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Rajmund Mirdala, Marianna Siničáková et al.

MONETARY RULES AND THEIR IMPORTANCE IN CONTEXT OF MONETARY UNION AND ECONOMIC CRISIS

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FOREWORD

Nowadays, in the time of economic and debt crisis, many European Union member countries are exposed to the large complex of negative implications of recession, peaking rates of unemployment, increased public debt burden as well as worsen conditions to maintain fiscal sustainability. Moreover, increased uncertainty on the financial markets resulted in higher volatility of market prices/rates that reduced predictability of market trends, even in the short period. As a direct response to the crisis related issues that put economies under the pressure resulted from the initial shock followed by a lagging recession, central banks employed discretionary monetary policy mix to reduce liquidity constrains and improve downward interest rates flexibility.

While the overall access of commercial banks to the liquidity clearly improved afterward, private sector and governments still suffered from reduced supply of new loans. Even more, high risk margins reduced effects of monetary incentives. Introduction of new elements in the monetary policy strategies (massive quantitative easing, additional refinancing facilities on short-term as well as long-term basis, debt market interventions, etc.) helped central banks to reduce interest rates down. However, the overall responsiveness of economies to reduced costs of capital seems to be limited. As a result, more and more questions associated with optimal monetary policy mix arises daily as a direct response to the puzzling effects of discretionary monetary fine-tuning or even monetary policy driven post-crisis economic recovery at all.

Current crisis period represents very convenient example of how traditional monetary policy strategies doesn't work (or at least are not so effective) at bad times while being quite successful in guarantying monetary stability at good times. Money demand instability, monetary base "explosion" and liquidity trap are key examples of problems that are really challenging for monetary authorities. Even the key monetary policy objective of low and stable inflation became a subject of a wide academic discussion provided its relevancy during the crisis affected by increased uncertainty and weak overall demand. Competitive internal devaluation and reflation represents vicious discretionary based examples of inflation driven recovery with hardly expected and potentially dangerous medium-term implications especially for sustainability of weak economic growth rates, natural market incentives.

However, there are also other problems that may follow alongside the success in demand driven economic recovery associated with inflation pressures and short-term interest rates instability originating in excessive money supply and its subsequent reduction during the early periods of recovered economic growth. Associated reduced signal function of interest rates leading path and excessive market distortions may accelerate another even more dangerous wave of crisis.

The main objective of our monograph - *Monetary Rules and their Importance in Context of Monetary Union and Economic Crisis* - is to address selected problems of the monetary policy decision making. Contributing authors examined wide variety of aspects associated with bi-directional relationships between interest rates and macroeconomic fundamental variables. Short-term interest rates represent one of the most crucial variables in the monetary policy frameworks of central banks. It serves not only as a very effective vehicle for a transmission of monetary policy decisions by monetary authorities but also as a convenient indicator of monetary conditions. Interest rates determination represents key pillar in the rules versus discretion dilemma as well as quality (interest rates) versus quantity (money supply) dilemma. While both dilemmas may be considered as obsolete issue in the main streams of economic theory for decades, their relevancy clearly arises in the time of sudden, sharp, lasting and complex downturns in particular as well as world economy.

The monograph *Monetary Rules and their Importance in Context of Monetary Union and Economic Crisis* deals with was elaborated within the project VEGA 1/0973/11 on Monetary Rules and Their Importance in the Context of Monetary Union and Economic Crisis. The monograph is the result of the three year research. It summarizes main outcomes of contributing authors and is enriched by contribution of our foreign partners from the Institute of Economic Sciences in Belgrade in Serbia. The findings of our research were positively appreciated by the Institute; consequently the monograph is published in Belgrade. Multilateral activities, cooperation and experience of this Institute will enable us to disseminate our outcomes on international level. In addition, our research can be inspiring for other new European Union member states or accession countries, such as e.g. Serbia.

Monograph consists of four individual chapters. First chapter, *Interest Rates Determination in the European Transition Economies*, investigates the problem of interest rates determination under different exchange rate regimes and may provide crucial information about implications of relative exchange rate diversity in individual countries. Author analyzes sources of the short-term nominal interest rates volatility in ten European transition economies. Effects of structural shocks (demand, liquidity, inflation, monetary policy and exchange rate structural shocks) as well as changes in inflation expectations to the short-term interest rates are investigated. Author employed VAR methodology and estimated to compute impulse-response functions of the short-term nominal interest rates. Results of estimated model are discussed from the perspective of fixed versus flexible exchange rate dilemma. To provide more rigorous insight into the problem of the exchange rate regime suitability author estimated the model for each particular country employing data for two subsequent periods 2000-2007 (pre-crisis period) and 2000-2012 (extended period). Comparison of the results for both models is crucial to investigate the origins and key implications of current economic crisis on the short-term interest rates volatility.

Second chapter, *Monetary Rules and Their Importance in the Context of Monetary Union*, summarizes relevant literature resources on monetary rules problematic. It describes practical and theoretical background of monetary rules also from the perspective of time inconsistency aspect. Following subsection offers pros and cons concerning rules and discretion, it outlines monetary rules history as well as their current criticism due to financial and economic crisis. Later on, monetary rules are analyzed in the context of particular monetary strategies such as exchange rate targeting, inflation targeting, etc. Sixth subsection focuses on the methodology of monetary rules quantification also in respect to new European Union member states with particular impact on the Taylor rule. Finally, several monetary rules, precisely the Taylor-type rules are quantified for Slovak economy as an example of a post-transition economy facing the specific situation of its integration to the euro area and financial and economic crisis at the same time. Estimation process is based on linear regression with Newey-West standard errors approach. Unlike previous research aspect of monetary integration, breaking points as well as period of crisis are taken into account. Break points are identified and confirmed using the Quandt-Andrews and Chow break point test. Obtained results enable us to characterize monetary policy in the Slovak Republic and evaluate its compatibility with the single euro area monetary policy and to compare it with monetary policy setting in other Visegrad countries, i.e. the Czech Republic, Hungary and Poland, which experienced similar transition process but, unlike Slovakia, have not chosen, yet, to adopt euro.

Third chapter, *Effectiveness of the Interest Rate Channel in the Context of Monetary Union and Economic Crisis*, is focused on analysis of the transmission process of monetary policy in euro area in general as well as for the EMU countries and selected transition economies such as V4 countries. Authors employed VAR methodology to identify the effects of the monetary shocks on selected variables. From the calculated impulse-response functions authors investigated interest rate pass-through to macroeconomic variables. Model is estimated for the pre-crisis and extended period and countries are divided to three groups - northwest EU countries, south EU countries and Visegrad countries to improve empirical results and following discussion.

Fourth chapter, *Forecasting Serbian Quarterly GDP*, focuses on forecasting of Serbian GDP, which is crucial in application of forward-looking monetary policy. The authors of the chapter extend classical Box-Jenkins approach, also known as Seasonal Autoregressive Integrated Moving Average (SARIMA) stochastic model. The chapter is relevant as prediction is quite difficult in general and especially in countries in transition, which is the case of Serbia. Their results are confronted with the estimations of financial institutions in Serbia.

The monograph is dedicated to researchers, students, teachers, central bankers, general public and to all who are interested in the fields of macroeconomics, monetary policy and international finance. Individual chapters have ambition to enlighten issues and challenges of monetary policy implementation in the context of monetary union and economic crisis.

Košice, December 2013

Rajmund Mirdala

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Chapter 1

Interest Rates Determination in the European Transition Economies

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1.1 Interest Rates Determination under Different Exchange Rate Regimes
1.2 Interest Rates Determination and Inflation Expectations
1.3 References

INTEREST RATES DETERMINATION IN THE EUROPEAN TRANSITION ECONOMIES

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Abstract
Relative variability in the short-term interest rates adjustments under different exchange rate arrangements reveals disputable implications and associated risks of the breakdown in mutual interconnections between the overall macroeconomic development and the exchange rate leading path. Empirical investigation of interest rates determination under different exchange rate regimes may provide crucial information about implications of relative exchange rate diversity. In the chapter we analyze sources of the short-term nominal interest rates volatility in ten European transition economies. Effects of structural shocks to the short-term interest rates will be investigated. We also examine a relative importance of inflation expectations to the short-term interest rates volatility.

Keywords: interest rates volatility, structural shocks, inflation expectations, exchange rate arrangements, economic crisis, vector autoregression, variance decomposition, impulse-response function

1.1. Interest Rates Determination under Different Exchange Rate Regimes

1.1.1. Introduction to Exchange Rates in the European Transition Economies

Nowadays, in the time of economic and debt crisis, many European Union member countries are exposed to the large complex of negative implications of recession, peaking rates of unemployment, increased public debt burden as well as worsen conditions to maintain fiscal sustainability. Moreover, increased uncertainty on the financial markets resulted in higher volatility of market prices/rates reduces predictability of market trends, even in the short period. As a result, increased instability of exchange rates seems to be inevitable but painful implication. Due to many external causes we may also experience sudden changes in determination potential of exchanges rate especially toward key aspects of macroeconomic performance in countries under flexible exchange rate arrangements.

One of the most controversial implications of different exchange rate arrangements is addressed to their appropriateness and sustainability in countries at different stage of business cycle in short period while reflecting the overall macroeconomic performance. Wide range of such implications became highly discussed especially in the group of countries (so called European transition economies[2] which joined European Union in 2004. It may seem that fixed versus flexible exchange rates dilemma in the period of increased global uncertainty and

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negative trends in the global economy became alive again while discussions on policy issues, challenges and controversies may find it difficult to provide clear suggestions.

European transition economies already challenged a decision to adopt euro and participate in the project of common currency in the eurozone together with Western European countries few years before world economic crisis arises. Among many circumstances and policy issues associated with a proposition of convenient time table for the schedule of euro adoption became the sacrifice of monetary sovereignty a highly discussed implication. The loss of exchange rate flexibility in the eurozone candidate countries raised as a direct contrary effect of gained exchange rate stability associated with sacrificed monetary sovereignty. Despite real benefits of fixing exchange rate to euro followed by the euro adoption it may seem that the risks of loss in mutual interconnections between the overall macroeconomic development and the exchange rate leading path are still not well observed in the current empirical literature.

Exchange rate regimes evolution in the European transition economies refers to one of the most crucial policy decision in the beginning of the 1990s employed during the initial stages of the transition process. Despite its differences there seem to be some similar features of the starting point affecting exchange rate regime choice in each particular economy, such as similar macroeconomic development after initial transition shock (recession followed by restoration of macroeconomic stability), number of transition packages employed to support market principles and incentives as well as intention to apply for European Union membership followed by the euro adoption in the near future.

During the period of last two decades we may identify some crucial milestones in the exchange rate regimes evolution in the European transition economies. Macroeconomic stability, as one of the primary objectives in the initial phase of the transition process, revealed an absence of nominal anchor and its crucial role in reducing the risks of excessive external imbalances while providing firm constrains for national authorities. A decision to adopt so pegged exchange rate regimes (feasibility to estimate the "right" equilibrium exchange rate may be still disputable) might seem to be the most convenient and appropriate solution to reduce current account imbalances, strengthen fiscal discipline and provide a suitable anchor for prudential monetary policy.

On the other hand, sustainability of pegged exchange rate is obviously determined by central bank's ability to maintain safe level of exchange reserves. Inadequate stock of foreign exchange held by central banks in Bulgaria, Romania and Slovenia refers as a most common reason to their inability to establish soft-pegged exchange rate regime in the early 1990s. Despite general expectations, European transition economies did not follow a common trend in the exchange rate regime evolution during last two decades.

