Mendel University in Brno
Faculty of Business and Economics

Comparison of monetary policies of the ECB and selected European national banks in the crisis period

Diploma thesis

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Declaration

Herewith I declare that I have written my final thesis: **Comparison of monetary policies of the ECB and selected European national banks in the post-crisis period** by myself and all sources and data used are quoted in the list of references. I agree that my work will be published in accordance with Section 47b of Act No. 111/1998 Coll. On Higher Education as amended thereafter and in accordance with the *Guidelines on the Publishing of University Student Theses*.

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Abstrakt

Niederle T. Srovnání monetárních politik Evropské centrální banky a vybraných evropských centrálních bank v období krize, diplomová práce, Brno: Mendelova univerzita v Brně, 2015.

Tato diplomová práce se zabývá vlivem monetární politiky na ekonomický výkon v eurozóně, v České republice a v Polsku. Studie se soustředí na rozdílné reakce ekonomického výstupu na změny v měnové zásobě v podobě peněžních agregátů M1 , širšího agregátu M2 a reálných úrokových mírách vypočtených z hodnot EURIBOR, PRIBOR a WIBOR. Tyto rozdíly jsou zkoumány s použitím Grangerovy kauzality. Výsledky prezentují statistické důkazy o vlivu měnové zásoby a reálné úrokové míry na reálný výstup v Eurozóně, v České republice a v Polsku ve smyslu Grangerovy kauzality. V práci jsou také měnové politiky porovnávaných centrálních bank popsány a vzájemně porovnány využitím Taylorova monetárního pravidla

Klíčová slova

Monetární politika, Grangerova kauzalita, Taylorovo pravidlo, reálný produkt, Evropská centrální banka, Česká národní banka, Polská národní banka

Abstract

Niederle T. Comparison of monetary policies of the ECB and selected European national banks in the post-crisis period, Diploma thesis, Brno: Mendel University in Brno, 2015.

This diploma thesis investigates the impact of monetary policy upon economic performance in the Eurozone, the Czech Republic and Poland. The research focuses on differences in sensitivity of output on money supply in form of monetary aggregates M1 and broader M2 and Real Interest Rate calculated from the EURIBOR, PRIBOR and WIBOR. The sensitivity is examined using Granger causality. The thesis proves whether money supply and real interest rate granger causes real output in the Eurozone, the Czech Republic and Poland. Also monetary policies of the selected central banks are described and compared using Taylor monetary rule.

Keywords

Monetary Policy, Granger Causality, Taylor Rule, Real Output, the European Central bank, the Czech National Bank, the National Bank of Poland

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1 Introduction and Motivation

The integration process of the European Union as well as the Eurozone has been an extensively discussed topic over the last few decades. All members of the European Union have agreed to transfer part of their national sovereignty to the supranational organizations. Almost all member states, except of Denmark and the United Kingdom, have already transferred their monetary policy authority to the European Central Bank by adopting the euro as their official currency or are bound to join the Eurozone in the future because of their liabilities connected with entering to the European Union.

When the financial crisis spread from the United States of America across the ocean and transformed into the economic crisis in the European Union and its member states in 2008, the new questions raised about ability of the monetary union and its monetary authority to react in efficient way and reduce the impact of the crisis over its economy and economy of its members. Other European countries with their own independent monetary policy authorities were affected directly by the economic crisis as well. Unusual circumstances for central banks have been brought by it. This crisis therefore created amazing opportunity to examine how particular central banks will act and what effect it will have on their economies.

My motivation for writing a diploma thesis on the topic *"Comparison of monetary policies of the ECB and selected European national banks in the post-crisis period"* is based on this occasion. The consequences of the European Central Bank actions to the Eurozone area could be compared with the consequences for the selected members of monetary union and also with the actions of national banks of the EU member states that stand out of the authority of the ECB with their own currency and independent monetary policy. These policies should be compared and evaluated within this thesis. Countries from the similar geographic region are chosen for this comparison. Therefore impact of the ECB to Germany, as the biggest Eurozone's economy, and to Austria, as an example of small open economy member of the Eurozone should be compared with the actions of the National Bank of Poland and the Czech National Bank and consequences for their economies.

The Diploma thesis should not only answer the questions whether the economic performance of selected European countries were similarly reacting on the monetary policy actions of the compared central banks or their reactions somehow differed, but the thesis should evaluate an impact of these central banks upon economic performance as well.

The thought of potential acceptance of the Euro as national currency in the Czech Republic and in Poland is also often discussed topic in these countries. Opponents of euro acceptance use frequently an argument that loosing of ability to manage independent monetary policy is large cost of the euro acceptance and it is better to remain for these states with its own currency. It is hoped that the Diploma thesis should contribute to the this larger discussion concerning the impact of the Monetary policy over the economic performance within the Eurozone, its members Germany, Austria and countries that are obliged to entry the monetary union in future, the Czech Republic and Poland.

2 Objectives and Methodology

2.1 Objectives of the thesis

The diploma thesis *"Comparison of monetary policies of the ECB and selected European national banks in the crisis period"* focuses on the impact of monetary policy over economic performance of selected European economies. First of all it evaluates historical data of the Eurozone as a whole economy and effects of the monetary aggregates policy on it and compare it not just to the other European economy systems of the countries with independent national monetary policy makers in case of the Czech Republic and Poland, but the thesis also compare Eurozone monetary policy effects over selected members of the Eurozone. Germany and Austria were nominated as representatives of the member states over which the effects are examined.

Findings of the thesis should consist of answer to the main research question:

1. *What are essential differences among the Eurozone's, Czech and Polish economies responsiveness to the monetary policy set by their monetary authorities?*

The thesis should answer other partial research questions as well. These are as follows:

1. *Do selected central banks drive similar monetary policies? Does exist any crucial differences among them?*
2. *Is monetary policy effective in case of selected European economies? Does historical quarter data obtained for periods from 1999 to 2013 and from 2009 to 2013 give prove of expected responsiveness of the output to the monetary policy manipulation as it should according to the economic theory in selected compared European economies?*
3. *How is the common monetary policy effecting economies of particular member states of the Eurozone?*

The thesis also compare and evaluate selected banks approach to the Taylor monetary rule. Could the Taylor rule be a good lead for these central banks?

2.2 Methodology used in the thesis

For the purpose of the diploma thesis research, the empirical study includes multivariate regressive modelling in sense of Granger causality. Taylor rule and its comparison with actual short-term interest rates for the Eurozone, the Czech Republic and Poland are also examined in the thesis. At the last but not least the comparative and deductive methods are used as well.

The structure of diploma thesis "*Comparison of monetary policies of the ECB and selected European national banks in the crisis period*" is as follow:

First chapter "1 *Introduction and Motivations*" and chapter two – "2 *Objectives and Methodology*" are introduction chapters and contain motivation of the author, objectives of the thesis, and thesis methodology.

Chapter three "3 *Literary review*" contain theoretical background for the purpose of the further research. The chapter is important to comprehend elementary backgrounds of the monetary policy, central banking and models used further in the thesis. The results of similar researches and its comparison is also included in this chapter.

Chapter four – "4 Empirical Analysis" as main part of the thesis is connected with research of the historical data of compared economies. The chapter contains four main sub-chapters. Nominal data used for the research were obtained from the statistical databases as follow:

- EUROSTAT database
- European Central Bank
- Česká Národní Banka (Czech National Bank)
- Narodowy Bank Polski (National Bank of Poland)

These observed data were deflated to the real form by Harmonised Index of Consumer Prices 2005 deflators of the particular examined economy.

First sub-chapter "*4.1 Inflation targeting and application of the Taylor rule over compared economies"* deals with monetary strategy in sense of inflation targeting of the compared central banks and associates actual inflation during observed period with target inflation. This is done because inflation targeting is currently believed in the mainstream economic theory to be an optimal stabilization monetary policy. Second part of this sub-chapter elaborates Taylor rule which represent a monetary rules as a guideline for central banks. That means that it allows central bankers to calculate

an interest rate that should be used for current economic conditions using relatively simple formula. In this section actual interest rates of the ECB both for whole area particular compared members Germany and Austria, the CNB for the Czech Republic and the NBP for Poland are compared with the Taylor rule recommendations.

Second sub-chapter – "*4.2 Unit root of compared time series*" is concerned with a feature of processes that evolve through time that can cause problems in statistical inference involving models from the obtained time series of economic data. Time series used in this thesis must be deprived of a common trend for further examination in the thesis and thus they could be considered stationary. For this purpose, time series are tested with Augmented Dickey–Fuller test for stationary process whose joint probability distribution does not change when shifted in time. The testing procedure for the ADF test is as follow:

$$\Delta y_t = \alpha + \beta_t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \delta_{p-1} \Delta y_{t-p-1} + \varepsilon_t \quad (1)$$

The equation (1) contains α as a constant, β as the coefficient on a time trend and p as the lag order of the autoregressive process. Imposing the constraints $\alpha = 0$ and $\beta = 0$ corresponds to modelling a random walk and using the constraint $\beta = 0$ corresponds to modelling a random walk with a drift. The unit root test is then carried out under the null hypothesis $\gamma = 0$ against the alternative hypothesis of $\gamma < 0$. The chapter also deals with the non-stationarity in form of common trend if it is observed within any researched time series.

Sub-chapter 4.3 *"Granger Causality among variables of the Eurozone, the Czech Republic and Poland"* is related to the influence of changes in real interest rate and monetary supply that is represented by monetary aggregate M1 and broader M2 aggregate upon economy growth in sense of real gross domestic product in two different periods. The first period is longer and should be statistically more precise. This period contains quarter data from first quarter 1999 to the fourth quarter 2013. This longer period is furthermore called long period. The second period is concerned by the influence of variables M1, M2 and RIR on the GDP within the years 2009 and 2013. This shorter period is called furthermore in the thesis post-crisis period. Author is aware of the fact that post-crisis period of time is probably too short for showing significant results, but it is tested anyway. As a basic interest rates for calculations of real interest rates are used tree-month EURIBOR rate as Eurozone representative interest rate, tree-months PRIBOR rate as Czech representative interest rate and tree-months WIBOR rate as Polish representative interest rate. The influence of the variables are for the purpose of this thesis examined with multivariate regression analysis in sense of Granger causality. Granger causality is examined also for added lagged values of selected stationary variables from one to six lags for

demonstrating association in sense of Granger causality between real monetary aggregate M1, real monetary aggregate M2 and real gross domestic product (real GDP) and for modelling causal relationship between real interest rate (RIR) and real gross domestic product.

Every sub-chapter of chapter four includes also a summary of results.

The fifth chapter *"5 Discussion"* and sixth chapter *"6 Conclusion"* are concluding chapters that summarises the results and provides recommendations for economic policies of analysed economies.

The following chapter "7 References" contains a list of authors in alphabetical order and their literature that has been used as a theoretical background for completing this thesis. Appendixes containing complete results of the Granger causality testing and correlograms of time series used for purpose of this thesis are placed at the end of this thesis in the Appendix A Correllograms and Appendix B Granger causality.

3 Literature Review

The purpose of the literature review in this diploma thesis is to gather information about possible ways of monetary policy that can be applied by central banks and also historical researches on this topic, the structure and aims of the European Central Bank (the ECB) for the Euro Area, Germany and Austria and other selected European national banks – the Czech National Bank (the CNB) for the Czech Republic and the National Bank of Poland (the NBP) for Poland.

3.1 Monetary policy

Monetary policy belongs with a Fiscal policy among state policies which purpose is to influence and guide healthy economic grow. Monetary policy has an important role in determining the inflation rate, especially over the long term, because the inflation rate in the long term is crucial to manage the money supply. Taylor and Weerapana (2012) point importance of monetary policy on negatively correlated inflation with long term economic growth and they also shows it on theory of economic growth. This theory proposed by them tells that a lower capital growth and lower technological growth reduce economic growth. Monetary policy makers prefer to implement anti-cyclical policies to minimize fluctuations in the GDP. The main power over the monetary policy is embodied to the central banks with different independence over state government – the ECB, the CNB and the NBP for purpose of this thesis.

Mandel and Tomšík (2003) have identified three internal macroeconomic goals of monetary policy (natural rate of unemployment, continuous and adequate economic growth and stable price level growth) and one external goal (balance of payments equilibrium).

Fender (2012) introduces three strategies for achieving monetary policy macroeconomic objectives:

- Inflation Targeting
- Monetary Targeting
- Nominal Income as a Target.

The Inflation Targeting became to be a primary goal for the most European central banks including the ECB, the CNB and the NBP since 90s of the 20th century. The stable price level stability has been defined by Alan Greenspan (1996) as situation when inflation is so low than economical subjects do not take it into consideration

when they create prediction of future prices of their goods and services. Two percent growth is commonly considered as stable rate. Fender (2012) assumes combination of inflation targeting and nominal GDP targeting to be the most reasonable alternative for central banks. At the same time he points that it has so far not been tried by any central bank and it is not advocated by any serious commentators as he has added.

The control of monetary aggregates M2 (currency, checking deposits, time deposits, saving deposits and other deposits on which check writing is limited or not allowed) stock or M3 (M2 plus large time deposits, institutional money market funds, short-term repurchase agreements and other larger liquid assets) stock were seen as primary target of monetary policy before the modification of monetary policy into inflation targeting. Money stock targeting still survives as an important part of the monetary policies of the central banks and even the ECB, which primary policy is run to inflation targeting, has built second pillar of its policy on the monetary aggregate M3 growth (Polouček, 2003).

The reason for leaving the Monetary targeting since 90s of 20th century is described by Miles, Scott and Breedon (2012) as the problem of money creation power of commercial banks through their credit policies, rather than something that is under the direct control of central banks. Central bank can use interest rates only to influence the cost at which a commercial bank can borrow and cannot be fully certain whether this cost change in lending rates will affect demand for loans.

Mandel and Tomšík (2003) sees two problems that could be connected with set lower inflation target on the lower level than needed in case of smaller economies. Firstly the central bank could be forced to keep output gap in the economy to create disinflationary pressure and the second problem could be higher interest rate that leads to capital inflow to the economy and thus to the appreciation of exchange rate and negative effects on the export.

3.1.1 Practical aspects of the money's role in the economy

Money provides an essential foundation for economy. It delivers a three important functions within it:

- Medium of exchange
- Unit of account
- Store of value

Taylor and Weerepana (2012) defines money as: *"...that part of a person's wealth that can be used readily for transactions."*

Nowadays, money supply is defined as the sum of currency and deposits at banks and this definition just vary about types of deposits what should be included (monetary aggregates M1, M2 and M3). The relationship between money supply and economic output is summarized within the Quantitative Theory of Money.

The Quantitative Theory of Money states that money supply has a direct, proportional relationship with the price level. The Quantity Equation of Money is the equation relating the price level with the real gross domestic product (real GDP), to the quantity of money on the market (Money supply) and the velocity of money. The real GDP is a nominal gross domestic product in prices of the current period deflated by inflation to the prices of the selected base year (GDP deflator). The term velocity measures how frequently money is turned over in the economy. Modern equation was developed by Irving Fisher in 1930 (Friedman and Schwartz, 1982):

$$Money\ supply \times velocity\ of\ money = GDP\ deflator \times real\ GDP \quad (2)$$

The Quantity Equation of Money indicates how an increase in the money supply is related to increase in the GDP deflator (inflation) under condition that velocity and real GDP are not affected by this change. Taylor and Weerapana (2012) have pointed that according to the quantity equation, along a long-run economic growth path in which real GDP is equal to potential GDP growth, an increase in money growth will result in increase in inflation of the same size unless velocity changes.

As McCallum and Nelson (2011) emphasize the Quantity Theory of Money focus on the prediction of a long-run proportionate reaction of the price level to an exogenous increase in the nominal money stock. The nominal homogeneity conditions that deliver the quantity-theory result are the same as those that deliver monetary neutrality, an important principle of monetary policy formulation. They stress that the Quantity Theory of Money implies a ceteris paribus unitary relationship between money growth and inflation.

Miles, Scott and Breedon (2012) describe similar performance of different monetary aggregates as only theoretical concept. In practice they should behave in different ways. Therefore it is not easy task for the central bank to recognize which monetary aggregate is the right one to create policy targeting on it. Central banks debated to the relative merits of each monetary aggregate and they often switch from one monetary aggregate to another. However, none of them proved reliable. According to this

experience the Goodhart's Law was recognized. This law says that *„any observed statistical regularity will tend to collapse once pressure is placed upon it for control purposes"* (Goodhart, 1984) Therefore this statement could be understand that any observed regularity between a monetary aggregate and inflation will break down in exactly the same time when central bank choose to exploit this aggregate for purposes of the Monetary Policy.

Czech economist Kapounek (2011) argues that the stable money demand function is crucial for predictable impact of the money supply on the macroeconomic variables such as inflation and real economic growth. The author describes instability of money demand according to assumptions of money endogenity. Hence, central banks have just a particular influence over money supply, they cannot fix the stock of money in the country. He proves his statements on the empirical data observed in Europe in period from September 2008 to end of the 2009 when despite the ECB ran strong monetary expansion by lowering official interest rates to historical minimum, there has been no increase in the intermediate and broad money.

The interest rate is still the most important instrument for the central bank policy makers. It is related positively to inflation and negatively to output. Under normal conditions a cut in interest rates should give a short term improvement in economic activity that will soon be offset by grow of the price level – inflation. Therefore lowering short-term interest rate should give to the economy a short-run "lift" and vice versa.

John Taylor (1993) designed a nowadays well known formula that could be easily applied to calculate optimal short-term interest rate in case when formula fits to current conditions of the economy for which is rate calculated. This formula is named after its designer – the Taylor's rule, and belongs among monetary policy rules that can be used to assistant in policy maker's decisions.

On the other hand Swedish famous economist Lars Svensson (2003) recommends using of instrumental rules such is the Taylor rule only as guidelines and he considers them to be inadequate for monetary policies driven by central banks in Europe. His criticism of the monetary rules is primarily based on the fact that their formulation is backward looking description of inflation targeting and they should not serve as a normative recommendations for future monetary policy creation.

In Svensson (2000), author also compare the strict inflation targeting monetary strategy with flexible inflation targeting, where monetary policy strategy has additional objectives. His results indicate that strict inflation targeting implies a strong use of the direct exchange rate channel for stabilizing inflation for short period of time. On the other hand, flexible inflation targeting ends up stabilizing inflation for

longer period, and thereby stabilizes real exchange rates and other variables to a significant range. He states that in comparison with the Taylor rule, the inflation targeting in an open economy responds to more information, in particular to foreign disturbances.

Taylor (2001) argues that a monetary policy rule that reacts directly to the exchange rate, as well as to inflation and output, sometimes works worse than policy rules that do not react directly to the exchange rate and it could avoid more unpredictable fluctuations in the interest rate. On the other hand Taylor (2002) indicates that monetary policy in open economies is different from that in closed economies. Open-economy policymakers seem averse to considerable variability in exchange rate. In his view they should target a measure of inflation that filters out transitory effects of exchange rate fluctuations.

3.1.2 The Transmission Mechanism

The monetary transmission mechanism is one of the most studied areas of monetary economics. It is the process through which monetary policy decisions are transmitted into changes in real GDP and inflation. Financial market changed their way of function over last thirty years dramatically. Hence, the conduct of monetary policy has changed in dramatic ways as well with increasing focus on price stability. Monetary policy fluctuations are uncertain and work with the lag. Hence an understanding to the transmission mechanism of monetary policy current decisions and also how they perform in present and they will perform in the future real economy is essential for realizing of a quality and successful monetary policy by central banks. Fender (2012) publicised following seven impacts of monetary policy by which aggregate expenditure components of real economy could be influenced:

4. Direct Effects on Consumption
    4.1. Substitution effect of individuals consumption
    4.2. Income effects for borrowers and lenders
    4.3. Change in consumption of credit-constrained individuals when interest rates change.
5. Direct Effects on Investment
6. Effects of Higher Share Prices
    6.1. Rise of consumption because of the wealth effect of higher share prices
    6.2. Rise of investment through "Tobin's q"[1] effect

[1] Tobin's q effect is named after James Tobin (1969) who set q as a market value of firms divided by the replacement costs of capital including factor of interest rate. When the q is high interest rate is

7. Effect of Higher House Prices
   7.1. Wealth effect[2] of change in house prices on consumption
   7.2. A changed relative price of housing tends to change consumption of non-housing goods and services
   7.3. Change of house prices changes the amount of house building
8. Effects of Higher Bond Prices
   8.1. Wealth effect of higher bond prices on consumption
   8.2. A change in bond prices may change the net worth of firms and hence the investment
9. Effects of a Appreciated/Depreciated Currency
10. Effects via Expectations

Other authors such as Boivin, Kiley and Mishkin (2010) categorize monetary transmission mechanism into two basic types of channels. First type is neoclassical channels based on theoretical assumption of financial market perfections and second type is non-neoclassical channel grounded on assumption of market imperfections. Authors based this categorization on their research over data sets of real GDP and components of private expenditure in the US economy in periods from 1962Q1 to 1973-Q3 and 1984Q1 to 2008Q4. Empirical results of the research reveal difference between the periods in the correlation of real GDP growth and private expenditure (positive correlation in the case of first period and negative one in the second). According to the result of their research it could be considered as an evidence of potential differences within different economies over time.

Among neoclassical channels of the Monetary Policy belongs:

- Investment based channels (Interest rates, cost-of-capital and Tobin's q) – These channels states that changes in short-term policy rates affect the cost of capital for consumers and business investments.
- Consumption based channels – Short-term interest rates change affect discounted present values or Tobin's Q for various types of assets, and these

low which means value of firm is high relative to replacement costs of capital. So firm can easily raise money for investment expansion.

