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MONETARY POLICIES OF ECB AND FED IN COMPARISON

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Motivation

The aim of the thesis is to compare monetary policies of the ECB and Fed. There has been substantial focus on this topic because it is important to understand what stands behind the monetary decisions of the two major world's banks. The monetary policy is under the scrutiny in the time of the crisis and approaches to the monetary policy are still developing. Therefore, it is benefcial to understand and learn from differences in conducting monetary policy among central banks.

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Introduction

Theoretical approaches to monetary policy are constantly evolving because there is missing the one which would explain all monetary impacts on real economy. Central bankers around the globe come with new monetary models in order to conduct their policies. However, in the recent times of crisis nothing seems to work properly. The only solution is to test new approaches and to learn from other central banks (CBs). Two major CBs are the Federal Reserve Bank (Fed) and the European Central Bank (ECB). Therefore, the thesis analyzes differences in the monetary policies of the ECB and the Fed. These CBs are chosen because they stand to somewhat similar challenge since their aim is to conduct monetary policy of other states in the union. However, there are still difference among these CBs, since the ECB is much younger institution and its position is more difficult due to the disparity among euro area member states.

The aim of the thesis is to compare monetary policy of the ECB and the Fed. The methodology used is to compare their actual policies and then to compare their fit to monetary policy rules which the CB's, at least in the theory, should follow. For this purpose there is theoretical backround to monetary policy presented first. Therefore, it is neccessary to describe briefly the development of monetary policy and then there are introduced three main approaches to monetary policy in last decades. The monetary policy tools and transmission mechanism in general are described to better understand the role of monetary policy nowadays and to set the policies of the ECB and Fed within a theoretical framework. We employ Taylor rule in order to compare the CB's behavior. Finally, monetary policy rules, based on the previous theoretical backround, are introduced.

Secondly, the monetary policies of the ECB and Fed are compared with respect to their monetary policy objectives, policy tools and their monetary strategies. The ECB's and Fed's transmission mechanisms are introduced with the emphasis on altered mechanisms during the crisis. Then, there is a comparison of non-standard measures which are used in the crisis and their efficiency is compared.

In the empirical part, Taylor rule is estimated for the ECB and the Fed. The results give an answer whether the banks are more output or inflation stabilizing and how well they fit the Taylor rule recommendations. Further, the estimated results show whether the classic version of Taylor rule works during the crisis. Primary hypothesis is that the Taylor rule is not followed by neither of the banks and that the classic Taylor rule does not work properly. The chosen period is from 1999Q1 to 2013Q1 so it is comparable with regards that the ECB started conduct its monetary policy in 1999. Taylor rule is an interest rate rule which consists of output and inflation gap. Therefore, the

output gaps for the euro zone and US are computed by using Hodrick-Prescott filter since the potential level of output is unobservable value. Then, there are US and euro inflation gaps estimated. The used method for computation of Taylor rule is Ordinary Least Square regression and non-linear Tobit model, which sets lower bound to interest rate.

The structure of the thesis is as follows; first chapter lays down theoretical backround to to monetary policy and its brief development with main policy approaches such as Old Monetrarism, New Keynesian Economics and New Monetary Consensus. Then, the chapter continues with monetary policy tools in general and it describes the transmission mechanism which is crucial in order to understand the impact of monetary decisions on real economy. Then, there are inroduced monetary policy rules which the CBs usually follow in order to conduct the monetary policy. Taylor rule is discussed in more details since the last chapter presents its results for the ECB and Fed.

The second chapter introduces the monetary policy of the ECB and Fed. There are compared monetary policy objectives, instruments and policy strategies of both CBs. The chapter continues with description of CB's transmission mechanisms and the way how it changed in the crisis. Finally, there are analyzed non-standard policy measures which were undertaken in the crisis and which differ among both CBs.

The third chapter introduces econometric models for computation of interest rate rules for each CB. First, there are analyzed recent approaches and innovations to the classical version of Taylor rule and the data used. Then, there are described the methods for computation of output and inflation gaps for each CB. Taylor rule is estimated by using two methods: OLS regression and non-linear Tobit model. Finally, there are presented the results of computed Taylor OLS and Tobit model for the ECB and the Fed.

1. Monetary policy rules and the development of monetary policy

To understand monetary policy it is necessary to introduce some theoretical background. In this part there are briefly discussed main approaches to conducting monetary policy in the last few decades. Then the monetary policy tools and transmission mechanism is explained in general and finally the monetary policy rules are introduced, especially Taylor rule which the central bankers use nowadays in order to conduct their main objective.

1.1. Brief description of monetary policy development

Real foundations of monetary policy were laid in the 20th century. After the Second World War, fiscal policy had a leading role in a process of macroeconomic stabilization as Issing O. (2010, p.4) pointed out. "*Monetary policy in the immediate post-war period was a struggle to get rid of the subordinance to the government and regain sovereignity on the decisions by the central banks."* Keynesian economics suppoused that there is a trade off between the unemployment rate and inflation level as the Phillips Curve (PC) suggests. Thus a reduction in unemployment level leads to an increase in inflation. Turning point in the perception of importance of fiscal policy was its inability to explain periods of stagflation in the 1970s and 1980s. The explanation provided by Friedman and Phelps who argued that the PC shifted itself because once agents in the economy expect higher level of inflation then inflation really increses. This new sight to the PC was later incorporated to New Keynesian models.

In the long-run the PC is at natural level of umenployment which is not known. When there is a stimulus in fiscal or monetary policy the aggregate demand increases and the unemployment level falls. Thus, the economy moves form point A to B and worker bargain about their higher nominal wages which creates inflation and the economy return to its natural level with higher level of inflation to point C. Because of the money illusion when workers do not differ between increase in real or nominal wages this process continues on and the inflation becomes still higher.

After 1975 it is believed that the inflation level is not affected only by the expecations but by price contracts, fixed-duration wage and lags which affects final product prices as well (Gordon, 2008).

There are many approaches on how to conduct monetary policy. There lacks one theoretical consensus that explains everything. Central bankers seem to follow mainstream thinking but nowadays start employing New Keynesian models as supportive tools. There are introduced three main approaches to monetary policy.

The solid foundations to the monetary policy are linked to Milton Friedman's Old Monetarism (1960;68;69) and his work with Schwartz (1963). In monetarism the central role play monetary aggregates which induce changes in income and prices. This is described by *Friedman's k-percentage rule* which is based on the quantitative theory of money. Monetarists suggest that interest rate smoothing adds volatility into the economy because money stock fluctuates procyclically (Goodfriend, King, 1997).

To answer the question how should be monetary policy conducted, it is the most convenient to use the words of Friedman himself (1968, p. 14, 15, 16): "*The first requirement is that the monetary authority should guide itself by magnitudes that it can control, not by ones that it cannot control. If, as the authority has often done, it takes interest rate or the current unemployment percentage as the immediate criterion of policy, it will be like a space vehicle that has taken a fix on the wrong star. No matter how sensitive and sophisticated its guiding apparatus, the space vehicle will go astray. And so will the monetary authority… My own prescription is still that the monetary authority go all the way avoiding such swings by adopting publicly the policy of achieving a steady rate of growth in a specified monetary total. The precise rate of growth, like the monetary total, is less important than adoption of some stated and known rate."*

An important feature of monetarism is the belief that the quantity theory of money is a key equation and there is a stable money demand. Further, there is no trade-off as proclaimed in the Phillips curve in the long run. However, there are sticky prices but these are not important for monetary policy and that inflation causes significant welfare losses (Williamson, Wright 2010).[1]

Another approach to monetary policy is New Keynesian Economics (NKE). NKE was developed partially as a response to the flaws of monetarism and represented an alternative approach to the RBC as well. In the first generation Gordon (1982) and Taylor (1980) focused their works on the wage rigidities and rational expectations. In the second generation NKE concentrated on price stickiness and monopolistic competition (Goodfriend, King, 1997). Main characteristics of NKE are that the money are not neutral in the short run due to frictions in markets, the monetary authority sets the short term interest rate and there is a trade-off in the short run of Philips curve between inflation and output (Williamson, Wright, 2009). However, the NKE is still developing and there is

[1] The fact that the monetary policy is useful in contrast to what was believed earlier under the teachings of Keynes, was supported by the Andersen-Jordan work (or St. Louis Model) which examined relations between money and nominal income (HAFER, 2001).

missing money supply curve and the money demand is often solved like cash-in-advance or money-in-the-utility-function model (Woodford, 1998)[2]

The most recent approach to the conducting of monetary policy is presented in the New Monetary Consensus (NMC). The NMC is built on NKE, Taylor rule and it steps aside from IS – LM model. Thus there is a consensus that the short interest rate is the main policy instrument for achieving desirable price level. The restrictive monetary policy lowers the long run level of inflation and there is no impact on real side of economy including real interest rates (Lavoie, Seccareccia, 2004). It departs from the monetarist view on the importance of monetary aggregates.

However, in the recent times the NMC fails to explain the crisis as Bearn et al. (2010) pointed out: *"The financial crisis has brought the monetary policy consensus formed in the recent years prior to the crisis under scrutiny."* (Weber, 2011, p. 1).