Central European countries (the Czech Republic, Hungary, Poland, Slovak Republic) have experienced a long trend of successive shift from soft-pegged exchange rate regimes to floating regimes. Baltic countries implemented pegged exchange rate regimes in the first half of the 1990s. Estonia and Lithuania anchored exchange rate based stabilization by employing hard peg regime (currency board), while Latvia implemented soft peg regime (conventional fixed pegs). Bulgaria challenged an intensive financial crisis in 1996-97 initiated by imbalanced growth and low credibility (excessive amount of failed commercial bank loans) followed by forced shift from floating regime (managed floating) to hard peg regime (currency board). Romania and Slovenia remained as the only two countries not enjoying benefits of exchange rate based stabilization and kept employing floating exchange rate regimes during the whole period.

Determination process of the exchange rates leading path in the European transition economies followed quite similar principles in the long run. At the same time, it has also reflected effects of many specific features of the transition process, i.e. structural changes in the production capacities, institutional changes, deregulation of markets, price liberalization, changing structure of relative prices, etc. All those country-specific processes substantially affected long-run trends (even in the area of the exchange rate determination), that is why a rigorous insight into their principles seems to be crucial for understanding and implementation the appropriate exchange rate regime in particular country from the group of the European transition economies.

Considering a substantial similarity of exchange rate arrangements employed by the most of the European transition economies in the early 1990s (provided their diversity at later stages of the transition process) similar initial conditions at the starting point of the transition process seem to be a crucial for its understanding. A decision to adopt pegged exchange rate regimes reveals an intention to benefit from firm external nominal anchor in fighting high inflation and reducing costs of disinflationary process. Such an approach reflected the fact that the most of the countries from the past Eastern bloc performed as small opened economies.

After successful accession of the European transition economies to the European Union in 2004 and 2007 (Bulgaria and Romania) it seems that new European Union countries with flexible exchange rate arrangements enjoyed higher exchange rate stability. Participation of national currencies in ERM 2 followed by euro adoption seems to be the only feasible solution at the final stage of the successful lung-run integration process of the European transition economies.

Despite the fact, there seems to be no real perspective alternative to euro adoption for the European transition economies, we emphasize disputable effects of sacrificing monetary sovereignty in the view of positive effects of exchange rate volatility and exchange rate based adjustments in the country experiencing sudden shifts in the business cycle. On the other hand, due to existing diversity in exchange rate arrangements in the European transition economies in the pre-ERM2 period there seems to be two big groups of countries - “peggers” (Bulgaria, Estonia, Latvia, Lithuania) and “floaters” (the Czech Republic, Hungary[3], Poland, Romania, Slovak Republic, Slovenia). Effects of sacrificing exchange rate flexibility and its spurious effects on real output and inflation can be conventionally interpreted as fixed versus flexible exchange rates dilemma. At the same time, macroeconomic effects of various exchange rate arrangements during the crisis period may provide a better insight into

[3] Hungarian forint operated during pre-crisis period in de facto fixed peg regime, but due to substantial range for fluctuations provided by wide horizontal bands it was included in the group of countries, so called “floaters”

suitability of relative exchange rate volatility in each individual economy during sudden changes in the business cycle.

In this chapter we analyze sources of the short-term nominal interest rates volatility in ten European transition economies. From estimated VAR model (structural factorization will be employed to identify structural shocks from the unrestricted VAR model residuals) we compute impulse-response functions to analyze responses of short-term interest rates to the five types of structural shocks (demand shock, liquidity shock, inflation shock, monetary policy shock, exchange rate shock). Results of estimated model are discussed from the perspective of fixed versus flexible exchange rate dilemma. To provide more rigorous insight into the problem of the exchange rate regime suitability we estimate the model for each particular country employing data for two subsequent periods 2000-2007 (pre-crisis period) and 2000-2012 (extended period). Comparison of the results for both models is crucial to investigate the origins and key implications of current economic crisis on the short-term interest rates volatility.

We suggest that our results provide a rigorous insight into short-term interest rates determination potential in ten European transition economies. Relative diversity in the short-term interest rates adjustments under different exchange rate arrangements may reveal disputable implications and associated risks of the breakdown in mutual interconnections between the overall macroeconomic development and the exchange rate leading path.

1.1.2. Overview of Exchange Rate Arrangements Evolution in the European Transition Economies

Macroeconomic stability, fast recovery from deep and sudden transition shock and real output growth stimulation represents one of the most challenging objectives for the European transition economies in the early 1990s. Consistent choice as well as flexible adjustments of monetary policy framework and exchange rate regime accompanied key crucial economic policy decisions in this process. Associated changes in monetary-policy strategy reflected wide range of macroeconomic aspects underlying sustainability of appropriate exchange rate regime choice.

Among key determinants of the exchange rate regime choice in the European transition economies at the beginning of the 1990s we may consider an effort to regain macroeconomic stability, foreign exchange reserves requirements and availability, overall external economic (trade and financial) openness, etc. At the later stages of transition process we emphasize the role of massive foreign capital inflows, sustainability of real economic growth, institutional adjustments according to perspectives of ERM2 entry.

Initial transition shock followed by the sharp real output decline associated with intensive inflation pressures (caused by rapid exchange rate devaluations, price liberalization and deregulation, tax reforms, fiscal imbalances, etc.) emphasized a crucial importance of strong nominal anchor for monetary authorities and their framework in restoring a macroeconomic stability and confidence as well as positive expectations of economic agents. However immediate exchange rate based stabilization became an appropriate strategy only for countries with adequate foreign exchange reserves while being able to significantly reduce inflation pressures in adequate (short) time period to prevent undesired rapid overvaluation. As a result it seems to be convenient to divide the European transition economies in two groups (so called “peggers” and “floaters”) considering initial exchange rate regime framework.

Relative diversity in exchange rate regimes in the European transition economies revealed uncertain and spurious conclusions about the exchange rate regime choice during last two decades. Moreover, the eurozone membership perspective (de jure pegging to euro) realizes uncertain consequences of exchange rate regime switching especially in the group of large floaters.

Successful anti-inflationary policy associated with stabilization of inflation pressures and inflation expectations in the European transition economies at the end of 1990s significantly increased the role of short-term interest rates in the monetary policy strategies. At the same time, so called qualitative approach to the monetary policy decision-making performed in the low inflation environment, gradually enhanced the role of real interest rates expectations in the process of nominal interest rates determination. However, economic crisis increased uncertainty on the markets and thus worsen expectations (inflation expectations including) of agents.

Eurozone member countries as well as global economy are currently exposed to the negative effects of the economic and debt crisis. To alleviate recession and support economic recovery, monetary authorities dramatically reduced key interest rates. Low interest rates together with quantitative easing, however, should not necessarily increase supply of new loans to the private sector due to prudential credit policy of commercial banks reflecting increased uncertainty on the markets and high risk premia. As a result, policy of low interest rates seems to be inefficient.

Exchange rate policy evolution represents one of the key parts of crucial economic policy decisions at the beginning of the transition process in countries from the region of Central and Eastern Europe in the early 1990s. Despite its complexity and particularity there seems to be some similar features at the starting point of transition process in all European transition economies such as recession followed by initial transition shock and common vision of European union and Economic and Monetary union membership.

Macroeconomic stability as one of the primary objectives in the initial phase of the transition process affected exchange rate regime choice in the European transition economies. However, low credibility of monetary institutions, lack of foreign exchange reserves and high inflation differentials represented real constraints and difficulties related to the sustainability of pegged exchange rate regimes. Brief overview of the exchange rate regimes evolution in the European transition economies provides table 1.1.

Table 1.1 Exchange Rate Regimes in the European Transition Economies

	exchange rate regime				
Bulgaria		managed floating	currency board		
Czech Republic	peg with horizontal bands	managed floating			
Estonia		currency board	ERM2	eurozone	
Hungary	adjustable peg	crawling peg	peg with horizontal bands	managed floating	
Latvia		floating	conventional fixed peg	ERM2	
Lithuania		floating	currency board	ERM2	
Poland		crawling peg	free floating		
Romania	free floating	managed floating			
Slovak Republic	peg with horizontal bands	managed floating	ERM2	eurozone	
Slovenia		managed floating	crawling band	ERM2	eurozone
	1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012				

Note: Exchange rate regime evolution in the European transition economies: *Bulgaria* - since 1991 floating (pegged exchange rate regime undesirable due to possible low credibility), currency board since 1997 (after 1996-1997financial crisis (public debt, bad commercial banks loans)). *Czech Republic* - exchange rate pegged to currency basket with narrow but continuously widen horizontal bands, since May 1997 after currency attacks switch to managed floating with no predetermined path for the exchange rate with DEM (EUR) as reference currency. *Estonia* - currency board since 1992 till 2011 (euro adoption), plan to adopt in 2008 but delayed due high inflation, since 2011 the eurozone membership. *Hungary* - managed floating till February 1995, since March 1995 till the end of 1999 crawling peg with continuously decreased rate of periodical devaluation and widen horizontal bands, since January 2000 exchange rate pegged to euro combined with wide horizontal bands (since May 2001), since May 2008 managed floating with EUR as reference currency. *Latvia* - since February 1994 exchange rate pegged to SDR (fixing the exchange rate to a basket of currencies (SDR) instead of a single currency serves to promote long-term stability) (since January 2005 pegged to EUR), since 2014 the eurozone membership. *Lithuania* - since April 1994 currency board (exchange rate pegged to USD, in February 2002 pegging switched to EUR). *Poland* - since the end of 1991 crawling peg with continuously decreased rate of periodical devaluation and widen horizontal bands, since April 2000 free floating. *Romania* - free floating, since 1998 exchange rate arrangement reclassified as managed floating. *Slovak Republic* - exchange rate pegged to currency basket with narrow but continuously widen horizontal bands, since October 1998 after currency attacks switch to managed floating with no predetermined path for the exchange rate with DEM (EUR) as reference currency, since 2009 the eurozone membership. *Slovenia* - managed floating with no predetermined path for the exchange rate (since February 2002 crawling band - the monetary authority manages the float of the domestic currency within certain fluctuating margins around a depreciating path - a heavily-managed crawling band with pragmatic monetary, real, external and financial indicators).

ERM2 - June 2004 - Estonia (left in January 2011 after euro adoption), Lithuania, Slovenia (left in January 2007 after euro adoption)

- May 2005 - Latvia (leaves in January 2014 after euro adoption)
- November 2005 - Slovak Republic (left in January 2009 after euro adoption)

.***Source:*** IMF AREAER 1990-2012, author's processing.

It seems to be clear that the European transition economies did not follow common practice in the process of the exchange rate regime choice at the beginning of the 1990s.

Small Baltic countries adopted currency board regime (Estonia and Lithuania) eventually conventional fixed peg regime (Latvia). Hungary adopted crawling peg regime (after few years of adjustable peg in place) together with Poland. The Czech Republic and Slovak Republic adopted pegged regime with horizontal bands. Despite high inflation rates Bulgaria, Romania and Slovenia adopted floating exchange rate regime due to low level of reserves and lack of credibility though Bulgaria switched to currency board after 1996-97 financial crisis. It seems to be clear that most of the European transition economies enjoyed disinflationary and credibility benefits of so called hard or soft exchange rate regimes. Fixed exchange rates as the nominal anchor significantly contributed to the successful disinflationary process at the end of the 1990s.

Till the end of the decade many countries from the group continuously switched to more flexible exchange rate regimes (the Czech Republic in 1997, Slovak Republic in 1998 and Poland in 2000). Similarly, Hungary switched to intermediate exchange rate regime by widening horizontal bands. Although Hungary stacked to exchange rate pegged to euro, by employing wide horizontal bands de facto followed the same trend as previous group of countries.

