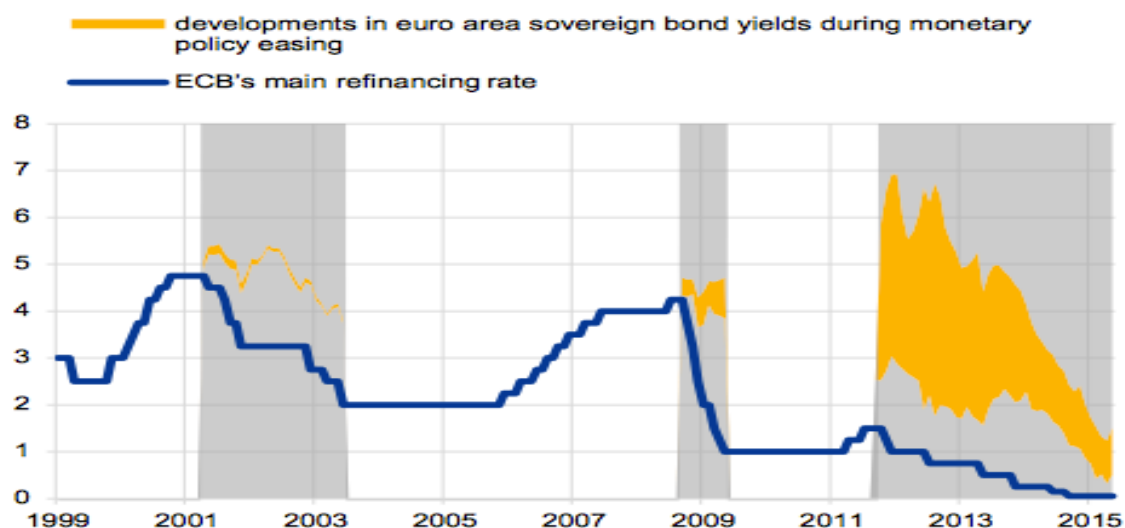
Figure 4: Implicit volatility plotted against ECB policy rate decisions



Source: V2TX: Bloomberg, ECB interest rate: ECB statistics

The correlation is quite evident, but from 2013 onwards it breaks down. The reason is to be found in the unconventional monetary policy implemented by the ECB to sustain the sovereign debt crisis, - the famous “whatever it takes”. Financial instability impacted the fixed income asset class. As we can see in Figure 3 yields spreads widened in the sovereign debt market.

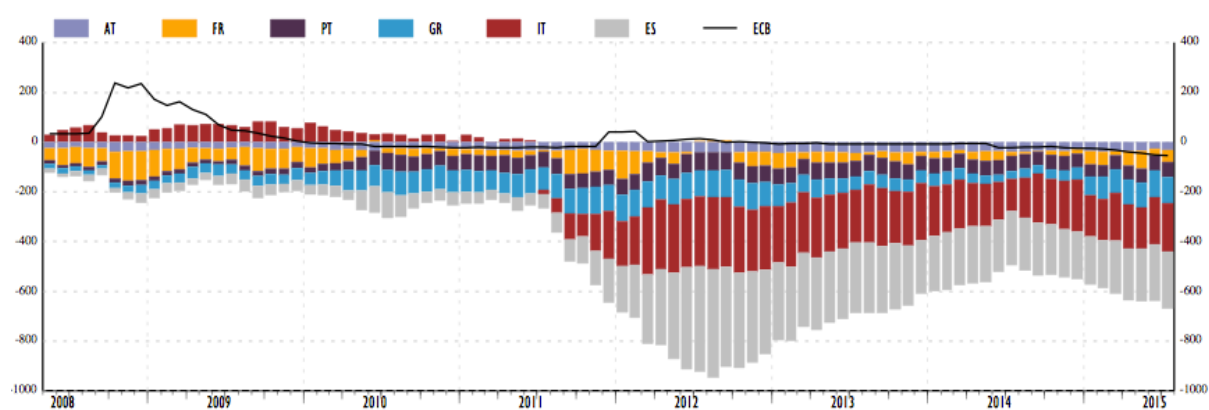
Figure 5: In yellow 25%-75% quartiles of spread of European sovereign debts



Source: See footnote 73

Other variables that the ECB strictly monitors are Target 2 imbalances⁷⁴. Target 2 is the infrastructure used in the Eurozone for the settlement of cross-border payment. The piling up of net positive Target claims in northern Europe countries and the accumulation of deficits by the other member countries prompted ECB to adopt unconventional monetary policies to help the monetary transmission mechanism to run smoothly. Since October 2008 the Euro system implemented liquidity-providing tenders with a fixed-rate, full allotment procedure to support funding needs and avoid disorderly deleveraging. The recourse to central bank funding prevented the banking sector from plummeting even further, but significant TARGET liabilities emerged for the most affected countries. The exposures widened during the sovereign debt crisis because capital movements caused large inflows to the most resilient countries.

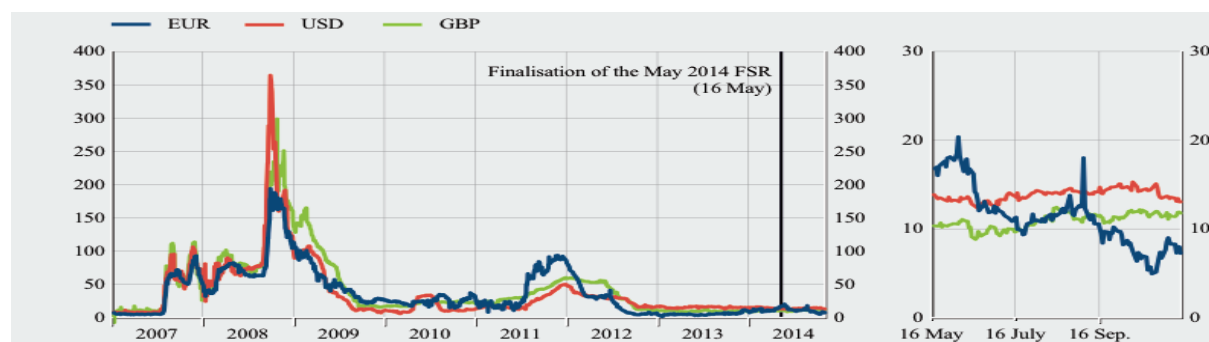
Figure 6: Target 2 balances for the so-called PIGS + France - EUR Billions



Source: See footnote 74

To conclude the following Libor-OIS spread graph shows again, that the Eurozone money markets -which are fundamental for the effective transmission of monetary policy- stopped working smoothly during the periods of financial crisis/instability⁷⁵.

Figure 7: Libor-OIS spread



Source: ECB, November 2014 Financial Stability Report

⁷⁴ ECB (March 2013), "Target balances and monetary policy interventions" – Monthly bulletin: https://www.ecb.europa.eu/pub/pdf/other/art3_mb201305en_pp103-114en.pdf

⁷⁵ Abbassi P., Linzert T, (2011), "The effectiveness of monetary policy in steering money market rates during the recent financial crisis". ECB, Working paper series No. 1328/April 2011. pp 10

4 Econometrical analysis

My analysis focuses on the Eurozone. In the next paragraph I'm going to describe the dataset.

4.1 Dataset

The reference period of my analysis is 2001Q1 – 2015Q4. The dataset is made of 60 quarterly observations for each of the 6 variables. All data series are Real-time and provided by the ECB statistical Warehouse.

- 1) MRO
- 2) HICP
- 3) Real GDP growth
- 4) Lending – Outstanding stock amounts of loans to the economy
- 5) Target balances
- 6) CISS – Composite Index Of Systemic Stress
- 7) M3 annual growth rate

1) Main Refinancing Rate (MRO)

The dependent variable is the Main Refinancing Rate. It is set monthly by the ECB⁷⁶ and it is the counterpart of the Federal Funds Rate set by the FED. It is the ECB main policy instrument. It provides the bulk of liquidity to the banking system and steers short-term interest rates by signaling the policy stance. Since the financial crisis (October 2008) the auctions are conducted on a fixed-rate full allotment basis.

2) HICP (HICP_Target)

According to the ECB's definition, Inflation is defined as year on year percentage change of the Harmonized Index of Consumer Prices published by Eurostat⁷⁷. It is published every quarter by the ECB, and it is readily available.⁷⁸ I will employ two different measures of HICP, a forward-looking one and a backward looking. The former, (forward looking) is assumed to be the mean point estimate of one-year ahead inflation (HICP). Working in a rational expectations regime, I will assume that the mean point coincides with the expected value. The choice has fallen on the 1 year ahead expected inflation (rather than the 2 or the 5 years). The reason being that the 5 years ahead inflation expectations have been firmly anchored around 2% during the whole sample size, and this idleness makes it unsuitable as a regressor. This is due to the credibility of the ECB in fulfilling its mandate, and the ECB in the monthly bulletin of July 2012 carries an analysis that confirms this fact⁷⁹. That accounts to say that markets participants believe that the ECB will be able over a 5

⁷⁶ <https://www.ecb.europa.eu/stats/monetary/rates/html/index.en.html>

⁷⁷ https://www.ecb.europa.eu/stats/prices/indic/forecast/html/table_hist_hicp.en.html

⁷⁸ https://www.ecb.europa.eu/stats/prices/indic/forecast/html/table_hist_hicp.en.html

⁷⁹ ECB, (2012). Monthly bulletin. July 2012. "Assessing the anchoring of longer-term inflation expectations"

year horizon to bring inflation back on track. The 2 years ahead inflation rate instead shows far higher standard errors in the estimation of the models than its 1 year counterpart. Another innovative measure of expected inflation is the BEIR (Break Even Inflation Rate), which is interpolated from financial data. There are different methodologies to estimate the BEIR, however there is the problem to consistently estimate the risk premia for the different asset classes (i.e. to obtain the expected inflation 5 year ahead, we could take the yield of an inflation protected instrument and subtract the yield of its non-inflation linked counterpart, but this requires to estimate also the premium required by investors to hold a riskier asset as the latter). Unfortunately the ECB does not publish its estimated BEIR, differently from the FED. This is the main reason why I did not use this forward measure in my analysis. Instead, consistently with Taylor (1993) the backward looking variable is simply the average of the last 12 months yearly inflation.

However I will not regress the simple backward and forward looking measures of HICP, but their deviations from the official ECB's target of year over year rate of inflation of 2%. As already pointed out in the literature review (Paragraph 1.1), a forward measure of inflation allows the CB to factor other variables when estimating expectations (for example asset prices). Moreover a forward looking HICP variable has another advantage compared to a backward looking one: since the monetary transmission mechanism is subject to lags, a backward looking variable may imply too much inertia. Yet a forward measure suffers of higher estimation errors.

3) Real GDP growth (GDP_Target)

Real GDP growth is defined as year on year percentage change of real GDP, based on standardized ESA definition⁸⁰. As for HICP, I will employ both a backward and a forward looking variable. The backward looking version is simply the last quarter GDP real growth rate, while the forward looking measure is again the mean point estimate of one year ahead GDP real growth⁸¹. Consistently, both are real-time available for the ECB.

I will focus on the deviation of GDP from an assumed long run target of 2%. I've have chosen the Target GDP growth rate taking steps from a Jordi Galí (2004) work⁸². Galí proposed a range of 2-2.5% for the long term equilibrium real growth rate in the Eurozone. In light of the recent slowdown in the long run growth perspectives for the Eurozone, I've chosen the lower bound. The Q2 2015 Survey of Professional forecaster run by the ECB now indicates a long run growth potential of 1.7%⁸³.

Differently from the standard Taylor rule, I'm assuming that the information (i.e. slack, long run unemployment) carried to decision makers by the Output Gap, the variable used by Taylor in its original paper, could be conveyed also by the deviations of the

⁸⁰ https://www.ecb.europa.eu/stats/prices/indic/forecast/html/table_hist_rgdp.en.html

⁸¹ https://www.ecb.europa.eu/stats/prices/indic/forecast/html/table_hist_rgdp.en.html

⁸² J. Galí, (2004), "*The monetary policy strategy of the ECB reconsidered*", Centre for economic policy research, p 11

⁸³ The ECB survey of professional forecaster , Q2 2015

https://www.ecb.europa.eu/stats/prices/indic/forecast/shared/files/reports/spfreport2015_Q2.en.pdf?da2241ab892f1c16774da6b7cbaee1e3

real GDP growth rate from its long run equilibrium. Other authors have already employed this alternative approach⁸⁴.

The main reason for using real GDP growth rate rather than the output gap is that output gap estimates suffer of high estimation errors. Moreover they are subject to subsequent revisions and are not readily available, while GDP estimates they are. Orphanides (2001)⁸⁵ gave valuable insights in stressing the importance of using real-time data instead of ex-post revised data for estimating monetary policy function. The rationale is that only the former were available at the moment when CBs choose its actions. The high estimation errors for the Output Gap are highlighted and recognized in a Monthly bulletin of the ECB where it is stated: *“Overall, while there is high uncertainty as regards the size of the output gap, a number of cyclical indicators suggest that the economic “slack” in the euro area economy may be smaller and may close faster than currently estimated by international institutions”*⁸⁶. Orphanides⁸⁷ showed that misconceptions about the size of the output gap lead to wrong monetary policy decisions in the 70's.

In the same paper Orphanides argued: *“One problem, in particular, is that, as specified, these rules incorrectly assume that the policymaker has accurate information regarding the current values of inflation and the output gap when setting the interest rate. In fact, however, both inflation and the output gap are measured with considerable noise that should be taken into account in constructing an accurate depiction of realistic policy alternatives.”*⁸⁸

4) Lending (LoansCyc)

Monthly variable. I have chosen this variable because it is a proxy for credit. On top of that it measures the health of the banking system and how much financial institutions support the real economy. The assumption underneath is that healthier financial institutions should lend more to the economy. Other interesting variables used in the literature (i.e. Non performing loans) could not be used because the ECB started to collect much of the financial data starting only from 2007 onwards, when the ESRB board (European Systemic Risk Board) was born. It is backward looking and weighted for the share of each country and bank. The official ECB's definition states *“Outstanding amounts at the end of the period (stocks), MFIs – major financial institutions - excluding ESCB reporting sector - Loans, Total maturity, All currencies”*⁸⁹. As we see in the graph below, there has been a clear upward trend in the total stock of loans to the economy. The reasons are multiple, but two important ones are the increasing role of the shadow banking system and financial innovations.