Weber (2011) suggests that the NMC should consider macroprudential tools along with policy rate tools. Further, monetary authority should be cautious when purchasing the governments bonds since it loses credibility and the boundaries between fiscal and monetary policy are shrinking. Therefore to smoother functioning of monetary policy there must be some stable prudent fiscal rule. Another critic of the NMC is Galbraith (2008, p. 14) who rather prefers explanation of Minsky of the ongoing economic downturn. Galbraith absolutely reprobates the NMC with the following words: "*But if Friedman was wrong, the "new monetary consensus" is even more wrong.*"

1.2. Monetary Policy Tools

Central bank use main instruments in order to conduct the money supply. These instruments are *Open Market Operations* (OMO)*, interest rate* and *minimum reserve requirements* or *deposit loans*. OMO is the most used monetary instrument and we can distinguish *open market sales* where the CB sells government bonds to decrease the monetary base and *open market purchases* where the monetary authority buys the government bonds or securities in order to increase monetary base. These effects on monetary base are pernament, however there are temporary tools among OMO as well.

One tool is *repurchase Agreement* (repo) where the CB purchases government securities with an agreement to repurchase them at a specified date and price so the

[2] DSGE NKE models are nowadays employed like subsidiary models by central bankers around the globe. They are policy invariant and assume that the economy is not at the full employment level, thus either fiscal or monetary policy can help to reach it.

monetary base is only temporarily increased. The other one is *Matched Sale-Purchase Transaction* (reverse repo) in which the central bank agrees to sell the government bonds and buyer sells them back on an agreed date and at agreed price. The discount loans are used as an instrument by the Fed which provides a discount loan, sometimes called *discount window*. If there is a higher discount rate then the commercial banks demand less loans since they are now more expensive for them so the total volume of loans is reduced. The opposite holds for a lower discount rate however, the CB does not have a full control over provided loans (Mishkin, 2006).

1.3. Transmission mechanism

To understand clearly how the CB achieves its primary goal through the system of the operational objectives, it is necessary to understand the transmission mechanism process. In general transmission mechanism sets the operational goal at first which has a direct effect on intermediary markets. These markets affect the other intermediary markets which finally influence the desired final market goal. This whole process operates through the system of parallel channels.

In general, the whole transmission process can be divided into two phases. In the first one, the changes in interest rate or in money base are transmitted in changes in financial market which influences money market conditions, credit supply or exchange rate. In the next phase, the changed financial market conditions affect nominal spending by households and firms that leads to changes in general price level in the long run. Notwithstanding, in the short to medium run nominal spending can have an impact on real economy but the effect depends on the price and other rigidities (ECB Monthly Bulletin, 2010). The official interest rate affects asset prices, exchange rates and investment decisions which is a way how the ECB's decisions can lead to changes in the demand through changes in supply.

Thus, the most important is the *interest rate channel* which supposes that monetary policy tightening increases interest rate and subsequently also the cost of capital so the investments decline which in turn lowers aggregate output. Taylor argues that increased nominal interest rate affects, due to the rational expectations and sticky prices, also the real interest rate which in turn lowers fixed investments of a business sector and purchases of consumer's durable goods (Mishkin, 1995).[3]

[3] Ben Bernake (chairman of the Fed) has different opinion than Taylor. Bernanke argues that the effect of interest rate might not be so strong because there is not much evidence in its support since it is difficult to examine the effects on the cost of capital (Mishkin, 1995).

The *credit channel* enables providing bank's loans to clients. Credit channel can be divided to *narrow bank lending channel* and *bank capital channel*. In the credit channel a decrease in interest rate leads to an increase in loans. This in turn has impact on higher money supply and thus on higher level of inflation, GDP and employment (Jilek,2004).Within the bank lending channel a decline in bank's reserves leads to a decline in a provided volume of loans. This reduction in loans causes a decline in investments made by private sector (Oliner, Rudebush, 1996). *Borrower balance sheet channel* transmits changes in household's net worth to decisions about consumption and investments. In *wealth channel*, the CB alters asset prices which influence household's consumption (Cournede et al., 2008). The bank lending channel gained its importance especially in current financial crisis. In this transmission it is the balance sheet that has a significant impact on the interest rate (Romer et al., 1990).

The *exchange rate channel* has impact on the level of inflation via three means. First, depreciation of exchange rate makes the foreign goods relatively more expansive compared to the domestic ones so inflation increases. Insofar, these foreign goods are used as intermediate goods, its higher price leads to higher price of the final goods. Further, depreciation makes domestic goods more competitive thus creating upward inflationary pressures.[4]

1.4. Monetary policy rules

Nowadays, it is widely accepted that the monetary policy rule is preffered to a period by period approach in order to conduct the monetary policy. One of the most profound rules is the Milton Friedman's and then Taylor's rule. This part introduces two main approaches for central banks to achieve their monetary objectives which are based on the monetary policy approaches introduced earlier.

1.4.1. Friedman's k-percent rule

Friedman's k-percent rule (1960) was widely used in the past and it conducts the growth rate of money supply. In log terms, it has the following form:

$$\Delta m = \pi^* + \Delta q^* - \Delta v^*$$

where π^* represents inflation target, Δq^* is the potential growth rate of the economy and $\Delta v^*$the trend value of the velocity of money. The term v is the reverse value of k which is

[4] Further, we could think of the expectation channel which alters longer-term expectations of the private sector which play crucial role as it is apparent for instance from the Fisher equation. The more credible monetary policy is, the greater the effect on price developments it has.

the constant growth of money.[5] An advantage of Friedman's rule is that when the velocity of money is stable then only potential output needs to be calibrated and the rule is robust.

However, k-percent rule does not contain an interest rate instrument. Wicksell (1898) developed the simplest interest rate rule with the main idea of targeting the price stability given the assumption that the interest rate is equal to the natural or equilibrium interest rate (Orphanides, 2007). Friedman does not believe that the monetary policy could stabilize the economy and he denies focusing on output deviations (Nelson, 2008).[6] In the last few decades the attention moved from the money growth rule to an interest rate rule, especially the Taylor rule.

1.4.2. Taylor rule

Taylor, a Stanford university professor, wrote an underlying work called '*Discretion versus policy rules in practise*' in 1993. In his paper, Taylor demostrates the usefulness of monetary policy rules instead of policy discretions. A simple rule that CB follows in order to achieve its goals has numerous advantages. The rule is credible because it incorporates rational expectations and furthermore enables to solve time inconsistency that bothered discretion policy. The simplicity facilitates to connect the short-term interest rate to monetary policy goal directly. However, Taylor himself warned policymakers to follow the rule without any further consideration which is a current issue nowadays in the time of crisis. Taylor rule is a systematic interest rate rule in contrast to previous optimization problem that was solved in a discrete time (Taylor, 1993).

General form can be expressed as following:

$$i_t = \bar{r}_t + \pi_t + a_\pi (\pi_t - \pi^*) + a_y(y_t - y^*)$$

where i_t is the short-term nominal interest rate, $\bar{r}_t$ represents the equilibrium interest rate, π_t is the rate of inflation and hence π^* corresponds to its target value, $y_t - y^*$ is the output gap (measured as the difference between the current output y_t and its target value y^*), a_π is the reaction coefficient representing inflation and a_y is an output coefficient. If the current inflation or output is above its target rates then the central bank should increase its target i_t.

[5] In 1935, a statistican at the Fed Carl Snyder was the first one, who expressed this idea and estimated the growth rate of money in the United States at 4 percent per year. In the 1960s, Friedman recommended the Fed to set the growth rate of money also to 4 percent per year given the assumption that the potential output is roughly about 4 percent per year as well (Friedman, 1960).

The implication of Taylor rule for policymakers is that they can stabilize the economy by setting $\alpha_\pi > 1$ which corresponds with tuning the interest rate instrument more than one-to-one with inflation.[7] In a case that the α_π would be smaller than one then there would not be a unique solution. A great advantage of the Taylor rule is that it represents sufficient and necessary condition to get rational expectations equilibrium. Otherwise, the shocks of fundamentals would cause larger fluctuations in inflation and output and the existence of multiple bounded equilibria would lead to sunspots. For above reasons some economists argue that the failure to meet the Taylor rule was the cause of macroeconomic downturn and inflation in the US in the 1960s and 1970s (Davig, Leeper, 2007).[8]

The current monetary policy has undergone several periods of endurance. It is very likely that monetary models will have to change in order to incorporate financial markets. Nevertheless, the main theoretical approaches to conducting monetary policy are the New Monetary Consensus and New Keynesian Economics so far. Taylor rule seems not to provide the most reliable recommendations during the crisis. Therefore, it is reasonable to compare what works for each CB and to learn from their experience.

2. The ECB and Fed in comparison

This chapter compares the monetary policy of the ECB and the Fed. First, the main monetary objectives and monetary policy strategies of the ECB and the Fed are described and the key distinctions are compared. Then, the comparison continues with the transmission mechanisms and non-standard measures of both CBs.

The ECB with the headquaters in Frankfurt, is relatively new central bank since it was established according to The Maastricht Treaty (1992) in June 1998 but fully started conducting monetary policy in January 1999. Currently the ECB takes care about euro that has been adopted by 17 EU member countries. The national central banks of EU countries all together with the ECB are part of the European System of Central banks (ESCB).