Exchange rate regime choice also affected corresponding monetary policy strategy framework. Countries with exchange rate as the nominal anchor (hard pegs or soft pegs with narrow horizontal bands) successfully implemented nominal exchange rage targeting. Countries with soft pegs (pegs with wide horizontal bands or crawling pegs) and floating regimes employed monetary targets as intermediate criteria of monetary policy (monetary targeting).

Overall success of disinflationary process represents one of the key milestones and success on the road to the stable macroeconomic environment with crucial role of low, stable and thus predictive inflation expectations. Low inflation combined with stable inflation expectations is considered to be a substantial condition for switching from quantitative (money supply) to qualitative (interest rates) approach in the monetary policy decision-making. This adjustment in monetary policy strategies seems to be obvious in the European transition economies since the end of 1990s as a part of prevailing trend in weakening of relationship between monetary aggregates dynamics and inflation. Increased role of inflation expectations together with raising credibility of monetary authorities resulted in adoption of direct (explicit) inflation targeting strategy in many European transition economies - the Czech Republic (1998), Poland (1999), Hungary (2001), Slovenia (2002), Romania (2005) and Slovak Republic (2005).

European transition economies challenged a decision of a euro adoption and the eurozone membership several years before the economic crisis arises. Disputable policy implications of sacrificing monetary sovereignty rose as a crucial assumption affecting main features as well as durability of preparation phase timetable in countries with flexible exchange rate regimes (the Czech Republic, Poland, Romania, Slovak Republic and Slovenia). Among a variety of determinants and aspects we emphasize the role of decisions inevitably associated with “right” scheduling of the eurozone entry. Some countries from the group of the European transition economies already joined the eurozone (Estonia (2011), Slovak Republic (2009), Slovenia (2007)) followed by participation of their currencies in ERM2 (Estonia (June 2004), Slovak Republic (November 2005), Slovenia (June 2004)). On the other hand currencies of Lithuania and Latvia are still participating on ERM2 ERM2 (Latvia's currency leaves in January 2014 after euro adoption).

The loss from sacrificing exchange rates flexibility in the eurozone candidate countries became directly confronted with benefits related to exchange rate stability associated with sacrificing monetary autonomy. Despite plausible advantages of pegging exchange rates of candidate countries to euro followed by the euro adoption it seems to be clear that risks associated with potential effects of breakdown in mutual interconnections between macroeconomic development and flexible exchange rates leading path seem to be of a minor interest in current empirical literature.

Economic theory provides clear suggestions in fixed versus flexible exchange rates dilemma in fighting high inflation pressures. At the same time exchange rate based enhancement of external competitiveness may provide a convenient framework to foster economic growth even when domestic economy is cooling down.

On the other hand, discretionary incentives to increase external demand during the crisis period may start unfavorable spiral of competitive devaluations. Central banks and governments may tend to devaluate currencies (internal devaluation) especially in times when low policy of interest rates associated with quantitative easing doesn't provide correct and sufficient incentives to foster domestic demand. Internal devaluation causing real exchange rate to depreciate became highly discussed nowadays, in the time of economic and debt crisis in the eurozone, when inability of low performing economies to increase foreign competitiveness of their production forces authorities to experiment with internal devaluation considering all adjustments are made by prices, wages (and associated costs of production) and assets values falling.

1.1.3. Overview of the Literature

Gerlach-Kristen and Rudolf (2010) compared three monetary operating procedures by examining optimal policy reaction functions, impulse responses and simulated volatilities of inflation, the output gap and the yield curve to examine volatility of interest rates and other main macroeconomic variables. Their results suggest that volatilities in key variables under different monetary-policy framework (commitment vs. discretion) are strongly dependent on general preconditions (normal times vs. financial distress). Eiffinger, Schaling and Vehagen (2000) analyzed the relevancy of the term structure of interest rates for the transmission process of the monetary policy. Authors identified and empirically tested the long-term interest rates as a crucial indicator for monetary policy discretionary changes. Emiris (2006) decomposed long-term interest rates into term premium and inflation premium to investigate the sources of average premium on ten years bonds variability. Author also examined responses of the term premia to the different shocks. Fendel (2009) intended to support the empirical findings on the information content of the term structure of interest rates for monetary policy. Kulish (2007) analyzed two roles (first, as a key determinant in the reaction function of the monetary authority; second, as instruments of policies) that long-term nominal interest rates can play in the conduct of the monetary policy. McGough, Rudebusch and Williams (2005) investigated the problem of short-term versus long-term interest rates suitability to operate as a monetary policy instrument. Authors highlight and discuss a crucial role of inflation expectations and real interest rate for selecting the most appropriate interest rate as a key pillar of a monetary policy framework. Michaud and Upper (2008) identified the origins of interbank interest rates volatility by examining the possible determinants of the risk premium contained in the money market interest rates. Rudebusch, Sack and Swanson (2007) examined the origins and implications of changes in bond term premiums for economic activity to analyze the stability of long-term interest rates. Authors also analyzed empirical relationship between short-term and long-term interest rates.

1.1.4. Econometric Model

VAR models represent dynamic systems of equations in which the current level of each variable depends on past movements of that variable and all other variables involved in the system. Residuals of vector ε_t represent unexplained movements in variables (effects of exogenous shocks hitting the model); however as complex functions of structural shocks effects they have no economic interpretation. Structural shocks can be still recovered using transformation of true form representation into reduced-form by imposing a number of identifying restrictions. Applied restrictions should reflect some general assumptions about the underlying structure of the economy and they are obviously derived from economic theory.

There are two general (most used) approaches to identify VAR models. Cholesky decomposition of innovations implies the contemporaneous interactions between the exogenous shocks and the endogenous variables are characterized by a Wald causal chain. Ordering of the endogenous variables than reflects expected particular economy structure following general economic theory assumptions. However the lack of reasonable guidance for appropriate ordering led to the development of more sophisticated and flexible identification methods - structural VAR (SVAR) models. Identifying restrictions implemented in SVAR models reflects theoretical assumptions about the economy structure more precisely.

We implement a VAR methodology to analyze sources of the short-term nominal interest rates volatility in the European transition economies. Identification scheme based on imposing long-run restrictions on the variance-covariance matrix of the reduced-form VAR residuals is employed to identify structural shocks hitting the model.

True model is represented by the following infinite moving average representation:

$$X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + \ldots = \sum_{i=0}^{\infty} A_i\varepsilon_{t-i} = \sum_{i=0}^{\infty} A_i L^i \varepsilon_t = A(L)\varepsilon_t \qquad (1.1)$$

where X_t represents n x 1 a vector including endogenous variables of the model, $A(L)$ is a n x n polynomial consisting of the matrices of coefficients to be estimated in the lag operator L representing the relationship among variables on the lagged values, ε_t is n x 1 vector of identically normally distributed, serially uncorrelated and mutually orthogonal errors (white noise disturbances that represent the unexplained movements in the variables, reflecting the influence of exogenous shocks):

$$E(\varepsilon_t)=0, \quad E(\varepsilon_t\varepsilon_t')=\Sigma_\varepsilon=\mathrm{I}, \quad E(\varepsilon_t\varepsilon_s') = [0] \quad \forall t \neq s \tag{1.2}$$

Vector X_t consists of six endogenous variables - industrial production $(y_{r,t})$, money supply (m_t), core inflation (p_t), short-term nominal interest rates $(ir_{n,t})$ and real exchange rate $(er_{r,t})$. In the five-variable VAR model $(X_t = [ip_{r,t}, m_t, p_t, ir_{n,t}, er_{r,t}])$ we assume five exogenous shocks that contemporaneously affects endogenous variables - demand shock $(\varepsilon_{ip_r,t})$, nominal shock $(\varepsilon_{m,t})$, inflation shock $(\varepsilon_{p,t})$, monetary policy shock $(\varepsilon_{ir_n,t})$ and exchange rate shock $(\varepsilon_{er_r,t})$.

Structural exogenous shocks from equation (1.1) are not directly observable due to the complexity of information included in true form VAR residuals. At the same time, the shocks in the reduced form are likely to be correlated so they cannot be considered as true structural shocks. As a result, structural shocks cannot by correctly identified. It is than necessary to transform true model into following reduced form

$$X_t = C(L)Y_{t-1} + e_t \tag{1.3}$$

where $C(L)$ is the polynomial of matrices with coefficients representing the relationship among variables on the lagged values and e_t is a n x 1 vector of normally distributed errors (shocks in reduced form) that are serially uncorrelated but not necessarily orthogonal:

$$E(e_t)=0, \quad \Sigma_u = E(e_te_t') = A_0E(\varepsilon_t\varepsilon_t')A_0' = A_0A_0', \quad E(e_te_s') = [0] \quad \forall t \neq s \tag{1.4}$$

Relationship between reduced-form VAR residuals (e_t) and structural shocks (ε_t) can be expressed as follows:

$$e_t = A_0\varepsilon_t \tag{1.5}$$

As we have already noted at the beginning of this section structural VAR (SVAR) approach, is based on decomposing a series into its permanent and temporary components. It imposes long-run restrictions to the reduced-form VAR model. Identification scheme in the SVAR models reflects a long-run neutrality assumption so that we expect the cumulative effect of a certain shock on the certain endogenous variable development is zero.

The equation (1.6) we can now rewrite to the following form:

$$\begin{bmatrix} 1 & 0 & 0 & a_{14} & a_{15} \\ 0 & 1 & 0 & 0 & a_{25} \\ 0 & a_{32} & 1 & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & 1 & a_{45} \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{y_r,t} \\ u_{m,t} \\ u_{p,t} \\ u_{ir_n,t} \\ u_{er_r,t} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{y_r,t} \\ \varepsilon_{m,t} \\ \varepsilon_{p,t} \\ \varepsilon_{ir_n,t} \\ \varepsilon_{er_r,t} \end{bmatrix} \tag{1.6}$$

In order to correctly identify the VAR model we have to impose fifteen restrictions. The number of long-run identifying restrictions is given by the simple equation n(n+1)/2, where *n* denotes the number of endogenous variables of the model. Five restrictions we obtain by normalizing the original matrix. Ten remaining long-run restrictions are identified as follows:

- demand shock does not have permanent effect on money supply (1), inflation (2), real exchange rate (3),
- liquidity shock does not have permanent effect on real output (4), real exchange rate (5),
- inflation shock does not have permanent effect on real output (6), money supply (7), real exchange rate (8),
- monetary policy shock does not have permanent effect on money supply (9), real exchange rate (10).

Estimated SVAR model is used to compute impulse response functions to analyze responses of short-term nominal interest rates to the one standard deviation structural shocks in the European transition economies.

1.1.5. Data and Results

We employed monthly data for period 2000M1-2007M12 (model A) consisting of 96 observations and with period 2000M1-2012M12 (model B) consisting of 156 observations for the following endogenous variables - industrial production[4] (nominal volume of the industrial product deflated by averaged PPI), money supply (monetary aggregate M2), inflation (core inflation), short-term nominal interest rates (interbank offered rates with 3 months maturity[5]), real exchange rate (real effective exchange rate) and balance of payment's current account (Figure 1.1).