[2] Wealth effect is according to Brumberg & Modigliani (1954) is based on exchange between money keeping and demand for non-financial assets. When interest rate gets lower the demand will increase prices of these assets.

changes in the market value of assets induce changes in according consumption. This is called the Wealth effect. In the intertemporal substitution effect is the slope of the consumption profile affected by a short term interest rate change.

- International trade based channels – Changes in short-run policy interest rates induce changes in the exchange rate through uncovered interest parity and portfolio balance effects.

The non-neoclassical channels are known also as „credit view" channels. According to authors (Boivin, Kiley and Mishkin – 2010) classification is as following:

- Regulation induced credit effects – Restrictions on financial institutions such deposit rate ceilings or credit restrictions affect spending through.
- Bank based channels – Banks play a specific role addressing problems of asymmetric information for certain borrowers. Hence, decreases in bank's lending capacity impact spending in economy and vice versa.
- Balance sheet channel – Changes in net worth associated with the asset price effects of monetary actions modify external finance premium facing firms and households.

Real effect of the transmission mechanism of the monetary policy to the economy output was subject of many researches. One of the first econometric attempts to estimate the effect of money appears in the work of Friedman and Meiselman (1963). Authors tested which policy is more important to determining nominal income whether it is monetary or fiscal policy. They compared nominal income, output, price level, autonomous expenditures, monetary aggregates and other variables applicable to nominal income. Authors stated in the conclusion of their research that it exists more stable and statistically significant effect of monetary policy over output than it is in the case of the fiscal policy. On the other hand, the research used nominal income as dependent variable, hence this approach does not directly states how a change in nominal spending is divided between change in real output and the growth of prices.

$$y_t^n = y_t + p_t = y_0^n + \sum_{i=0} a_i A_{t-i} + \sum_{i=0} b_i m_{t-i} + \sum_{i=0} c_i z_{t-i} + \varepsilon_y, \quad (3)$$

Other authors tried examine the transmission mechanism with the approach of Granger causality. Important note about the Granger causality is that it is not a proper causality as philosophy understands it. The Granger causality is a statistical kind of causality referred by author whenever "causality" is mentioned. The methodology of causality in Granger sense (Granger 1969) is built on idea that time series Y Granger cause time series X, relative to vector of time-series including X and Y as components (U), if predictions of X(t) based on U(s) is improved in comparison with

predictions without Y. It means, that it is tested whether coefficients b_i of the equation (2) are equal to zero.

First introduction of the Granger causality idea to the scientific debate over real effect of money over economic output was presented by Sims (1972), the winner of the Nobel Prize in Economic Science for his "*...empirical research on cause and effect in the macroeconomy".* The variable of money supply is said to Granger cause output only if adding lagged values of money helps forecast output, which has been clarified by past values of output. Sims used levels of nominal gross national product of the USA and both M1 monetary aggregate and the monetary base as money supply. He found an evidence that money Granger causes gross national product. According to results of his research he stated that the past behaviour of money supply supports prediction of the future gross national product.

Sims also compared the USA with Germany in his other research (1980) where he used an index of industrial production to measure real output and found explanation of output variation by money was reduced when a nominal interest rate is added to the model, so that y consists of the log price level and an interest rate. Therefore it seems that sensitivity of model's conclusion model is high to the specification of the set of other variables included in the equation. In this research Sims also draw attention to higher sensitivity of the German economy for the shocks than in case of higher and closer economy such as the USA. According to his results it could be expected similar behaviour of the smaller economies such as Czech, Poland and also member states of the Eurozone compared to the Eurozone as whole economy.

Buiter (1981) tested in his research the Granger causality relationships between development of the money supply and output of the economies. Empirical results of his research stated just one side Granger causality from development of the money supply to development of the output, but not vice versa.

Eichenbaum and Singleton found in their research (1986) that money supply seems to be less significant if variables are quantified as their log first differences form rather than in form of log levels with a time trend.

Czech economist Izak (1995 and 1997) performs several Granger causality tests. Input data for his research were in nominal form, they were non-stationary trended and used times series were observed from very short period. The result of the research was identified impact of the broader monetary aggregate M2 to GDP in the Czech Republic without lags, but not vice versa.

Tomšík and Viktrová (2005) point problems connected with use of the data in nominal and non-stationary form. They see results of such a testing as probably biased. To avoid these problems they use in their research analysis stationary time series deflated to their real form (real GDP, real M2 monetary aggregate and as interest rate 1-year PRIBOR). Result of their analysis shows dependence of real M2 on real GDP and real GDP on real interest rate, but not vice versa.

3.1.3 Ineffectiveness of the monetary policy – the Liquidity trap

The global crisis brought back into the economical discussions the term liquidity trap. Many authors slightly differ in the definition of it. Taylor and Weerapaana (2012) describe liquidity trap as: *„…a situation in which increases in the money supply (liquidity) do not lower the interest rate any further; the interest rate is at or near zero."* Miles, Scott and Breedon (2012) explain situation of liquidity trap as extremely low inflation or even deflation and a large output gap at the same time in affected economy.

Central banks cannot decrease nominal interest rate under zero under all circumstances. Hence, Taylor and Werapaana (2012) propose a possible scenario for central banks of economies in the liquidity trap. Central banks can continue to boost the money supply by increasing reserves instead. This is called quantitative easing. Quantitative easing have three identified channels by which it could have a real effect on the economy:

- Expectations channel – Central bank might convince the private sector that economy is more likely to recover and inflation is more likely to rise.
- Excess monetary base channel – Central bank inject excess amount of money into the economy, hence the private sector in general is more willing to invest in non-monetary assets like loans.
- Purchases of financial assets channel – Injection of money into the economy through large scale open market operations. Banks can inject money indirectly focusing on government debt (like in UK after 2008) and as a result encourage investors to sell safe government debt and buy more risky investments. Direct approach[3] (the FED and the ECB after 2008) means purchasing risky assets directly.

Svensson (2003) suggested to focus on expectation channel to deal with liquidity trap. Recommended instrument for escape from this critical position of the economy for the monetary policy according to author is an expected future real interest rate.

[3] Also known as qualitative easing (Miles, Scott, and Breedon, 2012)

Therefore central banks have to manipulate private sector beliefs, what would make this sector have faith in future inflation. Therefore, the real interest rate would fall, and the economy would soon emerge from recession. But even Svensson acknowledges that manipulation with public believes is not easy and it can negatively affect future credibility of the central bank.

Krugman (2008), on the other hand, enhances that for credible central bank, such is the ECB, is even harder to convince private sector believes. If the bank run expansionary policy and injects huge amounts of money to the economy the private sector can still believe in the banks high credibility in the future and do not change its expectations over future prices increase. The public expects that whatever the credible central bank may do now, given the chance in the future, it will return to steady prices near their present intensity. Krugman also with other economists (Miles, Scott, Breedon, 2012, Fender 2012, etc.) recommends expansionary fiscal policy to be a better response of government for economy within a liquidity trap situation.

3.2 Central bank – the European Central Bank, the Czech National Bank and the National Bank of Poland

Central banks have not direct authority over monetary base or real interest rates as mentioned in subchapters above. They can only control some instruments to influence these important parts of the economy. These instruments are called instruments of central bank and among them belong interventions on foreign exchange market, minimal interest rates, open market operations, minimal reserves etc. Minimal interest rate represent a minimal price for which central bank lend money to the commercial banks over set period of time. Open market operations regulate amount of money on the money market by purchasing or selling state bonds. If the central bank would like to set a restrictive policy over the economy, it has to sell the government bonds and this action lowers money supply on the money market. If the central bank would like to support economy by increase of money supply it just do opposite and buy government bonds from the public. (Mankwin, 2008)

3.2.1 Role of central banks independence in the monetary policy

Monetary policy is a constant struggle against cyclical development of economy. Once it avoids booms and overheating of economy and in different period it has to avoid busts. Central banks carry out this policy by trying to keep the aggregate demand curve in a position at which real GDP is equal to the trend of potential GDP and the real inflation rate is equal to the targeted one. The modification of monetary policy towards a higher inflation target will raise real GDP for the short period, but only inflation will be higher in the long run. Hence, this change in real GDP does not have effect on the inflation in the short run because of the slowness of firms to

change their price decision. The economic pain in sense of higher inflation is a longer period issue than the period of the election in the democratic states. Therefore close central banks dependence on government could be misused for re-election of politicians over the objectives of monetary policy. This so called "The Gain Then Pain Scenario" is crucial argument for independence of the central banks. It is difficult for governments to resist the temptation to use monetary policy for short run gain. Governments declare lowering inflation policy and later they follow policies that lead to higher inflation. This is well known as time inconsistency.

Taylor and Weerapala (2012) describes disadvantages of central banks independence. They perceive independence as no guarantee against mistakes made by following set monetary policy, however, they express worries that high independence can even lead to more mistakes. Authors warn against the extreme independence when decision-makers of central bank decide to blindly focus on inflation lowering and this policy has a large negative impacts on real GDP, employment and hence, create or deeper recession. Hence, need of accountability is an important feature of every central bank for its credible actions.

3.2.2 The Eurozone – The European Central Bank

Creation of the monetary union, or currency union, was the next step of economic integration process in Europe after the Second World War. Since 1st January of 1999, when the new supranational central bank was established including eleven founding members[4]. The European Central Bank (hereinafter the ECB) has taken place in the in Frankfurt, previous seat of the German Bundesbank. Position of headquarter of the new central bank has a symbolical significance because Germany as the strongest economic of the European Union (hereinafter the EU) had to give up its strong and internationally valuable currency Mark as a result of founding treaties. Another symbolism of the ECB seat is hidden in new common European monetary policy rules that were designed on the strategy of the German Bundesbank. The beginning of the European Monetary Union dates to 1980's, when it became clear that low inflation is necessary condition for economic growth of the EU members. Difference of member's monetary policies was seen as unsustainable and leading politics of member countries agreed to deeper integration process of the EU.

[4] Among eleven founding members of the euro area belongs Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain

Nowadays, according to data from International Monetary Fund (2014)[5], the ECB manage a monetary policy over the second largest economy with a single currency in the World. Since the beginning, the monetary union has expanded and new member countries gradually entered under authority of the ECB.[6] Every country attempting to entry the Eurozone is obliged to fulfil convergence criteria that were established in Maastricht treaty in February 1992. From the viewpoint of monetary policy are most interesting criteria of price development included into two articles of the Treaty:

- The first indent of Article 140(1) of the Maastricht Treaty requires: "*the achievement of a high degree of price stability; this will be apparent from a rate of inflation which is close to that of, at most, the three best performing Member States in terms of price stability*".
- Article 1 of the Protocol (No 13) on the convergence criteria referred to in Article 140(1) of the Treaty specifies: "*The criterion on price stability referred to in the first indent of Article 140(1) of the Treaty on the Functioning of the European Union shall mean that a Member State has a price performance that is sustainable and an average rate of inflation, observed over a period of one year before the examination, that does not exceed by more than 1 ½ percentage points that of, at most, the three best performing Member States in terms of price stability. Inflation shall be measured by means of the consumer price index on a comparable basis taking into account differences in national definitions.*"

The ECB's monetary policy framework is based on two fundamental principles. First, the ECB's mandate have to focus clearly and unambiguously on maintaining price stability and second, the central bank must be independent. The ratification of the Lisbon Treaty clarified the assignment to this ECB's mandate to maintain price stability and the Treaty also reinforced this primary objective to an objective of the European Union as a whole, not just for Eurozone members. Since 1998 the ECB has defined price stability as a year-on-year increase in the Harmonised Index of Consumer Prices for the euro area of below 2% over the medium term. The definition makes it clear that inflation above 2% is not consistent with price stability –the primary objective of the ECB. The primary objective also means that very low inflation rates, and particularly deflation, are not consistent with price stability in the EU. The ECB is given full independence from political influence of the governments in the

[5] The largest economy in the world with a single currency in use is the United States of America.

[6] Greece became member of euro area in 1st January 2001. Slovenia entered in 2007, Malta and Cyprus in 2008, Slovakia in 2009, Estonia in 2011 and as the last enlargement of the euro area included entry of Latvia in 2014.

implementation of its mandate, including the prohibition of monetary financing of public authorities.

The Institutional framework of the Eurozone

The legal background of the Eurozone and its single monetary policy over the members was laid down in the Treaty on European Union (also known as Maastricht Treaty)[7], the Treaty on the Functioning of the European Union and the Statute of the European System of Central Banks and the European Central Bank. Only two of the members[8] of the EU have got a so called opt-out status that allows them to stay with their own currencies. Rest of the member states of the EU are already members of Eurozone or accepted candidate status for adoption of the euro.

Decision-making bodies of the ECB are based on the collective system for the purpose of the monetary policy. The ECB has a two decision-making bodies which are responsible for preparation, conduct and implementation of the single monetary policy over the Eurozone member states.

First, the Governing Council of the ECB consists of the six members of the Executive Board and governors of Eurozone member national central banks[9]. Among its responsibilities belong formulating Eurozone's monetary policy includes monetary objectives such as key interest rates, the supply of reserves and taking decisions necessary to ensure the performance of the ECB tasks. According to new responsibilities of the ECB connected with recent crisis, the Governing ECB's is responsible to banking supervision and to adopt general framework for this supervisory decisions. Councils voting procedure is based on simple majority. Each member has one vote and in the case of a tie, the President of the ECB has a casting vote. On 19 March 2009 the Governing Council decided to implement a rotation system for voting rights. It was decided that when number of Eurozone governors exceeds 18 it will be applied rotating system in which the Executive Board members will maintain permanent voting right and voting rights of national bank governors will be based on rotation system.

[7] The Treaty of Lisbon entered into force on 1 January 2009 and has amended the Treaty on European Union.

[8] Among the countries with opt-out provision against need to euro acceptance as their national currency belongs the United Kingdom and Denmark

[9] They are 18 governors of the Eurozone member countries in 2014

Second, the Executive Board of the ECB consists of the President, Vice-President of the ECB and four other board members. The Executive Board is appointed for eight years. Members of the Executive board are elected by leaders of all EU member states. As the Governing Council is responsible for formulating policy of the ECB, the Executive Board of the ECB is responsible for implementation of these decisions. Hence, members of the Board are at the same time members of the Governing Council, they have also important role in creation of the policy.

Third body of the decision-making process within the ECB is the General Council. The General Council of the ECB consists of the President and Vice-President of the ECB and the governors of all 28 EU Member States. It will remain in existence for as long as there are EU Member States whose has not yet accepted euro as their national currency. The General Council has not any responsibility for monetary policy decisions over the Eurozone. Its role is set by Statute of the ESCB and by the Treaty on the Functioning of the European Union. According to these documents, The General Council role is mainly in strengthening the coordination of monetary policies of the EU Member States whose still have own national currency, collecting of statistical information and reporting activities to the ECB.

3.2.3 The Czech Republic – The Czech National Bank

The Czech Republic belongs among states that transformed its economy from the planned one into the free market during the 90's of the 20th century after the fall of the communist regimes in east European countries. The Czech National Bank (hereinafter the CNB) was founded on 17 December 1992 by the law about Czech National Bank as one of the successors after splitting of the common monetary policy Czechoslovakian National Bank into two new state banks. The CNB´s monetary policy objective is set forth in Article 98 of the Constitution of the Czech Republic and in Article 2 of Act No. 6/1993 Coll., on the Czech National Bank. Hence, the CNB is required to maintain price stability within the Czech economy. Without negative influence to its primary objective, the CNB could support the economic policies of the Government and support by it the sustainable economic growth.

Since the beginning of the CNB existence in 1993, it managed the monetary policy within the regime of monetary aggregate M2 targeting. Since 1998, the CNB left the monetary aggregate targeting and converted monetary policy into Inflation targeting. This change of the monetary strategy was caused among others by the banking crisis that peaked in 1997 and also by introduction of managed floating regime of the Czech Koruna. From the Table 1 is obvious that the CNB was decreasing inflation expectation over time to the current targeted value of 2%. That is the primary goal of the ECB as well. Hence, this could be seen as reasonable convergence in inflation with the ECB for the future enter to the Eurozone by Czech Republic.

Table 1: The target levels of inflation set by the CNB since 1998

Year	Target level of inflation		Set in
1999	4% - 5%		1998
2000	3.5% - 5.5%		1997
2001	2% - 4%		2000
	Band start	Band end	
2002-2005	3% - 5%	2% - 4%	2001
2006 – 2009	3% (+-1%)		2005
2010 – 2014	2% (+-1%)		2009

Source: The CNB, 2014

The CNB monetary policy is directed by the supreme governing body which is the Bank Board of the Czech National Bank (hereinafter Bank Board). Bank Board consists of four Bank Board members, two Vice-Governors and Governor. The Bank Board shall set monetary policy and the instruments for implementing this policy, and shall decide upon the fundamental monetary policy measures of the Czech National Bank and measures in the area of financial market supervision. Its mandate is concerned with price stability in the Economy, financial market stability in the Czech Republic and issuing of the coins and banknotes of the national currency – Czech Crowns. The CNB is highly independent organization. The members of Bank Board are appointed and relieved by president itself without any assistance of the government. The accountability of the CNB is given by fulfilling of the publicly known aims of the monetary policy. The CBN issues quarterly Inflation Reports, which are submitted to the House of Deputies and made public via CNB website. So, the public is kept informed and bank is under pressure of public to fulfil its primary objective – stable prices. The Bank Boards votes about important decisions in the act of simple majority. In the event of tie, the chairperson (Governor or, Vice-Governor in case of Governors absence) has the casting vote.

3.2.4 Poland – The National Bank of Poland

The history of the National Bank of Poland (hereinafter the NBP) dates back to the time right after the end of Second World War in 1945, when new Polish central bank was founded. The modern structure of the NBP was established by new Polish Constitution that occurred in 1997. The Constitution gave to the supreme governing body – the Monetary Policy Council of the NBP an independent responsibility over the monetary policy in Poland. The maintaining the price stability in Poland is the

main objective of the NBP. Since 1999 the NBP has ran inflation targeting as a primary monetary policy. Bank gradually decreased inflation target and since 2004 it has pursued a continuous inflation target at the level of 2.5% with a permissible fluctuation of plus-minus 1 percentage point. Poland also, as the Czech Republic, is obliged to join the monetary union and Euro as their currency. On the other hand, according to the current development in both countries it does not exist a strong political will to join the Eurozone in the near future.

The governing bodies of the NBP are the President of the NBP, the Monetary Policy Council and the Management Board of the NBP. The President of the NBP is appointed for a six-year term by the lower chamber of the Polish Parliament at the request of the President of the Republic of Poland. He is the head of the Monetary Policy Council and the Management Board of the NBP.

The Monetary Policy Council is chaired by the President of the NBP and includes nine other members, appointed in equal numbers by the President of the Republic of Poland and both chambers of the Polish parliament. The Monetary Policy Council determines monetary policy guidelines and the basic principles of their implementation. The Council sets the level of basic interest rates and determines the principles of open market operations as well as the principles and procedure of calculating and maintaining required reserves. The Management Board directs the NBP activities. Its basic objective is the implementation of resolutions of the Monetary Policy Council, adoption and implementation of the NBP activities plan, the execution of the financial plan approved by the Council and the performance of tasks related to the exchange rate policy and the payment system.

4 Empirical Analysis

The following chapter is divided into three subchapters that are main concern of this research. Therefore this chapter should help to answer the main questions set in the objective chapter of the thesis.

How it is declared by all compared central banks, the inflation targeting is set to be a main monetary policy strategy. Inflation refers to the rate at which prices for goods and services rises. In general, as interest rates are lowered, more people are able to borrow more money. The result is that consumers have more money to spend, causing the economy to grow and inflation to increase. On the other hand if interest rates are increased, consumers tend to have less money to spend. With less spending, the economy slows and inflation decreases. Inflation and interest rates are linked, and frequently referenced in macroeconomics. Therefore it is interesting to describe and calculate the Taylor rule as representative of monetary rules, which can be used as a guideline for using of short-term interest rate as a monetary instrument. A success of the central banks in fulfilling their inflation targets and furthermore applying Taylor rule over the economies interest rates is content of first subchapter within empirical analysis.

The second subchapter is concerned about analysis of input data – the output, monetary aggregates M1 and M2, real interest rates and real gross domestic product of the selected compared economies that will be used further in the subchapter 4.3 Granger causality that analyses these data. The Granger causality should reveal causal relationships between monetary aggregates and GDP and between Real Interest Rate (RIR) and GDP in long period from 1999 to 2013 the short post-crisis period from 2009 to 2013. Pursuant to testing results causal relation is marked as none, one-sided causality or both-sided causality. The VAR model are constructed also with lags to improve their informational merit from one to six lags for long tested period. The same procedure is used for short post-crisis period with difference that models use lagged values of variables only up to four lags. This is caused by unsufficient amount of observations for testing in these time series for more than four lags.

4.1 Inflation targeting and application of the Taylor rule over compared economies

Many economic studies propose an idea that inflation targeting could improve economic prospects and living standards of citizens by maintaining price stability in a lasting way. The ECB (2004) understands to the role of price stability in monetary policy as accomplishing output's high levels and employment. This approach is

based on five reasons. Firstly, the ECB sees simplification of price recognition for inhabitants within the economy. Therefore participants of the economy could make better decisions over their consumption and this should help to more efficient market resources allocation and also to the increase of potential of the production. Second reason for the inflation targeting is seen by the ECB in the lower risk of sudden inflation and therefore lower inflation risk premium on investments. Thus economic subjects are willing to invest more within the economy because it costs them less. Third reason for stable low price raise is connected to the lowering hedging against inflation. Fourth reason for stable price level growth is hidden within the theory as a defence against tax and welfare incentives that distort economic behaviour within the economy. Last but not least reason is that successful inflation targeting supports social cohesion and stability because it does not allow high redistribution of wealth that could be initiated by unexpected changes in price level.