The Fed was established by the president Wilson with the signature of the Federal Reserve Act on 23 December 1913. The headquarters is situated in Washington, D.C.

[7] In his original paper, Taylor introduces the rule that has the following form which suits well for US economy especially after the year 1982: $r = p + .5y + (p - 2) + 2$. So, both inflation and output targets are 2 per cent per year (Asso et al., 2010).

where are seven members of Board of Governors, while the twelve Reserve Banks are in other major cities in the US (Alfan, 2012).

2.1. Monetary policy objectives

According to the Articles 127 (1) and 130 of the Treaty on the Functioning of the EU, the primary goal of the ECB's monetary policy is to maintain price stability.[9] The Treaty sets the price stability as a primary objective, however lacks an explanation what it really represents. So the term was specified by the Governing Council of the ECB as follows: "*Price stability is defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%*."[10]

The Federal Reserve Act states the dual mandate for the Fed which means that there are two main goals. The first is providing maximum purchasing power which means price stability and the second is achieving maximum employment that can be attained via low inflation level which leads to higher economic growth which increases employment (Poole, 2006). Later The Full Employment and Balanced Growth Act known as *Humphrey-Hawkins Act* (1978) stated that the Fed should achieve three goals which are maximum employment, stable prices and low inflation but since low inflation is achieved in the long run, there are two policy goals in practice.

Both monetary policy objectives are frequently criticized. The Fed is critized because there is not any ranking among goals and these goals are not quantitatively defined. The biggest problem is the definition of maximum employment. The *Federal Open Market Comittee* (FOMC)[11] rather focuses on sustaining maximum economic growth under stable prices. There was some discussion among FOMC members about its policy goals which depicts for instance Greenspan unwillingness to state any specification about employment level.[12] Nowadays, the FOMC rather focuses on short-run economic stabilization since the inflation is near its zero bound and Bernanke puts greater emphasis on level of output rather than growth. In 1995 *Economic Growth and Price Act*

[9] Pursuant the Article 126(1) of the Treaty EU Members are suppoused to keep the financial system stable, thus prevent the excessive government deficit procedure. An important adjustement is no-bailout clause which was violated many times in the recent crisis.

[10] Source: http://www.ecb.europa.eu/mopo/strategy/pricestab/html/index.en.html

[11] The main concern of the FOMC is to manage OMOs and thus to define total amount of currency and credit. The recordings of sessions are disclosed to the Congress twice a year and released to the public to enhance transparency which makes the Fed more transparent than the ECB (Alfan, 2012).

[12] The dual mandate has evolved over time and it is still not closed topic. Chairman Paul Volcker decided to focus only on reduction of inflation level while ignoring achievement of full employment so his period was connected with high unemployment level. In the mid-1990 there begun a discussion about setting quantitative inflation target. (Thorton, 2012).

brought an improvement of Humphrey-Hawkins Act by making price stability as the only long run goal so the inflation target could be quantified to enhance transparency (Thorton, 2012). Recently, there is an inflation target that is set to 2 percent which is measured by the annual change in the price index for personal consumption. The Fed releases long-term inflation goals and FOMC's Summary of Economic Projections of inflation and federal funds four times a year since 2012 (Statement on Longer-Run Goals and MPS, 2013).

Although, the ECB deems the HICP as an adequate measure to quantify the price stability, opponents argue it is not the case.[13] There is a difference comparing the definition of price stability with the Fed which describes it rather in a qualitative instead of quantitative way. Contrary to the ECB, the Fed uses Consumer Price Index for All Urban Consumers (CPI-U) that allows for measurement of cost of living index and 'owner-occupied housing services' with 20% weight.[14]

Furthermore, as Pentecost (2012) argues, there is an inconsistency within the ECB's monetary objective since it does not aim level of prices in reality but inflation which is the rate of change in prices. As this discrepancy can be apparent the Governing Council rather specifies that the inflation rate is targeted "*below, but close to 2% over the medium term*" thus preventing not only inflation but the deflation as well.[15]

2.2. Monetary policy instruments

Monetary policy instrument represents a stable rule of operational framework to achieve central bank's primary objective. The instruments of the ECB and the Fed are very similar to each other. There are three main instruments of the Eurosystem: *open market operations, standing facilities and required commercial bank's minimum reserves* that are held on accounts of the ECB. The Fed's policy tools are: *OMOs, discount rate and minimum reserve requirements.*

Open Market Operations (OMOs) is the most important instrument in conducting the monetary policy. The ECB uses the OMO's in order to achive its desired level in short-term market interest rate or to manage liquidity. There are five types of OMO's from which the ECB can choose; *the reserve transactions, outright transactions, issuance of*

[13] Cecchetti and Wynne (2003) are of the opinion that the HICP is biased and consists noise which together with an endeavor to avoid the deflation have caused that 2% price level is too low.

[14] The HICP gathers only price changes and thus cannot capture precisely the quality changes since it is not a cost of living index as in the US CPI-U case. Thus, there is a question whether some less traditional measures of inflation could provide a better service, as for an example the PCE or DFI (Cecchetti; Wynne, 2003).

[15] Source: http://www.ecb.europa.eu/mopo/strategy/pricestab/html/index.en.html

ECB's debt certificates, foreign exchange swaps and the collection of fix-term deposits (ECB, 2011).

Before the crisis, the most used OMOs were *main refinancing operations* (MROs) which enable the ECB to lend money against collateral. The number of MROs recipients increased significantly after the relaxation of criteria for obtaining MROs. The *longer-term refinancing operations* (LTROs) are reserve transactions with three months maturity in order to provide extra liquidity to the banks. The ECB does not intend to affect the market therefore it acts like a rate taker. The last OMOs, *fine-tuning operations*, are used for smoothing liquidity imbalances which affect the interest rate. So these operations are employed during the last day of a reserve maintainance period (ECB, 2011).

To understand the Fed's OMOs it is important to define the *federal funds rate* first which is determined in the federal funds market where banks can borrow from the depository institutions that have extra reserves. Borrowings are provided on the short term basis and the interest rate paid is an overnight borrowing rate which is usually referred as the federal funds rate (FRB-San Francisco, 2004).[16] Albeit, the Fed directly affects only short-term interest rates, it can also influence the longer-term rate via the funds rate indirectly; notwithstanding the inflation expectations and transparency play a crucial role (Labonte, 2013). The OMOs are conducted in the daily basis by the FRB of New York to meet the federal funds target rate by altering the reserve supply (Carpenter, Demiralp, 2006).

The ECB uses also two standing facilities as an instrument. The first tool is the *marginal lending facility* which is used for granting the overnight loans against collateral at interest rate that is higher than the market interest rate. The other tool is *deposit facility* which is used by banks to make overnight deposit with the ECB at lower interest rate. This lower and upper bound form a corridor in which the ECB's main refinancing operations rate lie. The variance between the rate of marginal and deposit facilities and MRO rate fluctuates about ±1%. The last ECB's standard instrument is required minimum reserves which is set at 2% (Frangakis, 2011).

Discount lending which enables banks to borrow from the Fed usually on an overnight basis at the discount window. The banks must pay a discount rate which represents mark-up over the funds rate (Labonte, 2013). The current discount rate for the primary

[16] The funds rate is an interest rate target of the monetary policy thus a cut in the rate increases money and credit since there is more lending in the economy. The current federal funds target is in a corridor between 0 and 0.25 percentage points. Source: http://www.frbdiscountwindow.org/index.cfm

credit is set to 0.75 percentage points and the secondary credit rate to 1.25 percentage points.[17]

There are few differences in use of momentary tools between the ECB and the Fed. In a case of OMOs, the ECB provides main refinancing operations on a weekly basis, while the Fed on a daily basis. Moreover, the Fed purchases or buys only US government securities, whereas the ECB deal with wider types of assets. Another distinction is that in a case of discount window, the Fed delimits amount of borrowings by discount rate, whereas the ECB does not put any constraints on borrowings from standard facilities. Both CBs provide facilities for banks to make overnight deposits; however the ECB pays interest on deposits, while the Fed does not. Overnight Index Average Rate (EONIA) has lower and upper bound. Contrary, we could only think of discount rate as a bound for federal funds (Pollard, 2003).

2.3. Monetary Policy Strategies

The strategy specifies how to achieve its final monetary targets throught the intermediate objectives considering the lag problem. The ECB's *Monetary Policy Strategy* (MPS) is based on a two-pillar approach, monetary and economic analysis, whilst the Fed has one pillar strategy. The ECB's monetary pillar is a source of wide criticism and there is not a counterweight of this pillar in the case of the Fed. The ECB uses monetary aggregate M3 as an economic indicator, while the Fed uses rather M2.

Since 1998 reference value for the growth in M3 in the Euro zone has been set to 4.5 percent per year which is perceived as a consistent level enabling the maintenance of price stability over the medium run. The reference value for M3 is based on the following relationship (Jilek, 2004):

The growth rate of M3= growth of real GDP + iflation – change in the velocity of money in circulation

The second pillar of the ECB analysis is the economic pillar. The economic analysis is similar to the Fed's analysis and rests on evaluation of the shocks to the economy, inflation and economic performance subsequently. The forecasts based on the economic pillar are focused on two to three year period. The economic analysis is published in the ECB's monthly bulletin twice a year.[18]

[17] Source: http://www.frbdiscountwindow.org/currentdiscountrates.cfm?hdrID=20&dtlID=51

[18] The ECB analyses the development of fundamentals such as real GDP, balance of payments, asset prices, labor market or impacts of fiscal policy measures (Jilek, 2004).