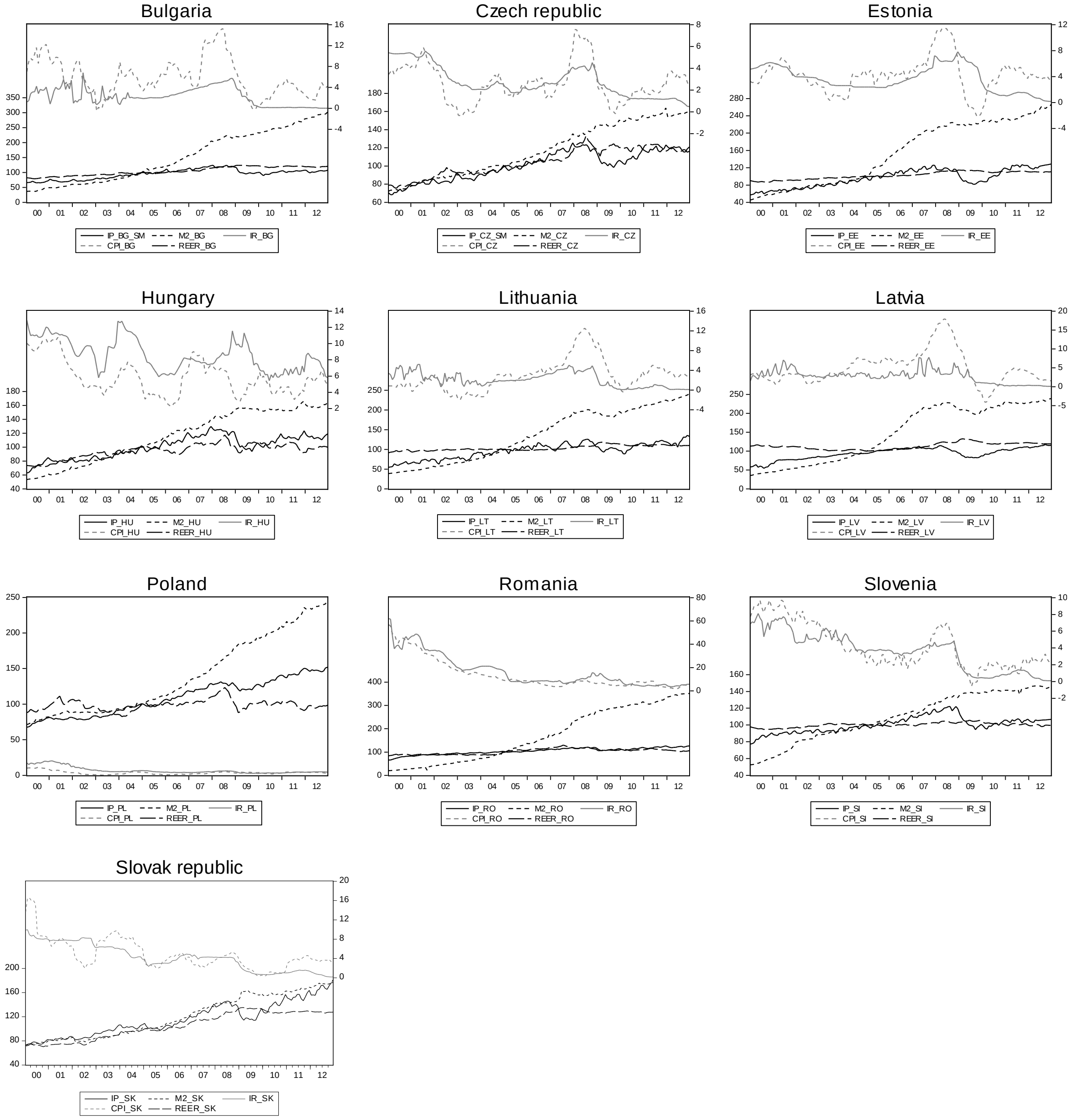
Estimation of two models is in line with the primary objective of the section to estimate the responses of the short-term nominal interest rates to the demand, liquidity, inflation, monetary policy and exchange rate structural shocks considering possible implications of the crisis period on presented results. Time series for all endogenous variables were drawn from IMF database (International Financial Statistics, November 2013). Time series for industrial production, money supply and inflation were seasonally adjusted.

To correctly identify structural exogenous shocks hitting the model and to compute impulse-response functions it is necessary VAR model to be stationary. To check the model it is necessary to test the time series for unit roots and cointegration as well as to check the whole model to be stationary.

[4] Time series for monthly industrial production were employed due to absence of data on the same basis for real output (GDP).

[5] Short-term interest rates in Estonia, Slovak Republic and Slovenia we replaced by EURIBOR after euro adoption in each particular country (2007, 2009 and 2011).

Figure 1.1 Industrial Production, Money Supply, Inflation, Interest Rates and Real Effective Exchange Rate in the European Transition Economies (2000M1-2012M12)



Note: Endogenous variables - industrial production (IP), money supply (M2) and real effective exchange rate (REER) are expressed as indexes (left axis in figures) (2005 = 100). Inflation (INF) and interest rates (IR) are expressed in percentage (right axis in figures).

Source: Compiled by author based on data taken from IMF - International Financial Statistics (IFS) (November 2013).

A. Testing Procedures

The augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests were computed to test the endogenous variables for the unit roots presence. Both ADF and PP tests indicate that most of the variables are non-stationary on the values so that the null hypothesis of a unit root cannot be rejected for any of the series (Table 1.2) (detailed results of unit root are not reported here to save space. Like any other results, they are available upon request from the author). Testing variables on the first differences indicates the time series are stationary so that we conclude that the variables are I(1).

Because there are endogenous variables with a unit root on the values it is necessary to the test the time series for cointegration using the Johansen and Juselius cointegration test (we found reasonable to include variables I(0) for testing purposes following economic logic of expected results). The test for the cointegration was computed using three lags as recommended by the AIC (Akaike Information Criterion) and SIC (Schwarz Information Criterion).

Table 1.2 Unit Root Tests

Country	**Model**	**Order of integration of endogenous variables**									
		IP		**M2**		**IR**		**CPI**		**REER**	
		ADF	PP	ADF	PP	ADF	PP	ADF	PP	ADF	PP
Bulgaria	A	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Czech Republic	A	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Estonia	A	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Hungary	A	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)	**I(0)**	I(1)	I(1)	I(1)	I(1)	I(1)
Latvia	A	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Lithuania	A	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Poland	A	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	**I(0)**	I(1)	I(1)
Romania	A	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Slovak Republic	A	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Slovenia	A	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)

Source: Author's calculations.

The results of the Johansen cointegration tests confirmed the results of the unit root tests (Table 1.3) (detailed results of cointegration tests are not reported here to save space. Like any other results, they are available upon request from the author). Both trace statistics and maximum eigenvalue statistics (both at 0.05 level) indicate that there is no cointegration among the endogenous variables of the model.

To test the stability of the VAR model we also applied a number of diagnostic tests. We found no evidence of serial correlation, heteroskedasticity and autoregressive conditional heteroskedasticity effect in the disturbances. The model also passes the Jarque-Bera normality test, so that errors seem to be normally distributed. The VAR models seem to be stable also because the inverted roots of the model for each country from the group lie inside the unit circle (Figure 1.2).

Table 1.3 Johansen and Juselius Cointegration Tests

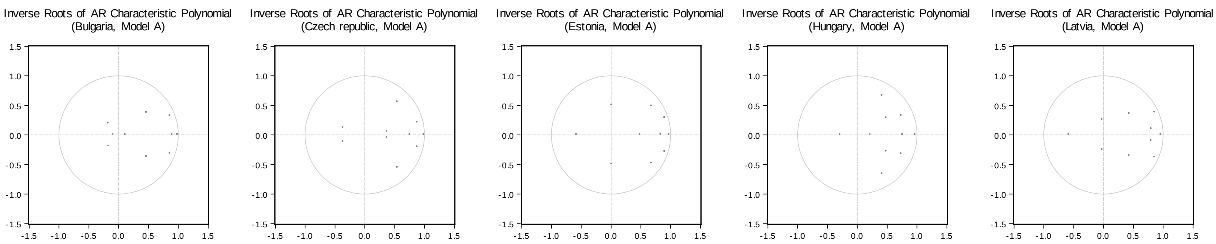
Country	**Number of cointegrating equations**			
	Model A		**Model B**	
	trace stat.	max eigvalue stat.	trace stat.	max eigvalue stat.
Bulgaria	0	0	0	0
Czech Republic	0	0	0	0
Estonia	0	0	0	0
Hungary	1	0	0	1
Latvia	0	0	0	0
Lithuania	0	0	0	0
Poland	1	0	1	0
Romania	0	0	0	0
Slovak Republic	0	0	0	0
Slovenia	0	0	0	0

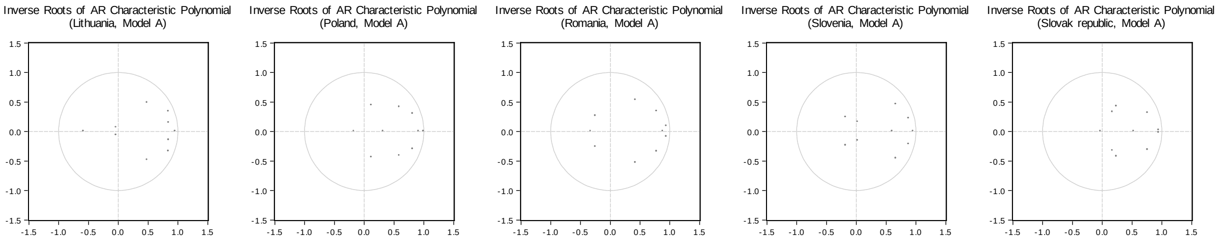
Source: Author’s calculations.

Following the results of the unit root and cointegration tests we estimated the model using the variables in the first differences so that we can calculate impulse-response functions for all ten European transition economies. In line with the main objective of the section we focus on interpretation of the responses of the short-term nominal interest rates to the positive one standard deviation demand, liquidity, inflation, monetary policy and exchange rate shocks.

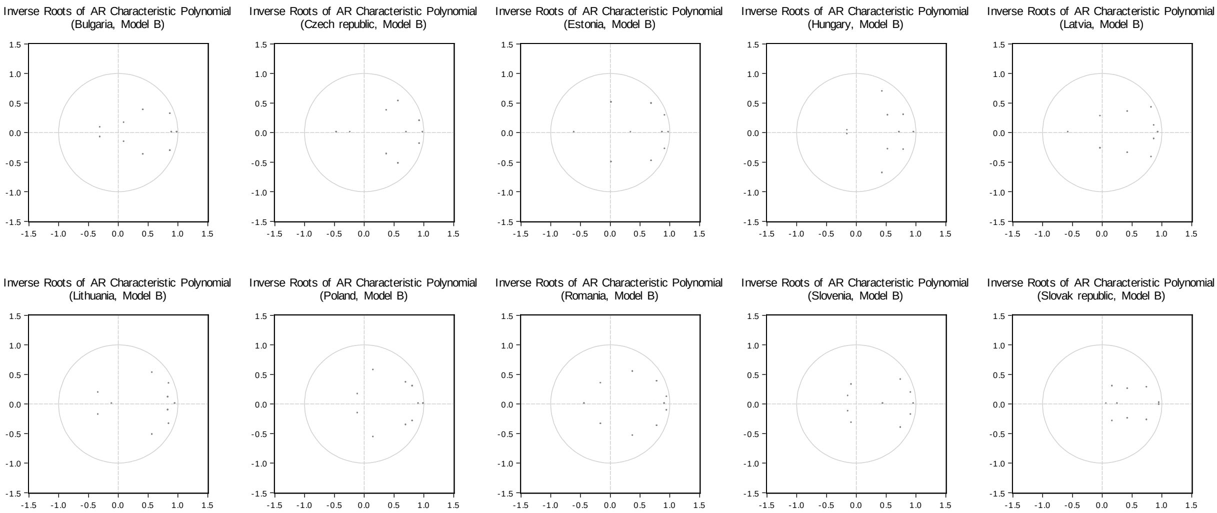
Figure 1.2 VAR Stability Condition Check

Model A





Model B



Source: Author's calculation.