⁸⁴ ex: <https://www.clevelandfed.org/newsroom-and-events/publications/economic-commentary/2012-economic-commentaries/ec-201217-gaps-versus-growth-rates-in-the-taylor-rule.aspx>

⁸⁵ Orphanides, A. (2001), *“Monetary policy rules based on real-time data”*, The American Economic Review, Vol. 91, No. 4, pp. 964-985

⁸⁶ ECB. Monthly Bulletin. June 2011. *“Economic and monetary developments: Output, demand and the labor market”*. Box 5. A Cross- Check of Output Gap estimates

⁸⁷ Orphanides, A (2003): *“The quest for prosperity without inflation”*, Journal of Monetary Economics, no 50(3), pp 633–63.

⁸⁸ Ivi, p 11

⁸⁹ http://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=117.BSI.M.U2.N.A.A20.A.1.U2.2240.Z01.E

Conversely, a recent downward trend could have been caused by the Basel II and Basel III protocols. Since the variable is not stationary, it has to be detrended. The variable used in the regressions is the Hodrick Prescott filtered variable.

After I've detrended the series, I am left with the cyclical component. As a matter of fact, MFIs increase leverage during economic expansions and deleverage during economic slowdowns. Leveraging the balance sheet helps the supply of new loans to the real economy, and the process is further amplified and subject to lags due to the so-called financial accelerator effect (See Bernanke, Gertler 2000)⁹⁰.

Figure 8: Outstanding Loans - Stock (Billion of EURO)

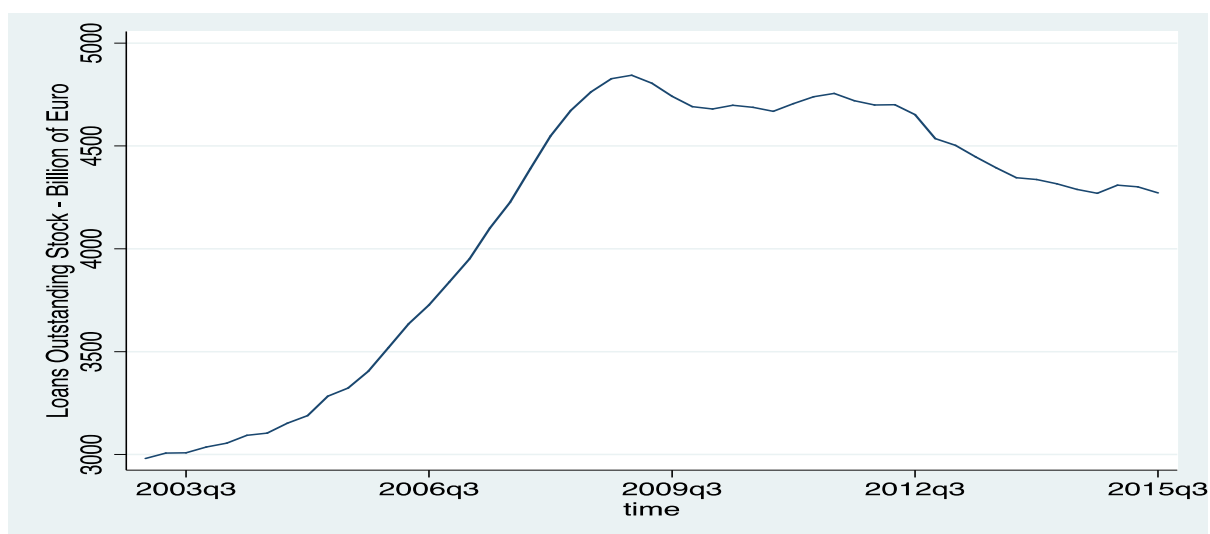
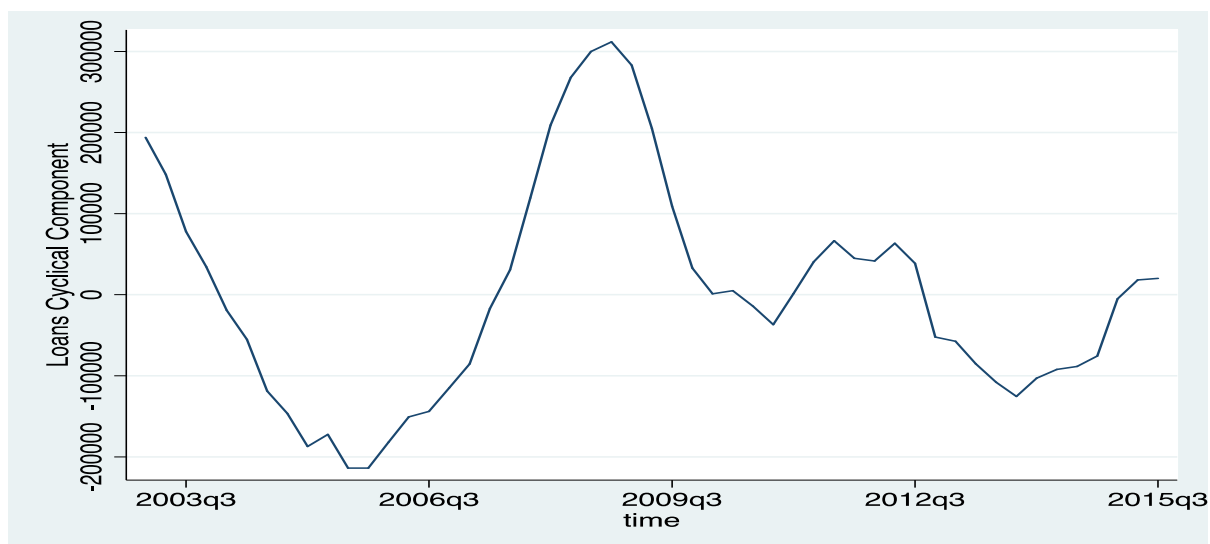


Figure 9: Outstanding Loans - Cyclical component (Million of EURO)



⁹⁰ Bernanke, B.S., and M. Gertler, "Monetary Policy and Price Volatility" NBER Working Paper 7559, February 2000.

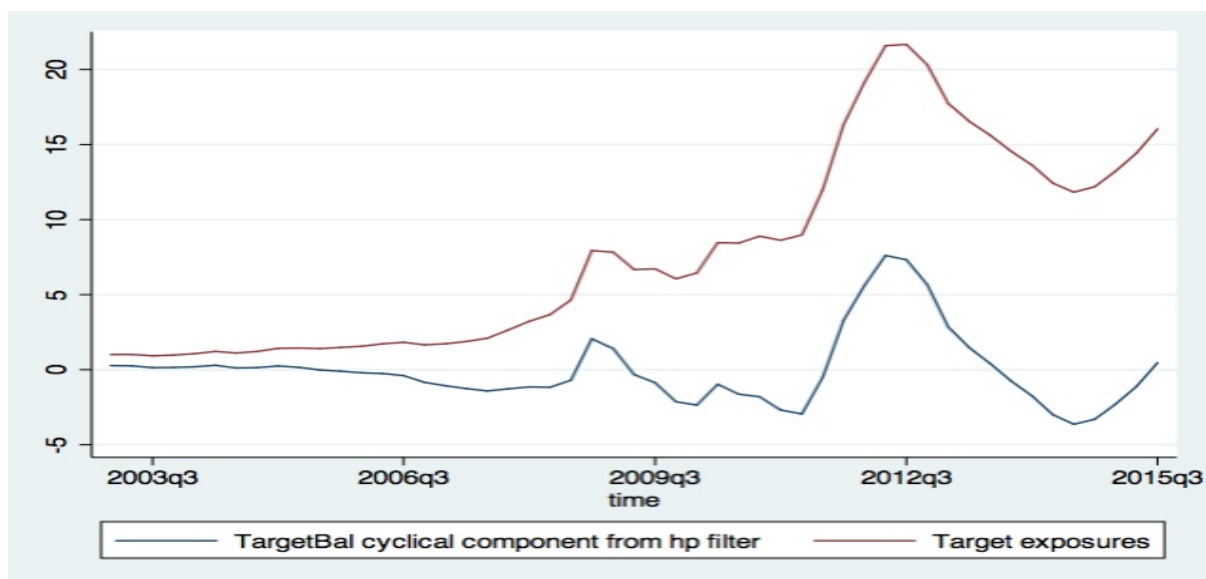
5) Target Balances (TargetCyc)

This dataset is published monthly, starting from January 2001. The Target program, and its updated version Target2 (2007 onwards), is the infrastructure used in the Eurozone for the real-time settlement of cross-border payments. By definition the sum of the exposures is zero (some member states pile up liabilities, other net claims). As already discussed at the end of chapter 3, during the crisis the gap between the so called “northern / virtuous” countries and the “southern / Mediterranean” countries (Portugal, Italy, Spain, Greece -PIGS- + France) widened dramatically due to the needs of funding of those countries during the sovereign debt crisis. While capitals moved to the safe havens (ex: short term German bonds experiencing negative yields), the imbalances kept on piling up. The ECB strictly monitors the Target balances because they are a key indicator to check whether the monetary transmission mechanism works smoothly. In an ideal, shock-free state of the world the long-term equilibrium is represented by zero exposure in the targets balance for each participant to the program.

Using the Target balances I have created a new indicator. It is built as the sum of the absolute value of the exposure of each country. This indicator aims to represent the disequilibrium in the cross-country settlement balances.

However this variable is not stationary, as it can be easily inferred from the graph below (red line). The existence of a trend could be driven by the increasing interlinkages and economic trades in the European economic area, and also because some minor countries joined the program years after its inception. The Hodrick-Prescott filter with smoothing parameter 1600 (standard for quarterly data) extracts the cyclical component, which is the variable actually regressed in my model (blue line in the graph). Caveat: in chapter 5 I will use the cyclical component of the logarithm of Target Exposures, therefore the coefficient will have to be interpreted accordingly.

Figure 10: Target imbalances (Hundreds of Billion Euro)



6) CISS (CISS)

CISS stands for Composite Indicator of Systemic Stress. It is an innovative measure of systemic stress in the financial markets. The only reference publication, that explains what CISS actually is computed, comes from Holló, Kremer and Lo Duca (2012)⁹¹. The authors explain its peculiarities: *“The main methodological innovation of the CISS is the application of basic portfolio theory to the aggregation of five market-specific subindices created from a total of 15 individual financial stress measures. The aggregation accordingly takes into account the time-varying cross-correlations between the subindices. As a result, the CISS puts relatively more weight on situations in which stress prevails in several market segments at the same time”*⁹².

This indicator comprehensively monitors systemic stress to the money, forex, equity, bond markets and financial intermediaries. This is the reason why it is a very well suited variable for being chosen as threshold.

Even though it is a relatively recent indicator, it could be easily retrospectively constructed. In fact the indicators on which it is built are widely available (ex: volatility for the equity markets, or yields spreads for the bond markets). It is almost a real-time indicator as it is computed weekly with reference to the week before, but in case of necessity it could be computed daily or disaggregated for specific countries. All these properties make it a synthetic variable to monitor for the ECB.

The authors, after having described the index, go further and test a VAR threshold model. In this model they found out that the financial instability has statistically significant negative impact on the output growth of the economy, and they find as optimal threshold the level of 0.3233⁹³, which as we will see in the next paragraph is close to the one I've estimated as threshold in my regression model.

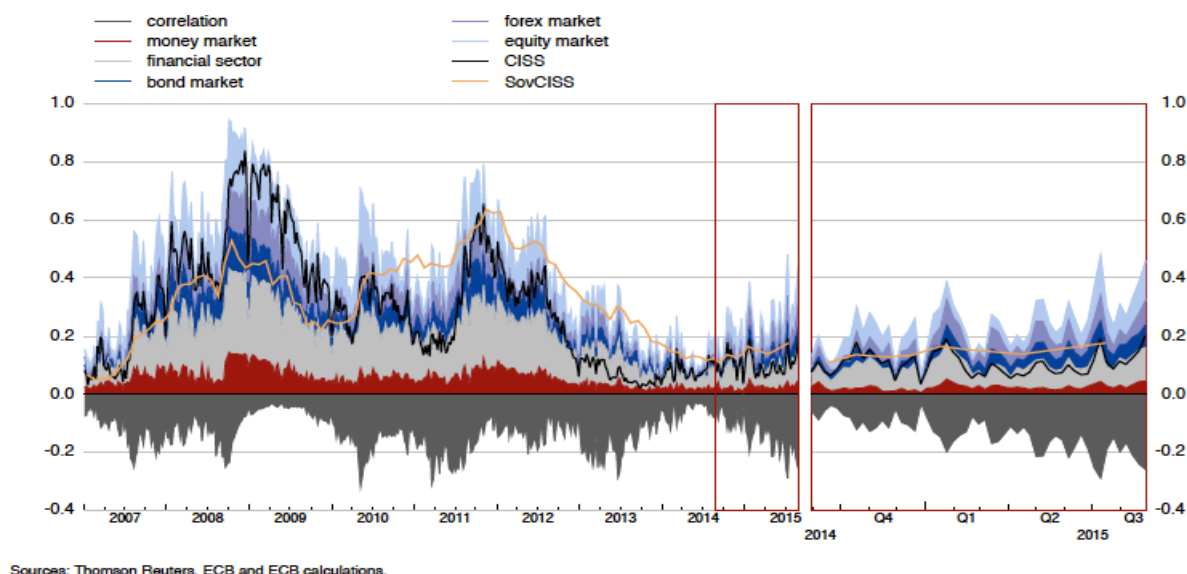
In my model I use the quarterly moving average of the indicator (i.e. last 3 months). This accounts for inertia of the ECB in reacting to shocks, but also implicitly recognizes that for the ECB to intervene, instability signals should last a minimum. In fact the first best scenario is the one where markets self-regulate without the intervention of the CB.

⁹¹ Dániel Holló, Manfred Kremer, Marco Lo Duca (2012) “CISS a composite indicator of systemic stress in the financial system”; ECB working paper series No 1426, March 2012

⁹² Ivi, p2

⁹³ Ivi, p38

Figure 11: CISS time-series. The two distinct peaks of the 2007/2008 stock market collapse and of the 2011/2012 sovereign debt crisis in the Eurozone emerge clearly.