4.1.1 Inflation targeting in compared economies

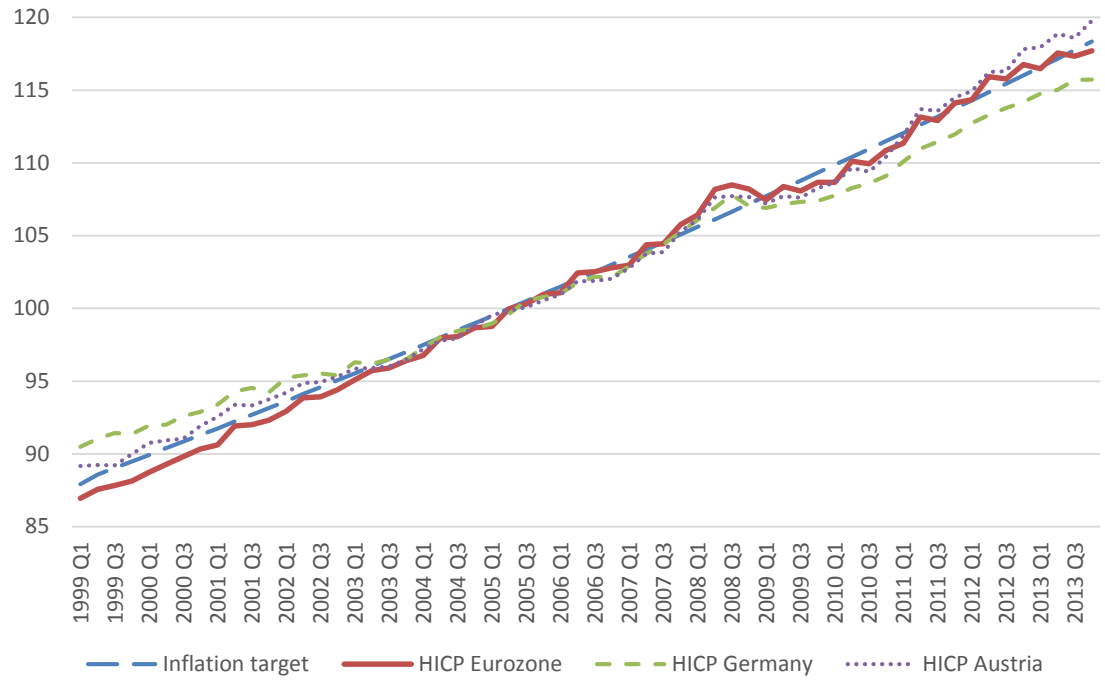

Figure 1 – Target vs. actual inflation in the Eurozone, Germany and Austria. Source: Eurostat

The ECB based its monetary policy on one goal only. This goal is inflation targeting with year to year inflation target of 2% value within economy of the whole Eurozone. This objective was constructed on the goal of the ECB predecessor – the German Bundesbank. According to figure (1) it could be identified that the ECB is successful in fulfilling this objective in form of a medium-term price increase of 2% over

the years. It succeeded to keep diversions from targeted inflation tight and therefore the banks strategy can be considered as successful from the point of view that it kept fulfilling its strategy even during last crisis. Germany's and Austria's inflation is kept tight to the Eurozone's targeted one except few little deviation as well. Thus the Eurozone as whole and also Germany with Austria could be seen as price stable and credible economies.

The Czech Republic changed its monetary policy from M2 targeting to inflation targeting in 1998. The target has been changed over the years and stabled in 2005 at the value of 3% growth in sense of HICP index implemented by the Czech Republic from the European Union statistical approach to the inflation. The CNB converged this goal once more in 2010 when the bank decreased targeted value of inflation to the value of 2%. Consequently it means that the Czech target is fully converged with the ECB target nowadays.

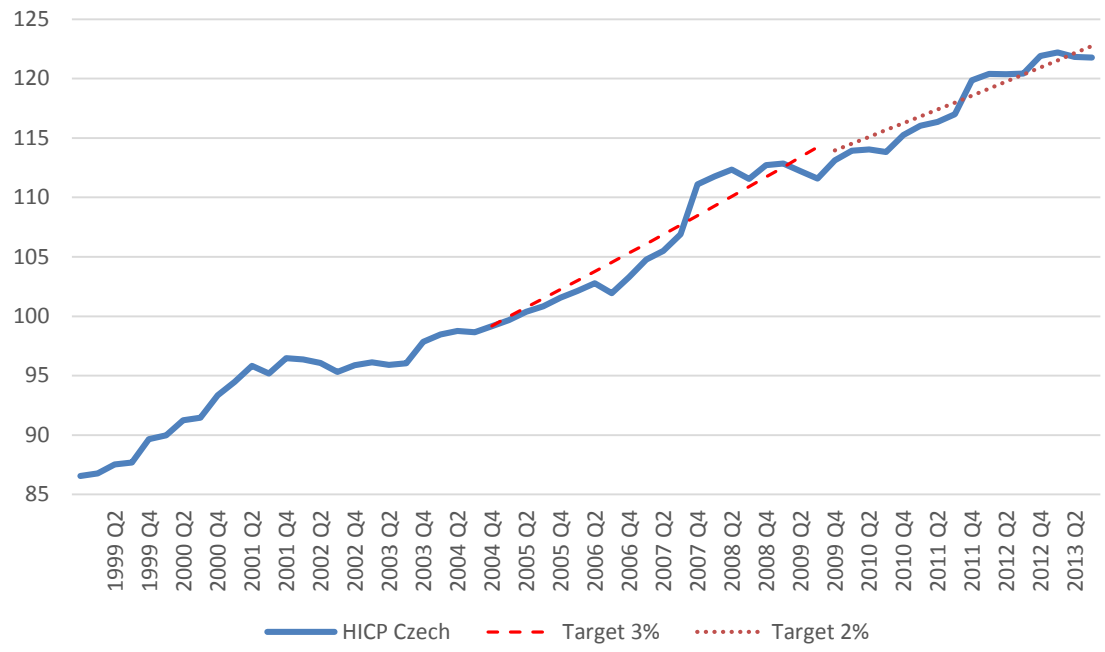

Figure 2 – Targets vs. actual inflation in the Czech Republic. Source: Eurostat

As it could be observed in figure 3, the CNB was successful in its inflation target fulfilment most of the time. This was not really easy, because the Czech Republic as highly open economy is under the pressure of the external influences. Therefore the Czech Republic could be considered stable, credible economy. Its inflation policy gradually adopted approach and also target of the ECB and therefore the entrance

to the Eurozone could not be connected with change in inflation expectations of economic subjects within the economy.

Poland has oriented its monetary policy strategy on inflation targeting since 1999. The NBP gradually lowered targets since the first year of this new strategy to the 2004. The inflation target was stabilized to the value 2.5% that preserved and was not change since then. The sufficiency of the NBP could be observed from the figure 3. It appears that the NBP was also successful to keep actual inflation tight to the set targeted level and hence they fulfilled the primary goal of the monetary policy in Poland. Even that the ECB and the NBP have a different targets of inflation targeting the difference within these is just 0.5 percentage point. Therefore the future change of the target connected with entrance to the ECB could not be seen as a problem.

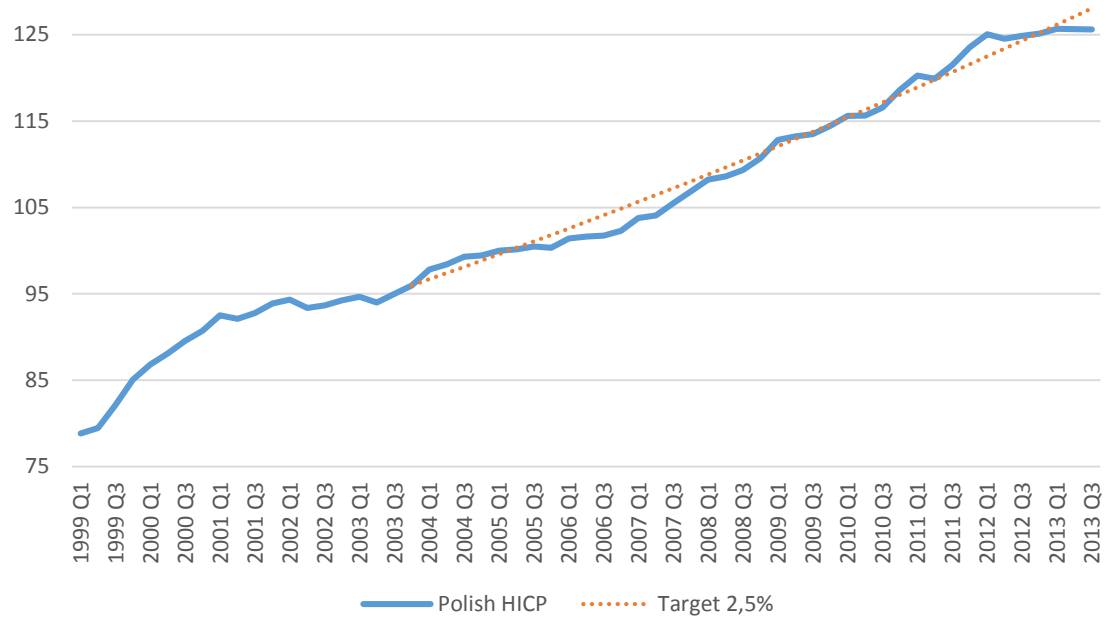

Figure 3 – Target vs. actual inflation in Poland. Source: Eurostat

4.1.2 Taylor rule application

The inflation and inflation targets are important variables for calculating of the Taylor rule as a guideline for the economy. In previous part of this subchapter was showed, that compared central banks are successful in the strategy of inflation targeting within their economies. Another important part of the Taylor rule is the minimal short time in interest rate set by the monetary authority. The central bank compares inflation prognosis with the inflation target and when it is forecasted to be

above the targeted inflation the central banks should according to theory increase the interest rate. Opposite when the inflation is under targeted one the central bank should increase interest rate.

The ECB refinancing rate, The CNB two weeks repo rate and the NBP reference rate are used as nominal short term interest rates for further calculations of the Taylor rules for compared economies. Development of these interest rates in observed period could be seen in the figure 4.

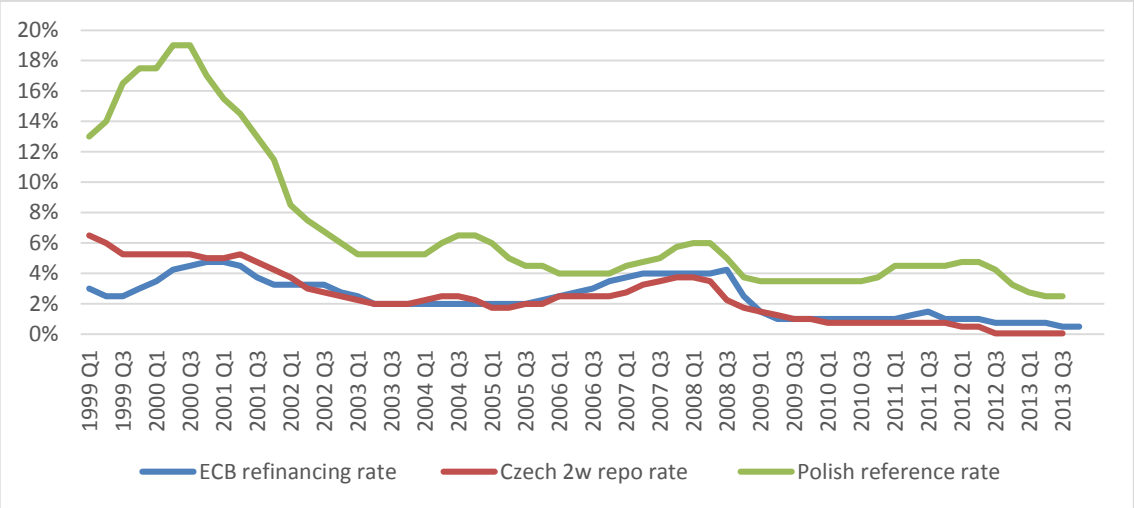

Figure 4 – Evolution of short-term interest rates in Eurozone, the Czech Republic and Poland. Source: the ECB, the CNB and the NPB

The figure 4 reveals differences between Polish reference rate development and similar development of the Czech 2w repo rate and the ECB's refinancing rate that converged and have similar evolution since 2001. The range of the interest rates in case of Poland but also in other two cases are remarkable. The rule introduced by John Taylor in 1993 can be used as a guideline to the central to drive changes of these minimal rates for the decision making bodies of the central banks.

The rule could be simplified into straightforward recommendation that short-term interest rates should be changed according to the current level of the price level and real income within the economy. When they are above the target values the central bank should rise interest rate and the bank should lower interest rate in case that one of them or both are below the target values. Taylor also implemented in his policy rule coefficients, which according to his consideration, are representing a "steady state" values. Taylor rule is so simple that it has revolutionized the way many central

banks think about monetary policy. It has framed the conduct of policy as a systematic response to incoming information about economic conditions. The Taylor rule has taken a form described in the following equation 4:

$$r = r^* + p + 0.5(p - p^*) + 0.5(y - y^*) \quad (4)$$

Where r stands for minimal nominal short term interest rate, p is the inflation rate measured by the GDP deflator over the previous four quarters, p* is the desired inflation rate set by Taylor to the level of 2%, is (y-y*) is a output gap where y stands for a real output in form of the 10 based logarithm of real GDP and y* is a potential output in form of 10 based logarithm. The potential output should be the output when economy fully use its potential and full employment exists inside it. The CNB in its inflation report (2010) suggests three possible methods of estimating potential output. For purpose of this thesis was chosen the third one which involves application of the Hodrick-Prescott filter to the GDP time series and hence use of the trend obtained from the filter as a potential GDP for further calculations.

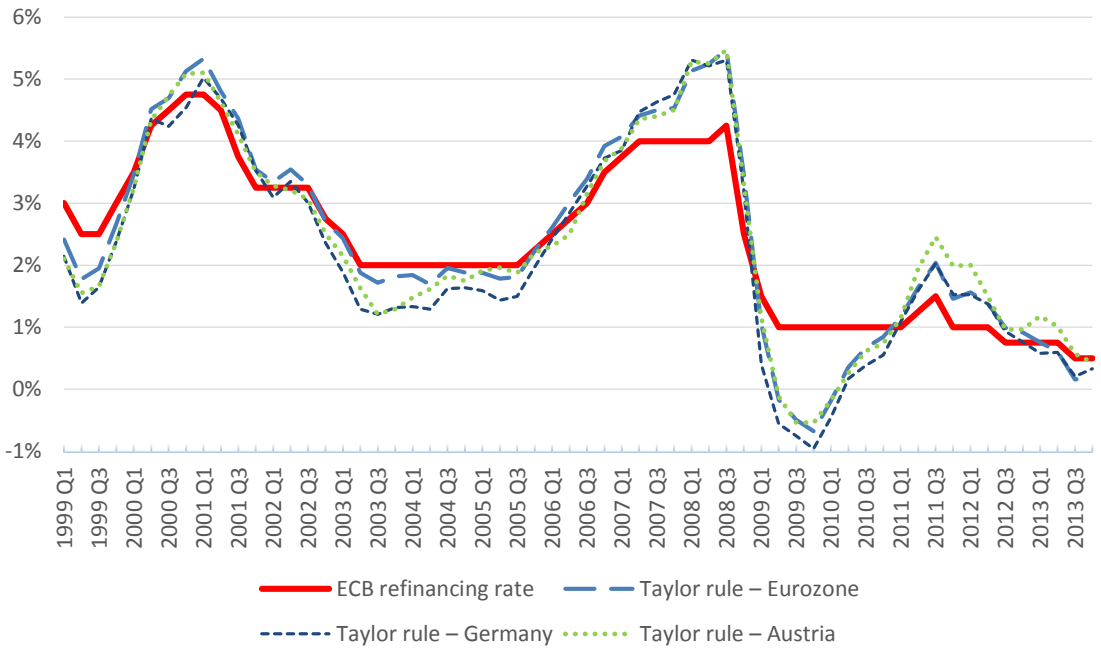

Figure 5 – Taylor rule comparison to short-term interest rates in Eurozone, Germany and Austria. Source: ECB, Eurostat, author's calculations.

The figure 6 reveals that the ECB behaved responsibly in sense of the setting interest rates according to Taylor rule in the period from 1999 to 2007. The ECB gradually decreased interest rates when it was recommended to support outputs grow within

the Eurozone. Since 2005, When the Taylor rule recommends opposite approach, the ECB increased interest rate to prevent overheating of the economy. Taylor rule proposes even higher increase of the interest rate in period 2007-2008 but bank haven't followed it. The reason in not following it in this period could be hidden in the financial crisis raising in the USA at this period therefore the ECB probably waited to its impacts over Eurozone before applying more restrictive monetary policy over the economy.

When the crisis changed its roots from the financial crisis into crisis of economy the Taylor rule recommends to decrease interest rates to the negative levels. That was not possible to follow from the practical reasons that nominal interest rate cannot be set negative under any circumstances in the real economy according to the mainstream economy practise. On the other hand, the bank had still some room to decrease short term interest rate and it has not been done when it is recommended by rule in period 2009 to 2011. Because the Eurozone's economy is not still in the good condition the ECB continued decrease of its short term interest rates and this is again in accordance with Taylor rule's recommendation. The Taylor rule for the Eurozone does not differ to the Taylor rules for the Germany and Austria. Therefore the ECB policy could be considered as fitting also to these Eurozone's member economies.

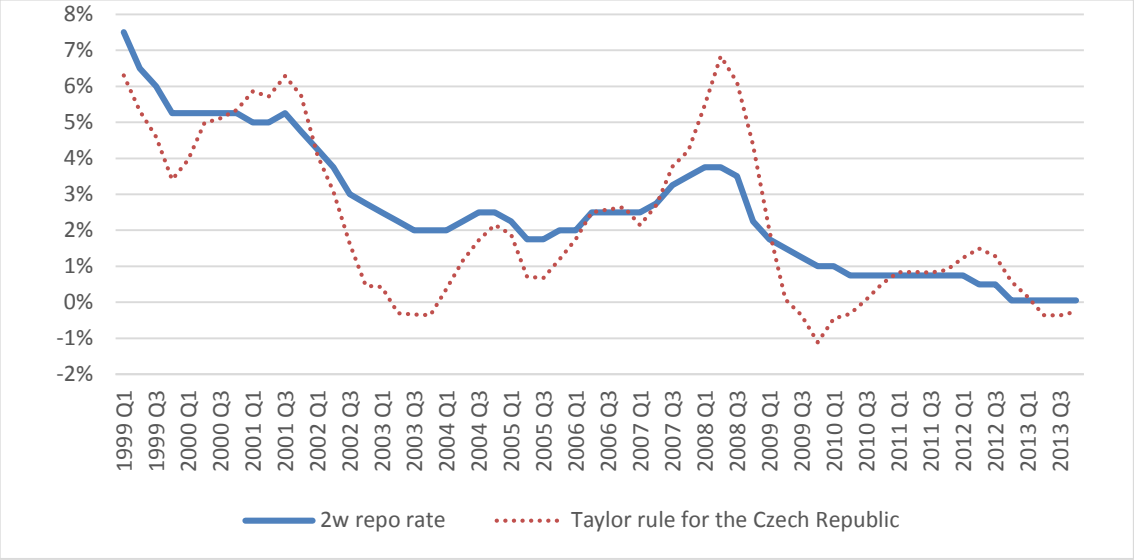

Figure 6 – Taylor rule comparison to short-term interest rate – 2w repo rate in the Czech Republic. Source: the CNB, Eurostat, author's calculations.

The Czech Republic and its monetary authority the CNB on the other hand do not seem as a follower of the Taylor rule's recommendations. Hence it increases or decreases the 2w repo rate as is it is suggested by the rule, the intense of these changes

is much lower than referred. From this viewpoint the CNB seems to be more conservative with manipulating with the short-term interest rate than the ECB. The CNB decreased its rate to the historical minimum of 0.25% level to fight rising risk of deflation in the economy. The risk of deflation revealed and bank could not use more room to effectively decrease the interest rates.

Therefore and according to the suggestion of the International Monetary fund the CNB devaluated value of the Czech Koruna in the last quarter of 2013. Effect of this step cannot be valuated within this thesis because impacts of the intervention are still not clear and because it was made in the last quarter of the examined period than these effect could not been included in the research.