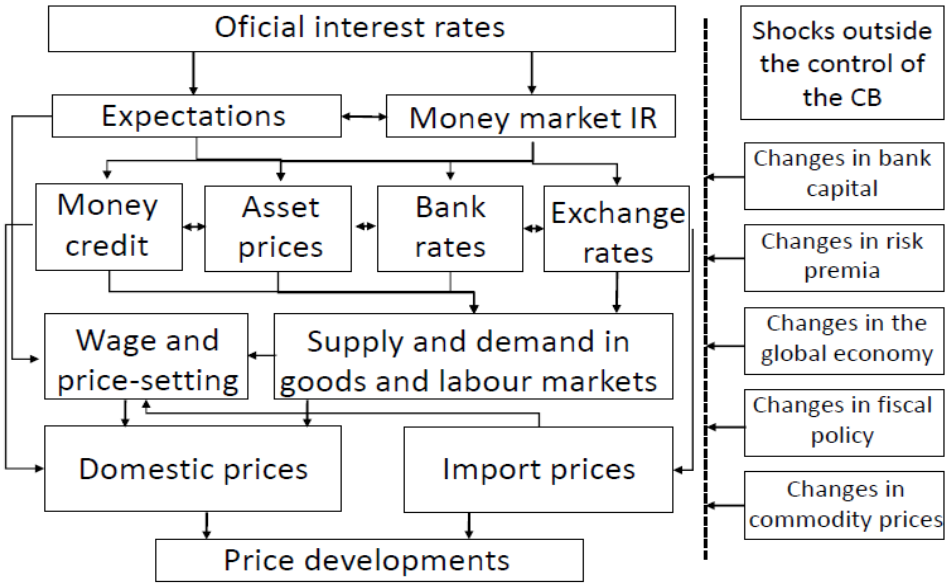
It is just the monetary pillar which constitutes the main distinction between monetary strategies of the ECB and the Fed. Critics suggest that there is no need for a single pillar for money growth. Conversely, the Fed does not target the monetary aggregate itself. Despite the dissimilar view, there is still an ongoing discussion between the two CBs about the role of money in the conduct of monetary policy and thus subsequent communication with public. In the Fed's approach the monetary aggregates are taken as an economic indicators that have information value which is further used for appraisal of future expected economic situation. The Fed views money supply as an instrument for achieving its goal but there is not paid any special attention to money itself. The econometric assessments do not find the relationship between the growth rate of M3 and interest rate so obvious (Gerlach, 2004). As Khan (2007) argues there are numerous reasons why aggregates are better indicators in the case of the ECB than the Fed. There is higher correlation among money growth and inflation, more stable velocity of money above that there is stable link among nominal spending and money growth in the euro area.

2.4. Transmission mechanisms

The ECB's transmission mechanism is similar as the Fed's transmission process; however the channels do not work properly in the recent crisis. First, there is a brief description of transmission in normal times. Then, this part continuous analyzing the altered channels in the recession. Transmission channels are altered mostly due to the changes in financial market developments. The transmission mechanism was weakened, especially in the bank lending channel where the mutual confidence between banks was disrupted.[19]

[19] Since the linkages among banking and financial sectors have strengthened, the transmission became even more complicated. The interest rate channel was supported by faster channels through which the bank's interest rate is transmitted. This was caused due to the fact that more bank loans were based on market pricing because of financial innovations. Further, the credit channel became weaker because the additional sources of funding caused that supply of loans became less sensitive to the monetary policy. While the risk-taking channel became stronger since the intermediaries were able to reduce risk and expand their balance sheets (ECB, Monthly Bulletin, 2008).

Figure 1: Transmission mechanism in the Eurozone

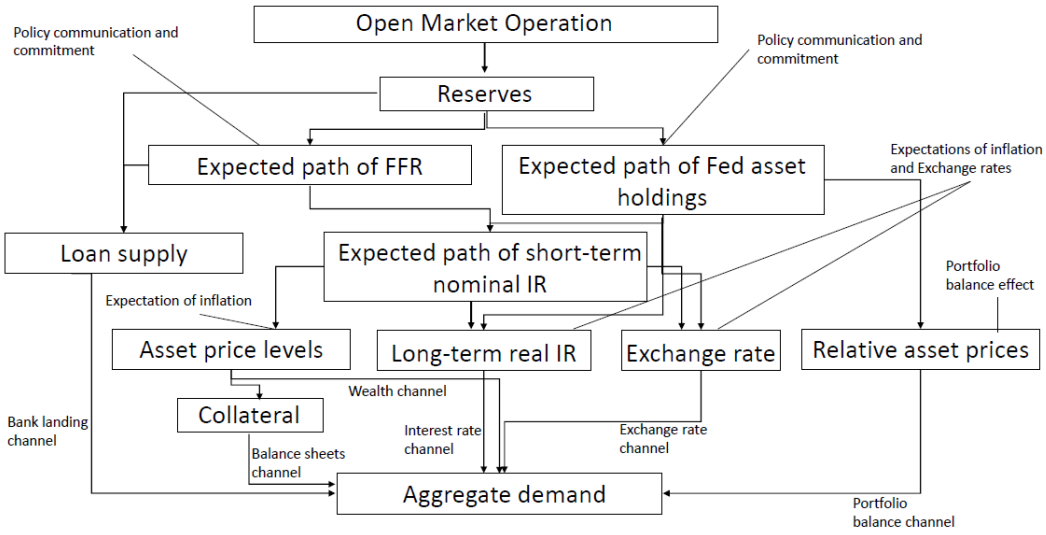


Source: own layout, ECB

The process is the same in the Eurozone as it is described in chapter one during the normal times. As it can be seen in the figure 1, different types of shocks have impact on interest rate which further alters the market expectations and the interest rate at the money market. Changes in expectations money market interest rate translate to changes in money credit, asset prices, bank rates and exchanges rates. Once these changes affect wages and volume of goods in the economy, it alters price developments. It is crucial for the ECB to understand development of price settings and structure of labor markets since the monetary policy is neutral in the long run.

The transmission mechanism in the US is somewhat similar to transmission in the Eurozone as it is shown in figure 2 below. In normal times a key channel is via funds rate which is translated into the change of real interest rate. Subsequently, the cost of capital is affected and the investment and consumption decisions as well. The asset prices and expectations about future development of inflation are crucial in the US. Thus, policy communication and transparency plays greater role in the US than in the Euro zone.

Figure 2: Transmission mechanism in the US



Source: own layout, (Kuttner, 2002)

During the crisis, the creditworthiness of the stable relationship between refinancing rate and money market rates was disrupted in the euro area (ECB, Monthly Bulletin, 2010). The Euro zone faces further factor that slows the changes in policy to inflation, which is wage rigidity. Labor markets are segmented in the euro area which makes it less competitive compared to US labor market.[20] Due to the introduction of euro, the exchange rate risk premium was removed so the trade increased and the financial integration deepened thanks to lowering the transaction costs.

The recent innovations in the Euro zone and the US financial markets together with securitization of loans enhanced the access to additional funds. Furthermore, the derivatives enabled to transfer risk from the balance sheet that increased the value of provided credit and reduced the capital constraint. This all together significantly altered the bank lending channels in the euro area and the US which is less effective nowadays compared to pre-crisis period. On the other hand the role of bank capital channel gained more importance since it enables to higher capitalized banks to obtain easier funding, whereas for poorly capitalized banks fund obtaining is harder. Likewise, the risk-taking channel worsens conducting of monetary policy and in the past ten years gained much

[20] Angeloni and Ehrmann (2003) run a regression to assess the impact of the EMU on transmission mechanism. Some of their findings are that the size of lending and deposit interest rate changed to a small extent, however the speed of the "pass-thorugh" accelerated. Comparing pre-euro period and post-euro the value of mortgages and loans to firm magnified in which the maturity played an important role. They suggest that the convergence among European countries is not a cause of joining the EMU but rather this process does not depend much on the entry to the EMU, nor on joining the euro zone.

more importance (ECB, Monthly Bulletin, 2010).[21] Both CBs therefore tightened capital requirements and regulated financial innovations which have led to reducing the risk taking behavior of banks.

2.5. Non-standard measures

During the crisis many CBs including the ECB and the Fed had to undertake non-standard measures as tools for achieving monetary policy goals. Nowadays, it is obvious that the financial markets are source of instability and CBs have to deal with this fact by altering their monetary policy instruments. Another reason for non-standard measures is that the interest rates in the euro-area and US reached zero-level bounds (ZLB) and deflation is unwanted solution so the standard measures do not work anymore.