7) M3 growth rate (targetM3_1)

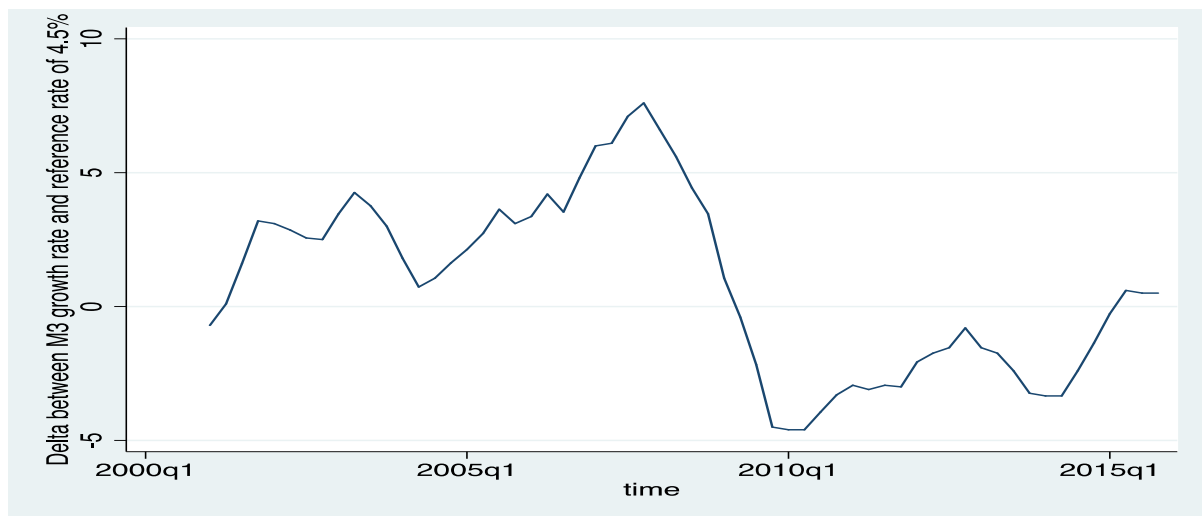
The ECB defines M3 aggregate as: “M3 comprises M2 and certain marketable instruments issued by the resident MFI sector. These marketable instruments are repurchase agreements, money market fund shares/units and debt securities with a maturity of up to and including two years (including money market paper). A high degree of liquidity and price certainty make these instruments close substitutes for deposits. As a result of their inclusion, broad money is less affected by substitution between various liquid asset categories and is more stable than narrower definitions of money”⁹⁴.

The second pillar of the ECB relies on the monetary aggregates to further analyze the risks to price stability. Monetary aggregates are instruments to cross-check the medium to long term developments in prices. The ECB initially declared a reference rate for M3 growth of 4.5% per annum⁹⁵. In the model below I use the lagged (1 month) monthly average of the quarter before the observation. The targetM3_1 variable is then obtained subtracting from the latter the 4.5% reference rate of growth. It has been chosen the 1 month lagged average because monetary aggregate are not readily available. They are subject to subsequent revisions that may take up to 1 month before the new data are published. This is consistent with the real time data approach used in my work.

⁹⁴ <https://www.ecb.europa.eu/mopo/strategy/monan/html/index.en.html>

⁹⁵ ECB Governing Council, 01/12/1998, Press release “The quantitative reference value for monetary growth”, https://www.ecb.europa.eu/press/pr/date/1998/html/pr981201_3.en.html

Figure 12: Delta between M3 realized growth rate and reference rate of 4.5%



4.2 OLS Estimates

Below, I will analyze two different versions of the Taylor rule, a backward looking one and a forward looking one. In the backward looking version, I will use the simple average of the last 12 months HICP and the quarterly year by year real GDP growth. Instead, in the forward looking version I will use the quarterly mean point estimate of one year ahead Inflation and real GDP growth.

A straightforward linear regression is estimated with the following results:

Figure 13 : Backward looking Taylor Rule (Eurozone) 2001Q1 - 2015Q4

Source	SS	df	MS	Number of obs = 60		
Model	56.3936648	2	28.1968324	F(2, 57) = 30.17		
Residual	53.2723352	57	.934602372	Prob > F = 0.0000		
Total	109.666	59	1.85874576	R-squared = 0.5142		
				Adj R-squared = 0.4972		
				Root MSE = .96675		

MRO	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
HICP_back	1.001035	.1521953	6.58	0.000	.6962687	1.3058
GDP_back	.274619	.0642596	4.27	0.000	.1459414	.4032966
_cons	2.306485	.1415713	16.29	0.000	2.022993	2.589976

Figure 14 : Forward looking Taylor Rule (Eurozone) 2001Q1 - 2015Q4

Source	SS	df	MS	Number of obs = 60		
Model	68.3426809	2	34.1713405	F(2, 57) = 47.13		
Residual	41.323319	57	.724970509	Prob > F = 0.0000		
Total	109.666	59	1.85874576	R-squared = 0.6232		
				Adj R-squared = 0.6100		
				Root MSE = .85145		

MRO	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
HICP_Target	2.822485	.3692704	7.64	0.000	2.083034	3.561936
GDP_Target	.4007663	.1276554	3.14	0.003	.1451408	.6563918
_cons	3.146126	.1674892	18.78	0.000	2.810735	3.481517

Therefore the two simple Taylor Rules would look like:

Backward Looking:

$$DepFR_t = 2.30 + 1 (HICP - 2\%) + 0.27 (GDP - 2\%)$$

Forward Looking:

$$DepFR_t = 3.14 + 2.82 E_t(HICP_{t+1} - 2\%) + 0.40 E_t(GDP_{t+1} - 2\%)$$

This time series includes also the 2001 recession, and the 2001 stock market crash (IT bubble). In the Stata outputs we observe that all coefficients, of both regressions, are significant at the 99% confidence level.

The main difference between the estimates lies in the magnitude of their inflation coefficient. Why is this a key difference? Because of the Taylor principle, which requires the coefficient of inflation and GDP to be larger respectively of 1 and 0 in order for the monetary policy rule to be stabilizing.

As already noticed by the literature⁹⁶, the backward version of the Taylor rule for the ECB fails to satisfy the Taylor principle (half confidence interval of the inflation

⁹⁶ Gerlach-Kristen, P. (2003), "Interest rate reaction function and the Taylor rule in the euro area", ECB Working Paper Series No. 258.

coefficient < 1). Conversely the forward one shows an estimated coefficient of 2.82 with the lower bound of the 95% confidence interval equal to 2.08, well above 1.

Since we have not observed self-fulfilling inflation phenomena in the Eurozone and the policy of the ECB has been so far stabilizing, it is more probable that the ECB is targeting a forward looking measure of inflation; measure that allows an higher degree of flexibility.

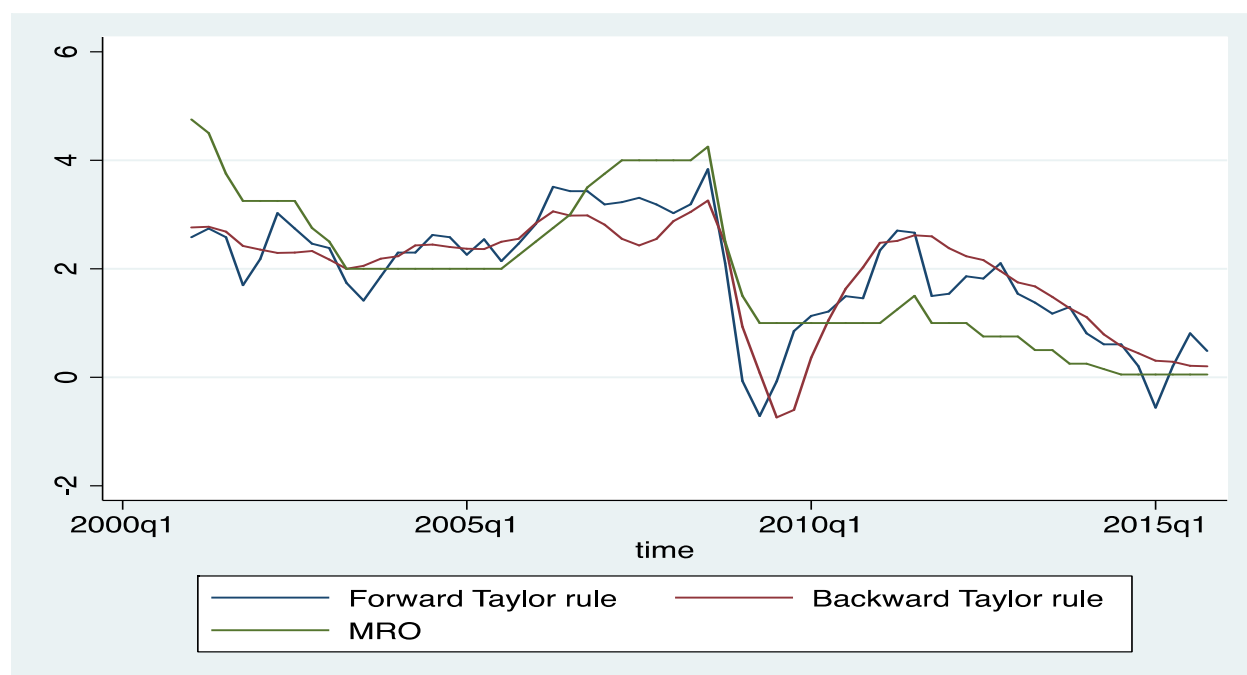
Furthermore, even though it is still quite low, the forward rule enjoys a substantively higher R^2 (61% vs. 49%).

My hypothesis is that during periods of financial instabilities the monetary policy reaction function of the ECB will be better approximated by a different regime. In the next paragraph I will introduce my model, where a Taylor rule is augmented with financial variables and will be estimated through a Threshold regression model. In such a way I will try to capture non-linearities in the ECB's behavior, and to take into account the ZLB and financial instability.

Differently from the FED, the ECB has by statute a single mandate: keeping medium term inflation at 2%. This estimate could be inconsistent with respect to what we expect due to non-linearities or it could suffer of omitted variable bias.

Omitted variable bias is a candidate because the explained variance of this regression is only 60% (adjusted R-squared). Non-linearities also are at stake, since it is widely believed that CBs reacts to shocks in a non-linear way, but react more than proportionately to larger shocks.

Figure 15 : Forward vs. Backward Taylor Rules (2001 - 2015)



5 The model

I wish to test whether the monetary policy of the ECB could be better described by a two-regime model. I speculate that financial instability factors are key for determining and signaling the two regimes. Therefore I'm going to estimate a Threshold Regression model with a systemic risk variable chosen as threshold variable for the sample splitting.

Threshold regressions are a nonlinear time series model that exhibit a regime switch. The coefficients of the model are constant in each regime, but can change between them. These are the reasons why I believe this model allows more flexibility in taking into account the peculiarities of the financial crisis than the linear regression model. The theoretical background for testing and building confidence intervals for the Threshold is provided by a well known paper by Hansen (2000)⁹⁷. Even though Threshold regression model have been widely used in applied economics, Hansen managed to derive asymptotical distributions for the estimates by inverting the likelihood ratio. Moreover the author also shared its stata codes for implementing the routine estimation and testing processes⁹⁸.

In order to work properly the model requires some assumptions to be fulfilled. The most important one is: stationary of the explanatory variables.⁹⁹ I will comply with the standard assumption that Inflation and GDP growth are stationary time series, even though some academics believe that GDP and inflation are unit root processes which need to be worked out with cointegration, see Gerlach et al (2003).¹⁰⁰ For further details see also Cochrane¹⁰¹.

The equation I'm going to estimate is the following:

$$DepFR_t = constant + \alpha(\pi_t - \pi_t^*) + \beta(y_t - y_t^*) + \gamma Credit + \delta Lending + \theta TargetBal$$

- Where **CISS** is variable used to determine the threshold.

⁹⁷ B.Hansen (2000) "Sample Splitting and Threshold Estimation". *Econometrica*, Vol. 68, No. 3 (May, 2000), pp. 575-603

⁹⁸ Freely available at: http://www.ssc.wisc.edu/~bhansen/progs/progs_threshold.html

⁹⁹ B.Hansen (2000) "Sample Splitting and Threshold Estimation." *Econometrica* Vol. 68, No. 3 (May, 2000), pp. 575-603

¹⁰⁰ Gerlach-Kristen, P. (2003), *Interest rate reaction function and the Taylor rule in the euro area*, ECB Working Paper Series No. 258.

¹⁰¹ Cochrane J., (2011) "Determinacy and Identification with Taylor Rule", *Journal of Political Economy*, Vol. 119, No. 3 (June 2011), pp. 565-615

5.1 Correlation between the independent variables

The two financial variables have been chosen to represent 2 different aspects of financial instability. The low linear correlation between them confirms this hypothesis.

Figure 16: Pearson Linear Correlation

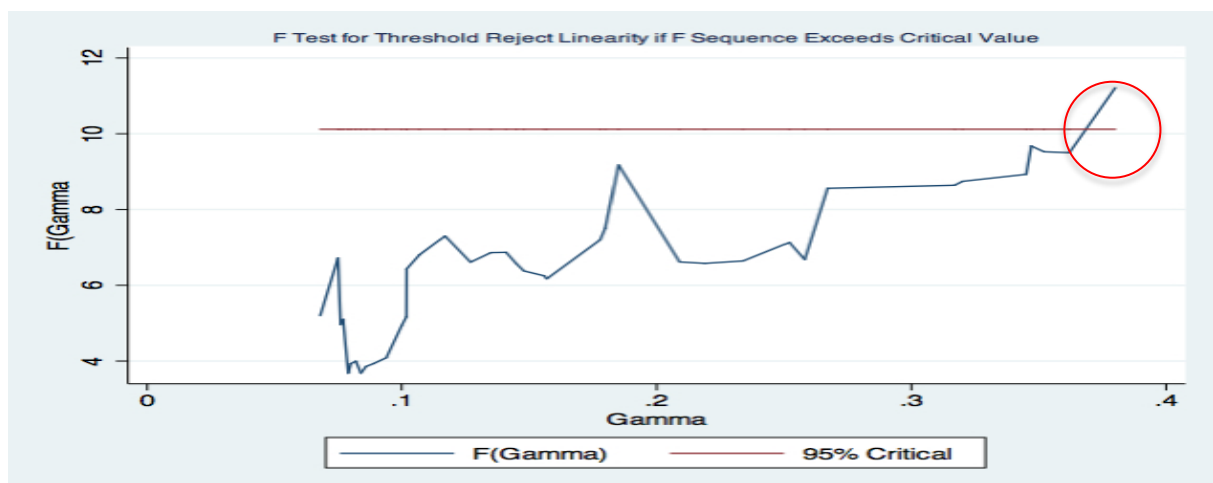
	MRO	GDP_Target	HICP_Target	targetM3_1	TargetBal	LoansCyc
MRO	1.0000					
GDP_Target	0.4868	1.0000				
HICP_Target	0.7470	0.3290	1.0000			
targetM3_1	0.7393	0.3352	0.5617	1.0000		
TargetBal	-0.1056	-0.6042	0.0826	-0.1398	1.0000	
LoansCyc	0.2623	-0.4329	0.0792	0.1189	0.4695	1.0000

5.2 Threshold regression for the Classical Taylor Rule

First of all I'm going to estimate a Threshold regression model for the classical forward looking version of the Taylor rule (therefore without financial variables as regressors), with GDP and HICP set as independent variables. The aim is to check if non-linearities exists and could be successfully accounted for by such a model. Moreover I wish to check if the results of the previous simple linear regression could be improved by a two regime model that allows different coefficients for each regime.