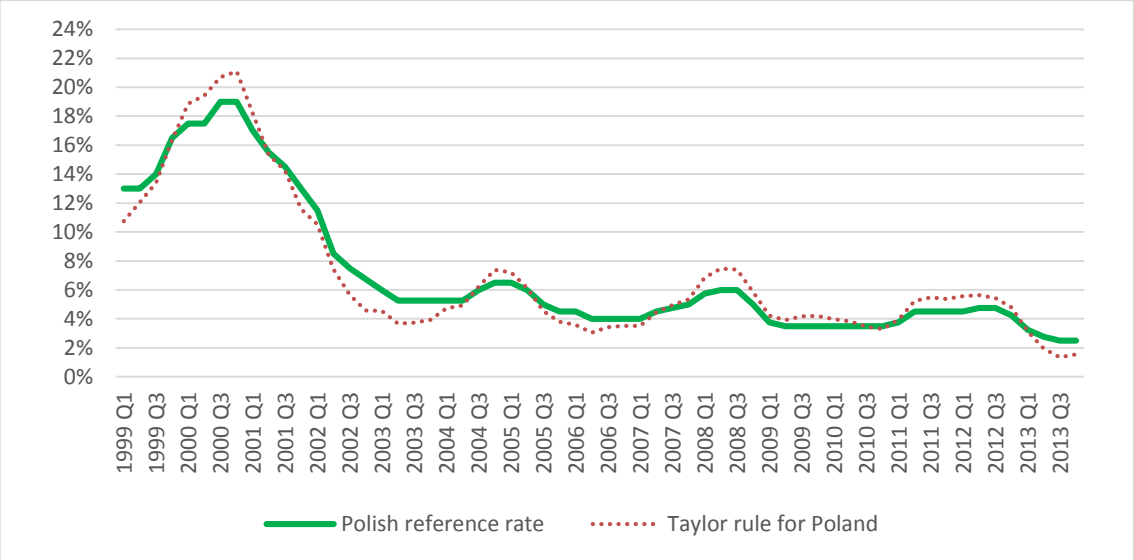

Figure 7 – Taylor rule comparison to short-term interest rate in Poland. Source: the NBP, Eurostat, author's calculations.

According to the application of the Taylor rule on the Poland it is important to notify that polish economy as an only one in the Europe Union has not suffer any negative effects connected with the economic crisis in Europe. Figure 7 reveals that the monetary policy of the NBP is closely related to the Taylor rule. Its recommendations for the setting of the interest rate by the NBP seems to be a quality and applicable guideline in times when economy does not suffer any economic shock.

4.1.3 Summary

This subchapter revealed that all compared banks use same monetary policy strategy in sense of the inflation targeting since 1999. The ECB uses 2% target for its

whole history. On the other hand the NBP and the CNB gradually decreased their targeted inflation. The Czech Republic adopted same value as the ECB did since 2010 and Poland is using the target 2.5% since 2004. According to figures in this subchapter, it is possible to state that the ECB, the CNB and the NBP were very successful in their primary goal of inflation targeting.

Second part of the subchapter applied the Taylor rule over the compared economies. The rule looks applicable and fits to the ECB and the NBP under the ideal conditions within economy. The CNB seems to be more conservative and do not apply such an active policy as the Taylor rule is suggesting to it. When surprizing shock hit an economy the Taylor rule lose its informational value, for the reason that it suggests negative interest rate to be applied. Therefore it would not be clever for central banks to commit to this simple rule blindly.

4.2 The Input data and their stationarity as an important attribute for further research of the monetary policy efficiency

According to the economic theory, the output of the economy could be influenced by the monetary supply or interest rates on the market. Therefore these were obtained in form of nominal monetary aggregates M1 and M2 as representatives of the money supply, nominal Gross Domestic Product for the Eurozone and its members Germany and Austria, the Czech Republic and Poland from statistical databases for the purpose of the thesis. These data had to be deflated to achieve real values of the variables and to suppress influence of the inflation over them. The Harmonised Indexes of Consumer Prices (hereinafter HICP) in compared economies with base in year 2005 are used as deflators of nominal variables M1, M2 and GDP in the research.

Real Interest Rates as important variables used in the thesis are calculated according to equation of the CNB (5):

$$RIR = \left(\frac{100+R}{100+i} - 1\right) * 100 \quad (5)$$

The equation (10) is composed of the Real Interest Rate (RIR in %), nominal interest rate (R in %) which stands for EURIBOR in case of the Eurozone, Germany and Austria, PRIBOR for the Czech Republic and WIBOR for Poland, and real inflation (i in %). Central banks don't have power to directly influence these rates, but they are closely correlated with short-term interest rates set by them. Thus they can be used as representatives of monetary policies for the purpose of this research. Evolution

of the compared economies RIR is shown in the figure 1. Data of the RIR datasets of compared economies had to be converted to their first differences to obtain stationarity according to ADF testing. For further information see correlograms in the Appendix A.

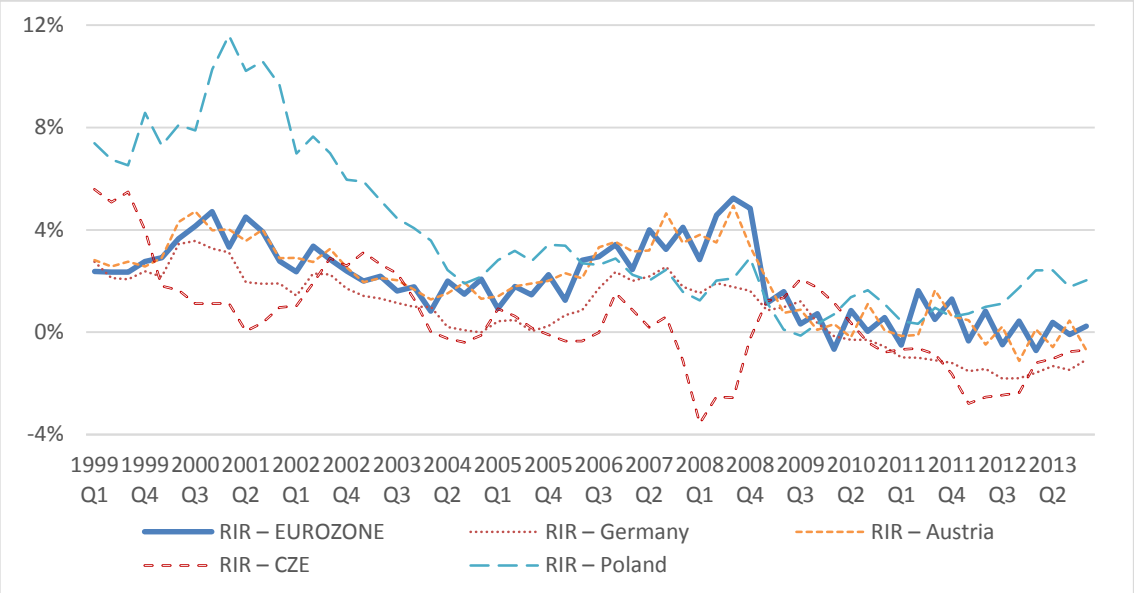

Figure 8 – Evolution of the Real Interest Rates in compared economies, Source: Eurostat, the ECB, the CNB, the NBP and author's calculations

As reader can see in the figure 9, the nominal form of GDP contains a trend that is affected with the price changes over years. Even when the GDP is deflated to its real form by HICP 2005 and thus the impact of the inflation is eliminated it remains to be suspicious for the prevailing trend. The other time series of compared economies outputs have a similar problem with trends in data.

The trend is the reason for non-stationarity of time series that is observed in the correlograms in the Appendix A. It is important to work with trend adjusted time series to obtain real influence of variables for the purpose of the thesis. Thus the development of annual percentage changes in GDP of compared economies is tested by Augmented Dickey Fuller tests of Unit roots (hereinafter the ADF test). The ADF testing displays that all GDP variables are probably integrated at degree one. Therefore time series are converted in form of base 10 logarithms and level 1 differences. The ADF testing afterwards shows that their first logarithmic differences should be without trend and stationary. Therefore variables should be qualified for further research in the thesis.

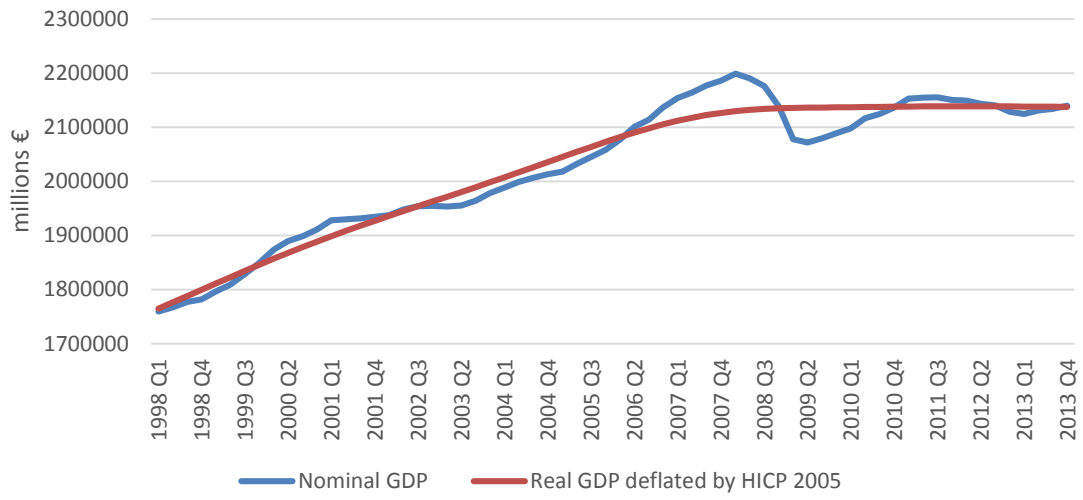

Figure 9 – Comparison of the Nominal GDP and Real GDP of the Eurozone in period 1999-2013, Source: Eurostat, author's calculations

Money supply of the compared economies is represented by the M1 and M2 monetary aggregates in the research. The nominal data were obtained from the ECB, the CNB and from the database of the NBP. These variables are affected by the inflation over years. Therefore data were deflated to their real form of the year 2005 prices by HICP 2005 deflator. According to ADF testing, all real variables probably contain unit roots and thus could be considered non-stationary. Correlograms 11-22 in the Appendix A suggest probability of integration of variables at degree one. Thus time series are converted in form of 10-based logarithms as it is common in case of economic data and converted to their first differences. Converted variables of real M1 and real M2 variables were then again tested for the unit roots by the ADF tests and results do not show prevailing stationarity in the compared monetary aggregates datasets.

4.2.1 Summary

The input data observed from the Eurozone, Germany, Austria, the Czech Republic and Poland were in the nominal form therefore they had to be deflated by HICP 2005 to their real form to suppress influence of the price development over years on them. They were after deflation tested for the potential existing trend that could cause a non-stationarity of time series. According to the Tomšík (2005) this trend could negatively influence further testing by furious dependence hidden within the common trend. Therefore data were tested by the Augmented Dickey-Fuller test which revealed unit root existence in the datasets. According to the correlograms, data were suspicious for integration of variables at degree one. Hence the log differentiation

was applied on them and trend was removed by this step. When variables were modified to their stationary form and impacts of common trend were eliminated in them, it could be continued to the determination of causalities between them in sense of the Granger causality in long period and shorter post-crisis period.

4.3 Granger causality between M1, M2, RIR and real GDP

Since, input data no more contain a trend they can be used for further examination. Granger causality could examine relations between the real GDP and other variables that represent monetary policy instruments in their real form – monetary aggregates M1 and M2 and interest rate (RIR).

4.3.1 Testing Granger causality between real GDP and real M1 monetary aggregate

The Granger causality equations for examination of relations between real GDP and money supply in form of the real monetary aggregate M1 are shown in equations (6) and (7).

$$real\ GDP_t = const + \sum_{i=1}^{j} \alpha_i real\ GDP_{t-i} + \sum_{i=1}^{j} \beta_i real\ M1_{t-i}\,, (6)$$

$$real\ M1_t = const + \sum_{i=1}^{j} \alpha_i real\ M1_{t-i} + \sum_{i=1}^{j} \beta_i real\ GDP_{t-i}\,, (7)$$

The null hypothesis of the Granger causality states that coefficients α and β in the equations are equal to zero. The significance level for the purpose of this research is set on level of five percent. Null hypothesis is rejected according to the values of the p-values. An exact version of the null hypothesis for particular testing is defined in the corresponding tables further in the chapter.

According to Granger causality testing of the long observed period, the money supply in form of monetary aggregate M1 is Granger caused by growth of the real GDP in first two quarters and in the higher lags there is both-sided causality between GDP and M1 aggregate in the Eurozone. According to these results, it could be stated that these real variables are highly affected by each other. Similar results of causality in all tested lags can be found in the table B2 in the appendix B. These describe behaviour of the biggest Eurozone's member economy – Germany. Therefore it seems

that whole Eurozone reacts in similar way to the change in M1 aggregate as the economy of its economical leader. According to this interesting information it could be stated, that monetary aggregate M1 and GDP influence each other in these economies and could be manipulated with one to achieve growth in second, but at the same time it could be hard for the ECB hard to manipulate with this aggregate when it is affected by the outputs development as well.

Table 2: Results of Granger Causality testing between the real GDP and the real monetary aggregate M1 in Eurozone –long period

Monetary aggregate M1 – EUROZONE				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	0.22707	0.6356	**Do not reject**
	GDP does not Granger cause M1	16.121	0.0002	**Reject**
2	M1 does not Granger cause GDP	1,9682	0,1500	**Do not reject**
	GDP does not Granger cause M1	7,8716	0.0011	**Reject**
3	M1 does not Granger cause GDP	6,1314	0,0013	**Reject**
	GDP does not Granger cause M1	5,0193	0,0041	**Reject**
4	M1 does not Granger cause GDP	3,5128	0,0139	**Reject**
	GDP does not Granger cause M1	2,8454	0,0344	**Reject**
5	M1 does not Granger cause GDP	3,0936	0,0179	**Reject**
	GDP does not Granger cause M1	2,6546	0,0354	**Reject**
6	M1 does not Granger cause GDP	2,4794	0,0392	**Reject**
	GDP does not Granger cause M1	2,4881	0,0386	**Reject**

Source: author's calculations

The causal relation between the M1 aggregate and GDP in the Eurozone is also tested for the post-crisis period. Results from this testing in table 3 mean, that quantitative easing in sense of monetary aggregate M1 could be helpful when the Eurozone is in the crisis. This does not apply in case of the Germany, where M1 seems to affect the GDP in first two lags only and not vice versa.

Table 3: Results of Granger Causality testing between the real GDP and the real monetary aggregate M1 in Eurozone – post-crisis period

Monetary aggregate M1 – EUROZONE				
Lag	Null hypothesis	F-statistics	p-value	Decision
1	M1 does not Granger cause GDP	2,1738	0,1611	**Do not reject**
	GDP does not Granger cause M1	8,7423	0,0098	**Reject**
2	M1 does not Granger cause GDP	4,5930	0,033	**Reject**
	GDP does not Granger cause M1	5,2023	0,0236	**Reject**
3	M1 does not Granger cause GDP	3,9733	0,0467	**Reject**
	GDP does not Granger cause M1	3,0981	0,082	**Do not reject**
4	M1 does not Granger cause GDP	2,2443	0,1799	**Do not reject**
	GDP does not Granger cause M1	9,8137	0,0084	**Reject**

Source: author's calculations

Austrian economy, on the other hand, shows different results in sense of Granger causality between the M1 and GDP in the long observed period. Results in table 4 illustrates that Austrian monetary aggregate M1 is mainly Granger caused by GDP development and changes in M1 base do not have impact over the economy output development except the results for lag 3, where both sided relation in sense of Granger causality is found. Hence, it is obvious that reaction of output to change in M1 aggregate is different in case of smaller Eurozone member's economy than in case of the big one. This is even emphasized by the results in the post-crisis period, where monetary aggregate M1 is caused by one sided causality from the output in first lag. Results for the post-crisis period testing could be found in the Appendix B.

Table 4: Selected results of Granger causality testing between real GDP and the real monetary aggregate M1 in Austria – long period

Monetary aggregate M1 – Austria				
Lag	Null hypothesis	F-statistics	p-value	Decision
1	M1 does not Granger cause GDP	0,0341	0,8542	**Do not reject**
	GDP does not Granger cause M1	10,085	0,0025	**Reject**
2	M1 does not Granger cause GDP	2,8404	0,0675	**Do not reject**
	GDP does not Granger cause M1	5,4981	0.0068	**Reject**
3	M1 does not Granger cause GDP	4.0803	0.0115	**Reject**
	GDP does not Granger cause M1	2,8846	0.0450	**Reject**
6	M1 does not Granger cause GDP	3,4456	0,0077	**Reject**
	GDP does not Granger cause M1	2,0440	0,082	**Do not reject**

Source: author's calculations

The Granger causality testing between the real variables M1 and GDP in the Czech Republic have not found any causal relationship in all tested lags in both observed periods. It is surprising result because it is against the economic theory, what says that change in the monetary aggregate should cause output increase in the economy in short term period. Therefore obviously this monetary aggregate is not good objective to be set as a target of the monetary policy for the Czech Republic and the CNB should not use it.

Table 5: Selected results of Granger causality testing between the real GDP and real monetary aggregate M1 in Poland – long period

Monetary aggregate M1 – Poland				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
2	M1 does not Granger cause GDP	6,3562	0,0034	**Reject**
	GDP does not Granger cause M1	1,8203	0,1721	**Do not reject**
3	M1 does not Granger cause GDP	6,0074	0,0014	**Reject**
	GDP does not Granger cause M1	5,2572	0,0032	**Reject**
4	M1 does not Granger cause GDP	4,5693	0,034	**Reject**
	GDP does not Granger cause M1	1,2444	0,3055	**Do not reject**
5	M1 does not Granger cause GDP	3,4135	0,011	**Reject**
	GDP does not Granger cause M1	1,2918	0,2852	**Do not reject**

Source: author's calculations

On the other hand, economy of Poland appears to behave completely different than the Czech Republic. According to results of testing in the table 5 of the variables in all observed lags in long period, M1 aggregate would cause growth of real GDP within four quarters. Therefore these results support the economic theory that states that change in monetary aggregate should improve performance of the economy for short period. Hence it could mean that monetary aggregate M1 can be used as a particular objective of regulations to set adequate monetary policy by the NBP. Sims (1980) obtained similar results as in this case in his research where he used nominal variables. He pointed out that effect of monetary aggregate M1 was significantly reduced when interest rate was added to equation. Nevertheless none Granger causality was proved in any lags of the post-crisis period. Therefore M1 aggregate could not be a good instrument for reaction of the NBP to the negative shock within the polish output.

4.3.2 Testing Granger causality between real GDP and real M2 monetary aggregate

The Granger causality equations for testing relations between real GDP and money supply in form of broader monetary aggregate M2 in its real form deflated by HICP 2005 are as follows:

$$real\ GDP_t = const + \sum_{i=1}^{j} \alpha_i real\ GDP_{t-i} + \sum_{i=1}^{j} \beta_i real\ M2_{t-i}\,, (8)$$

$$real\ M2_t = const + \sum_{i=1}^{j} \alpha_i real\ M2_{t-i} + \sum_{i=1}^{j} \beta_i real\ GDP_{t-i}\,, (9)$$

Table 6: Results of Granger causality testing between real GDP and monetary aggregate M2 in Eurozone – long period

Monetary aggregate M2 – EUROZONE				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	8,0356	0,064	**Reject**
	GDP does not Granger cause M2	0,2615	0,6112	**Do not reject**
2	M2 does not Granger cause GDP	11,7020	0,0001	**Reject**
	GDP does not Granger cause M2	1,3517	0,2979	**Do not reject**
3	M2 does not Granger cause GDP	7,4955	0,0003	**Reject**
	GDP does not Granger cause M2	1,5823	0,2059	**Do not reject**
4	M2 does not Granger cause GDP	4,9246	0,0022	**Reject**
	GDP does not Granger cause M2	1,1492	0,3458	**Do not reject**
5	M2 does not Granger cause GDP	3,6617	0,0077	**Reject**
	GDP does not Granger cause M2	0,6267	0,6803	**Do not reject**
6	M2 does not Granger cause GDP	3,5703	0,0065	**Reject**
	GDP does not Granger cause M2	0,7390	0,6214	**Do not reject**

Source: author's calculations

The Grange causality tests of the real GDP and real monetary aggregate M2 as representative of the money supply in the Eurozone show one sided causality between these variables where change in M2 aggregate causes growth in GDP in all observed lags for Eurozone and in five from six lags for Germany in the long observed period. According to results in table six and similar results for Germany in table seven, it seems that regulation of the M2 monetary aggregate is a good tool to influence economy output in the Eurozone and in Germany as well. The results of Granger causality

testing of the short period confirms one sided causal relation of the GDP on the M2 aggregate in first two lags for both Eurozone and Germany. According to this findings it seems that quantitative easing in form of increasing of monetary aggregate M2 may help to Eurozone and also to large members of the Eurozone such as Germany suppress negative output decrease.

Table 7: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in Germany – long period

Monetary aggregate M2 – Germany				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	0,5215	0,4733	**Do not reject**
	GDP does not Granger cause M2	6,4277	0,0141	**Reject**
2	M2 does not Granger cause GDP	5,3317	0,0078	**Reject**
	GDP does not Granger cause M2	2,7502	0,0732	**Do not reject**
3	M2 does not Granger cause GDP	6,3999	0,001	**Reject**
	GDP does not Granger cause M2	0,3325	0,8019	**Do not reject**
4	M2 does not Granger cause GDP	2,9881	0,0248	**Reject**
	GDP does not Granger cause M2	0,9786	0,4285	**Do not reject**
5	M2 does not Granger cause GDP	2,9744	0,0216	**Reject**
	GDP does not Granger cause M2	0,8421	0,5275	**Do not reject**
6	M2 does not Granger cause GDP	2,8210	0,022	**Reject**
	GDP does not Granger cause M2	0,3617	0,8987	**Do not reject**

Source: author's calculations

Nevertheless it is also important to remind in this case the Goodhart's law (1984) and be cautious with recommendation to focus on the M2 monetary aggregate targeting in sense of quality and effective monetary policy for the Eurozone.

Table 8: Selected result of Granger causality testing between the real GDP and real monetary aggregate M2 in Austria – long period

Monetary aggregate M2 – Austria				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
3	M2 does not Granger cause GDP	3,0583	0,0368	**Reject**
	GDP does not Granger cause M2	2,1677	0,1037	**Do not reject**

Source: author's calculations

Different results of the monetary aggregate causality appears for smaller Austrian economy. Testing revealed that the only relevant causality is observed in lag three in long tested period and it does not exist any causality relation within the post-

crisis period. Therefore the monetary aggregate M2 could not be considered as important for Austrian economy.