As Frangakis (2011, p. 2) pointed out, the central bankers have to ask themselves new questions and find out new ways how to conduct the monetary policy. He asks in his paper several questions that need to be answered: *"Are we at the dawn of a new era in central banking? Will the emphasis of policy shift from price stability to financial stability? If so, how will it be implemented? What are the implications for economic policy?"*

In the first phase of the crisis (2007-09) both CBs followed similar kinds of non-standard measures. After 2009, the process of the crisis altered since the euro area was hit by the financial instability and the sovereign debt crisis ensued. Market conditions deteriorated due to the reduced mutual trust and uncertainty about liquidity situations of its participants (ECB, Monthly Bulletin, 2010).

The main issue in the Eurosystem was the financial market's funding and thus extremely high risk premia arising from the fear that banks would reduce providing loans. In order to avoid such situation, the ECB introduced several non-standard measures. One of the most important measures is a *fixed rate full allotment* tender which is applied to support the bank's short-time liquidity to ensure access to credit for households and firms at reasonable rates. The fixed rate allotment tender and extended list of collaterals were designed like automatic stabilizers because in a case of an excess demand for liquidity its provision goes up and money markets rates are reduced against MRO rate. Then, the ECB provides supplementary refinancing operations with a maturity up to one year and decides to accept more assets as collaterals (ECB, Monthly Bulletin, 2010).

The ECB entered international cooperation with other central banks, especially with the Fed. They agreed on *swap arrangements* (2009) to conduct fixed rate allotment in the US dollars with an emphasis to restore money markets. In 2009 the *Covered Bond Purchase Program* (CBPP1, subsequently CBPP2) was introduced with the aim to cut rates in money markets, enhance banks to continue lending, improve access to funding for credit institutions and finally to elevate liquidity in financial markets (Collignon, 2012).

As Draghi (2012) argues, the threat arised with the crisis was that the costs of bank financing started to differentiate significantly among countries reflecting the fragmentation of capital markets. The transmission mechanism was thus disturbed so the ECB introduced the Outright Monetary Transactions (OMTs) under the *Securities Markets Program* (SMP, 2010) to purchase bonds up to three years maturity in the government securities markets to restore the confidence of investors.

In the first phase of the crisis (2007-09) the Fed introduced new types of assets such as *Term Auction Facility* (TAF) to ease bank lending against collateral for 28 and 84 days. In 2008 the *Commercial Paper Funding Facility* (CPFF) enabled the Fed buying 90-day commercial paper to provide more liquidity for households and firms (Reis, 2009)[22].

The Fed introduced *Operation Twist* in order to ease market conditions which alter transmission channels by selling short-run government bonds and buying long-run bonds instead thus leaving the balance sheet unaffected. The key differences between conducting monetary policy in the ECB and the Fed originated between 2010 and 2012 due to the increased stress on financial markets in the euro area. In the period before, there was not any major distinction among world's central banks. Fed's main interest was the stabilization and boost of the economic cycle through lowering long-term interest rates and *Quantitative Easing* (QE). QE influences bank's reserves by selling or buying securities from banking system to change interest rates. There is a difference in balance sheet's operations among the ECB and the Fed. The Fed purchased US Treasuries, major part of agency debt and agency-backed mortgage backed securitites, in order to affect the yields of distinct portion of assets especially firm's and household's bonds. Contrary, the ECB had to answer the imbalances in banking sector due to financial flows into the Southern member states by long-term repo operations that affected ECB's balance sheet (Joyce et al., 2012).

QE mostly consists of purchasing assets and lending operations. Whilst, credit easing represents particular type of QE since it targets concrete interest rates or improving

[22] An advantage of TALF is that these facilities are not desirable by agents once the market conditions would be normal again. So the borrowers would not be willing use these funding facilities after the markets restore. (Kohn, 2009)

market situation. One of the reasons why the ECB and the Fed had used different unconventional tools is the special role of banking system in the Euro zone, whilst bond market is more important in the US. Among first steps of the ECB was the extension of bank lending operations, whereas the Fed decided for outright asset purchases. The first Fed's launch (2008-09) is known as QE1 and was designed to restore especially credit housing markets. These asset purchases almost doubled US monetary base and were composed of *Government-sponsored enterprise debts* (GSE), *Mortgage-backed securities* (MBS) of GSEs and *long-term Treasury securities* (Neely, Fawley, 2013).

To enhance lowering the interest rates the Fed introduced *Maturity extension program* (MEP) in 2012 through which it would buy long-term Treasury securities and sell the same amount of short-term Treasury securities (Bernanke, 2012). The Fed's *Large-scale asset purchases* (LSAPs) were designed to lower private rates on borrowings by buying large amount of assets with medium to long maturities. LSAPs lower the supply of long duration assets to private sector (i.e. mortgage securities) (Gagnon et al., 2011). There is evidence that LSAPs had positive impact on long term interest rates of securities (i.e.Treasuries, MBS and corporate bonds). Moreover, LSAP1 together with LSAP2 increased the real GDP level by three percentage points and there are some models that estimate that inflation increased by one percentage point compared to what it would have been without these purchases. The ECB's fixed-rate full allotment is considered as more effective compared to the Fed's LSAPs (Joyce *et al.*, 2012). Bernanke (2012) argues that forward guidance is a useful communication tool in the crisis. According to him, it helped to form and to lower expectations of private sector because longer term interest rates decline which should ease situation in the financial markets.

In order to speed up the process of economic recovery, the Fed took responsibility for credit risk of US private investors. Contrary, the ECB decided to restore financial markets and helped to indebted countries by SMP and LTROs on a large scale, while simultaneously wanted to minimize its own risk. The ECB did not decide to introduce QE but the SMP provided the unconstraint liquidity flow to banks. Another issue raised by the crisis is the ECB's degree of transparency which worsened since 2007 mostly due to the SMP. Nevertheless, the information published by the ECB about the volume of weakly purchased bonds did not specify maturity, composition or purchasing plans for the future. In contrast, the Fed is precise in information provided to economic agents about its QE launches. The increased value of balance sheets tripled in the case of Fed and doubled in the case of ECB but it provides no information about balance sheet's quality. The amount of loans to banks by the Fed was much smaller than in the case of the ECB which had to lend to banks with worsened access to the market funding. Further, the Fed decided for QE to reduce the risk-free interest rate and the ECB decided rather for credit easing. The

Fed purchased especially US risk-free government bonds or assets, while the large part of the ECB's balance sheet was composed by LTROs (Gros et al. 2012).

To compare what types of non-standard measures each CB introduced see the table 1:

Table 1: Non-standard measures – Fed, ECB

Federal Reserve System:	**European Central Bank:**
Term Auction Facility	Long-term Refinancing Operation
Commercial Paper Funding Facility	Fixed rate full allotment
Mortgage-backed Securities	Covered Bond Purchase Program
Maturity Extension Program	Overnight Monetary transactions
Large-scale Asset Purchases	Securities Market Program

To conclude, the period of the US unconventional measures led to the average annual growth rate of economy about 2 percent since 2009, however it represents slower growth than expected. Notwithstanding, FOMC expects higher rate of economic recovery in a couple of next three years. Some parts of markets already recovered; especially housing market, car sales or labor market although the unemployment stays above its natural rate (Powell, 2013). Joyce *et al*. (2012) argue that slow recovery of both the US and Euro zone is due to fact that QE does not work and there should be implemented other measures. Meanwhile, it is obvious that unconventional measures contributed to lower yields on market assets and lower long-run interest rates that positively affected the economy. These measures had effect on the economy; however we cannot be sure about its scale, duration and particular channels.

The US recovery from the crisis seems to be faster that in the case of the ECB. There is some limited evidence that non-standard measures helped to start-up the economy.

3. The model

In this part Taylor rule for the ECB and the Fed is analyzed for time period starting in 1999Q1 until 2013Q1. The aim is to estimate the reaction parameters of inflation and output gaps for both CBs and to compare how these parameters fit the recommended short-term nominal interest rate. The reaction parameters also provide an answer as to whether the ECB and the Fed give higher weight to inflation or output. There is an assumption that the ECB focuses more on inflation gap whereas the Fed more on output gap. Finally, the results should tell us whether the original form of Taylor rule is sufficient in the period of crisis or not. At the beginning, two types of data and shortcomings of Taylor rule are specified. Then there is a description statistics of used data. The method of computation of model is as follows; first the output gap for the ECB and the Fed must be calculated using Hodrick-Prescott filter which enables to estimate potential GDP. Then the inflation gap is calculated and finally the reaction coefficients with lags are estimated. The are many economists who estimated the Taylor rule for the Eurozone, such as Gerdesmeier and Roffia (2003), Belke and Polleit (2006), Sauer and Sturm (2007) or Belke and Klose (2011). Taylor rule can be estimated by using two types of data. The first type of data are *ex post* which are released in the latest publications and the second type are *forward-looking* data which use inflation and output forecasts. Mostly, New Keynesian models work with forward-looking data since Clarida et al. (1999) provided theoretical background. There are different results when using ex post and forward-looking data. Belke and Klose (2011) argue that by using real time data there are higher coefficients on inflation and output gap than in the case with ex post data. As the authors point out, there is a problem with gaining forecast data since they are publically unknown so as the closest source of information we use central bank's projections.