Before running the model I control the values of the F-test proposed by Hansen (2000)¹⁰² to check the adequacy of a threshold model. The null hypothesis is linearity.

Figure 17: The F test rejects linearity for thresholds larger than 0.37 (red circle).



¹⁰² B.Hansen (2000) "Sample Splitting and Threshold Estimation." *Econometrica*, Vol. 68, No. 3 (May, 2000), pp. 575-603

Figure 18: General results of the Threshold regression

Threshold Estimation

Threshold Estimate:	.379999995
.95 Confidence Interval:	[.379999995, .379999995]
Sum of Squared Errors	25.7538132
Residual Variance:	.476922467
Joint R-Squared:	.76516137
Heteroskedasticity Test (p-value):	.356788016

The Threshold level for determining the Regime switching is 0.38. Regime 2 is made of 9 quarterly observations that can be labeled as below:

- 2008 Q1 – 2009 Q3 : Financial markets crash and Banks failures
- 2011 Q3 – 2011 Q4 : Sovereign debt crisis

The results are interesting and quite clear. A two regime model highly improves the overall fit up to a joint R-squared value of 76.51% (from the 61%) . Both regimes enjoys from the increase of goodness of Fit of Regime. See below figure 20.

This enhancement is the result of the exclusion of the periods where the ECB needed discretion in fulfilling its policy conduct. However the results of Regime2 (Figure 21), are not what we would expect. Regime2 refers to the subsample that covers the recession, still the coefficient of the GDP variable are not significant and the coefficient of expected HICP are extremely high. Therefore the overall goodness of fit of Regime2 may be yielded only by the few degrees of freedom available. Therefore the goodness of the estimates is debatable.

Therefore my hypothesis that the ECB controlled also for some other variables, originally omitted from the Taylor rule specification, may prove to be a valuable one.

As pointed out above, the 9 quarters that made up Regime 2,(CISS larger than threshold) coincided with the toughest period of the financial crisis (2008Q1-2009Q3) and of the sovereign debt crisis (2011Q3-2011Q4). In the next paragraph I will introduce a new parameterization of the model where I will add the financial variables.

In synthesis the two regimes will look like the equations below, with the CISS variable determining the switching:

Regime 1 – Normal monetary policy conduct – CISS < 0.38

$$MRO_t = 3.26 + 2.55 (HICP - 2\%) + 1.05 (GDP - 2\%)$$

Regime 2 – Financial Instability Regime – CISS > 0.38

$$MRO_t = 2.86 + 3.36 (HICP - 2\%) - 0.17 (GDP - 2\%)$$

Figure 19: Regime 1 – Normal monetary policy conduct – CISS < 0.38

Regime1 q<=.379999995

Parameter Estimates

Independent Variables	Estimate	St Error
Intercept	3.26480395	.155659444
GDP_Target	1.05656592	.131554931
HICP_Target	2.55321238	.275227205

.95 Confidence Regions for Parameters.

Independent Variables	Lower Bound	Higher Bound
Intercept	2.95971144	3.56989646
GDP_Target	.798718252	1.31441358
HICP_Target	2.01376705	3.0926577

Observations: 51
Degrees of Freedom: 48
Sum of Squared Errors: 21.9634883
Residual Variance: .457572672
R-squared: .76157691

Figure 20: Regime 2 – Financial Instability regime – CISS > 0.38

Regime2 **q>.379999995**

Parameter Estimates

Independent Variables	Estimate	St Error
Intercept	2.86364049	.52841621
GDP_Target	-.17067367	.248605892
HICP_Target	3.3636852	.593949785

.95 Confidence Regions for Parameters.

Independent Variables	Lower Bound	Higher Bound
Intercept	1.82794472	3.89933627
GDP_Target	-.657941219	.316593879
HICP_Target	2.19954362	4.52782678

Observations:	9
Degrees of Freedom:	6
Sum of Squared Errors:	3.79032498
Residual Variance:	.63172083
R-squared:	.762692697

5.3 Threshold regression model - Augmented Taylor Rule

At this stage I add the following variables: LoansCyc and TargetBal.

First of all, I check the results of the F-test proposed by Hansen. If the latter exceeds the 95% critical value, then linearity is rejected and a threshold model is advisable.

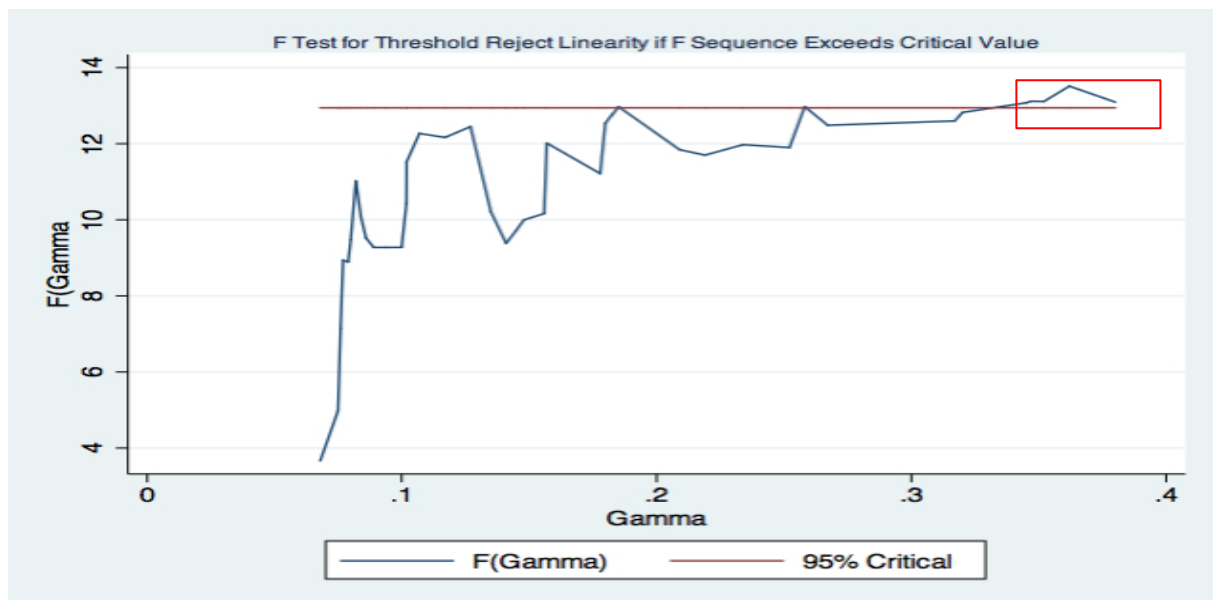
In figure 22 we see that the F sequence exceeds the critical value at the estimated new threshold level of 0.3477. This estimate is very close to the 0.3799 threshold for the simple Taylor rule, yet the subsample of Regime2 is now made up of 4 more observations.

Regime 2 is made of 12 quarterly observations that can be labeled as below:

- 2008 Q1 – 2009 Q3; 2010Q2 – 2010Q3: Financial markets crash and Banks failures
- 2011 Q3 – 2011 Q4; 2012Q2: Sovereign debt crisis

The results of the F test assure us that it is meaningful to proceed to the estimation of the 2 regimes model.

Figure 21: F test for Threshold. Linearity Rejected if F Sequence exceeds the 95% critical value (red line) – 5000 bootstrap iterations



In figure 23 (below) we see that the Threshold level of the CISS variable is unchanged from the classical specification (0.3477 of the Composite Index of systemic stress). The sample is split into two subsamples, that identify the two regimes.

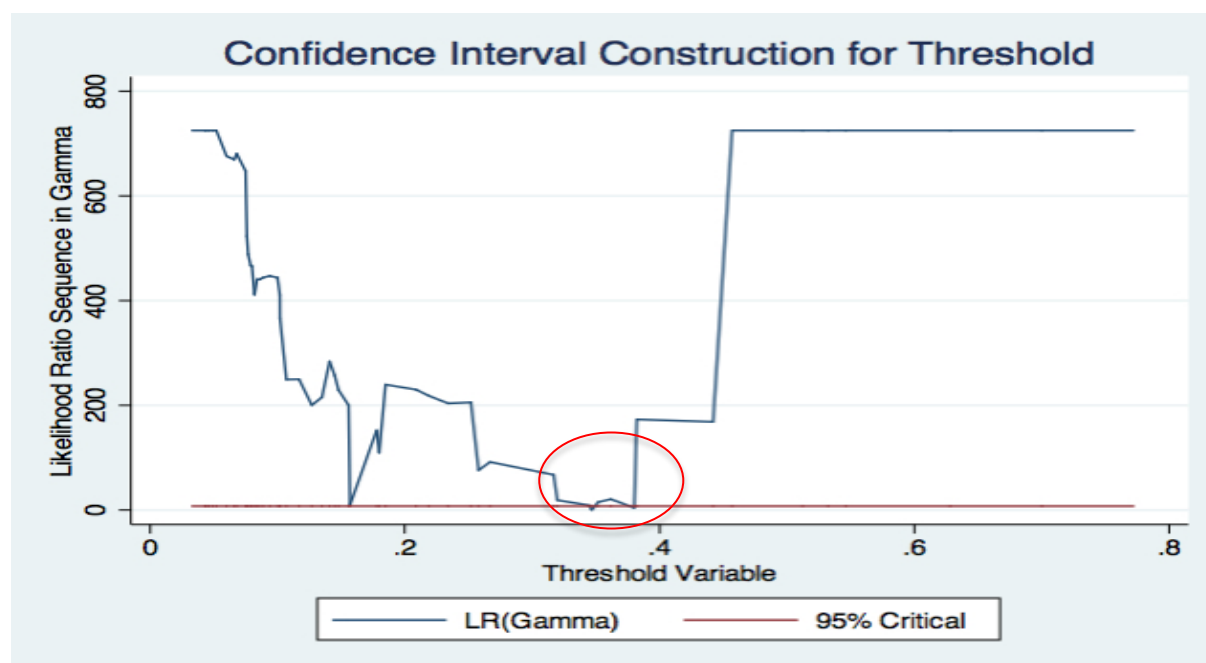
- A low instability regime, when CISS is lower or equal to 0.3477 with 48 observations
- A high instability regime with CISS larger than 0.3477 and 12 quarterly observations.

Caveat: the estimates of the Regime2 are too few for doing statistical inference, nonetheless they will provide us an indicative estimates.

Hansen's Stata codes perform the routine estimation process and provide us with 4 different tables:

1. A Threshold Estimation panel - General results of the Threshold regression
2. A baseline linear regression
3. Results for Regime 1 – Low instability
4. Results for Regime 2 – High instability

Figure 22: Confidence interval construction for Threshold



The baseline case is a simple linear regression (corrected for Heteroskedasticity). The Intercept, Inflation and GDP terms all have significant coefficients, but of the two financial variables, only TargetCyc is significant. Moreover, thanks to the 2 new

regressors, the R^2 increases strongly (from 62% to 77%) with respect to the classical version of the Taylor rule.

However, the scope of losing degrees of freedom due to their inclusion should be justified in a simple linear model that does not differentiate between low and high instability regimes.

Figure 23: General results of the Threshold regression

Threshold Estimation

Threshold Estimate:	.347000003
.95 Confidence Interval:	[.347000003, .379999995]
Sum of Squared Errors	15.9174907
Residual Variance:	.318349814
Joint R-Squared:	.854854826
Heteroskedasticity Test (p-value):	.591045511

Figure 24: Baseline linear regression

Global OLS Estimation, Without Threshold

Heteroskedasticity Correction Used

Independent Variables	Estimate	St Error
Intercept	3.18921204	.132557245
GDP_Target	.632019858	.195243591
HICP_Target	2.48732587	.321615419
TargetBal	-.739323888	.653398457
LoansCyc	4.64559168	.674893381

Observations:	60
Degrees of Freedom:	55
Sum of Squared Errors:	25.1573059
Residual Variance:	.457405561
R-squared:	.77060068
Heteroskedasticity Test (P-Value):	.591045511

5.3.1 The two regime model for the augmented Taylor rule

When we run the Threshold model, we observe a stark increase in the amount of variance explained. The overall (both regimes) R squared rises to almost 86%, up from the 62% of the simple linear model.

Most importantly we are finally able to explain the behavior of the ECB during Regime2 and to provide a specification that has a fair economic rationale.

We experience an improvement in the estimates because we are excluding the 12 observations where systemic stress is high (Regime 2). In Regime2 the behavior of the ECB has been driven by contingencies and discretion rather than a Taylor rule (If we accept the assumption that in normal times the ECB follows a feedback rule).