The testing of the impact of M2 monetary aggregates towards GDP in sense of Granger causality haven't determined any causality in the Czech Republic and only one sided causality was determined in lag 6, where GDP Granger causes M2 aggregate, in case of Polish economy in the long tested period. According to these results, it is possible to declare that money supply in sense of M2 monetary aggregate does not Granger cause GDP neither in the Czech Republic nor in Poland. According to these findings it is likely to conclude that the CNB or the NBP cannot impact output by influencing M2 aggregate. Causality has not been found within the post-crisis period neither. For complete results of Granger testing of M2 and GDP variables see tables B6-B10 in appendix B.

4.3.3 Testing Granger causality between variables RIR and real GDP

The testing influence of interest rate is really important because the short-term interest rate is a key tool for monetary policy for the ECB, the CNB and the NBP as well. It is examined whether it could be found Granger causality between output, represented by the real GDP, and the real interest rate (RIR), represented by a three-months EURIBOR, PRIBOR or WIBOR deflated by the HICP in the tested economy. Equations for real GDP and RIR are as follows:

$$real\ GDP_t = const + \sum_{i=1}^{j} \alpha_i real\ GDP_{t-i} + \sum_{i=1}^{j} \beta_i RIR_{t-i}\,, (10)$$

$$real\ RIR_t = const + \sum_{i=1}^{j} \alpha_i RIR_{t-i} + \sum_{i=1}^{j} \beta_i real\ GDP_{t-i}\,, (11)$$

Selected results of Granger causality testing between GDP and RIR for the Eurozone in the table 9 give an empirical evidence that output in the long observed period is caused by RIR in second and third lag. Therefore it can be stated that interesting rate is a crucial for correction of the output in the short period by the ECB for whole Eurozone's economy. Complete results of testing in the appendix B shows opposite causality for the other lags. On the other hand, testing for the post-crisis period have not revealed causality among the variables and therefore the interest rate could be seemed as unimportant when it gets close to zero.

Table 9: Selected results of Granger causality testing between the real GDP and RIR in Eurozone – long period

Real Interest Rate (RIR) – EUROZONE				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
2	RIR does not Granger cause GDP	3,0942	0,0457	**Reject**
	GDP does not Granger cause RIR	1,5809	0,2155	**Do not reject**
3	RIR does not Granger cause GDP	3,1653	0,0326	**Reject**
	GDP does not Granger cause RIR	1,7081	0,1776	**Do not reject**

Source: author's calculations

On the other hand, results of testing Granger causality for Germany in table 10 presents no affection of the output by the RIR and opposite causality in lag one and two. Austrian results in the table B13 of the appendix B shows same causality of GDP causing RIR for lags four, five and six. None causality from the RIR to output in the long period is found. Also in the post-crisis period Austrian economy seems to have none causality among tested variables. Thus it could be supposed as a confirmation that the ECB's policy is concerned about the Eurozone as whole economy and that the ECB does not set it to the particular member's economy interests.

Table 10: Selected results of Granger causality testing between the real GDP and RIR in Germany – long period

Real Interest Rate (RIR) – Germany				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	RIR does not Granger cause GDP	0,0005	0.9823	**Do not reject**
	GDP does not Granger cause RIR	5,6944	0,0205	**Reject**
2	RIR does not Granger cause GDP	1,6543	0,2011	**Do not reject**
	GDP does not Granger cause RIR	4,0119	0,024	**Reject**

Source: author's calculations

Similar results of Granger causality testing like in case of Eurozone were obtained from the data testing for Poland and the Czech Republic (table 11 and 12). The influence of variables was proved in lags 1 and 2 for both economies in long period. The Czech results are than completely the same in sense of one sided causality as in case of Eurozone where RIR influences real output in third lag as well. Therefore both the CNB and the NBP could attribute significant relevancy to the RIR in sense of monetary decision making in the normal times. The short period did not revealed any causality within the economies. Thus the short-term interest rate as the mostly used instrument of the monetary policy could be seen as ineffective in the post-crisis period within all compared economies.

Table 11: Selected results of Granger causality testing between the real GDP and RIR in the Czech Republic – long period

Real Interest Rate (RIR) – Czech Republic				
Lag	Null hypothesis	F-statistics	p-value	Decision
1	RIR does not Granger cause GDP	4,6220	0,036	**Reject**
	GDP does not Granger cause RIR	2,5750	0,1143	**Do not reject**
2	RIR does not Granger cause GDP	4,5595	0,015	**Reject**
	GDP does not Granger cause RIR	1,3577	0,2662	**Do not reject**
3	RIR does not Granger cause GDP	3,0372	0,0387	**Reject**
	GDP does not Granger cause RIR	1,1169	0,3522	**Do not reject**

Source: author's calculations

Table 12: Selected results of Granger causality testing between the real GDP and RIR in the Czech Republic – long period

Real Interest Rate (RIR) – Poland				
Lag	Null hypothesis	F-statistics	p-value	Decision
1	RIR does not Granger cause GDP	3,1271	0,017	**Reject**
	GDP does not Granger cause RIR	2,9155	0,0934	**Do not reject**
2	RIR does not Granger cause GDP	3,053	0,0356	**Reject**
	GDP does not Granger cause RIR	1,6320	0,2054	**Do not reject**

Source: author's calculations

According to these results of the causality testing between RIR and GDP variables in compared economies could be RIR considered as efficient monetary policy instrument how to influence economy through the monetary policy in short period of time within the normal economic times. Similar results are included in the research of Sims (1980) where he also states that interest rates provide better measure to monetary policy than in case of monetary aggregates. On the other hand RIR fails in the situation when the output is decreasing and economy needs to be helped to recover from external shock. For complete results of this testing see tables B11-B15 in appendix B.

4.3.4 Summary

The results of the granger causality testing of the RIR's and monetary aggregates M1 and M2 impact over the GDP in the Eurozone, Germany, Austria, the Czech Republic and Poland revealed that there might be found some different causality between these variables in conditions if different economy. In general, results showed that money base has similar impact over the Eurozone and Germany and also different impact over the Austrian economy. According to this result it can be stated that

quantitative easing could be used for active monetary policy by the ECB. On the other hand, economies of the Czech Republic and Poland do not react very well on the monetary base manipulation and hence it the monetary aggregates M1 and M2 are not an adequate instruments for affecting real output of these economies.

The causal relationship between GDP and RIR looks to be very influential over the compared economies in the long period. Therefore central banks could affect the real output by short-term interest rates under normal conditions within economies. Problem is that the Granger causality has not been found in any of the compared economies in the post-crisis period. This result supports economists that sees current situation in the Europe as the liquidity trap where it is hard to escape from this situation by use of the monetary policy instruments.

5 Discussion

The main objective of the diploma thesis *"Comparison of monetary policies of the ECB and selected European national banks in the crisis period"* was to examine whether monetary policy is efficient in the selected economic area and countries in use of potential instruments such as the basic short term interest rate and monetary aggregates M1 or broader M2. The ECB, the CNB and the NBP have common monetary strategy of the inflation targeting. The objective of it is keeping stability of prices in the economy and thus reduce risk of unexpected price changes for all market agents. According to the findings in the subchapter 4.1 it could be stated that all banks are successful in their main objective fulfilling and keep the inflation tight to their targets. Nevertheless this strategy of policy has not prevented economies from the economic crisis.

Application of the Taylor rule over analysed economies revealed that this monetary rule fits to the conditions of the Eurozone and Poland also even for the Germany and Austria under the normal development of economy. The CNB on the other hand has much more conservative approach to the manipulating with the short term interest rates in all observed period than Taylor rule suggests and therefor the rule does not seem to be applicable to the small open economy such as the Czech Republic. Another problem connected with the Taylor rule recommendations is, that it supports the use of negative interest rates in the post-crisis period such as one in 2009 but it is not a practical possibility for most of the modern central banks.

Results within the research of this thesis presented that the ECB may use quantitative easing in sense of the monetary aggregates M1 and broader M2 and it should help to regulate economy even in the post-crisis period. Manipulating with the interest rate is also a good instrument of the monetary policy how the ECB can affect Eurozone as a whole economy under the circumstances of the normal conditions in economy. The testing of interest rates impact to the output in the post-crisis period has not presented any impact of this monetary policy instrument.

Similar results as in case of whole Eurozone's economy were obtained for Germany. German output also react on the both monetary aggregates and real interest rates in long period. Nevertheless, in the short period, it could be found only one instrument affecting German output in form of changes in M2 monetary base it could be stated that steps of monetary policy set by the ECB are well suited to its biggest member's economy.

On the other hand, Austrian economic performance seems to be less stimulated by the ECB policy than the Germany. Testing revealed that Austrian economic output

could be caused by the change in base of the monetary aggregate M1 and by manipulation with the interest rates under normal conditions of the economy. On the other hand, there was not found any causality between compared monetary policy instruments and the output. Therefore it can be stated that the ECB is concerned about the policy that is effective and fit to the Eurozone as whole and its biggest economy and monetary policy could be seen as ineffective for smaller open members economies such is Austria or at one future point the Czech Republic.

According to testing of the variables for the Czech Republic it seems that only impacting instrument of the CNB is manipulating with the interest rate and this apply only in the time of the normal economic growth. The results of the post-crisis period shows that the Czech Republic is much more influenced by the other factors than the internal monetary policy. It is not as much surprising result if the openness of the Czech economy is taken into account. The high degree of openness of the Czech economy, with exports representing more than 75% of the GDP, is among others probably main cause why the CNB's instruments are not very efficient.

Poland, on the other hand, is larger economy with lower degree of openness than Czech Republic. Monetary aggregate M1 and interest rate could be seen as an appropriate instruments for the NBP under the conditions of the normal output growth. Testing of the short post-crisis period for Poland does not revealed any causality among variables. Nevertheless Poland was economy that did not suffer from the economic crisis as other European did, it seems that this was caused more by the fiscal expansion connected with the fact that Poland biggest beneficiary among member states of the money from the budget of the Europe Union more than by the effective monetary policy. (Faris 2013)

Remarkable results are found in the interest rate testing within all economies for the post-crisis period 2009-2013. None causality have been found between the all analysed variables in this period. It supports the Krugman's (2011) statement that almost all advanced countries are in the situation of liquidity trap and monetary policy became ineffective.

6 Conclusion

The diploma thesis *"Comparison of monetary policies of the ECB and selected European national banks in the crisis period"* focused on the impact of monetary policy over economic performance of the Eurozone, the Czech Republic and Poland. In this thesis, monetary policy of the European Central Bank, the Czech National Bank and the national bank of Poland were examined from several viewpoints. This examination was supposed to find answers to these research questions.

1. *What are essential differences among the Eurozone's, Czech and Polish economies responsiveness to the monetary policy set by their monetary authorities?*
2. *Do selected central banks drive similar monetary policies? Does exist any crucial difference among them?*
3. *Is monetary policy effective in case of selected European economies? Does historical quarter data obtained for periods from 1999 to 2013 and from 2009 to 2013 give prove of expected responsiveness of the output to the monetary policy manipulation as it should according to the economic theory in selected compared European economies?*
4. *Is the common monetary policy effecting anyhow to economies of particular member states of the Eurozone?*

According to findings of the empirical research within altogether with the literary investigation it is possible to declare that objectives of this thesis were successfully fulfilled. Essential differences among the Eurozone's, Czech and Polish economies responsiveness to the monetary policy was found. The Polish and Eurozone's both economy react to the changes in the base of monetary aggregate M1 and the M2 monetary aggregate could be used to affect Eurozone. On the other hand, the Czech Republic does not react on any of these. Hence it could be recommended to the Czech National Bank to do not try quantitative easing in money base in situation where the central bank needs to imply expansionary monetary policy and when it could not be in opposite to the main objective of the central banks in sense of the unstable and excessive growth in price level.

Compared central banks drive almost identical monetary policy. It is a policy of inflation targeting and banks have even set almost identical targeted inflation rate. Both the Czech National Bank and the European Central bank set target of 2% and the National Bank of Poland of 2.5%. Banks succeeded very well in keeping the growth of overall price stable within years. This added credibility to the compared economies and therefore the risk of the unexpected inflation and costs connected with it were decreased. The policy of the inflation targeting seems to be successful in these terms and the compared central banks appear to be credible because of

their ability to accomplishing these objectives. Therefore recommendation to carry on this policy further could be suitable for the ECB, the CNB and the NBP as well.

The compared Eurozone's member states Germany and Austria are also influenced by the monetary policy of the ECB. Economy of Germany seems to react in very similar way to it as in case of the of the Eurozone as a whole economic area and Austrian economy seems to be less influenced by it but still some impact of the ECB policy over it exists. According to these findings, the ECB fulfils its function to promote interests of the Eurozone over interest of particular members, nevertheless it looks that Germany as the biggest member's economy has enormous influence over it. On the other hand, connection between the German economic performance and economic performance of its business partners within the EU is vast. Therefore this policy could be reasonable and it could be recommended to remain.

According to findings, that monetary policy does not have essential impact over the Czech economy, it could be stated that discussed costs of Euro acceptance in sense of losing independent monetary policy could be irrelevant and hence from this point of view the Euro could be accepted by the Czech Republic. Therefore it could be recommended to accept the Euro and consequently lower the transaction costs and exchange rate risks for the economic agents.

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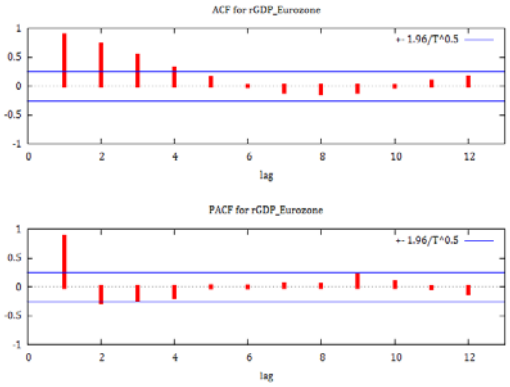
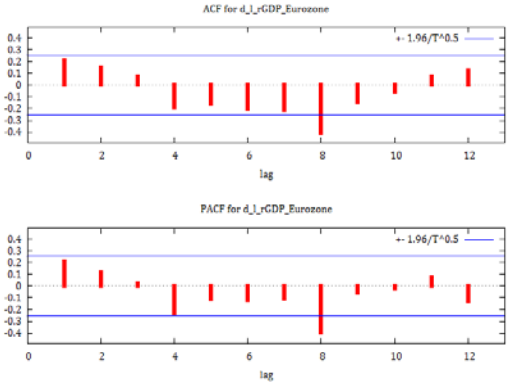
Appendixes

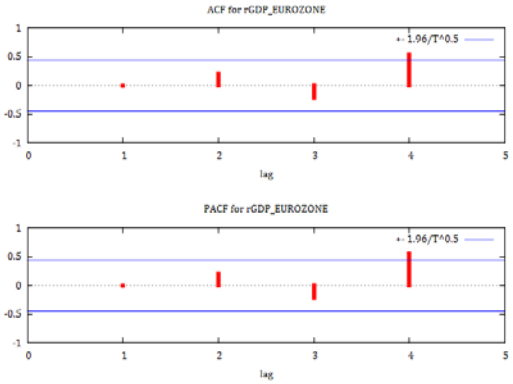
A Correlograms



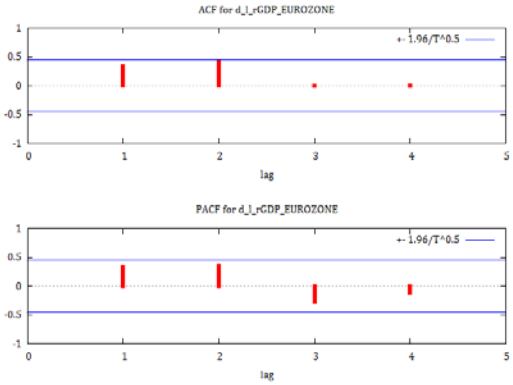
Correlogram 1 – Real GDP of the Eurozone, long period Source: Author's Examination



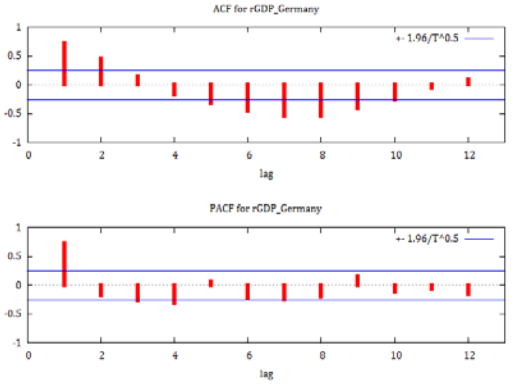
Correlogram 2 – 1st difference of the Eurozone's log real GDP, long period Source: Author's Examination



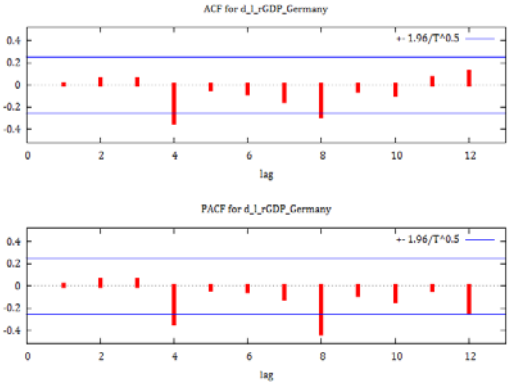
Correlogram 1 – Real GDP of the Eurozone, post-crisis period Source: Author's Examination



Correlogram 4 – 1st difference of the Eurozone's log real GDP, post-crisis period Source: Author's Examination



Correlogram 5 – Real GDP of Germany – long period, Source: Author's Examination



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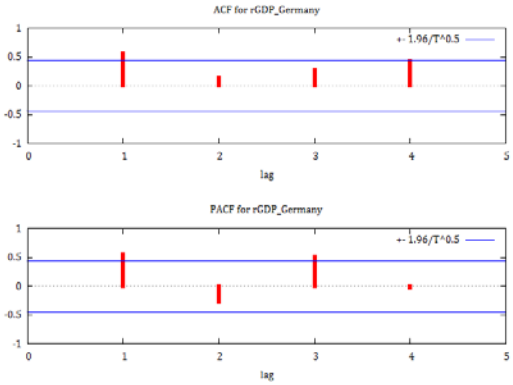
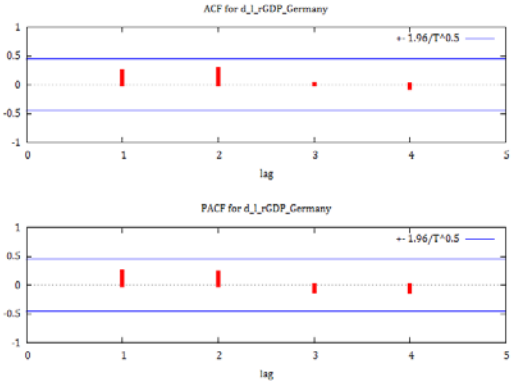
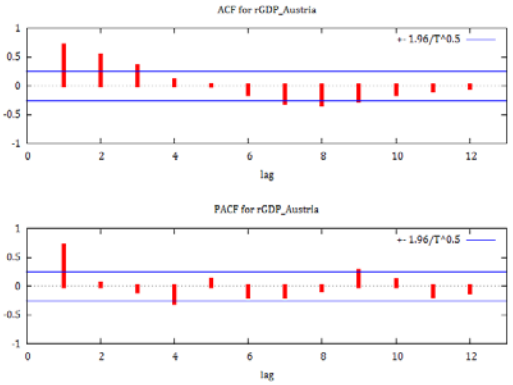


Correlogram 7 – Real GDP of Germany – post-crisis period, Source: Author's Examination



Correlogram 8 – first difference of the German log real GDP – post-crisis period, Source: Author's Examination



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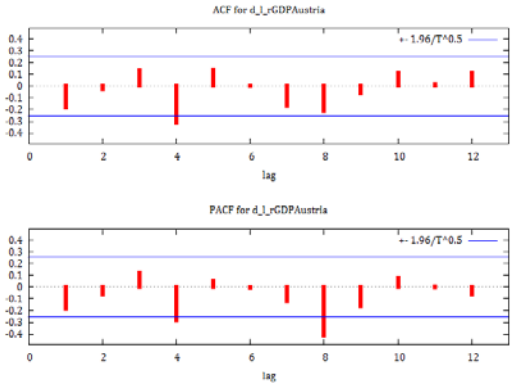

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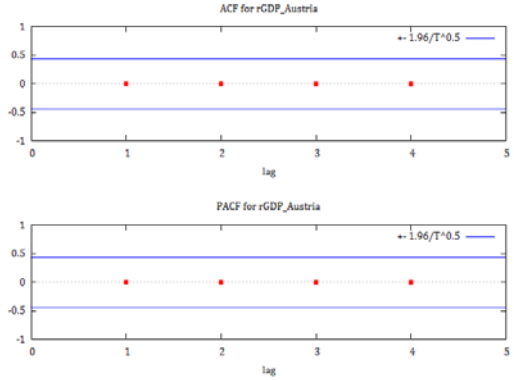