Taylor rule is under scrutiny nowadays and as many agree it should be modified since many CBs reached its ZLB. Some CBs therefore diverted from Taylor´s implications for official interest rate. There are different proposals on what variables in the Taylor rule to include. Very profound suggestion is the one made by Belke and Klose (2011). To deal with ZLB this form of Taylor rule estimates first equilibrium real interest rate (instead of nominal in a classical version) by using state-space-model which enables to work with unobservable variables. There are introduced six equations to find equilibrium real interest rate. Then they add four groups of variables to the model, such as growth of a target monetary aggregate (M2, M3), credit growth, interest rate spreads to measure risk in capital markets and asset price inflation. By using GMM model, they conclude that since the onset of the crisis, the Fed increased the weight of output, while decreasing the weight of CPI. In contrast, the ECB attached higher importance to HICP and less to the

output. We should be able to say whether Taylor rule really works in the time of crisis or whether it fails to provide a trustworthy rule.

3.1. The data and estimation issue

Times series data for the period from 1999Q1 to 2013Q1 are used for estimation of reaction coefficients. For estimating the Taylor rule for the ECB, there is used monthly year-on-year change in the HICP for inflation gap and quarterly data for real seasonally adjusted GDP at market prices to compute output gap.[23] Quarterly data are used since the frequency of data is not important for the results as Belke and Klose (2011) found out. Data for the ECB are taken from the Eurostat database.[24]

In the case of the Fed, there is used consumer year-on-year change in CPI for estimating inflation gap and quarterly real seasonally adjusted GDP at market prices for output gap. The data for the Fed comes from the OECD database.[25] The explanatory variable is day-to-day money market interest rate of the ECB and the Fed. The ECB's money market interest rate is *Euro Overnight Index Average* (EONIA) and the interest rate for the Fed is the Federal funds rate.The fit of actual monetary policy with Taylor proposals is then compared.

In a line with Mehra and Minton (2007) or Orhanides (2001) who estimated three Taylor rules for Greenspan era, the model uses simple linear regression by ordinary least square method (OLS) with backward-looking lagged values for output and inflation gap. Thus, Taylor rule has following form:

$$i_t = \alpha_0 + r_t + \pi_t + \alpha_\pi \pi_{t-1} + \alpha_\gamma y_{t-1} + \varepsilon$$

The equation should satisfy the Taylor principle which is $\alpha_\pi = 1 + \alpha_\pi$, where $\alpha_\pi > 1$. However, in the time of crisis it is expected that the Taylor principle is violated. Constant term α_0 is expected to be equal to zero. Further, it is expected that the proposed value for output gap $\alpha_\gamma > 0.5$ is satisfied.

[24] The website of Eurostat: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/
[25] The website of OECD: http://stats.oecd.org/Index.aspx?QueryId=350#

Along with OLS, there is run non-linear Tobit regression which works with lower level bound for the interest rate. It is very likely that Tobit results will perform better with respect to the selected data.

Null hypothesis for the ECB is that it should attach a greater importance to the inflation gap since its primary objective is to sustain price stability. So the α_π coefficient should be higher than α_γ. Contrary, the Fed has dual mandate so the price stability and the unemployment rate are both important. However, there is some evidence that in the recent crisis the output gap should have a greater importance since the inflation is very low in recent time span so the stabilizing output gains higher importance now. In other words, α_γ should be greater than α_π in the case of the Fed.

3.2. The output and inflation gaps

First, the output gap is estimated for both central banks. The output gap is $gap = y_t - y^*$ or alternatively $Y_t = 100[\log(y_t) - \log(y^*)]$ representing actual output which is below its potential value. However, the potential output is unobservable value so it must be estimated. So the potential output is computed using Hodrick-Prescott filter (HP) which represents one of five methods used by central banks for estimating the output gap.[26] The HP filter separates time series data (y_t) into trend (τ_t) and cyclical component (c_t) .

$$y_t = \tau_t + c_t$$

The aim is to find out the value of c_t which is stationary value which is determined by stochastic cycles. Since c_t represents deviations from τ_t then the basic problem can be rewritten as:

$$\min \sum_{t=1}^{n}(c_t^2) + \lambda \sum_{t=1}^{n}[(\tau_t - \tau_{t-1}) - (\tau_{t-1} - \tau_{t-2})]^2, \text{ where } c_t = y_t - \tau_t$$

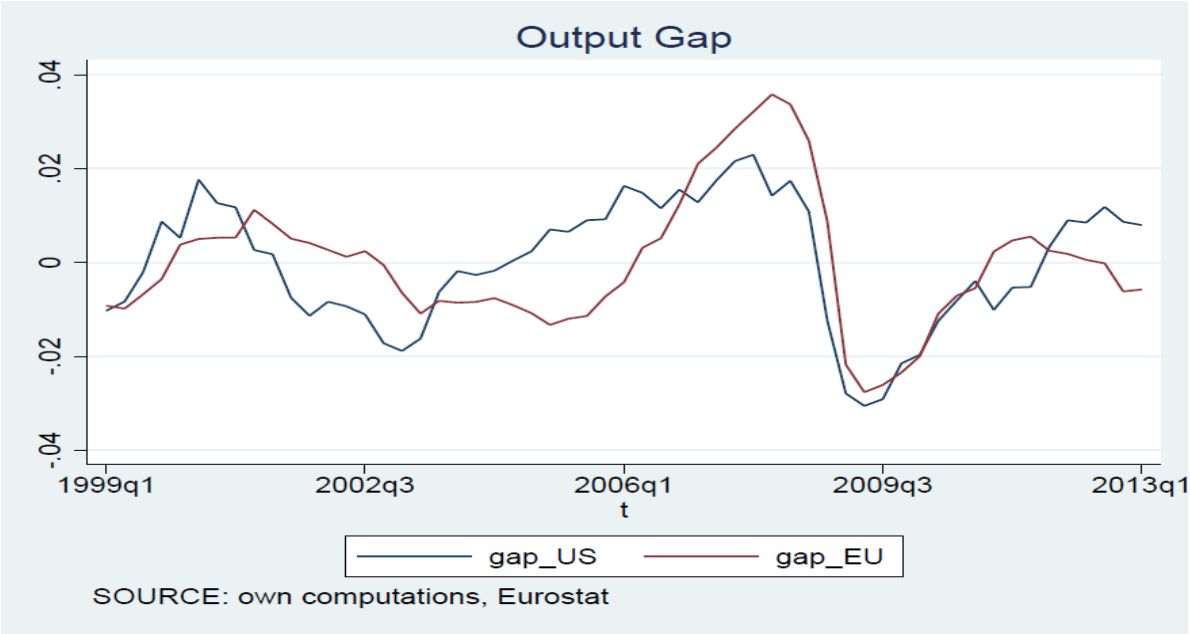
Inasmuch as the trend value usually includes a stochastic trend, the smoothing parameter λ is chosen and for quarterly data it is equal to 1600 (Hodrick, Prescott,

[26] The other four methods used for estimating output gap are; linear method which is the simplest one, then multivariate HP method which incorporates Okun's law and the Phillips curve, unobservable components method which decompose time series to unobservable variables. Last, production function method which usually works with Cobb-Douglas production function (De Brouwer, 1998).

1997). As λ approaches zero, the trend value is equal to time series and as λ goes to infinity, the trend value is linear which means that the potential output growth is constant. HP filter is used in this model since it enables the output gap to be stationary using different smoothing parameters and the trend value can change over time (De Brouwer, 1998).

Output gaps in the Eurozone and US

Chart 1



The estimated results of the output gaps in the US and Eurozone are displayed in chart 1. Results are in a line with Belke and Klose (2012) who estimated output gaps until 2010. First, the performance of euro area economy was somewhat slower after the ECB came into force. Then, the Eurozone economy started to perform better for a while, however it superseded by moderate slowdown until it reached its peak before the sovereign crisis. Subsequent downturn was faster than in the US and recently both economies are slowly recovering. Notwithstanding, the US economy is performing better.

Inflation gap is computed as follows; $\pi_t = 100[\log(\pi_t) - \log(\pi_{t-4})]$ where the inflation target is set to two percent for both central banks, since the ECB has it explicitly as a target value and the Fed sets the same target in its Statement on Longer-Run Goals and MPS (2013). Monthly data of HICP and CPI must be transformed into quarterly data. The choice of frequency data does not affect the result.

In the estimation the HICP, CPI, GDP gaps are independent variables, whereas the nominal interest rate is the dependent variable. The sample period is for both central banks the same so the results can be easily compared. Time series starts in 1999Q1 and ends in 2013Q2 so there are 57 observations in total. To avoid heteroskedasticity and autocorrelation, we use standard robust errors in OLS. Possible multicolinearity does not affect the properties of the model such as its efficiency and unbiasedness. All econometric verification test are attached in the appendix.

3.3. The ECB's Taylor rule

The result of the Taylor rule for the ECB is displayed in table 1 below:

Table 2: OLS estimates for the ECB

OLS estimates using 56 observations from 1999:2-2013:1 (T = 56)

Dependent variable: EONIA

	Coefficient	*Stderror*	*t-stat*	*p-value*	
Const	2,38493	0,236896	10,0674	<0,00001	***
α_π_EU_1	-0,484205	0,351581	-1,3772	0,17423	
α_y_EU_1	0,8102	0,15155	5,3461	<0,00001	***

The estimated OLS Taylor rule is $target\ rate = 2.38 - 0.48(\pi_t - \pi^*) + 0.81(y_t - y^*)$.