5.4 Regime 1

$$MRO_t = 3.45 + 2.52 E_t[HICP_Target] + 1.11 E_t[GDP_Target] + 3.73 LoansCyc + 0.31 TargetBal$$

- The GDP and HICP coefficients for Regime 1 are pretty similar to the ones found before. The Taylor principle holds. In fact the 95% confidence interval of the inflation coefficient is well above 1 and expresses the strong commitment of the ECB for anchoring inflations expectations, while the GDP coefficient is positive for the whole 95% confidence interval.
- The TargetBal variable is not significant. This should not surprise us, because in normal times the ECB strictly follows its mandate and there is no need to ease the monetary conditions to bring relief to the countries that show large imbalances in the cross-payment system of the eurozone. The latter must go back to a sustainable balance with their own capabilities (i.e. fiscal policies)
- Quite unexpectedly the positive coefficient of LoansCyc is statistically significant. However, as we will see, the absolute value of the regime 2 coefficient is twice the coefficient in regime 1 (7.21 vs. 3.73). This is consistent with the assumption that the ECB targets stronger the supply of credit to the economy during regime 2. A positive sign implies that ECB increases the Interest rates when the MFIs (major financial institutions) show a cyclically positive amount of loans supplied to the Eurozone's economy

The inclusion of both TargetCyc (not significant) and LoansCyc (significant) increases the R^2 by only 7% with respect to the Regime1 model where only HICP and GDP were used as independent variable (Paragraph 5.3).

In synthesis: the classical Taylor Rule is very effective in describing the monetary policy of the ECB for Regime1. The Threshold regression model allows slightly better fitting properties.

In the following paragraph we will see how including 2 financial variables helps explaining the behavior of ECB during Regime2.

Figure 25: Regime 1

Regime1 **q<=.347000003**

Parameter Estimates

Independent Variables	Estimate	St Error
Intercept	3.45241346	.139294162
GDP_Target	1.10747171	.187747399
HICP_Target	2.52326939	.39764531
TargetBal	.312828838	.709608075
LoansCyc	3.72713233	.847713742

.95 Confidence Regions for Parameters.

Independent Variables	Lower Bound	Higher Bound
Intercept	3.16725413	3.72543001
GDP_Target	.739486806	1.47545661
HICP_Target	1.74388458	3.30265419
TargetBal	-1.1128569	1.70366067
LoansCyc	2.014764	5.38865127

Observations:	48
Degrees of Freedom:	43
Sum of Squared Errors:	15.2681206
Residual Variance:	.355072571
R-squared:	.82998812

5.5 Regime 2

$$MRO_t = 2.07 + 1.43 E_t[HICP_{Target}] + 0.35 E_t[GDP_{Target}] + 7.21 LoansCyc - 1.90 TargetBal$$

But what happens when Systemic Risk bites? When the CISS indicator exceeds the threshold level, we have completely different coefficients. See below Figure 24 for the Stata output.

- **Constant:** The estimate of 2.07 is lower than the one of regime 1 because it reflects the fact that the observations of the Regime2 mostly refer to periods where the real rate fell to zero.
- **Inflation:** The most shocking result is the inflation coefficient. The 95% Confidence interval crosses 1, and almost touches 0 -> [0.028 – 2.25]. This implies that the Taylor principle does not hold in the whole CI. The theory tells us that the CB may not be able to control inflationary pressures. The high standard errors for this variable in Regime2 express the difficulty of the model to fit the ECB's behavior (Caveat: limited statistical validity with just 12 observations and 7 degrees of freedom). This could be motivated by the fact that while the ECB goal is to anchor inflation expectations in the medium term, it could leave short-term inflation to fluctuate if the shocks are deemed temporarily.

Therefore during the last financial crisis, the ECB may have lowered the interest rate to help fostering financial markets even though inflation was not falling yet. I conjecture that the ECB knew that expected inflation was still under control. After a while, when also inflation fell abruptly near zero, the ECB kept the MRO at the ZLB or just above because there was the concrete risk of deflation and it was trying to stimulate inflation expectations to recover. The ECB would not increase the interest rates at least until the Inflation expectations rise well above 0.

This interpretation finds support in the words of a member of the ECB board, Benoît Cœuré, who held a public speech hosted by the University of Orleans: *"if expectations are firmly anchored by the central bank's objective, short-term 'innovations' in policy conduct will not induce market participants to fundamentally re-assess their anticipations of where the economy will stabilize in the medium term, when all the current shocks have dissipated. This is particularly relevant in crises when the central bank is prompted to expand its toolbox so as to confront exceptional circumstances [...] To summarize, for a central bank to be able to confront short-run challenges while anchoring long-run expectations, it must stick to three principles. First, it has to consistently and unambiguously align any policy action with a clearly specified objective. Second, it has to adjust its policy conduct flexibly to the specific nature of the macroeconomic shocks hitting the economy. And third, in doing so it*

has to design its policy conduct in a way that does not bind its hands and thus possibly jeopardize its medium-term policy objective.”¹⁰³

The following table presents actual and expected inflation and allows a comparison with the MRO.

Quarter	CISS	Inflation (Actual)	Inflation (Expected)	MRO
2008 Q1	0.532	2%	2%	4%
2008 Q2	0.46	2.5%	2.1%	4%
2008 Q3	0.51	3%	2.4%	4.25%
2008 Q4	0.70	3.6%	1.9%	2.5%
2009 Q1	0.77	3.4%	1.4%	1.5%
2009 Q2	0.63	0.9%	1.2%	1%
2009 Q3	0.383	0.5%	1.2%	1%

- **GDP:** With respect to Regime1 the coefficient of real GDP falls a lot, but still it they show a small standard error and the 95% CI is above 0. However, since the linear correlation with the Target balance variable is quite high (-0.60), the identification of the coefficient may have been impaired by the latter.

We know from the data that during Regime 2, GDP growth rate fell well below the target and the larger magnitude of its coefficient could have been caused by the ZLB.

ZLB influence

Larger coefficients in regime 2 may be justified also by the binding ZLB. In fact *“the theoretical literature on optimal monetary policy argues that if the ZLB may bind in the future, then interest rates should be cut faster and more aggressively than suggested by macroeconomic conditions”¹⁰⁴.*

Financial Variables

Let's analyze the coefficients of the financial instability variables. They are all statistically different from zero and positive.

- Target Balances: Its negative coefficient is what I was expecting. Higher exposures/imbbalances across the eurozone push the ECB to lower the interest rates to ease the economic conditions and assure a smooth transmission of its

¹⁰³ Benoît Cœuré, Member of the Executive Board of the ECB at the Journées de l'AFSE 2013 “La crise de l'Union Economique et Monétaire (UEM): Enjeux théoriques et perspectives de politique économique”; Université d'Orléans, 17 May 2013

¹⁰⁴ Reifschneider, D. and Williams, J. (2000) “Three Lessons for Monetary Policy in a Low-Inflation Era”, Journal of Money, Credit and Banking 32:4, 936-966.

monetary stimulus. Further, the Eurozone is not yet an optimal currency area, therefore the ECB works to assure convergence within the member states. Too much divergent balances in its cross-country payments settlement system could not endure for long. Evidence of this is found in a monthly bulletin of the ECB.¹⁰⁵ A negative sign implies that ECB lowers the Interest rates when imbalances pile up in the Target program.

- Outstanding loans: A positive significant coefficient is consistent with sound economic principles. The economic rationale is simple: when the cyclical component is positive it means that the banking sector is fulfilling a credit expansion, and therefore the CB should increase interest rates to avoid an overheating of the Economy. A stronger reaction of the ECB to negative credit supply rates, due to the collapse of real GDP growth in the Eurozone may also signal nonlinearities in the CB's intervention policies.

Figure 26: Regime 2

Regime2 **q>.347000003**

Parameter Estimates

Independent Variables	Estimate	St Error
Intercept	2.07148801	.210973109
GDP_Target	.345469627	.142185265
HICP_Target	1.43384779	.41670717
TargetBal	-1.90463961	.413078643
LoansCyc	7.20527593	1.35013959

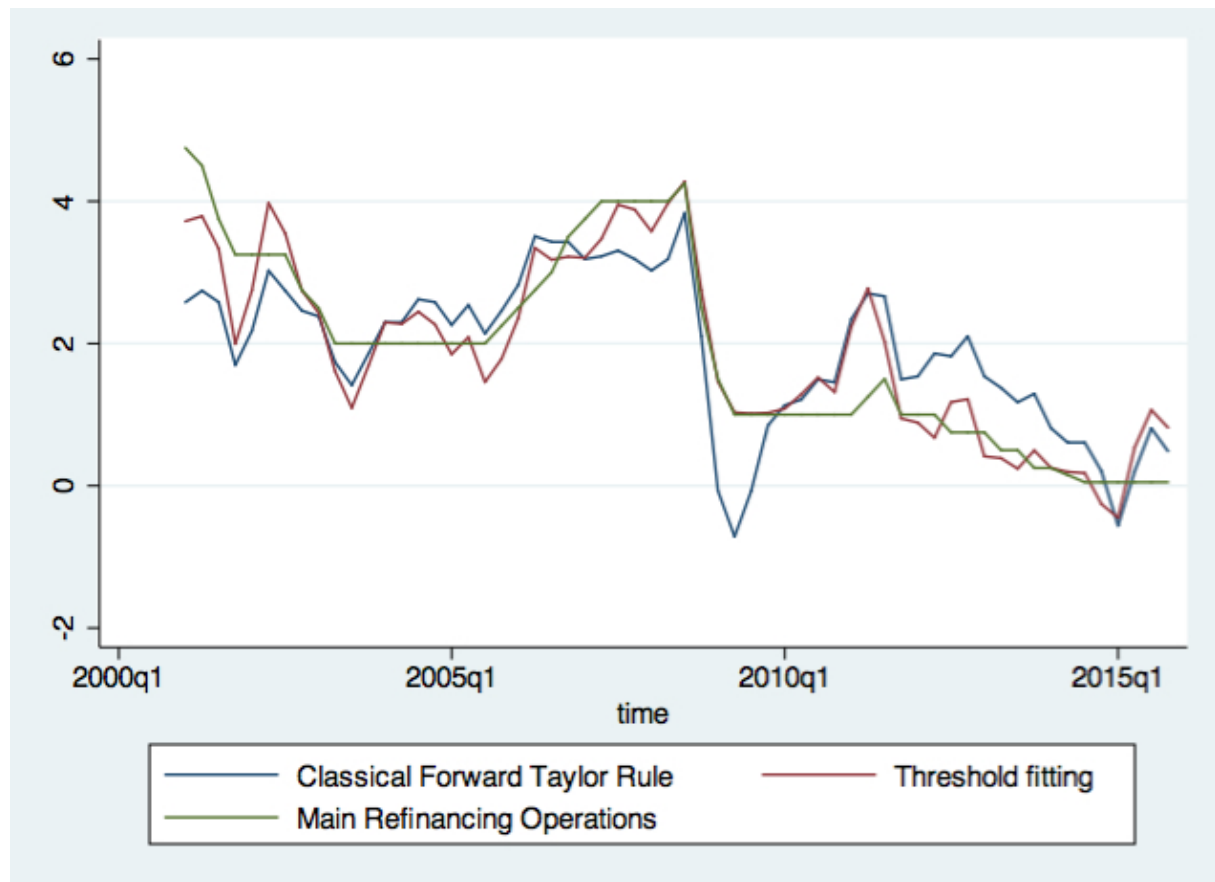
.95 Confidence Regions for Parameters.

Independent Variables	Lower Bound	Higher Bound
Intercept	1.28360508	2.4849953
GDP_Target	.066786508	.77521131
HICP_Target	.028998416	2.25059385
TargetBal	-3.22297602	-1.09500547
LoansCyc	4.55900232	12.2784202

Observations: **12**
Degrees of Freedom: **7**
Sum of Squared Errors: **.649370112**
Residual Variance: **.092767159**
R-squared: **.967215603**

¹⁰⁵ ECB (March 2013), "*Target balances and monetary policy interventions*" – Monthly bulletin: https://www.ecb.europa.eu/pub/pdf/other/art3_mb201305en_pp103-114en.pdf

Figure 27: Fitted values vs. Main Refinancing Operations Rate



In the graph above I have plotted the fitted values of the “classical” forward looking Taylor rule and the one of the Threshold regression (red line). It can be easily noticed the better fit of the latter. Moreover, while the “classical” Taylor crosses the ZLB in 2009, the Threshold model follows more strictly the actual behavior of the ECB and is successful in not crossing the ZLB.

Final Remarks:

1. The reader should remember that these specifications of the Taylor rule miss a welfare analysis, and therefore it is just a mere description of the behavior of the ECB. Therefore we cannot judge whether this rule was optimal given the states of the world and the challenges the ECB went through. Moreover also the estimates of the Regime2 coefficients lack statistical validity due to limited number of observations.
2. There is no smoothing parameter for the MRO. The reasons are three. The first and most important one is that Regime2 has too few observations and therefore there are too few degrees of freedom (3) to estimate another parameter. The second is that I wanted to use the non-standard distribution provided by Hansen (2000) for the confidence interval estimation of the

coefficients, however this model does not support GMM so far. The last one is that the estimate of an interest rate smoothing parameter is a minor missing because : A) The observations are quarterly and the ECB decides its policy stance monthly, therefore much of the smoothing is lost B) during high instability events like the last two financial crisis, the CBs reacts strongly and with less inertia, because the systemic shocks caused by financial instability are much faster than the reaction of the real economy and therefore CBs needed to adapt to the fast changing conditions without lag.

5.6 Robustness checks

5.6.1 Threshold robustness

The threshold estimate is robust to different CISS specifications. In the appendix I've tested two more specifications, CISS3m, that is the quarterly moving average of the CISS, and CISS2w, the moving average of the last two weeks. Moreover a threshold value of 0.3477 is very close to the one (0.32) found by Hollò, Kremer, Lo Duca (2012)¹⁰⁶. Their value came out to be the threshold level of CISS that causes GDP contractions. This is a further confirmation of the robustness of the threshold estimate.

5.6.2 Model specification robustness

The ECB states that its monetary policy strategy¹⁰⁷ is made of a price stability goal, supported by 2 further pillars. They are the so-called economic and monetary pillars, and both work as a cross-check for long term inflation dynamics. The monetary pillar focuses on the monetary aggregates (According the famous Friedman quote: *"inflation is always and everywhere a monetary phenomenon in the sense that it is and can be produced only by a more rapid increase in the quantity of money than in output"*¹⁰⁸).

At its inception the ECB indicated a 4,5%¹⁰⁹ reference annual growth rate for the M3 monetary aggregate. Now, as some monetarists papers suggest, this pillar seems to have lost importance. For example Orphanides (2015)¹¹⁰ suggests that the deflation in the eurozone may have been caused by the ECB letting the M3 growth rate fall

¹⁰⁶ Dániel Holló, Manfred Kremer, Marco Lo Duca (2012) *"CISS a composite indicator of systemic stress in the financial system"*; ECB working paper series No 1426, March 2012

¹⁰⁷ <https://www.ecb.europa.eu/mopo/strategy/html/index.en.html>

¹⁰⁸ Friedman, M. (1970) *"The counter-revolution in monetary theory"*, Occasional paper 33, The institute of economic affairs for Wincott foundation, London Tonbridge.