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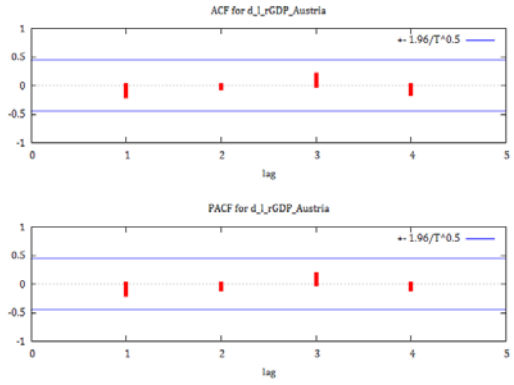

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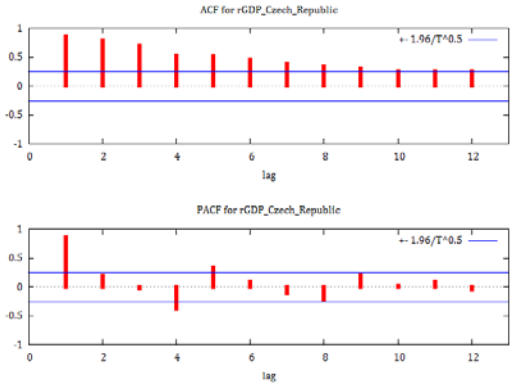

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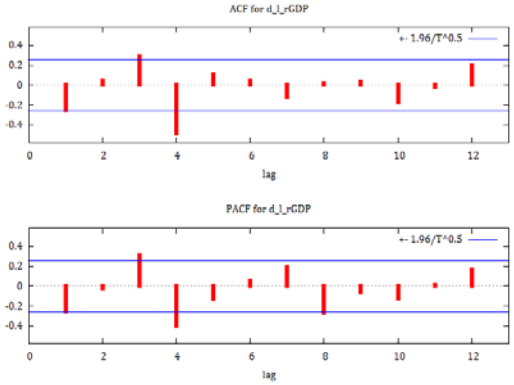

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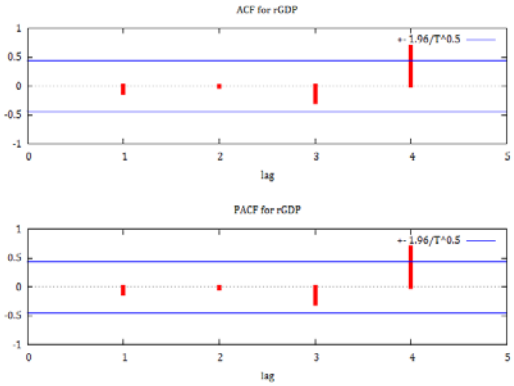
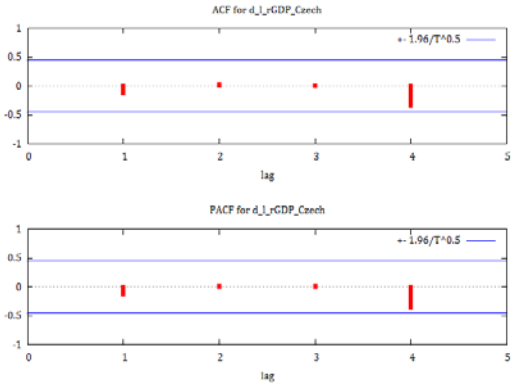


Correlogram 15 – Real GDP of the Czech Republic – post-crisis period, Source: Author's Examination



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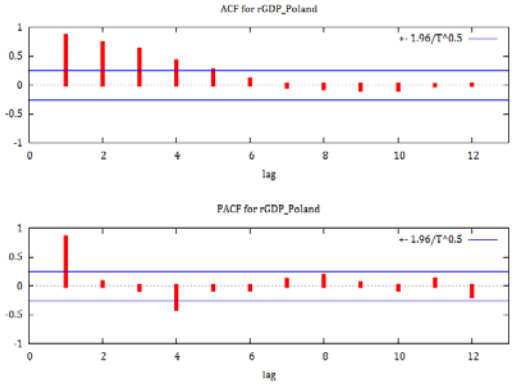

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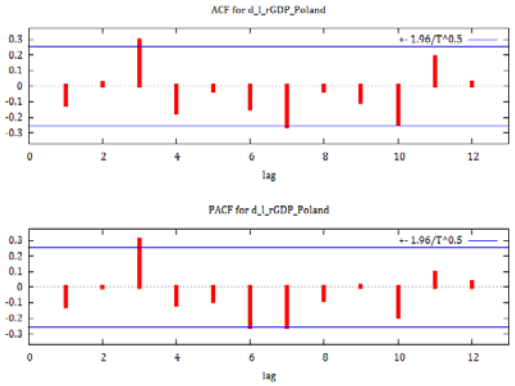

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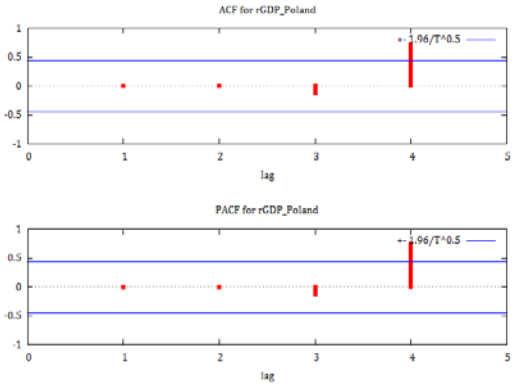

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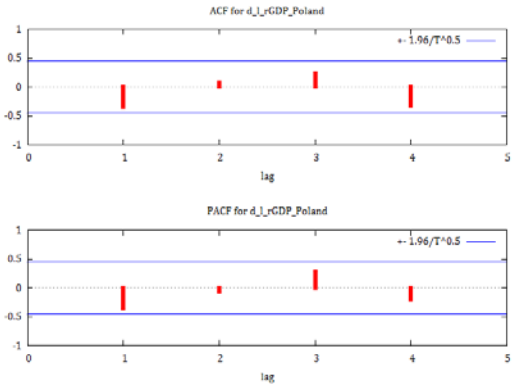

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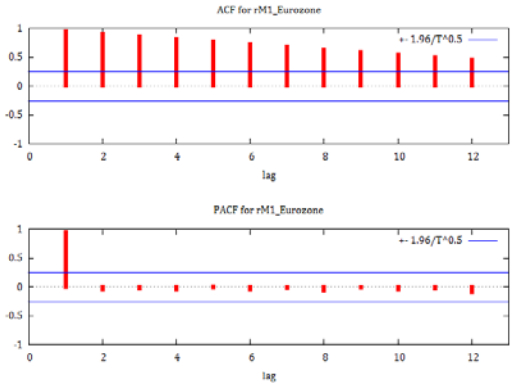
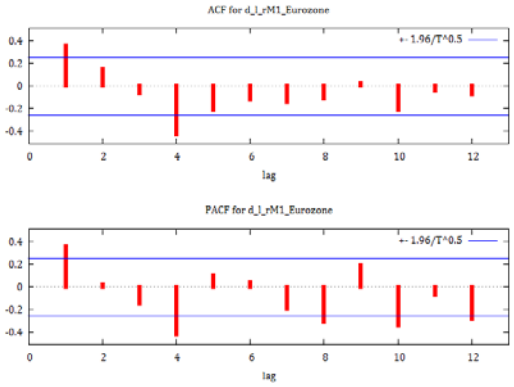


Correlogram 21 – Real monetary aggregate M1 of Eurozone – long period, Source: Author's Examination



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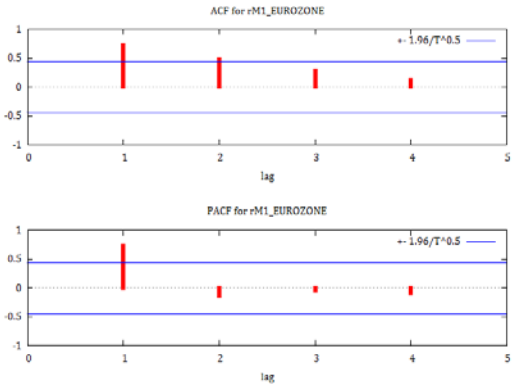

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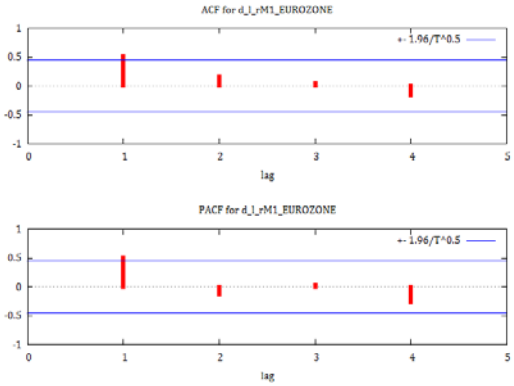

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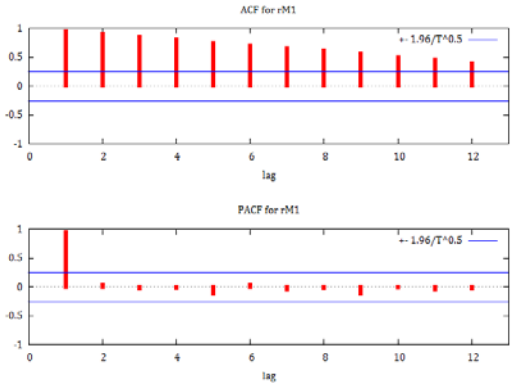

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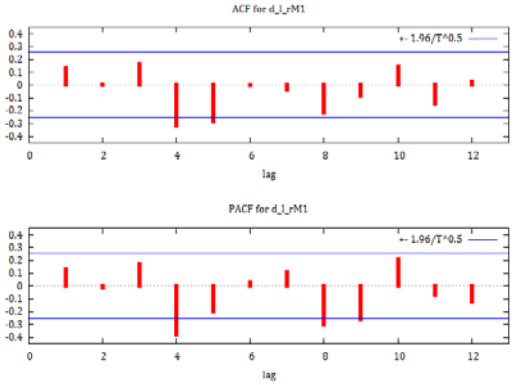

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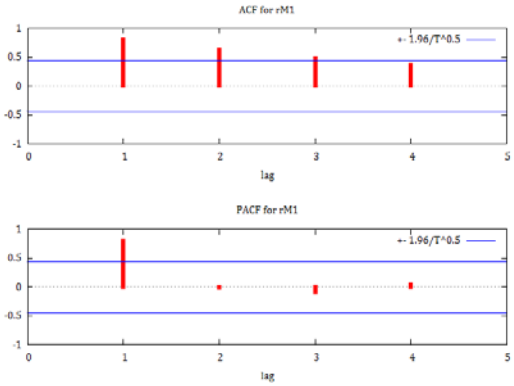

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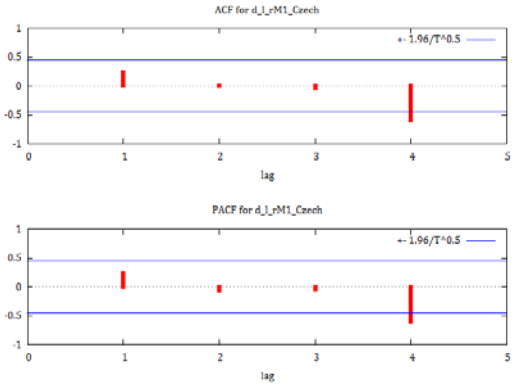

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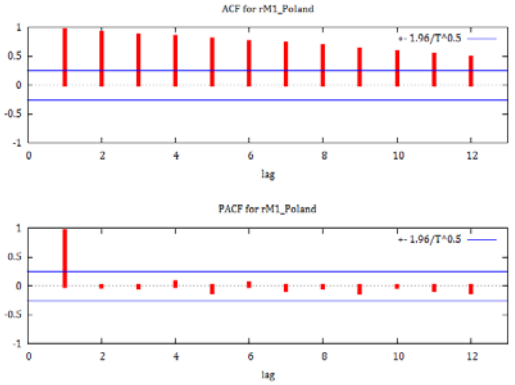

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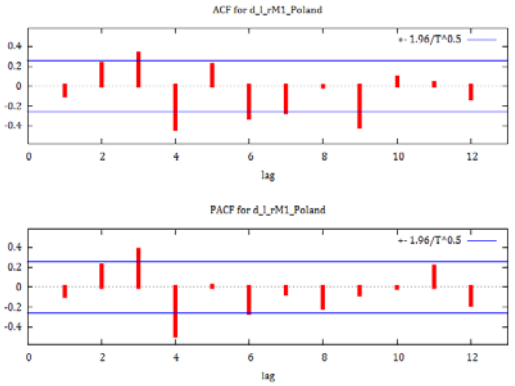

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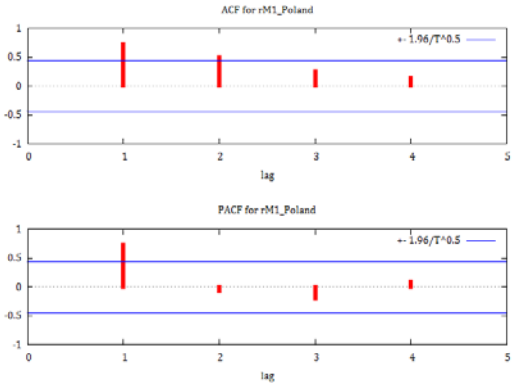

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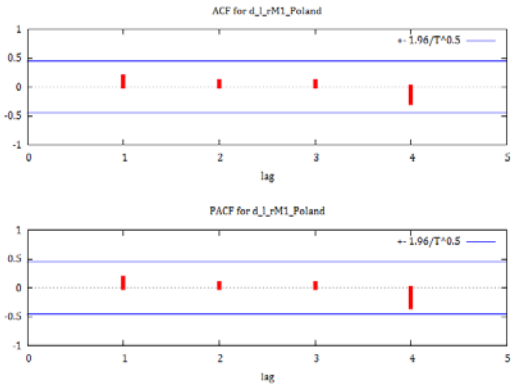

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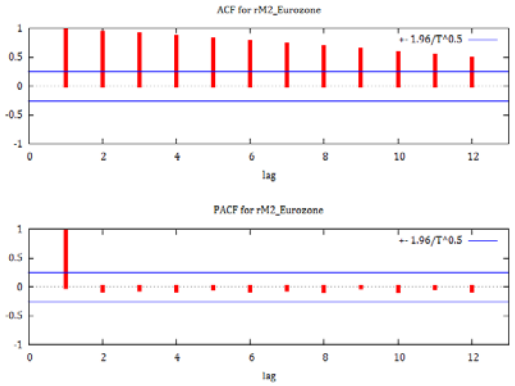

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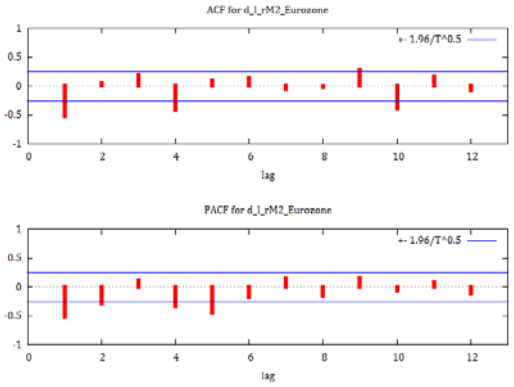

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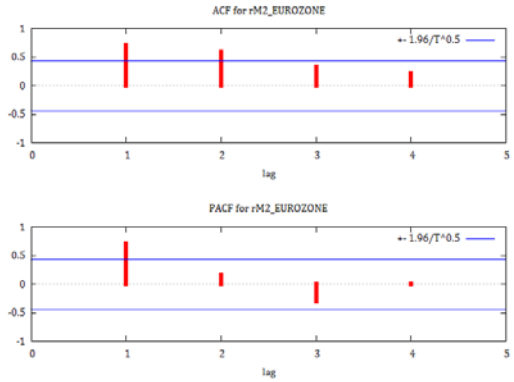

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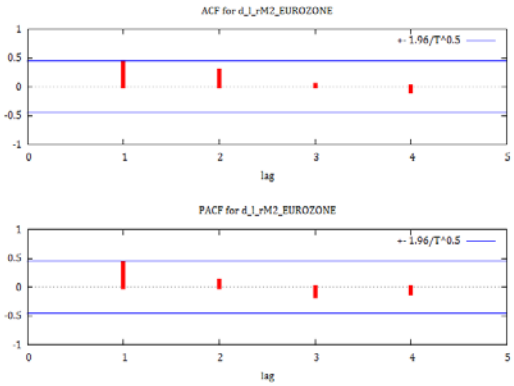

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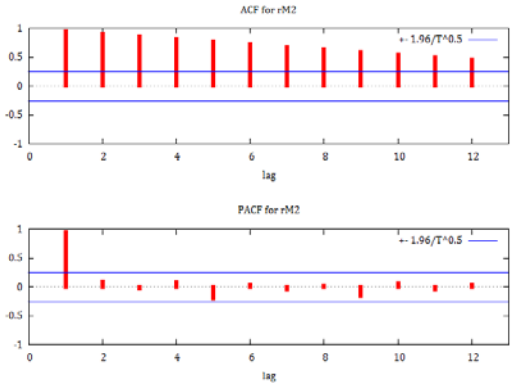
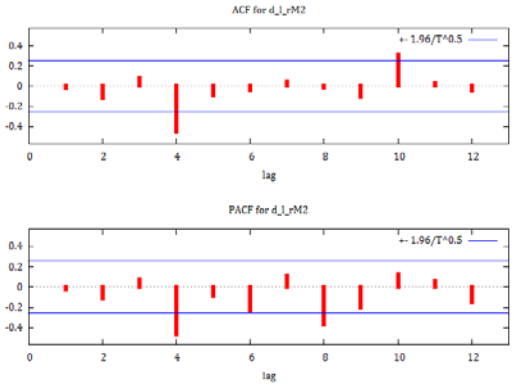


Correlogram 37 – Real monetary aggregate M2 of the Czech Republic – long period, Source: Author's Examination



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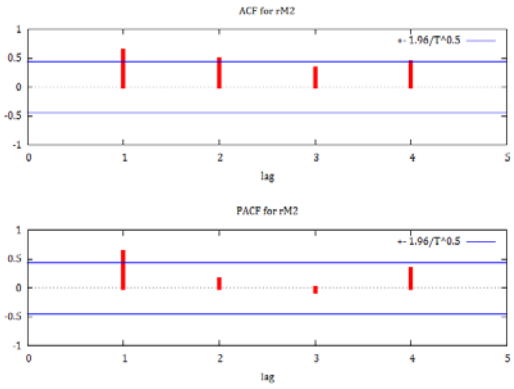
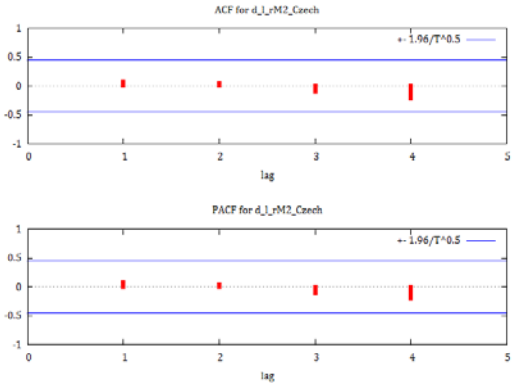
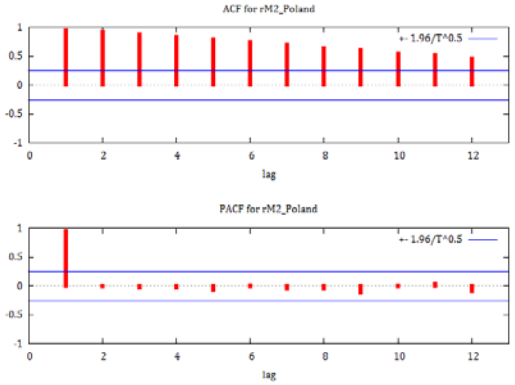


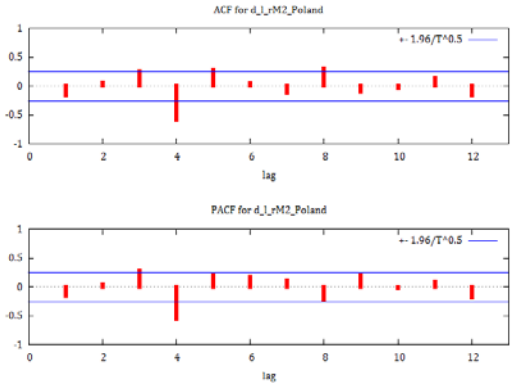
Correlogram 39 – Real monetary aggregate M2 of the Czech Republic – post-crisis period, Source: Author's Examination



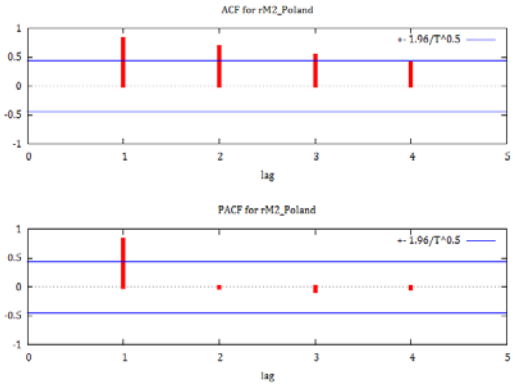
Correlogram 40 – first difference of the Czech log real M2 – post-crisis period, Source: Author's Examination



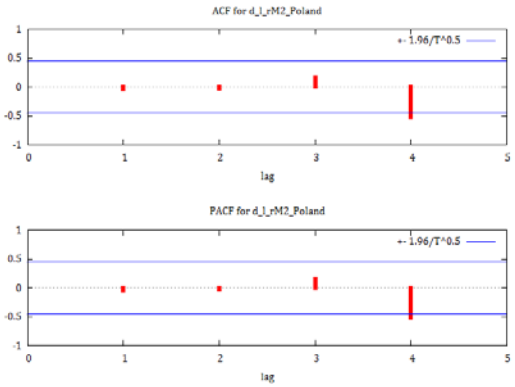
Correlogram 41 – Real monetary aggregate M2 of Poland – long period, Source: Author's Examination