The Taylor principle is violated as it was expected. This means that the results do not support assumption that an increase in inflation leads to larger nominal interest rates increase. The inflation coefficient is even negative but insignificant. Its negative value means that the ECB responds to an increase in inflation by a reduction in the interest rate which is in contrast to traditional Taylor rule recommendation. The coefficient for output gap α_y is greater than 0.5 as it was expected and it is equal to 0.81.

The null hypothesis for the ECB is to find out whether it attaches higher weight to inflation gap in order to follow primary objective. The results do not support the hypothesis since the reaction coefficient for output gap α_y is higher than the coefficient for inflation gap α_π. This suggests that the ECB does not follow its primary goal of price stability. Belke, Klose (2012) came to the same conclusion and their explanation is that during the crisis, the ECB rather focuses on stabilizing the economy than following its primary objective.

Moreover, insignificant and negative α_π should support the fact that traditional Taylor rule does not work in the crisis. The nominal interest rate is near its zero bound so it is reasonable to incorporate real interest rate into Taylor rule nowadays.

Due to the problem with ZLB there is the result of Tobit regression for the ECB in table 2 below:

Table 3: Tobit estimates for the ECB

Tobit estimates using 56 observations from 1999:2-2013:1 (T = 56)

Dependent variable: EONIA

Standard errors QML

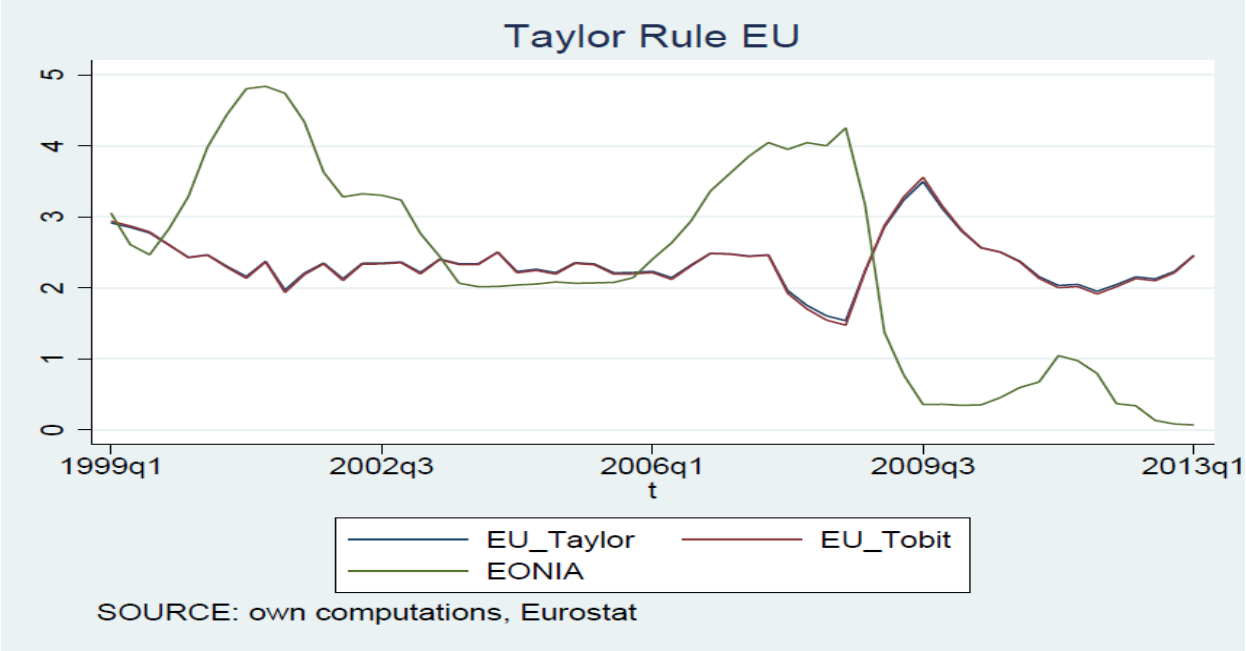
	Coefficient	*Stderror*	*z*	*p-value*	
Constant	2,36872	0,147618	16,0463	<0,00001	***
α_π_EU_1	-0,511072	0,248479	-2,0568	0,03970	**
α_y_EU_1	0,821853	0,10701	7,6802	<0,00001	***

The estimated Tobit Taylor rule is $target\ rate = 2.37 - 0.51(\pi_t - \pi^*) + 0.82(y_t - y^*)$.

The Tobit model is used when the estimated regression is bounded which could be the case here since there is ZLB for interest rate. The estimated results do not alter significantly when using Tobit for the ECB. The only difference with the Taylor rule without a lower bound is that the inflation coefficient is statistically significant.

To see how the ECB monetary policy fits the Taylor rule recommendations and the Tobit model, the results are displayed in chart 2 below:

Chart 2: Taylor rule for the Eurozone



The result of Tobit model and classic Taylor rule do not alter significantly, therefore it is not necessary to add lower bound for interest rate in the case of the ECB. The explanation may be that the interest rate levels did not reach its zero level bounds yet as in the case of the US.

3.4. The Fed Taylor rule

The results of estimated Taylor by using OLS method for the Fed are in Table 3 below:

Table 4: OLS estimates for the US

OLS estimates using 56 observations from 1999:2-2013:1 (T = 56)
Dependent variable: Funds_Rate

	Coefficient	*Stderror*	*t-stat*	*p-value*	
const	2,43696	0,439149	5,5493	<0,00001	***
α_π_US_1	-0,02055	0,367424	-0,0559	0,95561	
α_y_1	0,945466	0,336274	2,8116	0,00690	***

The estimated OLS Taylor rule is $target\ rate = 2.44 - 0.02(\pi_t - \pi^*) + 0.95(y_t - y^*)$.

The results are very similar to the results of the ECB and there is same pattern. The Taylor principle is also not fulfilled. The output gap coefficient is slightly higher than in the case of the ECB which means that the Fed pays somewhat more attention to

stabilizing of the economy. In the case of the Fed the α_γ result supports the null hypothesis for the Fed. The inflation coefficient is also negative and insignificant. Nevertheless, α_π is much smaller than in the case of the ECB. Thus, both central banks follow similar policy according to traditional Taylor rule. The explanation could be that they have coordinated their policy actions recently.

To conclude, the Taylor principle which sets $\alpha_\pi > 1$ is violated which means neither the ECB nor the Fed do not fulfill Taylor principle. Nevertheless, this is expected result in the time of financial distress. Notwithstanding, the results further suggest that there might be omitted variable bias. This result corresponds with recent works on Taylor rule. The conclusion made here is to include other variables into the regression as suggested earlier in this chapter. The reason for that is that during the crisis there are other variables affecting the interest rate significantly, such as the monetary aggregates, credit growth, interest rate spreads (to measure risk in capital markets) and asset price inflation. It is worth noting that the Fed's dual mandate is being often criticized also by the Fed, however as results show the ECB does not act significantly differently and it does not follow its primary objective.

Tobit model works better for the Fed than for the ECB. The results are in table 4:

Table 5: Tobit estimates for the US

Tobit estimates using observations from 1999:2-2013:1 (T = 56)
Dependent variable: Funds_Rate
Standard errors QML

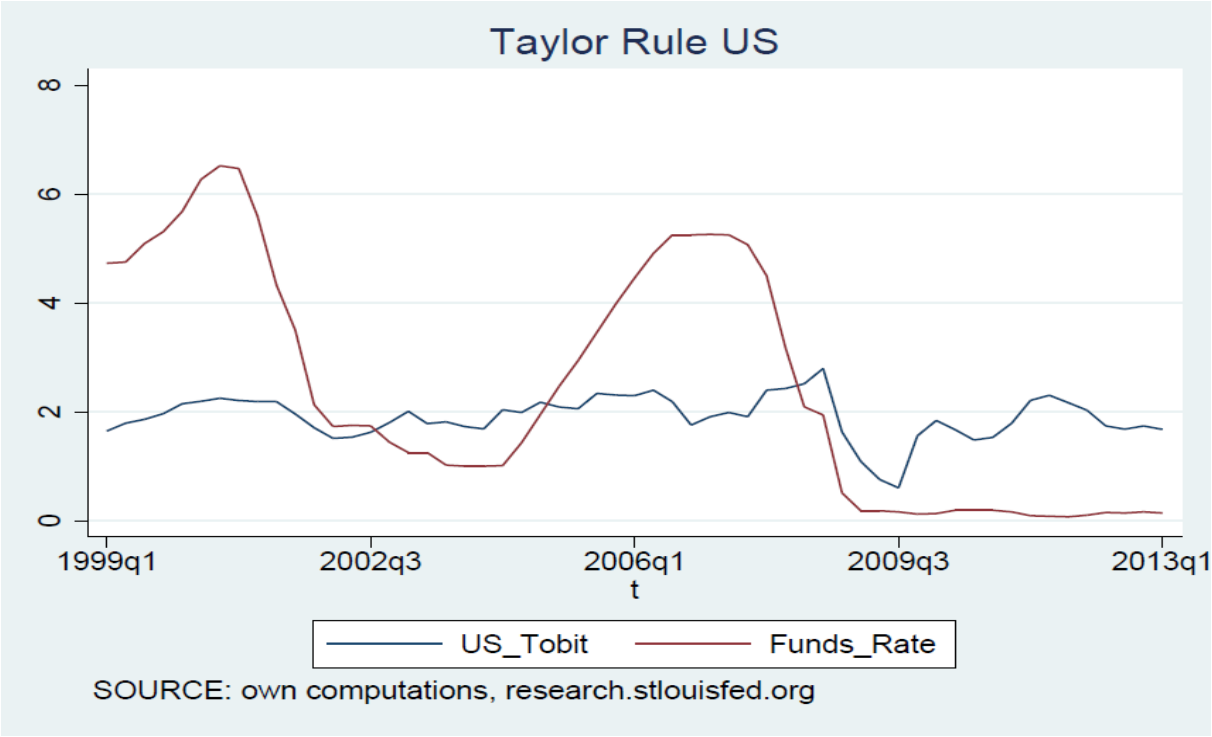
	Coefficient	*Stderror*	*z*	*p-value*	
const	1,76106	0,448535	3,9262	0,00009	***
α_π_US_1	0,313559	0,451041	0,6952	0,48694	
α_γ_US_1	1,13654	0,33397	3,4031	0,00067	***