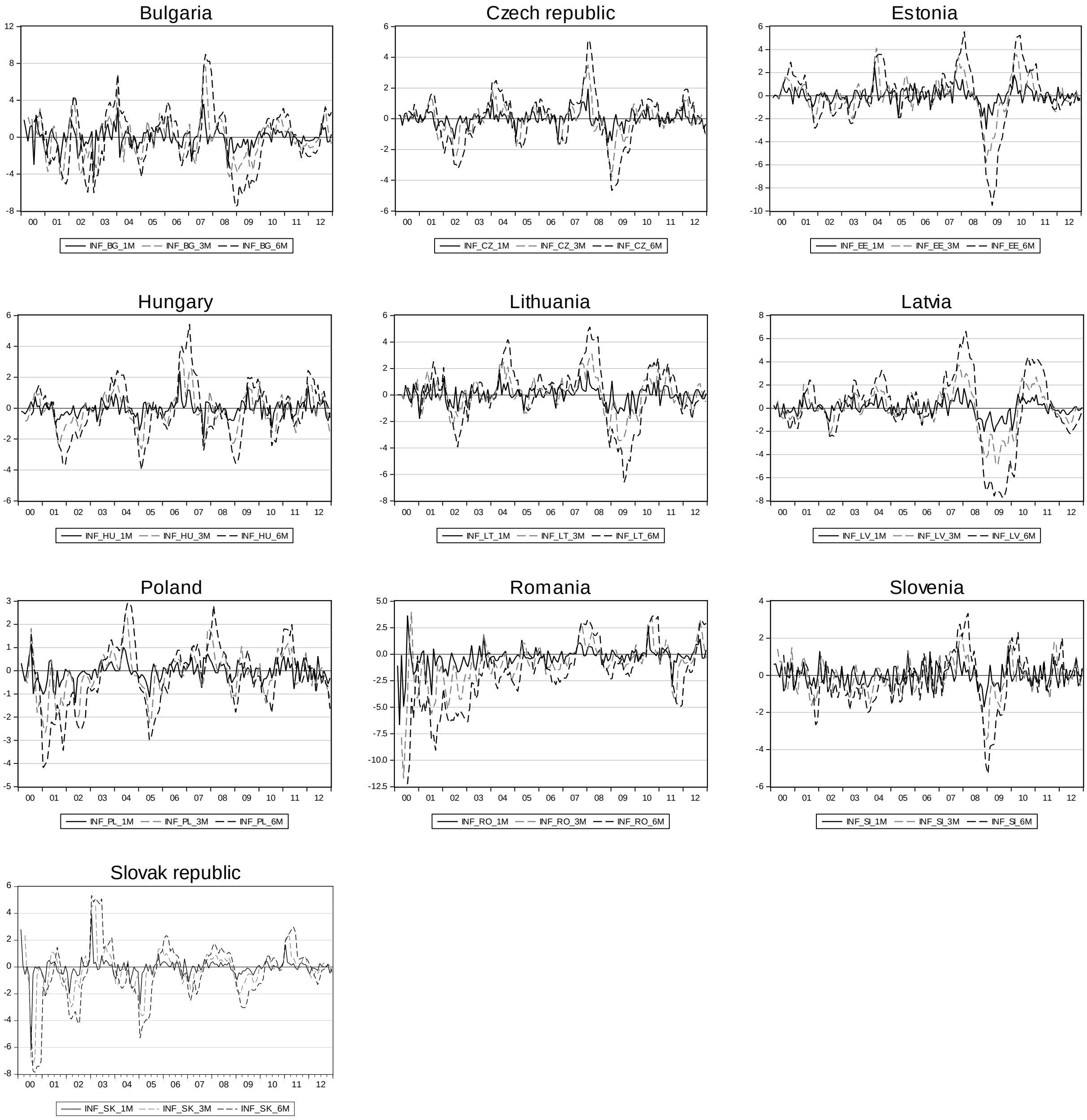
We also observe effects of the crisis period as well as unique implications of exchange rate arrangements on the short-term nominal interest rates determination in the European transition economies by comparing the results for models estimated employing time series for two different periods - model A (pre-crisis period; 2000M1-2007M12) and model B (extended period; 2000M1-2012M12).

B. Crisis Effects on Volatility of Inflation, Interest Rates and Exchange Rates

One of the most significant effects of the economic crisis refer to sudden changes in the price level accompanied by diverse effects on price levels and thus changing relative prices. So called redistributive price effects (even on international level) seem to be much more significant among large number of countries provided that they are operating a common market for free goods, services, labor and capital movements.

Figure 1.3 provides an overview of the inflation differentials calculated on one, three and six month basis in the European transition economies during the period 2000-2012. We suggest that smaller volatility in inflation differentials reveals slower speed of adjustment in price level to the price effects of market forces and thus reflects higher stability of inflation expectations. Sudden and sharp shifts in the inflation differentials seem to be associated with higher speed of adjustment in the price level with negative impact to the stability of inflation expectations.

Figure 1.3 Volatility of Inflation Adjustments (2000M1-2012M12)



Note: Curves represent inflation differentials calculated on 1, 3 a 6 month basis.
Source: Author's calculation.

Countries with pegged exchange rate arrangement experienced generally lower average inflation rates (4.38 percent during pre-crisis period and 4.53 percent during extended period) in comparison with countries employing flexible exchange rate regime (7.13 percent during pre-crisis period and 5.84 percent during extended period). It seems that nominal exchange rate anchoring contributed to the stable inflation expectations and reduction in inflation pressures. However, we observed relative high diversity in volatility of inflation rates among individual countries.

Despite some minor exception, Baltic countries ("peggers") experienced relatively stable speed of adjustments in the rates of inflation during the whole pre-crisis period (see Table 1.4 for more details). However, with increasing lag for differencing the inflation rates it seems that a volatility of inflation differentials increased though with generally lower dynamic than we would expect according to the one month differentials. The last country from the group of "peggers", Bulgaria, experienced little more volatile adjustments in the rates of inflation. It seems that the strong nominal anchor may provide a convenient vehicle for the reduction of inflation pressures however doesn't seem to be sufficient to successfully stabilize inflation expectations, especially in the low performing transition economy. Our results also reflect slightly higher average volatility of inflation differentials in the group of "floaters" during the pre-crisis period. The Czech Republic and Slovenia seem to provide better results followed by the Slovak Republic and Hungary.

Table 1.4 Inflation Adjustments[6] Statistics

	peggers (2007)	floaters (2007)	floaters (2007)[a]	peggers (2012)	floaters (2012)	floaters (2012)[a]
CPI (mean)	4.375	7.127	4.765	4.534	5.847	4.244
CPI_1M (s.d.)	0.662	0.763	0.706	0.615	0.786	0.719
CPI_3M (s.d.)	1.283	1.442	1.383	1.228	1.681	1.534
CPI_6M (s.d.)	1.936	2.017	1.831	1.932	2.761	2.516

Note: Selected descriptive statistics for inflation adjustments.
[a] represents data without results for Romania (with excessive inflation pressures at the beginning of 2000s).
Source: Author's calculation.

Despite an absence of the nominal anchor (i.e. fixed exchange rate) in this group of four countries it seems that adoption of direct inflation targeting was associated with reduction in the speed of inflation rates adjustments over time and thus providing very efficient framework for stabilizing inflation expectations. The highest speed of adjustment in price level we experienced in case of Romania reflects the absence of credible nominal anchor especially during the first half of the pre-crisis period. Inflation targeting implemented at the later stage in the low inflation environment significantly helped to reduce the volatility of inflation adjustment. Similarly to our results for the previous group of countries we observed increased volatility of inflation differentials with increasing.

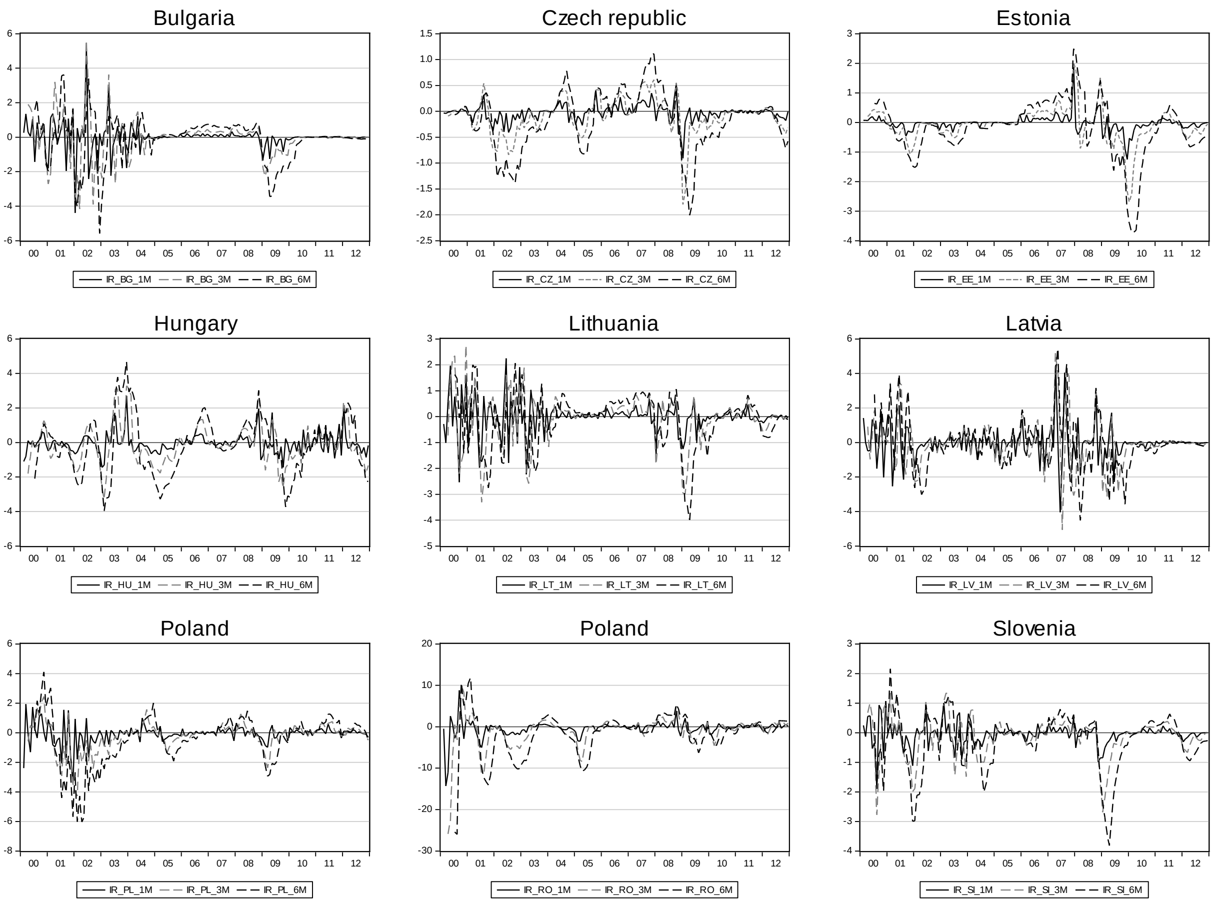
Economic crisis affected the volatility of inflation adjustments in the European transition economies with ambiguous results. Volatility of inflation adjustments in the European transition economies at the beginning of the crisis period significantly increased especially due to sharp decrease in the rate of inflation followed by peaking inflation pressures at the end of the pre-crisis period. However, the overall volatility of inflation differentials seems to be reduced. This trend is even present in 3 months inflation differentials but less in 6 months inflation differentials. Strong nominal anchor in the group of "peggers" (the size of the group increased due to the new eurozone member countries - Slovenia (2007) and Slovak Republic (2009)) even accelerated disinflation processes in countries with fixed exchange rate arrangement.