¹⁰⁹ ECB Governing Council, 01/12/1998, Press release *"The quantitative reference value for monetary growth"*, https://www.ecb.europa.eu/press/pr/date/1998/html/pr981201_3.en.html

¹¹⁰ Orphanides, A., (2015), *"European Headwind: ECB Policy and Fed Normalization"*, MIT Sloan School Working Paper 5119-14

consistently below the reference rate of 4.5% during the 2008-2014 period. As a matter of fact, only in 2015 the M3 growth rate started to pick up again.

However not all the monetary expansion translates into the real economy. This fact is key to understand the Eurozone prolonged recession. Much of the monetary expansion translated into idle liquidity in the banks' balance sheets. It has been pointed out that this is a major difference between the FED and the ECB. The FED was able to channel the monetary stimulus out of the balance sheets of the banking institutions thanks to its QE policies (ex: the asset purchase program). The QE policies have been introduced much later in the Eurozone.

For all these reasons above, I will run a control threshold model that includes also the monetary aggregates as instruments.

5.6.3 Taylor rule with monetary aggregates

The results indicate that including monetary aggregates is generally meaningful. However the inclusion causes some issues. First of all:

1. The likelihood ratio sequence changes and the threshold now takes the lower value of 0.18.
2. The 2 financial variables (TargetBal and LoansCyc) impair the estimates of the likelihood and of the monetary aggregates coefficients.
3. The results are virtually unchanged using M3 or M2 annual growth rate (same threshold and similar coefficients). M1 provides us with a regime switch equal to the one of the paragraphs above (threshold = 0.3799), but it performs very poorly in terms of goodness of fit [overall $R^2 = 53\%$ (Threshold model), 32% (Linear model)].

The lower threshold of 0.18 it's robust (isolated maximum in the likelihood). Furthermore it provides us with a characterization of the regimes very similar to the ones in the previous paragraphs. The difference is simply that also periods of medium financial instability are included in the subsample of regime 2 (Financial instability). Regime 2 now includes 23 observations, and remarkably also the 2001 recession is now included.

Now Regime 2 includes:

- 2001 Recession (2001 Q3/Q4)
- Financial crisis (2007 Q3 – 2010 Q4)
- Sovereign debt crisis (2011 Q2 – 2012 Q3)

The F-test rejects linearity and the threshold model is performed.

The results for Regime 1 are similar to the ones of paragraph 5.2.

The coefficients for GDP and HICP are respectively larger than 0 and 1 for all the 95% confidence interval. However the coefficient for the M3 growth rate are not statistically significant. The story changes completely in regime 2:

The coefficient for GDP is positive for the 90% confidence interval

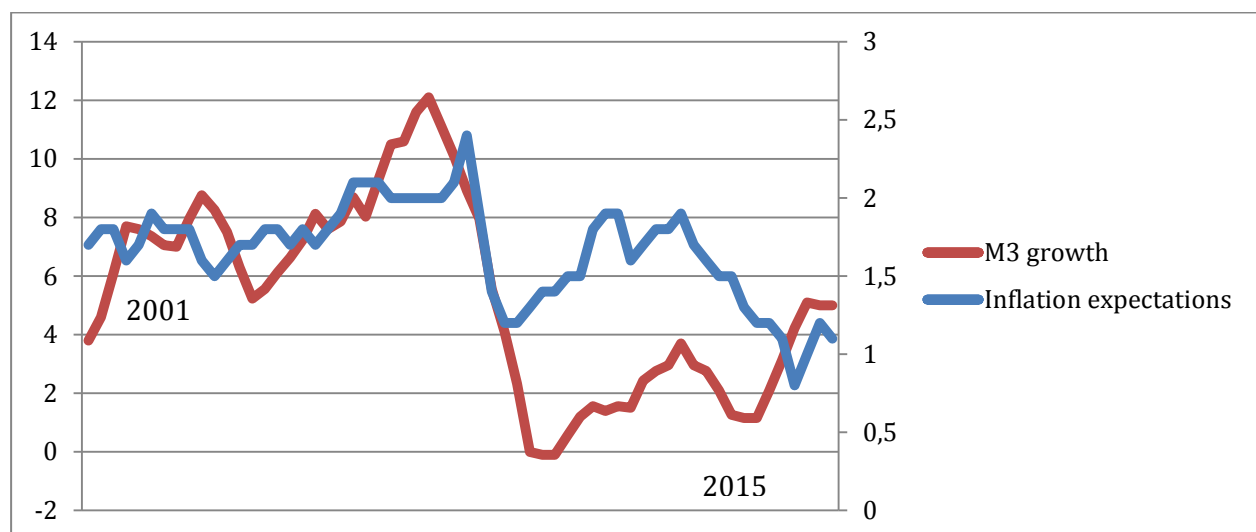
M3 growth is positive and highly significant (very small standard error, the whole 99% confidence interval is positive)

However HICP it's not significative at all. This result may be puzzling, however it is probably forced by three determinants. Firstly, it has a very high correlation with M3 growth (0.55 in the whole sample). Secondly, the subsample observations are still few. Lastly, as observed in paragraph 5.5, the ECB did not always worried about targeting Inflation during the financial crisis since the it fell towards zero and it was very far away from the 2% target (and MRO rates could not fell anymore).

I've made a last trial to disentangle the puzzle. I tried to exclude HICP from the model interestingly the estimated threshold is the same (0.18). Regime 1 results are similar , while the Regime 2 coefficients change. The GDP and M3 growth now are both significant and show an impressive stability, with smaller standard errors [estimates: respectively 0.37 vs 0.39 and 0.263 vs 0.274]. The overall goodness of fit is unchanged, suggesting that the inclusion of HICP has not predictive power in the second regime.

Another reasoning holds for Regime 1, where the goodness of fit plummets by 20%, indicating that in normal times the HICP variable is essential in the conduct of monetary policy by the ECB.

Figure 28: Decoupling of Inflation expectations and M3 growth rate after the crisis.



Concluding, the results show that the ECB does not systematically control for the growth rate of monetary aggregates. However the ECB seems to control for M3 growth during the financial instability regime.

From figure 29 above we see that inflation expectations and M3 growth correlation broke up during the crisis (2008-2014), with M3 falling abruptly towards zero. Different hypothesis may explain this behavior. For example the fact that inflation expectations are anchored and are more inertial in falling, while M3 aggregates miss this expectation anchor because the ECB did not target such variable in the past.

Whether it is a lucky correlation between two independent variables, or whether the ECB truly switched to control monetary aggregates is debatable. Further research, possibly with higher frequency data (i.e. at least monthly) is needed.

Figure 29: F-test and confidence interval for the existence of a Threshold

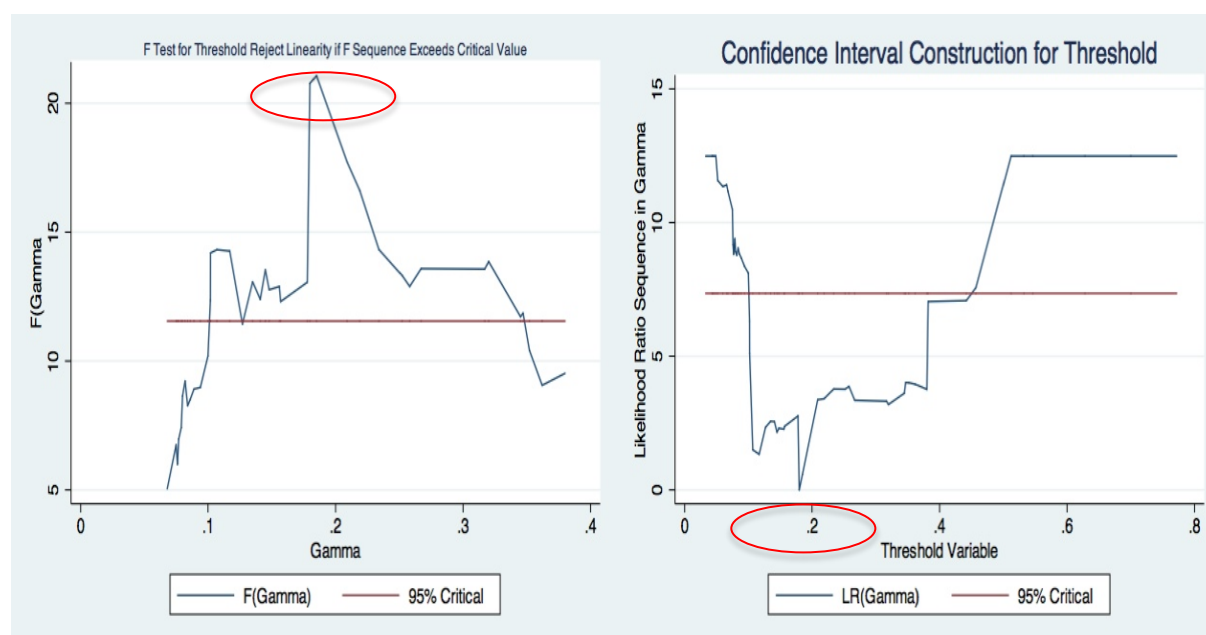


Figure 30: Threshold general results

Threshold Estimation

Threshold Estimate:	.180000007
.95 Confidence Interval:	[.101899996, .442000002]
Sum of Squared Errors	16.7381124
Residual Variance:	.321886777
Joint R-Squared:	.847371907
Heteroskedasticity Test (p-value):	.262465704

Figure 31 : Regime ½ results

Regime1 $q \leq .180000007$

Parameter Estimates

Independent Variables	Estimate	St Error
Intercept	2.96129954	.363486551
GDP_Target	1.00285052	.311097518
HICP_Target	2.22616005	.386119876
targetM3_1	.070516673	.072597408
.95 Confidence Regions for Parameters.		
Independent Variables	Lower Bound	Higher Bound
Intercept	2.14149511	3.99402789
GDP_Target	.236737068	1.79007633
HICP_Target	1.33236336	3.2556571
targetM3_1	-.179442368	.250800333
Observations:	37	
Degrees of Freedom:	33	
Sum of Squared Errors:	13.6170626	
Residual Variance:	.412638262	
R-squared:	.801718106	

Regime2 $q > .180000007$

Parameter Estimates

Independent Variables	Estimate	St Error
Intercept	2.48171684	.150101498
GDP_Target	.367146377	.083123186
HICP_Target	.25974257	.481922911
targetM3_1	.2634087	.023113763
.95 Confidence Regions for Parameters.		
Independent Variables	Lower Bound	Higher Bound
Intercept	2.13888915	2.86960479
GDP_Target	-.030811027	.547418628
HICP_Target	-.684826336	2.70011292
targetM3_1	.155726959	.308711676
Observations:	23	
Degrees of Freedom:	19	
Sum of Squared Errors:	3.12104976	
Residual Variance:	.164265777	
R-squared:	.921878227	

6 Analysis of the Riksbank

6.1 The Riksbank

The Riksbank is the central bank of Sweden. Similar to the ECB it follows a flexible inflation targeting approach. It targets a 2% annual inflation rate (CPI - Consumer Price Index).¹¹¹ Whenever inflation is under control, the Riksbank acts to minimize unemployment and maximizing output – without prejudice to inflationary expectations -. In the Riksbank website it is clearly pointed out that *“The fact that the Riksbank tries to stabilise both inflation and the real economy does not mean that it disregards the fact that the inflation target takes precedence”*¹¹²

When analyzing the monetary policy of the Riksbank, we should always remember that Sweden is a particular economy, because it is a *“small very open economy [...] With a special and oligopolistic financial sector”*¹¹³. This is the reason why I've decided to test a model specification where I will control also for the exchange rate between the Swedish Krona and the EURO. In fact, due to historical reasons, and because Sweden belongs to the European common market, there are strong interlinkages with the Eurozone and the ECB policies.

6.1.2 Criticisms to Riksbank's policy – Sadomonetarism

Sweden is a very interesting case studio because it was considered as one of the best performing countries in recovering out of the crisis.