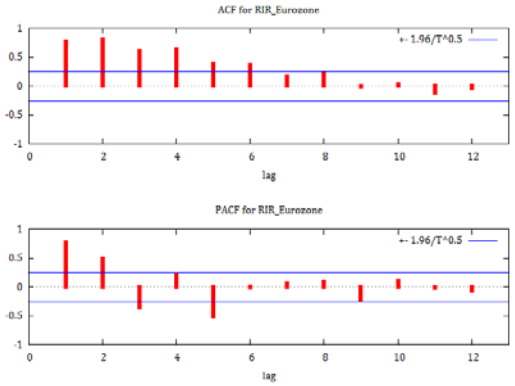
Correlogram 42 – first difference of the Polish log real M2 – long period, Source: Author's Examination



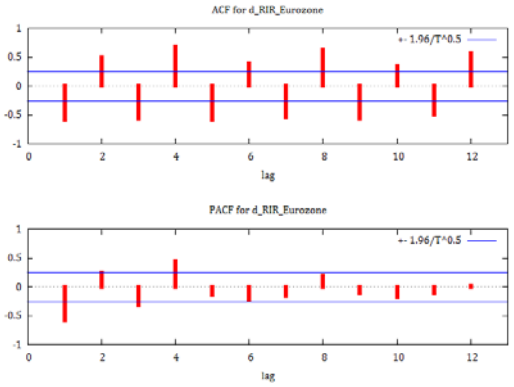
Correlogram 43 – Real monetary aggregate M2 of Poland – post-crisis period, Source: Author's Examination



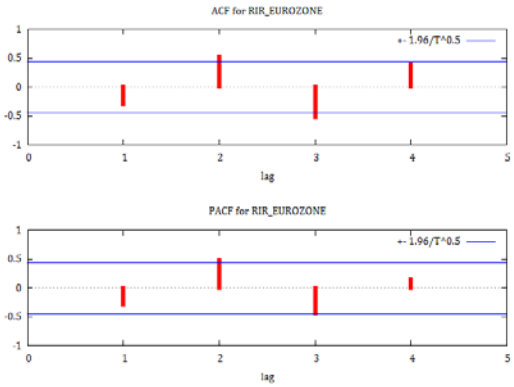
Correlogram 44 – first difference of the Polish log real M2 – post-crisis period, Source: Author's Examination



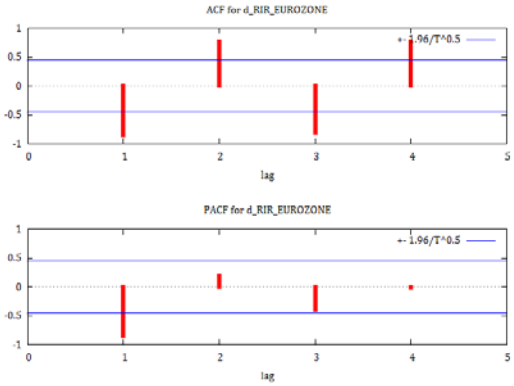
Correlogram 45 – RIR of Eurozone – long period, Source: Author's Examination



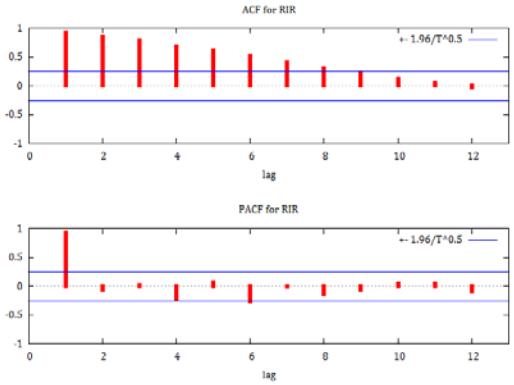
Correlogram 46 – first difference of the Eurozone's RIR – long period, Source: Author's Examination



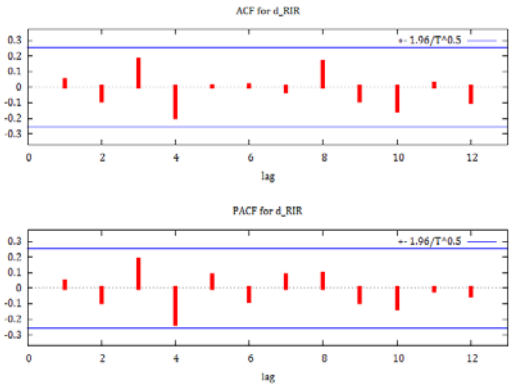
Correlogram 47 – RIR of Eurozone – post-crisis period, Source: Author's Examination



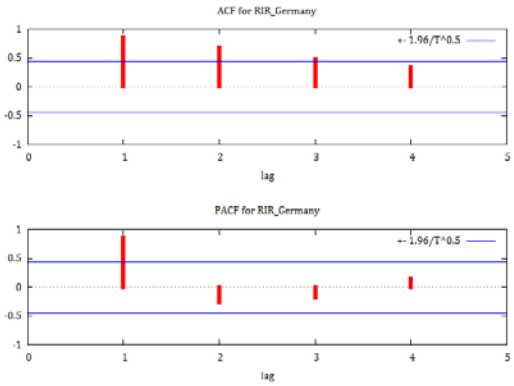
Correlogram 48 – first difference of the Eurozone's RIR – post-crisis period, Source: Author's Examination



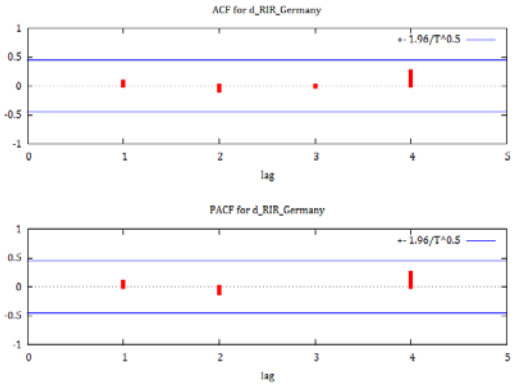
Correlogram 49 – RIR of Germany – long period, Source: Author's Examination



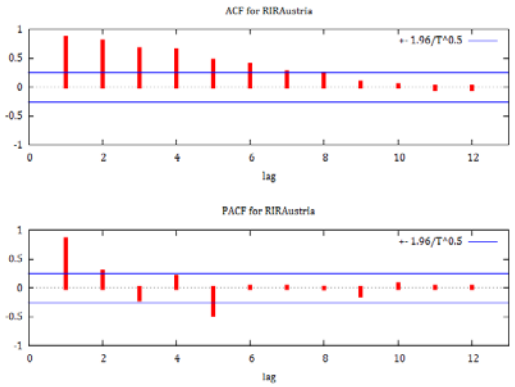
Correlogram 50 – first difference of the German RIR – long period, Source: Author's Examination



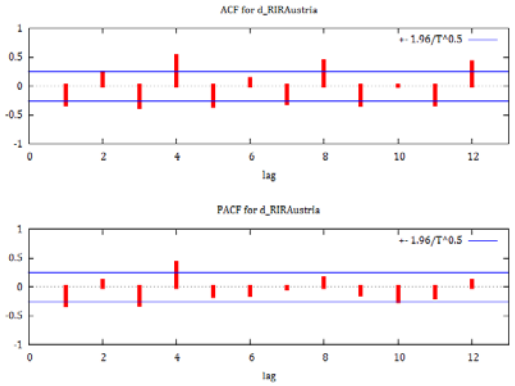
Correlogram 51 – RIR of Germany – post-crisis period, Source: Author's Examination



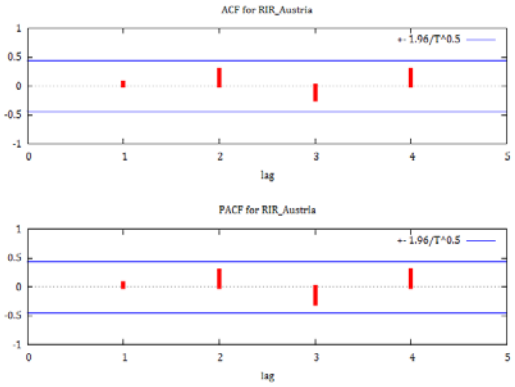
Correlogram 52 – first difference of the German RIR – post-crisis period, Source: Author's Examination



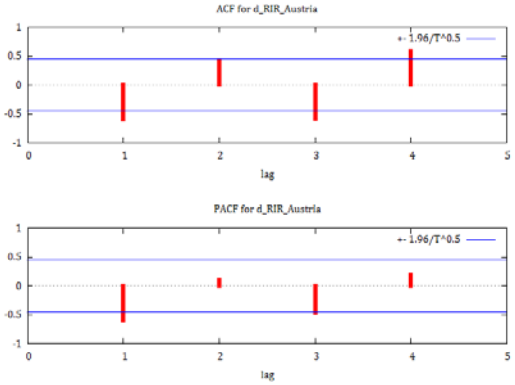
Correlogram 53 – RIR of Austria – long period, Source: Author's Examination



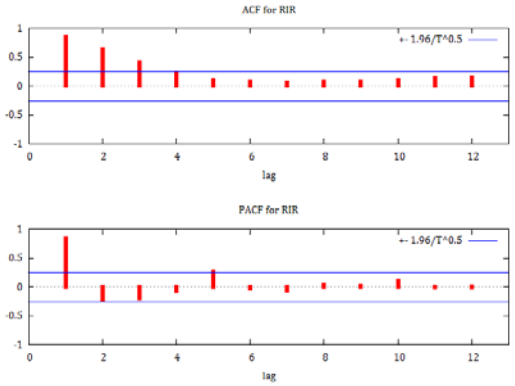
Correlogram 54 – first difference of the Austrian RIR – long period, Source: Author's Examination



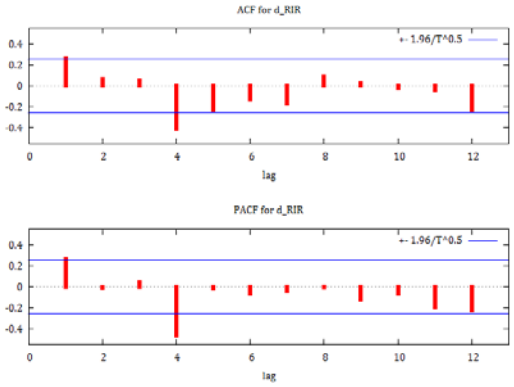
Correlogram 55 – RIR of Austria – post-crisis period, Source: Author's Examination



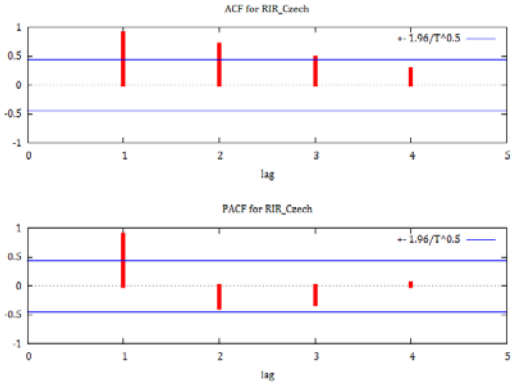
Correlogram 56 – first difference of the Austrian RIR – post-crisis period, Source: Author's Examination



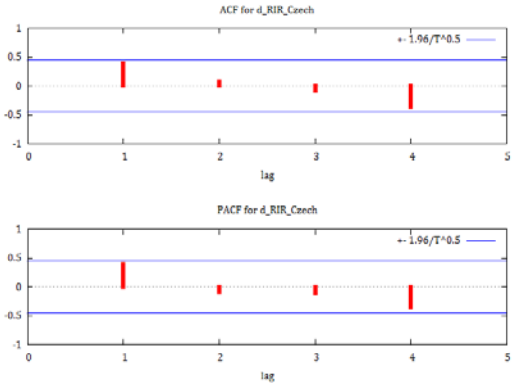
Correlogram 57 – RIR of the Czech Republic – long period, Source: Author's Examination



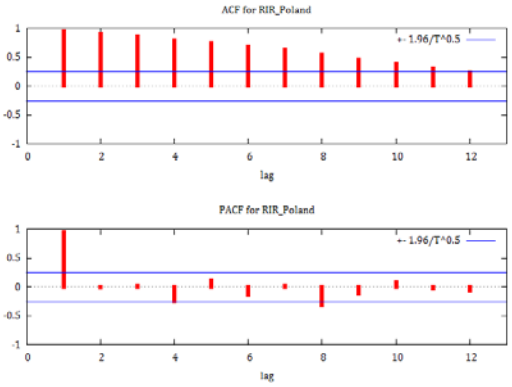
Correlogram 58 – first difference of the Czech RIR – long period, Source: Author's Examination



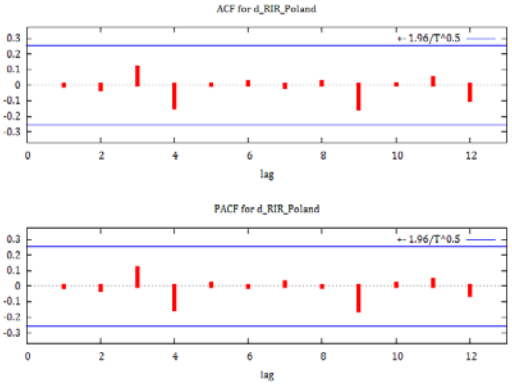
Correlogram 59 – RIR of the Czech Republic – post-crisis period, Source: Author's Examination



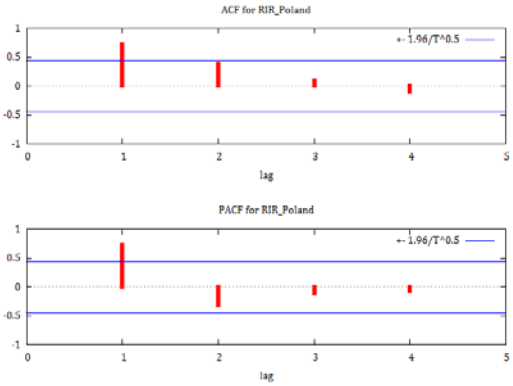
Correlogram 60 – first difference of the Czech RIR – post-crisis period, Source: Author's Examination



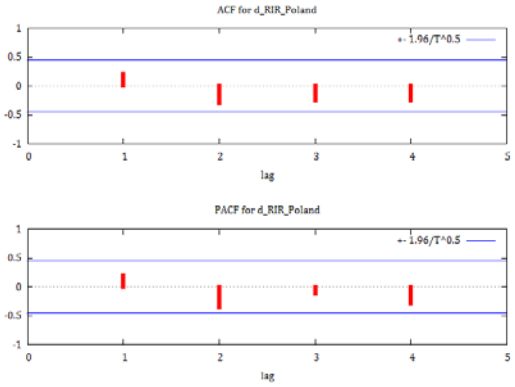
Correlogram 61 – RIR of Poland – long period, Source: Author's Examination



Correlogram 62 – first difference of the Polish RIR – long period, Source: Author's Examination



Correlogram 63 – RIR of Poland – post-crisis period, Source: Author's Examination



Correlogram 64 – first difference of the Polish RIR – post-crisis period, Source: Author's Examination

B Granger causality – results

Table B1: Results of Granger causality testing between the real GDP and real monetary aggregate M1 in Eurozone – long period. Source: Author's calculations

Monetary aggregate M1 – EUROZONE				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	0.22707	0.6356	**Do not reject**
	GDP does not Granger cause M1	16.121	0.0002	**Reject**
2	M1 does not Granger cause GDP	1,9682	0,15	**Do not reject**
	GDP does not Granger cause M1	7,8716	0.0011	**Reject**
3	M1 does not Granger cause GDP	6,1314	0,0013	**Reject**
	GDP does not Granger cause M1	5,0193	0,0041	**Reject**
4	M1 does not Granger cause GDP	3,5128	0,0139	**Reject**
	GDP does not Granger cause M1	2,8454	0,0344	**Reject**
5	M1 does not Granger cause GDP	3,0936	0,0179	**Reject**
	GDP does not Granger cause M1	2,6546	0,0354	**Reject**
6	M1 does not Granger cause GDP	2,4794	0,0392	**Reject**
	GDP does not Granger cause M1	2,4881	0,0386	**Reject**

Table B2: Results of Granger causality testing between the real GDP and real monetary aggregate M1 in Eurozone – post-crisis period. Source: Author's calculations

Monetary aggregate M1 – EUROZONE				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	2,1738	0,1611	**Do not reject**
	GDP does not Granger cause M1	8,7423	0,0098	**Reject**
2	M1 does not Granger cause GDP	4,5930	0,033	**Reject**
	GDP does not Granger cause M1	5,2023	0,0236	**Reject**
3	M1 does not Granger cause GDP	3,9733	0,0467	**Reject**
	GDP does not Granger cause M1	3,0981	0,082	**Do not reject**
4	M1 does not Granger cause GDP	2,2443	0,1799	**Do not reject**
	GDP does not Granger cause M1	9,8137	0,0084	**Reject**

Table B3: Results of Granger causality testing between the real GDP and real monetary aggregate M1 in Germany – long period. Source: Author's calculations

Monetary aggregate M1 – Germany				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	0,0477	0,9056	**Do not reject**
	GDP does not Granger cause M1	20,0440	0,0001	**Reject**
2	M1 does not Granger cause GDP	0,6053	0,5497	**Do not reject**
	GDP does not Granger cause M1	9,8280	0,0002	**Reject**
3	M1 does not Granger cause GDP	6,4980	0,0009	**Reject**
	GDP does not Granger cause M1	6,5373	0,0008	**Reject**
4	M1 does not Granger cause GDP	3,3014	0,0185	**Reject**
	GDP does not Granger cause M1	3,7542	0,0100	**Reject**
5	M1 does not Granger cause GDP	3,0278	0,0199	**Reject**
	GDP does not Granger cause M1	3,8816	0,0054	**Reject**
6	M1 does not Granger cause GDP	2,7856	0,0233	**Reject**
	GDP does not Granger cause M1	3,6733	0,0053	**Reject**

Table B4: Results of Granger causality testing between the real GDP and real monetary aggregate M1 in Germany – post-crisis period. Source: Author's calculations

Monetary aggregate M1 – Germany				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	1,6497	0,2185	**Do not reject**
	GDP does not Granger cause M1	13,0040	0,0026	**Reject**
2	M1 does not Granger cause GDP	2,7012	0,1075	**Do not reject**
	GDP does not Granger cause M1	4,6921	0,0312	**Reject**
3	M1 does not Granger cause GDP	3,4318	0,0657	**Do not reject**
	GDP does not Granger cause M1	3,1762	0,0778	**Do not reject**
4	M1 does not Granger cause GDP	2,8115	0,1245	**Do not reject**
	GDP does not Granger cause M1	2,2238	0,1825	**Do not reject**

Table B5: Results of Granger causality testing between the real GDP and real monetary aggregate M1 in Austria – long period. Source: Author's calculations

Monetary aggregate M1 – Austria				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	0,0341	0,8542	**Do not reject**
	GDP does not Granger cause M1	10,085	0,0025	**Reject**
2	M1 does not Granger cause GDP	2,8404	0,0675	**Do not reject**
	GDP does not Granger cause M1	5,4981	0.0068	**Reject**
3	M1 does not Granger cause GDP	4.0803	0.0115	**Reject**
	GDP does not Granger cause M1	2,8846	0.0450	**Reject**
4	M1 does not Granger cause GDP	2,4370	0,0604	**Do not reject**
	GDP does not Granger cause M1	1,0008	0,4169	**Do not reject**
5	M1 does not Granger cause GDP	2,3384	0,0579	**Do not reject**
	GDP does not Granger cause M1	1,7761	0,1381	**Do not reject**
6	M1 does not Granger cause GDP	3,4456	0,0077	**Reject**
	GDP does not Granger cause M1	2,0440	0,082	**Do not reject**

Table B6: Results of Granger causality testing between the real GDP and real monetary aggregate M1 in Austria – post-crisis period. Source: Author's calculations

Monetary aggregate M1 – Austria				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	1,8130	0,1981	**Do not reject**
	GDP does not Granger cause M1	0,1012	0,0177	**Reject**
2	M1 does not Granger cause GDP	0,7446	0,4957	**Do not reject**
	GDP does not Granger cause M1	0,9835	0,0888	**Do not reject**
3	M1 does not Granger cause GDP	1,0236	0,427	**Do not reject**
	GDP does not Granger cause M1	1,9804	0,1875	**Do not reject**
4	M1 does not Granger cause GDP	1,3750	0,3458	**Do not reject**
	GDP does not Granger cause M1	1,7077	0,6153	**Do not reject**

Table B7: Results of Granger causality testing between the real GDP and real monetary aggregate M1 in the Czech Republic – long period. Source: Author's calculations

Monetary aggregate M1 – The Czech Republic				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	0,0308	0,8612	**Do not reject**
	GDP does not Granger cause M1	2,333	0,1324	**Do not reject**
2	M1 does not Granger cause GDP	0,4435	0,6442	**Do not reject**
	GDP does not Granger cause M1	1,1957	0,3107	**Do not reject**
3	M1 does not Granger cause GDP	0,5980	0,6194	**Do not reject**
	GDP does not Granger cause M1	0,6483	0,5878	**Do not reject**
4	M1 does not Granger cause GDP	0,8351	0,51	**Do not reject**
	GDP does not Granger cause M1	1,3195	0,2769	**Do not reject**
5	M1 does not Granger cause GDP	0,1310	0,3586	**Do not reject**
	GDP does not Granger cause M1	0,6319	0,6764	**Do not reject**
6	M1 does not Granger cause GDP	0,9185	0,4919	**Do not reject**
	GDP does not Granger cause M1	0,7277	0,6299	**Do not reject**