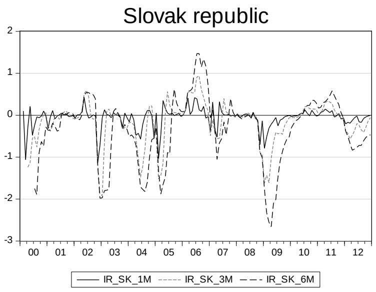
[6] Due to principles of inflation adjustments measurement, a standard deviation rises with an increased underlying lag. However, comparison of results for the same lag among countries may provide convenient information about the speed of adjustments in inflation, interest rate and exchange rate adjustments.

On the other hand, countries from the group of “floaters” experienced periods of more dynamic inflation changes associated with higher inflation volatility during the crisis period. Finally, due to complexity of the crisis effects on the volatility of inflation adjustments we provide some inspiring insight into fixed versus flexible exchange rates dilemma in the Section C.

Figure 1.4 provides an overview of the nominal interest rate differentials calculated on one, three and six month basis in the European transition economies during the period 2000-2012. We suggest that higher volatility in nominal interest rates differentials reveals intensification of processes affecting internal and/or external monetary stability. In general, increased volatility of nominal interest rates differentials is associated with higher volatility of inflation and/or exchange rate adjustments in our sample of countries during the most of the period. It seems that nominal interest rates serve as a convenient monetary policy vehicle to reduce negative effects of distortions originating in the excessive inflation and/or exchange rate volatility.

Figure 1.4 Volatility of Interest Rate Adjustments (2000M1-2012M12)





Note: Curves represent inflation differentials calculated on 1, 3 a 6 month basis.
Source: Author's calculation.

Volatility of interest rates provides clear evidence about interest rates leading path in individual countries from the group. It reveals relatively high diversity in the intensity and speed of the interest rate adjustments. It seems that interest rates in countries with nominal exchange rate anchoring ("peggers") experienced more volatile development during the pre-crisis period (except for Estonia) (see Table 1.5 for more details). At the same time, countries with nominal exchange rate anchoring experienced generally lower interest rates during both, pre-crisis (3.19 percent) and extended periods (2.69 percent) in comparison with countries with flexible exchange rate arrangement with 9.04 percent for pre-crisis period and 7.12 percent for extended period.

Table 1.5 Interest Rates Adjustments Statistics

	peggers (2007)	floaters (2007)	floaters (2007)[a]	peggers (2012)	floaters (2012)	floaters (2012)[a]
IR (mean)	3.193	9.040	6.382	2.685	7.118	5.223
IR_1M (s.d.)	0.806	0.610	0.422	0.688	0.551	0.391
IR_3M (s.d.)	1.097	1.198	0.786	1.015	1.072	0.731
IR_6M (s.d.)	1.183	2.045	1.122	1.216	1.807	1.135

Note: Selected descriptive statistics for interest rates adjustments.
[a] represents data without results for Romania (with excessive inflation pressures at the beginning of 2000s).
Source: Author's calculation.

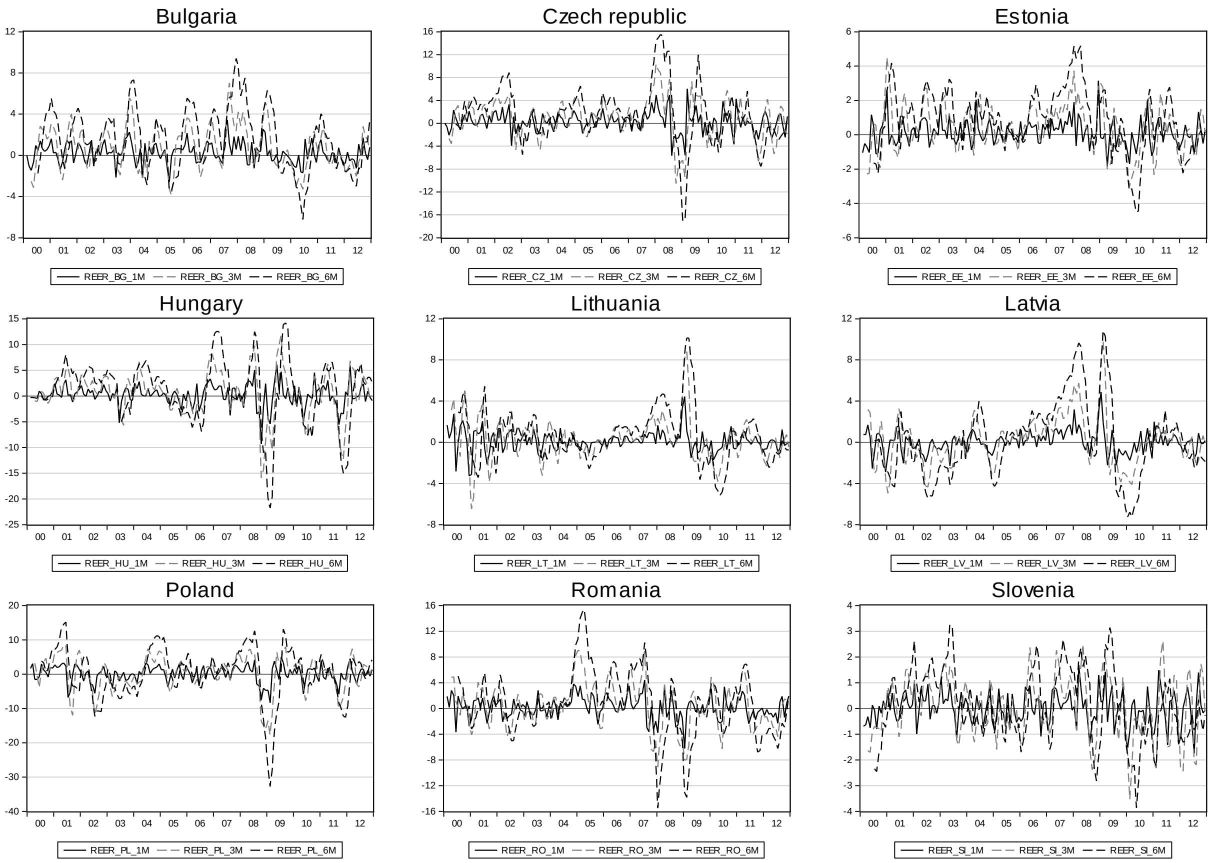
We suggest that higher volatility in the interest rates differentials was associated with increased discretionary involvement of monetary authorities following the objective of monetary stability to preserve the maintenance of pegged exchange rate arrangement. However, it seems to be the case of the interest rate adjustments on one month basis. Volatility based on lagged interest rate adjustments (on the three and six month basis) was clearly reduced revealing higher absorption of distortionary effects and thus higher stability in the medium-term adjustments.

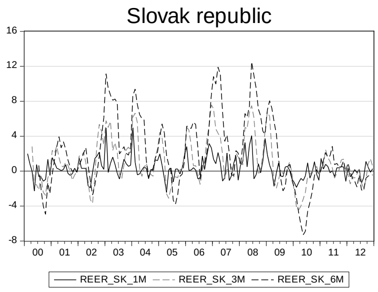
Short-term interest rates adjustments (on the one month basis) in countries with flexible exchange rate regimes provide an evidence of lower volatility in comparison with the countries from the group of "peggers". However, lagged adjustments (on the three and six month basis) seem to be more volatile revealing increased dynamics of the interest rate changes provided an absence of the nominal anchor. We suggest that inflation targeting serves as a less effective vehicle to reduce the short-term interest rates volatility in comparison with the exchange rate targeting.

Crisis period affected the intensity of the interest rates adjustments in both groups of countries. Despite large distortionary effects of the crisis at the beginning of the crisis period it seems that the overall dynamics of the interest rates changes during the crisis period decreased (effect is clear for interest rates adjustments on one month and three month basis). Even in this period we examined higher stability of interest rates in countries with flexible exchange rate arrangement (on the one month basis).

Figure 1.5 provides an overview of the real exchange rates differentials calculated on one, three and six month basis in the European transition economies during the period 2000-2012. The overall volatility of the exchange rates adjustments seems to be significantly higher in comparison to the volatility of inflation and interest rates adjustments. Despite effects of price adjustments, real exchange rates are determined by either nominal exchange rate adjustments (under flexible exchange rates arrangements) or adjustments in the exchange rate of the anchoring reference currency. As a result, real exchange rates may become more volatile (even under fixed exchange rate arrangement) provided that the leading paths of the nominal exchange rate and the rate of inflation follow different trend. On the other hand, the real exchange rate volatility may be reduced (under flexible exchange rate arrangement) provided that the nominal exchange rate leading paths (determining external purchasing power of the currency) is associated with inflation differentials and corresponding adjustments of the domestic price level (determining internal purchasing power of the currency).

Figure 1.5 Volatility of Exchange Rates Adjustments (2000M1-2012M12)





Note: Curves represent real exchange rate differentials calculated on 1, 3 a 6 month basis.
Source: Author's calculation.

It seems that real exchange rates leading path of countries from the group of "peggers" clearly reflected higher stability in comparison of those from the group of "floaters" during the pre-crisis period (see Table 1.6 for more details). We suggest that the volatility of real exchange rates in countries with flexible exchange rate arrangements was not inevitably associated with the dynamics in inflation differentials causing higher real exchange rates variability.

Table 1.6 Exchange Rate Adjustments Statistics

	peggers (2007)	floaters (2007)	peggers (2012)	floaters (2012)
REER (mean)	99.422	94.974	105.935	101.055
REER_1M (s.d.)	0.871	1.370	0.943	1.659
REER_3M (s.d.)	1.766	2.693	1.951	3.367
REER_6M (s.d.)	2.200	3.618	2.776	4.925

Note: Selected descriptive statistics for exchange rates adjustments
Source: Author's calculation.

Economic crisis increased exchange market pressures (Stavarek, 2012). As a result, nominal and real exchange rates of countries from the group of "floaters" became much more volatile. The lack of credible nominal anchor made freely floated exchange rates much more sensitive to the market imperfections. Here again we observed the stabilizing effects of the euro adoption to the real exchange rate deviations during the crisis period in Slovenia and Slovak Republic.

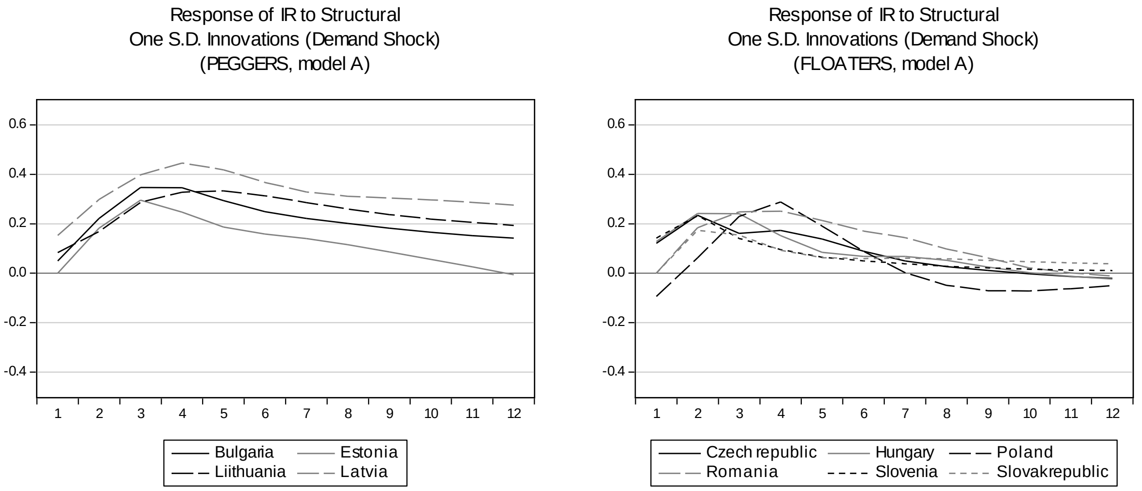
C. Impulse-Response Function

In order to analyze sources of interest rates volatility under different exchange rate arrangements in the European transition economies we estimate responses of short-term nominal interest rates to the positive one standard deviation structural shocks employing monthly data for two subsequent periods 2000-2007 (model A) and 2000-2012 (model B).