This was true until 2010. Starting from July 2010 on, it abandoned low rates and started increasing the REPO rate from 0.25% to 2%. This decision was justified by the fact that the household debt ratio was increasing way too fast, and the economy needed to be slowed down. This to avoid the fueling of further internal factors of risk. The decision was controversial and subject to both internal (Riksbank's Governor Lars Svensson leaved) and external critiques. Paul Krugman, used the “sadomonetarism” word to define the policy of the Riksbank. In an article of the New York Times he punctualized *“At least as I define it, sadomonetarism is an attitude, common among monetary officials and commentators, that involves a visceral dislike*

¹¹¹ <http://www.riksbank.se/en/Monetary-policy/Forecasts-and-interest-rate-decisions/What-factors-influence-an-interest-rate-decision/>

¹¹² Ivi

¹¹³ Svensonn, L., (2013) ,*“Some Lessons from Six Years of Practical Inflation Targeting”*, Sveriges Riksbank Economic Review 2013:3, p3

for low interest rates and easy money, even when unemployment is high and inflation is low” ¹¹⁴

Ex post these critiques look correct. In December 2011 the Riksbank had to admit that:

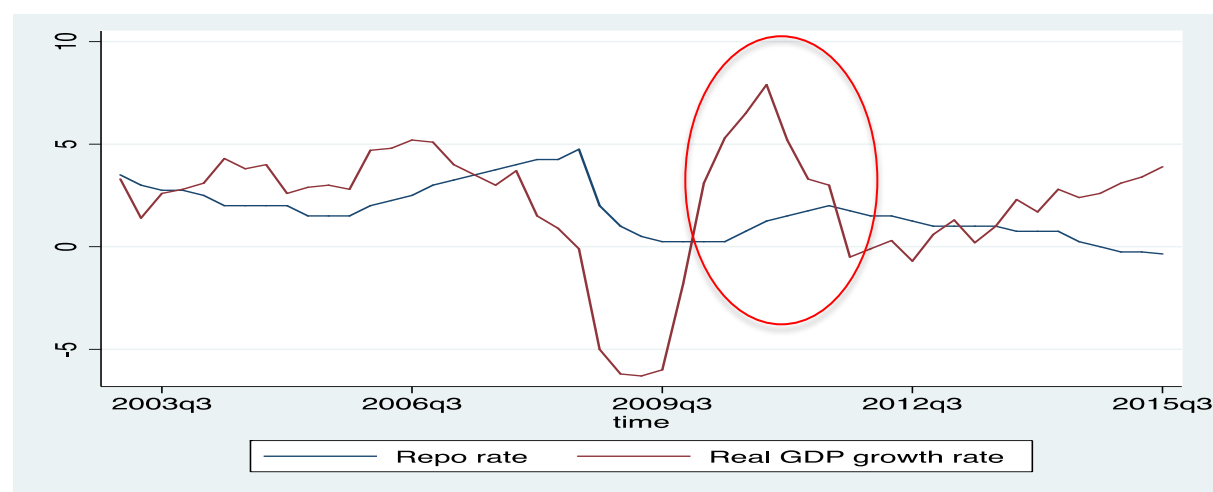
“Growth in the Swedish economy has been strong so far this year, but there are clear signs that it is now slowing down. [...] Poorer economic prospects also lead to a weaker labor market. During 2012, unemployment is expected to rise somewhat. Underlying inflation is currently low and the weak domestic demand, together with poorer global prospects, will contribute to inflationary pressures remaining low for some time.” ¹¹⁵

Moreover the economic conditions kept on worsening. Today the CB has to implement expansionary policies (negative repo rate + QE) to avoid that Sweden falls into deflation and unemployment keeps rising:

*“To safeguard the resilience of the upturn in inflation, monetary policy needs to remain very expansionary.[...] Purchases of government bonds will continue for the first six months of 2016 as was decided in October. The Board is also highly prepared to make monetary policy even more expansionary.”*¹¹⁶

In the graph below we can appreciate the drop in GDP after the Riksbank started increasing its Repo rate in 2010. (Red circle)

Figure 32: Repo rate vs Real GDP growth in Sweden



¹¹⁴ http://www.nytimes.com/2014/04/21/opinion/krugman-sweden-turns-japanese.html?hp&rref=opinion&_r=1

¹¹⁵ Riksbank, Monetary policy update – December 2011

http://www.riksbank.se/Upload/Rapporter/2011/PPU_dec/mpu_dec_2011.pdf

¹¹⁶ http://www.riksbank.se/Documents/Pressmeddelanden/2015/prm_151215_eng.pdf

6.2 Dataset

The dataset covers the period 2003Q1 – 2015Q3. 51 quarterly observations.

- 1) Repo rate
- 2) 1 year ahead expected CPI
- 3) Real GDP growth (backward)
- 4) Lending – Outstanding stock amounts of loans to the economy
- 5) CISS – Composite Index Of Systemic Stress
- 6) M3 annual growth rate
- 7) SEK/EURO exchange rate (control variable)

All the variables above have been chosen to replicate the ones used for the analysis of the ECB. The only difference lies in the GDP variable, which is backward because the official data for the forward measure are not available for the whole sample. The Repo rate and the M3 annual growth rate can be downloaded from the website of the Riksbank, while expected CPI is provided by Prospera¹¹⁷, who is a company commissioned by the Riksbank to map expectations. The other variables are provided by the ECB statistical warehouse.

1) Repo rate (REPOrate)

It is the main policy instrument of the Riksbank. Counterpart of the MRO rate for the ECB.

2) 1 year ahead expected CPI (Target_CPI_swe)

The Riksbank explicitly states that it targets expected inflation. The variable effectively used in the threshold regression model below is the deviation from the assumed target rate of 2% of the CB. Remarkably, the expectations maps also exchange rate expected movements, which are particularly important in a small open economy like Sweden.

3) Real GDP growth – backward looking – (GDPcyc)

There are no unanimously accepted long-term real GDP growth target for Sweden. Therefore I've Hodrick Prescott filtered the GDP time series, to obtain the cyclical variation around the trend. The Riksbank publishes also its own estimate of the output gap. I've controlled for this variable, and it yields very close and similar results to those of the cyclical component of real gdp growth. In my point of view, GDP growth has 2 major advantage vs the output gap: it is real time available and does it is not subject to large ex post corrections as pointed out in the literature review.

4) Lending – (Loanscyc)

This variable works as a proxy for credit. It is the Swedish cyclical component of the Lending variable used in the paragraphs above.

¹¹⁷ <http://www.prospera.se/inflation-expectations>

5) CISS – Composite Index of Systemic Stress

The Swedish component of the CISS.

6) M3 annual growth rate

Provided by the Riksbank. In absence of an officially stated target, I will use the cyclical variation (HP filter).

7) SEK/EURO exchange rate

It is the quarterly average of the exchange rate between the Swedish Krona and the EURO.¹¹⁸ It is a significant control variable because of the interlinkages between the Swedish economy and the Eurozone. Moreover, given the limited weight of Sweden in the world economy, the Riksbank it's not in the position to be a "market maker" for exchange rate. Rather, it has to smooth the exchange rate oscillations if it wants to preserve the competitiveness of the economy. This is especially true with respect to its main commercial partner - the Eurozone - .

Figure 33 : Paerson linear correlation between variables

	REPOrate	Target_CPI~e	M3cyc	LoansCyc	GDP_Cyc	Forex_~e
REPOrate	1.0000					
Target_CPI~e	0.8614	1.0000				
M3cyc	0.4059	0.3120	1.0000			
LoansCyc	0.3481	0.3514	-0.0472	1.0000		
GDP_Cyc	0.1056	0.1970	0.3140	-0.4500	1.0000	
Forex_swe	-0.4014	-0.3341	-0.4165	0.1998	-0.5684	1.0000

6.3 Threshold regression model

Below there are two different specification of a non-linear Taylor rule for Sweden. The econometrical model used is the same employed for the ECB. It is the Threshold regression model, with the confidence intervals of the estimates provided by the non-standard distribution proposed by Hansen (2000).

The first model tries to replicate the specification of the ECB's augmented Taylor rule with the only difference that Target balances have been excluded. Instead in light of the recent critique to riksbank's monetary policy (i.e. sadomonetarism), the M3 growth variable is included. M3 allows us to control also for monetary aggregates.

¹¹⁸ sdw.ecb.europa.eu/quickview.do?SERIES_KEY=120.EXR.Q.SEK.EUR.SP00.A

In the second model, I drop the M3 and the credit supply (LoansCyc) variables. The model is left with the backbone of the Taylor rule (CPI and GDP). On top of that I add the exchange rate control variable.

I wish to point out that also here holds the remarks that I've done at the end of the analysis of the ECB (See: p49). Too few observations (and too few degrees of freedom) for Regime2 must warn us of interpreting coefficients with caution.

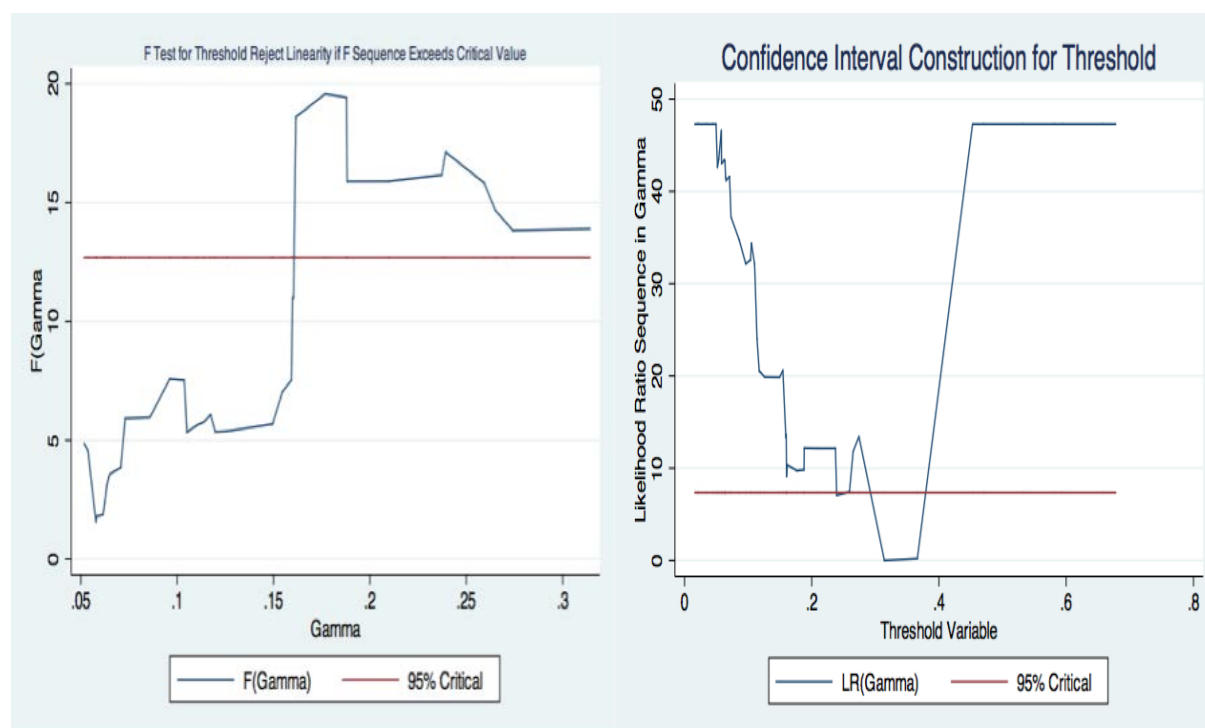
Nonetheless, how we will see below, it is statistically significant to use a 2 regime model also for the Riksbank (as for the ECB).

6.3.1 Model 1

The F test is positive, and rejects linearity. The determined threshold level is 0.314 (below: Figure 37). This level divides the sample into two subsamples, with Regime2 including two distinct periods of instability.

- 2008Q2 - 2009Q1
- 2011Q3 – 2012Q2

Figure 34/35 F test for the existence of a Threshold – Linearity rejected/ 95% Confidence Interval for the threshold



Regime 1 (CISS_swe < 0.314)

$$Repo_t = 2.36 + 1.69 E_t[CPI_{Target}] - 0.15 GDP_{cyc} - 0.90 LoansCyc + 0.08 M3Cyc$$

All, but LoansCyc are 95% significant. In the specific:

- Constant : of difficult interpretation, due to the fluctuations of the real interest rate during the Regime1 subsample period
- CPI : consistent with theory and with the stated goals of the CB, 95% CI always > 1
- GDP : negative sign probably yielded by the so called period of "Sadomonetarism". From 2010Q2 to 2011Q3 the riksbank significantly increased the Repo rate up to 2%, while GDP plummeted. The low positive weight normally given to GDP cannot be identified/verified due to this episode.
- Loans : not significant. Therefore there is no evidence of Riksbank supporting the credit supply to the economy during low and medium instability periods.
- M3 : positive rate. This is what we would expect. It seems that the Riksbank was fighting to high growth rate of the monetary aggregates for fear of inflationary spirals.

Regime 2 (CISS_swe > 0.314)

$$Repo_t = 2.04 + 0.192 E_t[CPI_{Target}] + 0.31 GDP_{cyc} + 11.04 LoansCyc + 0.12 M3Cyc$$

- Constant : Same as in regime 1
- CPI : Not significant. The regression is not able to identify a clear line of action of the Riksbank within this specification. Probably too few degrees of freedom.
- GDP : Positive, and consistent with the theory that calls for a larger support to the economy once it is hit by a financial instability shock and by binding ZLB.
- Loans : Positive and large. There seems to be evidence for the CB to support the credit supply in the economy during the 2 years of high instability.
- M3 : Positive (consistent with theory and with regime1 results), but not significant due to large standard error.

Figure 37 Threshold estimation

Threshold Estimation

Threshold Estimate: .314200014
.95 Confidence Interval: [.239299998, .366100013]
Sum of Squared Errors 9.85177245
Residual Variance: .240287133
Joint R-Squared: .879580003
Heteroskedasticity Test (p-value):.943273402

Figure 36 Linear model results

Heteroskedasticity Correction Used

Independent Variables	Estimate	St Error
Intercept	2.16208361	.133815948
Target_CPI_swe	1.43373487	.213988935
GDPcyc	-.047750928	.054871252
M3cyc	.060750723	.021956952
LoansCyc	.382249307	1.31727826

Observations: 51
Degrees of Freedom: 46
Sum of Squared Errors: 18.416442
Residual Variance: .400357434
R-squared: .774892498
Heteroskedasticity Test (P-Value): .943273402

Figure 38 Regime 1/2 results

Regime1 q<=.314200014

Parameter Estimates

Independent Variables	Estimate	St Error
Intercept	2.35645036	.10572834
Target_CPI_swe	1.68615199	.144567871
GDPcyc	-.146319343	.032509331
M3cyc	.076701956	.019741035
LoansCyc	-.901985597	1.14071052
.95 Confidence Regions for Parameters.		
Independent Variables	Lower Bound	Higher Bound
Intercept	2.13798911	2.56367791
Target_CPI_swe	1.39970332	1.96950502
GDPcyc	-.210037633	-.080021597
M3cyc	.038009527	.116616088
LoansCyc	-3.24703839	1.33380703
Observations:	43	
Degrees of Freedom:	38	
Sum of Squared Errors:	8.95641365	
Residual Variance:	.235695096	
R-squared:	.862038482	

Regime2 q>.314200014

Parameter Estimates

Independent Variables	Estimate	St Error
Intercept	2.04108233	.307178196
Target_CPI_swe	.192132461	.206940476
GDPcyc	.305828407	.064854457
M3cyc	.012014447	.051236598
LoansCyc	11.0357743	2.16403177
.95 Confidence Regions for Parameters.		
Independent Variables	Lower Bound	Higher Bound
Intercept	1.43901306	2.72764263
Target_CPI_swe	-1.06034901	.816586829
GDPcyc	.174325372	.432943142
M3cyc	-.150422008	.112438179
LoansCyc	6.79427202	17.1559321
Observations:	8	
Degrees of Freedom:	3	
Sum of Squared Errors:	.895358801	
Residual Variance:	.298452934	
R-squared:	.932385884	

6.3.2 Model 2 – Control variable (Forex_swe)

If we include the Forex_swe variable, we get a new CISS level of 0.3661, which is higher than the previous 0.31 (rounded). The very few observations of the Regime2 (7), does not allow me to include all the variables in the specification. Therefore I've chosen to keep only the backbone of the Taylor rule (CPI and GDP) plus the control variable (Forex_swe).