Table B8: Results of Granger causality testing between the real GDP and real monetary aggregate M1 in the Czech Republic – post-crisis period. Source: Author's calculations

Monetary aggregate M1 – The Czech Republic				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	0,0228	0,8821	**Do not reject**
	GDP does not Granger cause M1	1,2226	0,2863	**Do not reject**
2	M1 does not Granger cause GDP	0,1299	0,8794	**Do not reject**
	GDP does not Granger cause M1	1,3012	0,308	**Do not reject**
3	M1 does not Granger cause GDP	1,1286	0,3882	**Do not reject**
	GDP does not Granger cause M1	0,9346	0,4632	**Do not reject**
4	M1 does not Granger cause GDP	1,4363	0,3289	**Do not reject**
	GDP does not Granger cause M1	2,7905	0,1261	**Do not reject**

Table B9: Results of Granger causality testing between the real GDP and real monetary aggregate M1 in Poland – long period. Source: Author's calculations

Monetary aggregate M1 – Poland				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	0,0449	0,833	**Do not reject**
	GDP does not Granger cause M1	0,15315	0,6971	**Do not reject**
2	M1 does not Granger cause GDP	6,3562	0,0034	**Reject**
	GDP does not Granger cause M1	1,8203	0,1721	**Do not reject**
3	M1 does not Granger cause GDP	6,0074	0,0014	**Reject**
	GDP does not Granger cause M1	5,2572	0,0032	**Reject**
4	M1 does not Granger cause GDP	4,5693	0,034	**Reject**
	GDP does not Granger cause M1	1,2444	0,3055	**Do not reject**
5	M1 does not Granger cause GDP	3,4135	0,011	**Reject**
	GDP does not Granger cause M1	1,2918	0,2852	**Do not reject**
6	M1 does not Granger cause GDP	1,3714	0,2497	**Do not reject**
	GDP does not Granger cause M1	0,6405	0,6972	**Do not reject**

Table B10: Results of Granger causality testing between the real GDP and real monetary aggregate M1 in Poland – post-crisis period. Source: Author's calculations

Monetary aggregate M1 – Poland				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M1 does not Granger cause GDP	0,0826	0,7777	**Do not reject**
	GDP does not Granger cause M1	1,7084	0,2109	**Do not reject**
2	M1 does not Granger cause GDP	0,7885	0,4767	**Do not reject**
	GDP does not Granger cause M1	0,8983	0,433	**Do not reject**
3	M1 does not Granger cause GDP	2,7853	0,102	**Do not reject**
	GDP does not Granger cause M1	1,2120	0,3602	**Do not reject**
4	M1 does not Granger cause GDP	2,6803	0,1351	**Do not reject**
	GDP does not Granger cause M1	1,5361	0,3036	**Do not reject**

Table B11: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in Eurozone – long period. Source: Author's calculations

Monetary aggregate M2 – EUROZONE				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	8,0356	0,064	**Reject**
	GDP does not Granger cause M2	0,2615	0,6112	**Do not reject**
2	M2 does not Granger cause GDP	11,7020	0,0001	**Reject**
	GDP does not Granger cause M2	1,3517	0,2979	**Do not reject**
3	M2 does not Granger cause GDP	7,4955	0,0003	**Reject**
	GDP does not Granger cause M2	1,5823	0,2059	**Do not reject**
4	M2 does not Granger cause GDP	4,9246	0,0022	**Reject**
	GDP does not Granger cause M2	1,1492	0,3458	**Do not reject**
5	M2 does not Granger cause GDP	3,6617	0,0077	**Reject**
	GDP does not Granger cause M2	0,6267	0,6803	**Do not reject**
6	M2 does not Granger cause GDP	3,5703	0,0065	**Reject**
	GDP does not Granger cause M2	0,7390	0,6214	**Do not reject**

Table B12: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in Eurozone – post-crisis period. Source: Author's calculations

Monetary aggregate M2 – EUROZONE				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	7,3577	0,0161	**Reject**
	GDP does not Granger cause M2	4,2050	0,0582	**Do not reject**
2	M2 does not Granger cause GDP	5,8648	0,0167	**Reject**
	GDP does not Granger cause M2	2,9191	0,0927	**Do not reject**
3	M2 does not Granger cause GDP	1,9670	0,1896	**Do not reject**
	GDP does not Granger cause M2	0,4651	0,7137	**Do not reject**
4	M2 does not Granger cause GDP	0,8973	0,52	**Do not reject**
	GDP does not Granger cause M2	1,4192	0,3335	**Do not reject**

Table B13: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in Germany – long period. Source: Author's calculations

Monetary aggregate M2 – Germany				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	0,5215	0,4733	**Do not reject**
	GDP does not Granger cause M2	6,4277	0,0141	**Reject**
2	M2 does not Granger cause GDP	5,3317	0,0078	**Reject**
	GDP does not Granger cause M2	2,7502	0,0732	**Do not reject**
3	M2 does not Granger cause GDP	6,3999	0,001	**Reject**
	GDP does not Granger cause M2	0,3325	0,8019	**Do not reject**
4	M2 does not Granger cause GDP	2,9881	0,0248	**Reject**
	GDP does not Granger cause M2	0,9786	0,4285	**Do not reject**
5	M2 does not Granger cause GDP	2,9744	0,0216	**Reject**
	GDP does not Granger cause M2	0,8421	0,5275	**Do not reject**
6	M2 does not Granger cause GDP	2,8210	0,022	**Reject**
	GDP does not Granger cause M2	0,3617	0,8987	**Do not reject**

Table B14: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in Germany – post-crisis period. Source: Author's calculations

Monetary aggregate M2 – Germany				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	10,7180	0,0051	**Reject**
	GDP does not Granger cause M2	1,6921	0,213	**Do not reject**
2	M2 does not Granger cause GDP	5,3004	0,0224	**Reject**
	GDP does not Granger cause M2	2,1989	0,1536	**Do not reject**
3	M2 does not Granger cause GDP	2,3893	0,1364	**Do not reject**
	GDP does not Granger cause M2	0,3233	0,8086	**Do not reject**
4	M2 does not Granger cause GDP	1,0649	0,4491	**Do not reject**
	GDP does not Granger cause M2	0,7362	0,5999	**Do not reject**

Table B15: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in Austria – long period. Source: Author's calculations

Monetary aggregate M2 – Austria				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	0,0086	0,9264	**Do not reject**
	GDP does not Granger cause M2	2,0700	0,1559	**Do not reject**
2	M2 does not Granger cause GDP	2,4050	0,1002	**Do not reject**
	GDP does not Granger cause M2	2,6076	0,0833	**Do not reject**
3	M2 does not Granger cause GDP	3,0583	0,0368	**Reject**
	GDP does not Granger cause M2	2,1677	0,1037	**Do not reject**
4	M2 does not Granger cause GDP	1,8264	0,1399	**Do not reject**
	GDP does not Granger cause M2	2,3548	0,0676	**Do not reject**
5	M2 does not Granger cause GDP	1,4330	0,2318	**Do not reject**
	GDP does not Granger cause M2	1,5681	0,1895	**Do not reject**
6	M2 does not Granger cause GDP	1,4296	0,2275	**Do not reject**
	GDP does not Granger cause M2	1,1712	0,3409	**Do not reject**

Table B16: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in Austria – post-crisis period. Source: Author's calculations

Monetary aggregate M2 – Austria				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	0,6731	0,4248	**Do not reject**
	GDP does not Granger cause M2	0,8592	0,1928	**Do not reject**
2	M2 does not Granger cause GDP	1,2056	0,3333	**Do not reject**
	GDP does not Granger cause M2	1,5722	0,2475	**Do not reject**
3	M2 does not Granger cause GDP	0,8394	0,5057	**Do not reject**
	GDP does not Granger cause M2	1,6431	0,2476	**Do not reject**
4	M2 does not Granger cause GDP	0,6256	0,6617	**Do not reject**
	GDP does not Granger cause M2	0,7791	0,5775	**Do not reject**

Table B17: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in the Czech Republic – long period. Source: Author's calculations

Monetary aggregate M2 – the Czech Republic				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	2,1661	0,1468	**Do not reject**
	GDP does not Granger cause M2	2,0613	0,1567	**Do not reject**
2	M2 does not Granger cause GDP	1,0461	0,3586	**Do not reject**
	GDP does not Granger cause M2	0,7513	0,4768	**Do not reject**
3	M2 does not Granger cause GDP	0,8555	0,4705	**Do not reject**
	GDP does not Granger cause M2	0,6440	0,5904	**Do not reject**
4	M2 does not Granger cause GDP	1,5210	0,2118	**Do not reject**
	GDP does not Granger cause M2	2,2948	0,0735	**Do not reject**
5	M2 does not Granger cause GDP	1,8708	0,1195	**Do not reject**
	GDP does not Granger cause M2	2,3700	0,0551	**Do not reject**
6	M2 does not Granger cause GDP	1,6144	0,1684	**Do not reject**
	GDP does not Granger cause M2	2,8012	0,0227	**Reject**

Table B18: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in the Czech Republic – post-crisis period. Source: Author's calculations

Monetary aggregate M2 – The Czech Republic				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	0,2771	0,6063	**Do not reject**
	GDP does not Granger cause M2	0,2236	0,6431	**Do not reject**
2	M2 does not Granger cause GDP	0,2507	0,7823	**Do not reject**
	GDP does not Granger cause M2	0,6734	0,5282	**Do not reject**
3	M2 does not Granger cause GDP	0,0233	0,9948	**Do not reject**
	GDP does not Granger cause M2	0,5187	0,6798	**Do not reject**
4	M2 does not Granger cause GDP	0,3118	0,8605	**Do not reject**
	GDP does not Granger cause M2	1,2108	0,3964	**Do not reject**

Table B19: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in Poland – long period. Source: Author's calculations

Monetary aggregate M2 – Poland				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	0,8590	0,3581	**Do not reject**
	GDP does not Granger cause M2	0,6171	0,4355	**Do not reject**
2	M2 does not Granger cause GDP	0,4237	0,6569	**Do not reject**
	GDP does not Granger cause M2	0,4901	0,6154	**Do not reject**
3	M2 does not Granger cause GDP	0,4139	0,7437	**Do not reject**
	GDP does not Granger cause M2	0,3328	0,8017	**Do not reject**
4	M2 does not Granger cause GDP	0,3922	0,8131	**Do not reject**
	GDP does not Granger cause M2	0,2611	0,9014	**Do not reject**
5	M2 does not Granger cause GDP	0,3615	0,872	**Do not reject**
	GDP does not Granger cause M2	0,4870	0,7841	**Do not reject**
6	M2 does not Granger cause GDP	0,0766	0,9981	**Do not reject**
	GDP does not Granger cause M2	1,0944	0,3825	**Do not reject**

Table B20: Results of Granger causality testing between the real GDP and real monetary aggregate M2 in Poland – post-crisis period. Source: Author's calculations

Monetary aggregate M2 – Poland				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	M2 does not Granger cause GDP	0,0480	0,8295	**Do not reject**
	GDP does not Granger cause M2	0,6788	0,4229	**Do not reject**
2	M2 does not Granger cause GDP	0,1822	0,8357	**Do not reject**
	GDP does not Granger cause M2	0,5941	0,5675	**Do not reject**
3	M2 does not Granger cause GDP	0,3756	0,7729	**Do not reject**
	GDP does not Granger cause M2	0,4540	0,7209	**Do not reject**
4	M2 does not Granger cause GDP	3,7021	0,0752	**Do not reject**
	GDP does not Granger cause M2	2,5281	0,1489	**Do not reject**

Table B21: Results of Granger causality testing between the real GDP and RIR in Eurozone – long period. Source: Author's calculations

Real Interest Rate (RIR) – EUROZONE				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
s1	RIR does not Granger cause GDP	2,9740	0.0917	**Do not reject**
	GDP does not Granger cause RIR	0,9685	0.3294	**Do not reject**
2	RIR does not Granger cause GDP	3,0942	0,0457	**Reject**
	GDP does not Granger cause RIR	1,5809	0,2155	**Do not reject**
3	RIR does not Granger cause GDP	3,1653	0,0326	**Reject**
	GDP does not Granger cause RIR	1,7081	0,1776	**Do not reject**
4	RIR does not Granger cause GDP	2,4026	0,0633	**Do not reject**
	GDP does not Granger cause RIR	3,809	0,0093	**Reject**
5	RIR does not Granger cause GDP	1,9008	0,1141	**Do not reject**
	GDP does not Granger cause RIR	3,0755	0,0185	**Reject**
6	RIR does not Granger cause GDP	0,5140	0,7942	**Do not reject**
	GDP does not Granger cause RIR	3,1291	0,0131	**Reject**

Table B22: Results of Granger causality testing between the real GDP and RIR in Eurozone – post-crisis period. Source: Author's calculations

Monetary aggregate RIR – EUROZONE				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	RIR does not Granger cause GDP	0,7598	0,1208	**Do not reject**
	GDP does not Granger cause RIR	0,5463	0,4713	**Do not reject**
2	RIR does not Granger cause GDP	1,7084	0,2224	**Do not reject**
	GDP does not Granger cause RIR	1,0685	0,3741	**Do not reject**
3	RIR does not Granger cause GDP	0,9174	0,4706	**Do not reject**
	GDP does not Granger cause RIR	1,5511	0,2677	**Do not reject**
4	RIR does not Granger cause GDP	0,8446	0,5448	**Do not reject**
	GDP does not Granger cause RIR	3,5040	0,0835	**Do not reject**

Table B23: Results of Granger causality testing between the real GDP and RIR in Germany – long period. Source: Author's calculations

Real Interest Rate (RIR) – Germany				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	RIR does not Granger cause GDP	0,0005	0.9823	**Do not reject**
	GDP does not Granger cause RIR	5,6944	0,0205	**Reject**
2	RIR does not Granger cause GDP	1,6543	0,2011	**Do not reject**
	GDP does not Granger cause RIR	4,0119	0,024	**Reject**
3	RIR does not Granger cause GDP	2,3113	0,0877	**Do not reject**
	GDP does not Granger cause RIR	2,5172	0,069	**Do not reject**
4	RIR does not Granger cause GDP	1,7984	0,1454	**Do not reject**
	GDP does not Granger cause RIR	1,3533	0,2648	**Do not reject**
5	RIR does not Granger cause GDP	1,3559	0,2597	**Do not reject**
	GDP does not Granger cause RIR	1,6466	0,1683	**Do not reject**
6	RIR does not Granger cause GDP	1,6676	0,1543	**Do not reject**
	GDP does not Granger cause RIR	1,3635	0,2528	**Do not reject**

Table B24: Results of Granger causality testing between the real GDP and RIR in Germany – post-crisis period. Source: Author's calculations

Monetary aggregate RIR – Germany				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	RIR does not Granger cause GDP	0,0414	0,8414	**Do not reject**
	GDP does not Granger cause RIR	2,0209	0,1756	**Do not reject**
2	RIR does not Granger cause GDP	1,4619	0,2703	**Do not reject**
	GDP does not Granger cause RIR	0,9133	0,4274	**Do not reject**
3	RIR does not Granger cause GDP	0,8241	0,5129	**Do not reject**
	GDP does not Granger cause RIR	0,0751	0,9719	**Do not reject**
4	RIR does not Granger cause GDP	1,4953	0,3137	**Do not reject**
	GDP does not Granger cause RIR	0,2195	0,9181	**Do not reject**

Table B25: Results of Granger causality testing between the real GDP and RIR in Austria – long period. Source: Author's calculations

Real Interest Rate (RIR) – Austria				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	RIR does not Granger cause GDP	1,4948	0,2267	**Do not reject**
	GDP does not Granger cause RIR	0,6386	0,4277	**Do not reject**
2	RIR does not Granger cause GDP	1,2475	0,2957	**Do not reject**
	GDP does not Granger cause RIR	1,9957	0,1462	**Do not reject**
3	RIR does not Granger cause GDP	1,8265	0,1546	**Do not reject**
	GDP does not Granger cause RIR	1,7328	0,1725	**Do not reject**
4	RIR does not Granger cause GDP	1,502	0,2172	**Do not reject**
	GDP does not Granger cause RIR	5,581	0,001	**Reject**
5	RIR does not Granger cause GDP	1,5601	0,1918	**Do not reject**
	GDP does not Granger cause RIR	3,1271	0,017	**Reject**
6	RIR does not Granger cause GDP	1,5031	0,202	**Do not reject**
	GDP does not Granger cause RIR	2,7728	0,0238	**Reject**

Table B26: Results of Granger causality testing between the real GDP and RIR in Austria – post-crisis period. Source: Author's calculations

Monetary aggregate RIR – Austria				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	RIR does not Granger cause GDP	0,4962	0,492	**Do not reject**
	GDP does not Granger cause RIR	0,1969	0,6636	**Do not reject**
2	RIR does not Granger cause GDP	0,2290	0,7987	**Do not reject**
	GDP does not Granger cause RIR	0,3107	0,7386	**Do not reject**
3	RIR does not Granger cause GDP	0,9785	0,445	**Do not reject**
	GDP does not Granger cause RIR	0,1824	0,9057	**Do not reject**
4	RIR does not Granger cause GDP	0,6509	0,6471	**Do not reject**
	GDP does not Granger cause RIR	0,7537	0,2564	**Do not reject**

Table B27: Results of Granger causality testing between the real GDP and RIR in the Czech Republic – long period. Source: Author's calculations

Real Interest Rate (RIR) – The Czech Republic				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	RIR does not Granger cause GDP	4,6220	0,036	**Reject**
	GDP does not Granger cause RIR	2,5750	0,1143	**Do not reject**
2	RIR does not Granger cause GDP	4,5595	0,015	**Reject**
	GDP does not Granger cause RIR	1,3577	0,2662	**Do not reject**
3	RIR does not Granger cause GDP	3,0372	0,0387	**Reject**
	GDP does not Granger cause RIR	1,1169	0,3522	**Do not reject**
4	RIR does not Granger cause GDP	2,3905	0,0644	**Do not reject**
	GDP does not Granger cause RIR	0,89136	0,4768	**Do not reject**
5	RIR does not Granger cause GDP	1,6988	0,1555	**Do not reject**
	GDP does not Granger cause RIR	0,9070	0,4854	**Do not reject**
6	RIR does not Granger cause GDP	1,6557	0,1573	**Do not reject**
	GDP does not Granger cause RIR	1,215	0,3188	**Do not reject**

Table B28: Results of Granger causality testing between the real GDP and RIR in the Czech Republic – post-crisis period. Source: Author's calculations

Monetary aggregate RIR – The Czech Republic				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	RIR does not Granger cause GDP	3,0099	0,0875	**Do not reject**
	GDP does not Granger cause RIR	1,0193	0,3287	**Do not reject**
2	RIR does not Granger cause GDP	2,3053	0,1547	**Do not reject**
	GDP does not Granger cause RIR	0,0424	0,9586	**Do not reject**
3	RIR does not Granger cause GDP	1,5345	0,1954	**Do not reject**
	GDP does not Granger cause RIR	0,1396	0,9337	**Do not reject**
4	RIR does not Granger cause GDP	2,7711	0,1276	**Do not reject**
	GDP does not Granger cause RIR	0,1729	0,9444	**Do not reject**

Table B29: Results of Granger causality testing between the real GDP and RIR in Poland – long period. Source: Author's calculations

Real Interest Rate (RIR) – Poland				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	RIR does not Granger cause GDP	3,1271	0,017	**Reject**
	GDP does not Granger cause RIR	2,9155	0,0934	**Do not reject**
2	RIR does not Granger cause GDP	3,053	0,0356	**Reject**
	GDP does not Granger cause RIR	1,6320	0,2054	**Do not reject**
3	RIR does not Granger cause GDP	0,2483	0,8622	**Do not reject**
	GDP does not Granger cause RIR	1,2884	0,2888	**Do not reject**
4	RIR does not Granger cause GDP	1,6104	0,1877	**Do not reject**
	GDP does not Granger cause RIR	0,9759	0,43	**Do not reject**
5	RIR does not Granger cause GDP	0,3434	0,8836	**Do not reject**
	GDP does not Granger cause RIR	1,1005	0,3742	**Do not reject**
6	RIR does not Granger cause GDP	0,3768	0,8894	**Do not reject**
	GDP does not Granger cause RIR	0,95517	0,4675	**Do not reject**

Table B30: Results of Granger causality testing between the real GDP and RIR in Poland – post-crisis period. Source: Author's calculations

Monetary aggregate RIR – Poland				
Lag	**Null hypothesis**	**F-statistics**	**p-value**	**Decision**
1	RIR does not Granger cause GDP	0,1577	0,6969	**Do not reject**
	GDP does not Granger cause RIR	1,6981	0,2122	**Do not reject**
2	RIR does not Granger cause GDP	0,2057	0,8169	**Do not reject**
	GDP does not Granger cause RIR	1,3446	0,2972	**Do not reject**
3	RIR does not Granger cause GDP	2,1830	0,1598	**Do not reject**
	GDP does not Granger cause RIR	0,9456	0,4586	**Do not reject**
4	RIR does not Granger cause GDP	1,7197	0,2631	**Do not reject**
	GDP does not Granger cause RIR	0,7104	0,6138	**Do not reject**