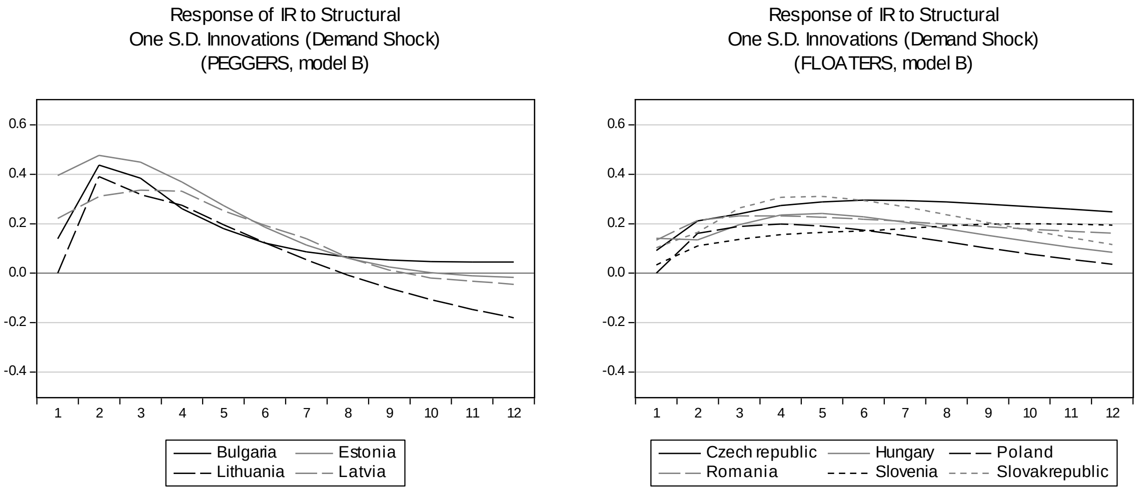
Figure 1.6 summarizes responses of the nominal short-term interest rates to the positive one standard deviation demand shock for the model with time series for the pre-crisis period (model A) and extended period (model B) in the European transition economies.

Figure 1.6 Responses of Interest Rates to Demand Shock

Model A



Model B



Note: Curves represent responses of interest rates (IR) to the positive one standard deviation demand shock in each country from the group of the European transition economies.

Source: Author's calculation.

Figure 1.6 shows estimated responses of short-term interest rates to the structural positive one standard deviation demand shock in the European transition economies during the pre-crisis period (model A, 2000-2007) and extended period (model B, 2000-2012). In general, positive demand shock was followed by an increase in the interest rates in all countries from the group. However, we observed interesting differences among countries according to the detailed characteristics in interest rates response patterns. Leading path of the interest rates response revealed some crucial implications of exchange rate arrangements in the European transition economies.

In the countries with pegged exchange rate regimes (exchange rate serving as the nominal anchor) it seems that interest rates were slightly more vulnerable to the unexpected demand shock. As a result, positive one standard deviation demand shock was followed by a dynamic interest rate increase during first four months after the shock. After reaching its culminating point, interest rates steadily decreased back to their pre-shock levels. However, we examined some differences in the speed of convergence toward long-run equilibrium. Nevertheless, negative effect of the demand shock on the short-term interest rates continuously weakened in the long run and thus revealed its long-run neutrality on the interest rates variability.

Key features in the short-term interest rates responsiveness pattern in the countries with flexible exchange rate arrangements seem to be similar to those of countries with exchange rate nominal anchor. However, we observed some crucial differences in the short-term interest rates response patterns. Countries with flexible exchange rate regimes experienced, in general, less intensive increase in the short-term interest rates after positive one standard deviation demand shock. Negative effect of the demand shock culminated, similarly, within one year after the shock. At the same time, effect of the shock seems to be less durable and it generally died out till the end of the tenth month since the shock.

In both groups of countries the demand shock has just a temporary effect on the short-term interest rates and resulted in long-term neutrality of the shock. As a result, our analysis of the short-term interest rates responsiveness to the positive demand shock did not provide clear evidence about postulated empirical expectation about its permanent effects on the nominal interest rates. However, negative effect of the demand shock seems to be much more persistent and durable in countries that conducted monetary policy based on nominal exchange rate anchoring. We suggest that higher persistency of the interest rates increase is associated with stabilization effects of higher interest rates according to the distorting effects of demand shocks on the exchange rate stability.

We suggest that less dynamic response of the short-term interest rates to the demand shock in countries with flexible exchange rate arrangements originates in associated exchange rate adjustments followed by the demand shock that intensified the process of convergence toward equilibrium restoration and thus put less intensive pressure on the interest rates increase. Exchange rate flexibility seems to be a convenient precondition for the nominal interest rates stability.

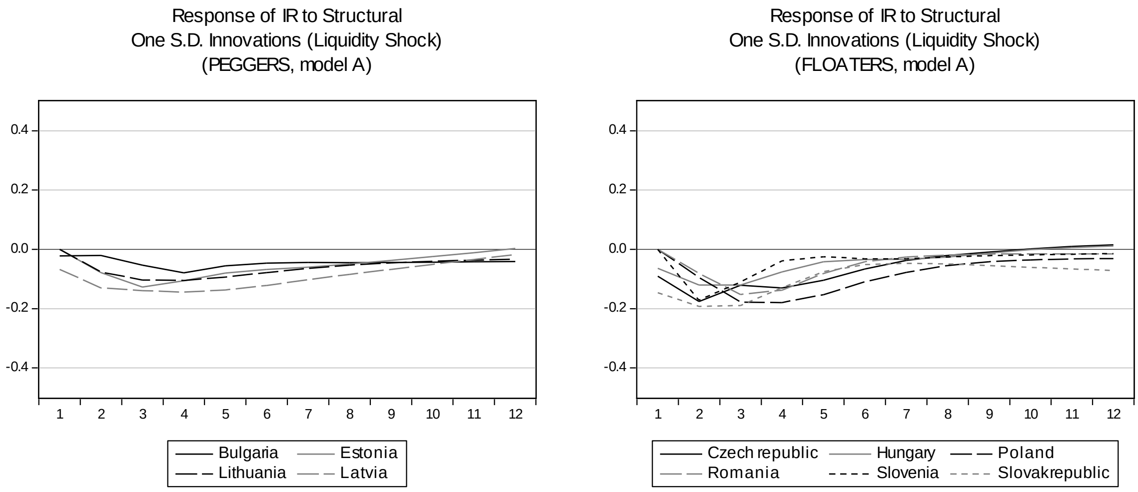
Crisis period affected responsiveness of the short-term interest rates to the positive one standard deviation demand shock. While the overall dynamics of the short-term interest rates increase seems to be comparable during both pre-crisis and extended periods in both groups of countries, detailed investigation of the response patterns revealed some crucial implications of the crisis period. Immediate response of the short-term interest rates in the group of “peggers” slightly increased. As a result, the negative impact of the demand shock culminated earlier (within first 2-3 months) while its effect on the short-term interest rates died out much faster.

On the other hand, the positive demand shock was followed by the moderate though much more durable interest rates increase in the group of “floaters”. However, in countries with large economies (Poland and Romania) a durability of the demand shock was generally lower in comparison with the rest of the countries from the group. It seems that the crisis period was associated with distortionary effects that affected the interest rates variability across countries with different exchange rate arrangements.

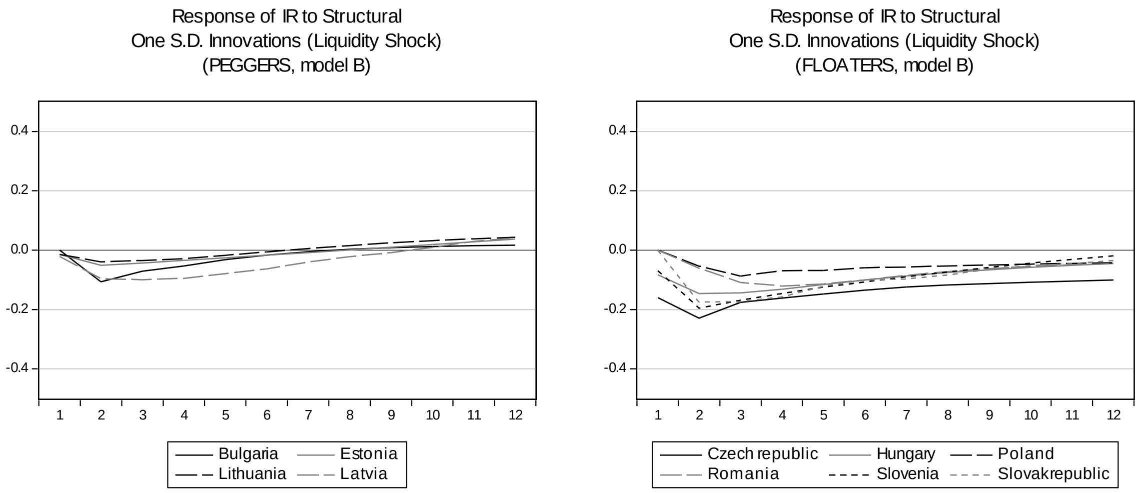
Figure 1.7 summarizes responses of the nominal short-term interest rates to the positive one standard deviation liquidity shock for the model with time series for the pre-crisis period (model A) and extended period (model B) in the European transition economies.

Figure 1.7 Responses of Interest Rates to Liquidity Shock

Model A



Model B



Note: Curves represent responses of interest rates (IR) to the positive one standard deviation liquidity shock in each country from the group of the European transition economies.

Source: Author's calculation.

Figure 1.7 shows estimated responses of short-term interest rates to the structural positive one standard deviation liquidity shock in the European transition economies during the pre-crisis period (model A, 2000-2007) and extended period (model B, 2000-2012). In general, positive liquidity shock was followed by a decrease in the interest rates in all countries from the group. However, we observed some interesting differences among countries according to the detailed characteristics in interest rates response patterns. In the group of countries with rigid exchange rate arrangement the positive liquidity shock caused a moderate decrease in the interest rates with less dynamic loading phase.

Negative effect of the shock culminated till the end of the first quarter and was followed by a steady convergence toward pre-shock levels. It seems that short-term nominal interest rates in countries with a nominal exchange rate anchor are less exposed to the liquidity shocks due to their high vulnerability to external (current account[7]) economic imbalances.

We suggest that effects of the liquidity shocks in our sample of countries with nominal exchange rate anchor are thus channeled more likely to the external (current account) disequilibrium. As a result, associated nominal interest rates adjustments are less dynamic, moderate and temporary. Negative effect of the nominal shock to the short-term nominal interest rates died out within one year.