The results show an overall good fit [Joint Rsquared of 86,48%], and a very significant role for exchange rate control. In fact this variable is statistically significant in both regimes. The impressively large coefficient in regime 2 for the Forex_swe variable must be interpreted with caution. The negative sign simply means that an appreciation of the Swedish Krona should, by response, push the Riksbank to lower the Repo rate.

Regime 1 (CISS_swe < 0.366)

$$Repo_t = 2.34 + 1.68 E_t[CPI_{Target}] - 0.14 GDP_{cyc} - 0.99 Forex_{swe}$$

- Constant: See model 1.
- CPI: The coefficient is almost equal to the one of model 1. Proving an impressive stability in the estimation (1.67 vs 1.68). Again the whole 95% CI lies above 1, and therefore they satisfy the Taylor principle. The result is consistent with the Riksbank indication that Inflation is the Target.
- GDP: See model 1. As for expected CPI, we observe an impressive stability in the estimates (-0.14 vs -0.15)
- Forex_swe: Interestingly the control variable is highly significative. The negative sign well couples with rationale economic reasonings (appreciation of the Krona vs its main commercial partner -> lower interest rate in order to depreciate the currency to restore competitiveness).

Regime 2 (CISS_swe >0.366)

$$Repo_t = 1.08 + 2.21 E_t[CPI_{Target}] - 0.15 GDP_{cyc} - 4.33 Forex_{swe}$$

- Constant : See model 1.
- CPI: Very different story with respect to model 1. Now the coefficient is even larger than the one of regime 1 and highly significant.

- GDP: Slightly negative and significant. However running the model without GDP does not impair the overall goodness of fit in regime 2, while it significantly does in regime 1. This fact, and the relatively high correlation suggests collinearity with Forex_swe.
- Forex_swe: Very high significant coefficient, 4 times larger than in regime 1. Magnitude that may also signal interventions by the Riksbank to strengthen the GDP recover by favoring Sweden's competitiveness in the international markets. Probably the very few observations does not allow a correct identification of the GDP response, which may be incorporated in this variable. Suspect that is reinforced by the -0.568 correlation between these two variables.

Figure 38 Confidence Interval for threshold

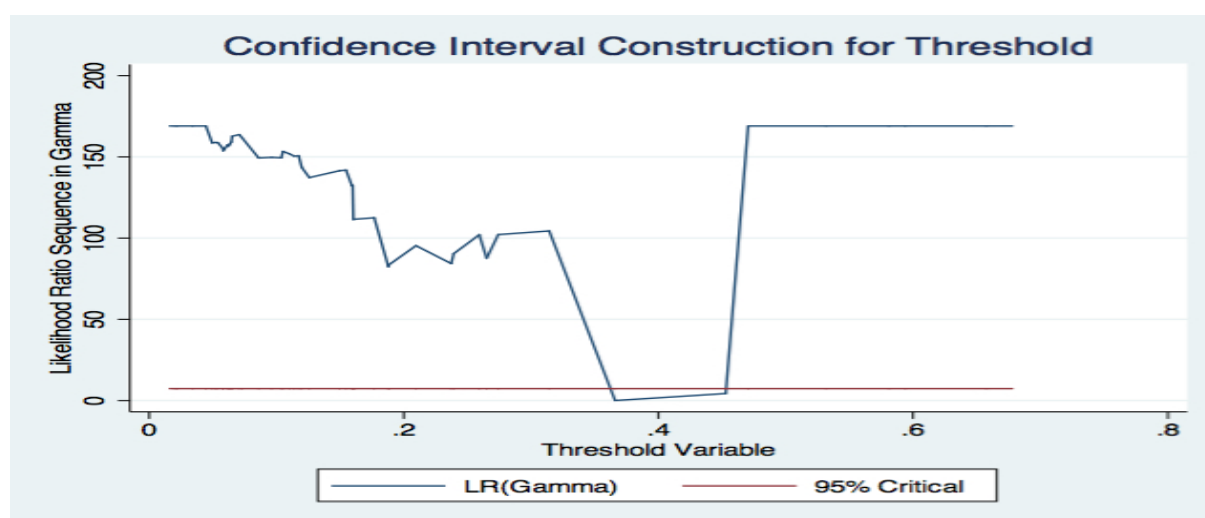


Figure 39 Threshold Confidence interval

Threshold Estimation

Threshold Estimate:	.366100013
.95 Confidence Interval:	[.366100013, .453000009]
Sum of Squared Errors	11.0598023
Residual Variance:	.257204704
Joint R-Squared:	.864814036
Heteroskedasticity Test (p-value):	.782617805

Figure 40 Linear Model

Global OLS Estimation, Without Threshold

Heteroskedasticity Correction Used

Independent Variables	Estimate	St Error
Intercept	2.16473612	.130356416
Target_CPI_swe	1.44240657	.187743805
GDPcyc	-.088842026	.041636753
Forex_swe	-.764925484	.230541664
Observations:	51	
Degrees of Freedom:	47	
Sum of Squared Errors:	17.9335403	
Residual Variance:	.381564687	
R-squared:	.780795093	
Heteroskedasticity Test (P-Value):	.782617805	

Figure 41 Regime 1/2

Regime1 q<=.366100013

Parameter Estimates

Independent Variables	Estimate	St Error
Intercept	2.34006279	.120107806
Target_CPI_swe	1.67554383	.13608221
GDPcyc	-.142142609	.026324582
Forex_swe	-.663878285	.167086686
.95 Confidence Regions for Parameters.		
Independent Variables	Lower Bound	Higher Bound
Intercept	2.08613472	2.57547409
Target_CPI_swe	1.40698503	1.94226496
GDPcyc	-.193738789	-.079727764
Forex_swe	-.991368189	-.282629674
Observations:	44	
Degrees of Freedom:	40	
Sum of Squared Errors:	10.5680029	
Residual Variance:	.264200073	
R-squared:	.838115377	

Regime2 q>.366100013

Parameter Estimates

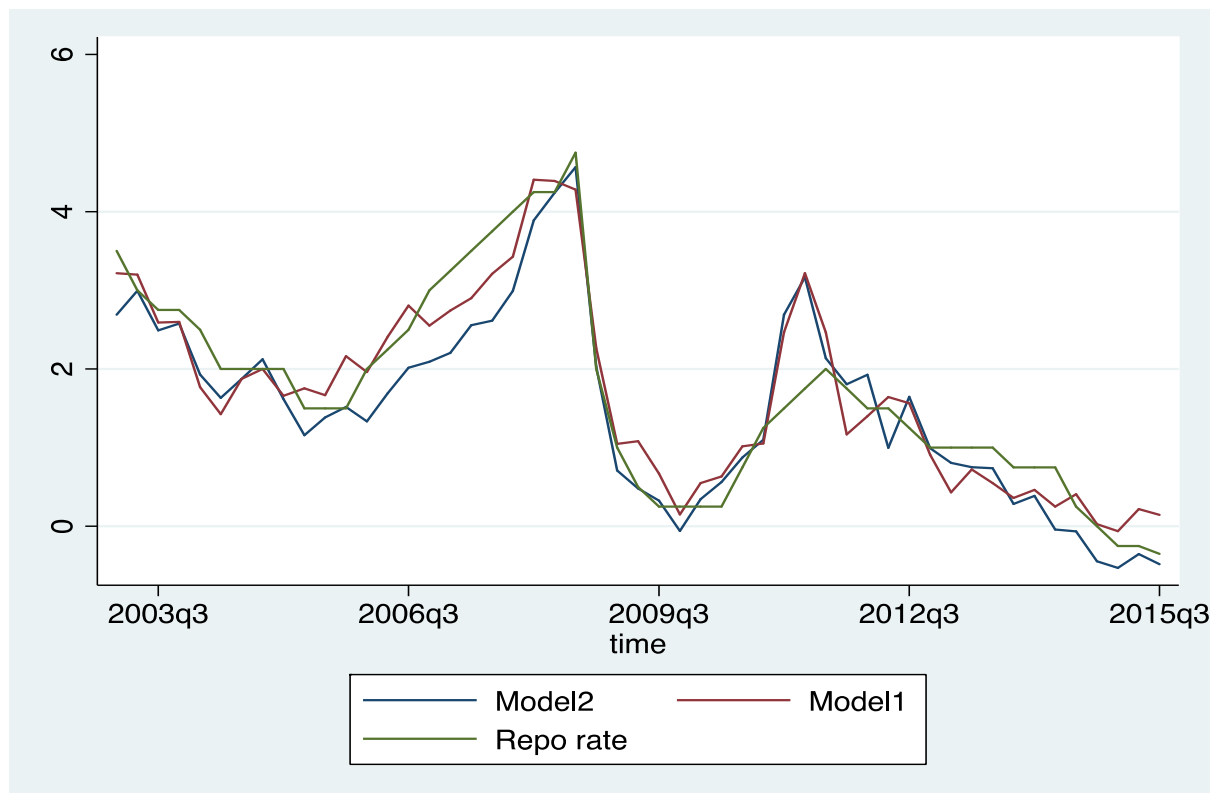
Independent Variables	Estimate	St Error
Intercept	1.08453278	.176284663
Target_CPI_swe	2.20756101	.200228205
GDP_Cyc	-.151953583	.058870562
Forex_swe	-4.33093584	.473319763

.95 Confidence Regions for Parameters.

Independent Variables	Lower Bound	Higher Bound
Intercept	.739014836	1.43005072
Target_CPI_swe	1.81511373	2.60000829
GDP_Cyc	-.291778002	-.036567283
Forex_swe	-5.43976227	-3.4032291

Observations: 7
Degrees of Freedom: 3
Sum of Squared Errors: .491799343
Residual Variance: .163933114
R-squared: .956005171

Figure 42 Model 1 vs Model 2 goodness of fit vs Repo rate



7 Conclusions

The Great moderation period has always caused fierce debates between the supporters of the successfulness of modern central banking and the supporters of the “good luck” theory (i.e. Great moderation as a lucky period without major systemic shocks). Notwithstanding the criticism, adherence to an optimal welfare rule such as the Taylor rule was deemed optimal. But as Blanchard (2006) pointed out:

*“Monetary policy can pretend to be close to science if it can be conducted using simple and robust rules. The rules can be formal, or informal. They may not be perfect, but they have to be robust, i.e. to do well especially when things are bad.”*¹¹⁹

As a matter of fact, the Taylor rule has impressively performed during the Great Moderation period. However, starting from the new millennium, it has failed to describe accurately as before the behavior of the CBs. During the recent financial crisis the Taylor rule prescriptions deviated from the actual interest rate set by the CBs and crossed the ZLB already in 2008. Therefore, the Taylor rule was not so much robust during the last 15 years.

On top of that the Taylor rule considers the short term interest rate as the major steering instrument of the CBs, a fact that can be debated in light of the rising importance of unconventional monetary policies, where QE is used to lower the whole yield curve.

My research works out non-linearities and the ZLB through the estimation of a non-linear switching regime model. Such an augmented 2-regime Taylor rule performs better than the traditional linear specification and is able to explain also the behavior during financial instability.

While during Regime1 the ECB mainly targets inflation (in accordance to its statute), when the composite index of systemic stress (CISS) rises over the threshold, the ECB does not target only medium-term inflation expectations. The results suggest a deeper support of the ECB to the real economy when it is hit by financial shocks. This discretionary support is made possible by the reputation built by the ECB in fighting inflation and in anchoring medium term price expectations.

We know that the eurozone is not yet an optimal currency area. Since the only mechanism for convergence of imbalances within a common currency area under fixed exchange rate, is internal devaluation¹²⁰ (very painful), the ECB has intervened

¹¹⁹ Blanchard, O. (2006), “*Monetary policy; Science or Art?*”, MIT ; Panel discussion, presented at “Monetary Policy: A Journey from Theory to Practice” An ECB colloquium held in honor of Otmar Issing, March 2006

¹²⁰ B. Eichengreen, January 2012, *Implications of the Euro's Crisis for International Monetary Reform*, prepared for the session entitled “A New International Monetary Order?” at the Allied Social Science

to smooth the resulting divergences.

This is the reason why the Target2 balances are a significative variable and are strictly monitored by the ECB: they are both a measure of liquidity and of health of eurozone. During the last crisis the flight of capitals and liquidity from the Southern countries to the Northern ones caused a widening of the gap, and increased the risk of the eurozone running with two different velocities. This explains also why the ECB's reaction function exhibits a larger coefficient for the Target2 variable during financial instability.

On the other side the Riksbank analysis seems to confirm the opinions of the authors who believed that Sweden was following a so-called "Sadomonetarism" approach. Negative GDP coefficients are probably the main shocking result. Another key result was to find out that the Riksbank exhibits an exchange rate control over the Krona/EURO market to preserve its international competitiveness.

The empirical results are quite clear-cut. What really is missing is:

- A. Welfare analysis:** such a 2-regime rules needs to be further studied to prove their welfare properties. So far, there are no welfare results on such two regime models in the literature. The only close result comes from IMF (2008) where it has been shown that a monetary policy rule that incorporates a financial instability variable (NPL – non performing loans) increases the welfare of the whole economy because the economy will recover faster after a slowdown induced by a financial shock¹²¹.
- B. High frequency data:** the identification of multiple regimes and of a large set of independent variables needs a larger sample size to be statistically significant. The Eurozone has started to collect high frequency financial data from 2007 on, but much has still to be done.

The classical Taylor Rule seems to be suitable to describe only low instability regimes, where non-linearities and the ZLB does not bind. The question now is whether the new discretionary approach of CBs to respond to financial instability shocks is optimal.

In the end, my results are pretty similar to the ones obtained by the literature on non-linear monetary policy rules. Moreover I have found evidence that the ECB's and the Riksbank's behavior are better approximated by a 2 regime Taylor rule augmented with financial instability variables, and I have shown the importance of the latter in the analysis of the ECB and of the Riksbank. However much research has still to be done on the welfare properties of such augmented non-linear rules.

Associated Meetings, Chicago, January 6, 2012, and forthcoming in the *Journal of Economic Policy Modeling*

¹²¹ Bauducco S., Bulir A., Cihak M., (2008). "Taylor Rule under financial instability", IMF Working paper, wp0818, January 2008

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