The estimated Tobit Taylor rule is $target\ rate = 1.76 + 0.31(\pi_t - \pi^*) + 1.14(y_t - y^*)$.

Inflation coefficient turns out positive but remains insignificant which is in contrast to the ECB. Inflation coefficient by using OLS is very close to zero but it is relatively much greater by using Tobit. This suggests that the Tobit model is better than OLS in the case of the Fed. After adding real historical values to the estimated Taylor rule functions, it is reasonable display only Taylor with Tobit model in graph, since inflation coefficient in OLS method is very low, thus the relationship gets more linear form than with Tobit model.

The fit of estimated Taylor rule using Tobit model is displayed in chart 3 below:

Chart 3: Taylor rule for the US



As it can be seen the funds rate never fits to estimated Taylor rule. From 1999 to 2002 the funds rate remained too high, however after the peak around 2000 it started to decrease until it reached values lower than the estimated Tobit suggests. Around 2005 the funds rate started to increase again and remained relatively high until 2008 and since that time stayed slightly above its zero level bound.

To conclude this chapter, it seems that both CBs act somewhat similar. The Taylor rule principle is violated by both cases. Both CBs focus more on stabilization of the output gap rather than inflation. However, the result of the Fed is expected, contrary to the ECB. Tobit model makes more sense in the case of the Fed which could be explained by the fact that its interest rates were lower compared to the ECB. Neither of the banks follow Taylor rule in practise. However, there is a suggestion to add other variables to the classic Taylor rule, since it does not work properly in the times of the crisis.

4. Conclusion

Firstly, the ECB and Fed were compared theoretically pursuant their policy objectives, strategies, tools and non-standard measures. Secondly, there is empirical comparison of their fit to the Taylor rule and whether they attach higher weight to inflation or output gap in reality.

To conclude the main differences between the ECB and the Fed, there are distinctions in the CB's institutional structure and history. The role of the Fed is somewhat easier since the ECB must conduct monetary policy of sovereign states and there is not any fiscal counterpart. In contrast with the ECB, the Fed follows dual-mandate. It is harder to have two policy goals, especially when there is not any ranking and when they are not quantitatively defined. The desired level of employment is not specified and the FOMC rather focuses on maximum economic growth. The Fed and the ECB use different measures of price stability, the HICP used in euro area can be perceived as inadequate measure.

Though, the policy tools are somewhat similar there are few differences such as the types of purchased assets. Further, the ECB does not pay interest on overnight deposits in contrast to the Fed. The fed has limit on amount of borrowings at discount rate, however the ECB does not constraint standard facilities.

Another distinction is in dissimilar view on the role of monetary aggregates in the monetary policy strategy. In contrast to the Fed, the ECB has a unique pillar for M3 and thus attaching monetary aggregate much greater weight. The Fed perceives M2 only as economic indicator, while the ECB targets M3 itself.

Transmission process is very important in order to conduct monetary policy. However, since the ECB's primary objective is to maintain price stability it is very important to know precise effects of change in its policy, its magnitude and timing. The Fed has dual-mandate so it alters the real economy also via other instruments than by change in expected inflation. The effectiveness of the monetary policy depends more on the labor markets characteristics and prices developments in the Euro zone, meanwhile more on the expectations of the future inflation in the US. The policy communication and transparency is more important in the US than in the euro area.

In the crisis both CBs introduced distinct non-standard measures. There was similar pattern in the first phase of the crisis (2007-09). Then, the euro area was hit by financial

instability and sovereign debt crisis. In the second phase strating in 2010, the Fed introduced QE and boosted economy via lowering of long-term interest rates. The ECB and the Fed employed different balance sheet operations. The Fed purchased mostly US Treasuries to affect firm's and household's bonds, while the ECB dealt with bank's imbalances and chose to use long-term repo operations. The reason why the CBs chose different balance sheet operations is the different role of banking sector. The ECB rather used credit easing instead of QE. In contrast to the Fed, the ECB's transparency worsened since 2007 because there were no precise informations about purchased bonds. The Fed provided smaller amount of loans to the banks than the ECB. The Fed purchased US risk-free Government bonds, while the ECB decided rather for LTROs. Empirical experience with these measures is short so it is difficult to evaluate their efficiency but the Fed perceives to be still more efficient. The Fed is also more transparent CB than the ECB.

To conclude, neither the ECB nor the Fed fits the Taylor rule recommendation. There are numerous reasons for why it is so. Even though both CBs are interest rate rule orientated, they rather use the Taylor as recommendation but follow own decisions about the target rates. This approach is reasonable, but the question remains if it is really worth to use Taylor in the CB's analysis when it is mostly never followed. The answer could be found in the recent research papers by many economists who argue that it is better to use forward looking data instead and to add other variables since the financial markets affects the monetary policy efficiency much more nowadays. Hence, the solution could be to stay with interest rate targeting but upgrade the Taylor rule so it is more flexible and to incorporate other theoretical approaches such as the New Keynesian economics.

The ECB is often criticized for somewhat ambiguous definition of its primary goal and for its monetary strategy inter alia. There also lacks transparency and communication with public as in the case of the Fed. The efficiency of non-standard measures is not clear yet, however there is some evidence that the Fed is more effective. Despite all the criticism, these all complaints should be seen as challenges and motivation for improvement. Considering, the ECB's history and the heteregeneity of euro area, it is more than obvious that it needs a lot of effort to make things working.

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Appendix

Table 6: Statistical tests of OLS estimates using 56 observations from 1999:2-2013:1 (T = 56)

Dependent variable: EONIA

Mean of dependent variable	2,362486		Standard deviation of dep.variable	1,446741
Sum of squared residuals	66,38246		Standard error of estimates	1,119151
Coefficient of determinancy	0,423354		Adjusted R-squared	0,401594
F(2, 53)	21,00845		P-value(F)	1,91e-07
Log likelihood	-84,22283		Akaike criteria	174,4457
Schwartz criteria	180,5217		Hannan-Quinn criteria	176,8013
rho (coefficient of autocorrelation)	0,962607		Durbin-Watson stat	0,111022

Table 7: Statistical tests of Tobit estimates using 56 observations from 1999:2-2013:1 (T = 56)

Dependent variable: EONIA

Chi- square test(2)	97,09229	p-value	8,25e-22
Log of likelihood	-85,31441	Akaike criteria	178,6288
Schwarz criteria	186,7302	Hannan-Quinn criteria	181,7697

sigma = 1,12655 (0,0882874)
Left-censored observations: 3 (EONIA <= 0,25)
Right-censored observations: 0

Test normality residuals -
Null hypothesis: errors are normally distributed
Testing stat: Chi – square test (2) = 13,3322 with p-value = 0,00127337

Table 8: Statistical tests of OLS estimates using 56 observations from 1999:2-2013:1 (T = 56)

Mean of dependent variable	2,413571		Standard deviation of dep. variable	2,170509
Sum of squared residuals	173,2224		Standard errors of estimates	1,807857
Coefficient of determinancy	0,331474		Adjusted R-squared	0,306247
F(2, 53)	10,26601		P-value(F)	0,000170
Log of likelihood	-111,0788		Akaike criteria	228,1577
Schwarz criteria	234,2337		Hannan-Quinn criteria	230,5134
rho (coefficient of autocorrelation)	0,936832		Durbin-Watson stat	0,113232

Table 9: Statistical tests of Tobit estimates using observations from 1999:2-2013:1 (T = 56)

Dependent variable: Funds_Rate
Standard errors QML

Chi – square test(2)	37,30931	p-value	7,91e-09
Log of likelihood	-100,0368	Akaike criteria	208,0737
Schwarz criteria	216,1751	Hannan-Quinn criteria	211,2146

sigma = 2,24899 (0,220306)
Left-censored observations: 17 (Funds_Rate <= 0,25)
Right-censored observations: 0

Test normality residuals - Null hypothesis: errors are normally distributed
Test statistics: Chi - square(2) = 13,572 with p-value = 0,00112946