While the similar scenario in the identified nominal interest rates responsiveness to the positive liquidity shock was also observed in the group of countries with flexible exchange rate arrangements, we examined some key differences in the response patterns. Initial load of the shock's effect was intensified revealing more dynamic immediate responsiveness of the nominal interest rates to the liquidity shock in this group of countries. Short-term path of the response patterns also revealed slightly reduced loading phase of negative effect to the nominal interest rates (effect of the shock culminated within 2-3 month since the shock). At the same, the overall durability of negative effect of the liquidity shock to the nominal interest rates was slightly reduced. Main effect of the liquidity shock in the group of "floaters" was less durable and it died out till the end of the eight month. However, negative (though small) effect of the shock in the long-run period never completely died out in most countries from group. As a result, liquidity shock seems to have a permanent effect on the nominal interest rates in countries with flexible exchange rate regime.

Crisis period affected responsiveness of the short-term interest rates to the positive one standard deviation liquidity shock. In general, the overall responsiveness of the nominal interest rates to the positive liquidity shock in countries with rigid exchange rate regimes seems to be reduced. Both intensity as well as durability of the short-term responses of interest rates decreased. It seems that, to some extent, effects of liquidity shocks and associated interest rates adjustments in countries with nominal exchange rate anchoring were diverted through the crisis intensified process of the cross-country expenditure/capital shifting. As a result, the overall responsiveness of the nominal interest rates to the liquidity shock in this group of countries decreased.

At the same time, we examined slightly increased durability in the nominal interest rates response to the liquidity shock in the group of countries with flexible exchange rate arrangement. Mixed results were obtained considering the overall intensity in the nominal interest rates decrease followed by the liquidity shock. Especially in countries with large economies the loading phase of the interest rates decrease followed by the liquidity shock was generally lower in comparison with the rest of the countries from the group. Long-run effect of the liquidity shock according to the short-term interest rates seems to be neutral in all ten European transition economies. We suggest that the crisis period in the countries with flexible exchange rate arrangement intensified a durability of interest rate vulnerability to the liquidity

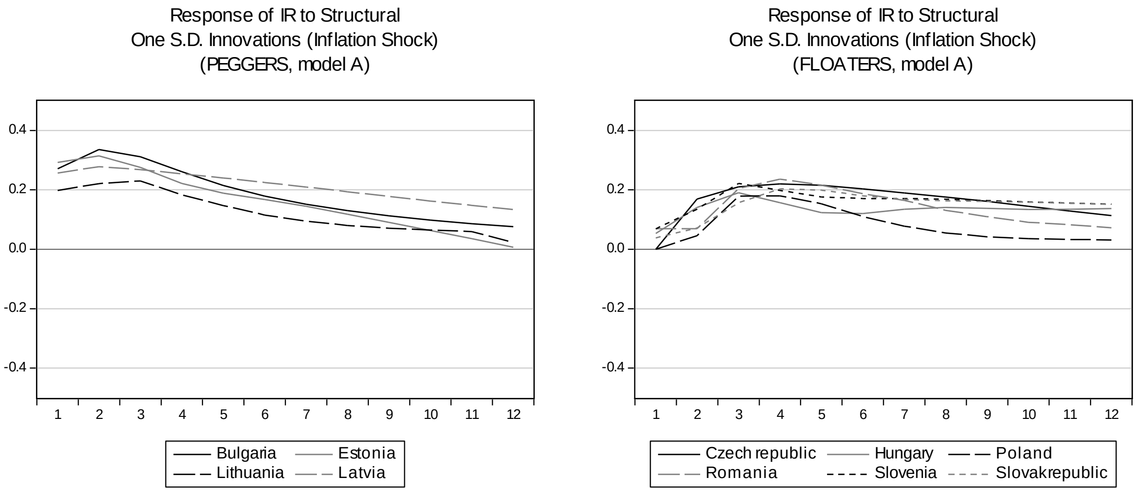
[7] Bulgaria and Baltic countries experienced high current account deficits during the whole pre-crisis period.

shocks due to generally lower cross-country exchanging affected by demand contraction followed by increased exchange rate volatility.

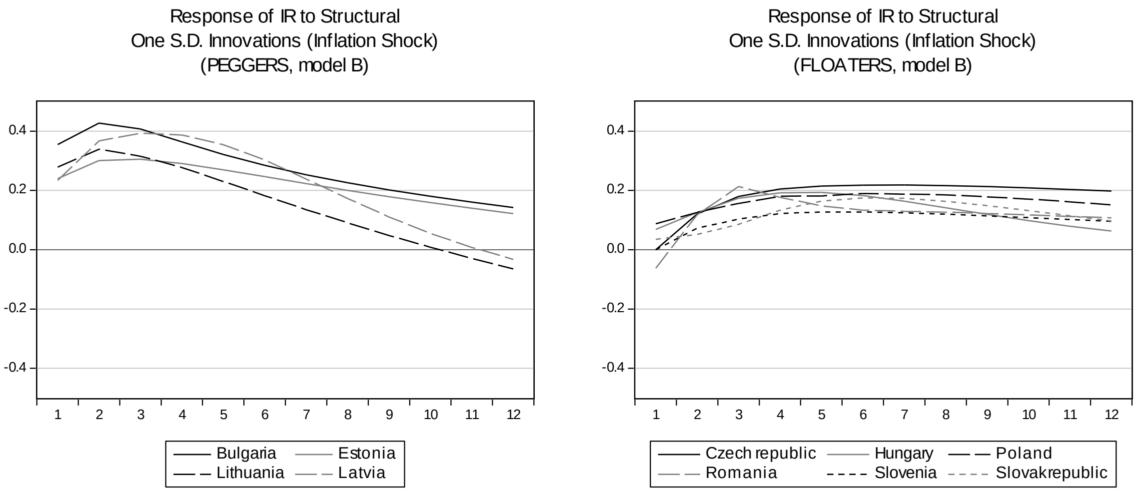
Figure 1.8 summarizes responses of the nominal short-term interest rates to the positive one standard deviation inflation shock for the model with time series for the pre-crisis period (model A) and extended period (model B) in the European transition economies.

Figure 1.8 Responses of Interest Rates to Inflation Shock

Model A



Model B



Note: Curves represent responses of interest rates (IR) to the positive one standard deviation inflation shock in each country from the group of the European transition economies.

Source: Author's calculation.

Figure 1.8 shows estimated responses of short-term interest rates to the structural positive one standard deviation inflation shock in the European transition economies during the pre-crisis period (model A, 2000-2007) and extended period (model B, 2000-2012). Inflation shock was followed by an interest rate increase in all countries though we observed some notable differences in the interest rate response patterns according to the employed exchange rate arrangement.

Positive inflation shock in the model with time series for a pre-crisis period was followed by an immediate increase in interest rates in the countries that employed nominal exchange rate anchoring. Despite some minor differences among individual countries from this group, an immediate negative effect on the short-term nominal interest rates culminated within first three months since the inflation shock hit the model. After this period an initial effect of the shock continuously and steadily weakened and it completely died out during the first half of the second year since the shock. Immediate increase of the short-term interest rates to the inflation shock reveals their high vulnerability to the unexpected inflation pressures.

We suggest that higher responsiveness of the short-term interest rates to the inflation pressures under pegged exchange rate regime is caused by increased role of interest rates in maintaining price stability when nominal exchange rate anchoring is adopted. As a result, immediate interest rates increase followed by inflation pressures strengthening should prevent monetary instability and thus help to preserve exchange rate stability.

On the other hand, in the group of countries with flexible exchange rate arrangement we observed slightly different pattern in the short-term nominal interest rates responsiveness to the unexpected inflation shock. Contrary to our finding for the group of “peggers” it seems that nominal interest rates responded to the positive inflation shock with around one month lag. Negative effect of the shock then steadily strengthened and it culminated at the end of the forth month.

While in the group of countries with pegged exchange rate arrangement the long-run effect of the inflation shock to the short-term nominal interest rates leading path seems to be neutral, in countries with smaller economies (Central European countries) from the group of “floaters” the negative effect of the inflation shock seems to be quite persisting even in the long run. We suggest that exchange rate flexibility together with high external openness represents more challenging combination of crucial determinants for monetary authorities that affects the overall price stability in comparison with countries employing pegged exchange rate regime.

It seems that for countries with flexible exchange rate arrangement combined with inflation targeting it is necessary to determine interest rate curve on both short-term and long-term sides to preserve price stability and meet the inflation target. As a result, unexpected positive inflation shock (unexpected increase in inflation) may cause a permanent increase in the short-term nominal interest rates with subsequent negative effects to the long-term interest rates.

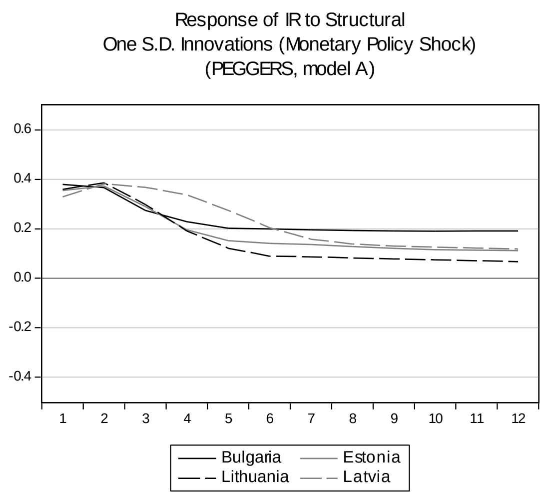
Crisis period affected responsiveness of the short-term interest rates to the positive one standard deviation inflation shock in both groups of countries. In countries with pegged exchange rate regime the overall responsiveness of the short-term interest rates increased in the model with time series for extended period. Alongside an increased immediate response of the short-term interest rates to the inflation shock in countries with nominal exchange rate anchoring we also investigated slightly ambiguous results about the durability of the grown effect in interest rates. Overall effect of the inflation shock in the short-term interest rates leading path seems to be neutral. That is why we suggest that mixed results about the time necessary for a negative effect of the inflation shock to completely die out and interest rates to return to their pre-shock levels (according to the results for a pre-crisis period) refer to the spurious implications of the crisis period.

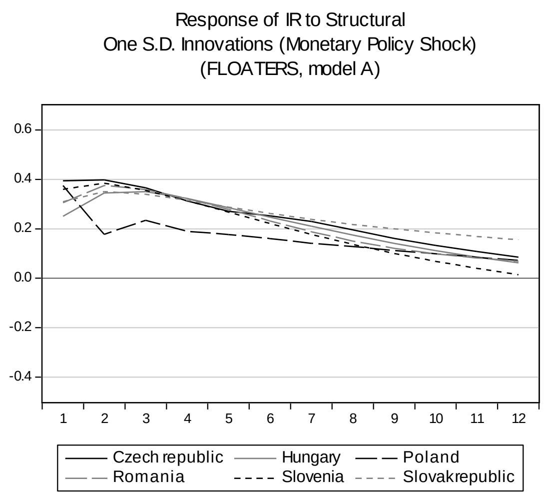
Different patterns in the short-term interest rates responsiveness to the inflation shock during the crisis period was also investigated in the group of countries with flexible exchange rate arrangement. In comparison with the pre-crisis period our results suggest that there is slightly reduced dynamic in the short-term interest rates response during the initial loading phase. On the other hand, we have identified increased medium-term interference between the inflation shock and short-term interest rates. It seems that negative effect of the inflation shock is more durable during the crisis period in most of countries from the group of “peggers”. However, despite higher mid-term responsiveness of the short-term interest rates to the inflation shock in these countries we found that the effects of the shock seem to be neutral in the long-run period. As a result, the short-term interest rates tend to converge to their pre-shock levels (though with a different dynamic) and the effect of the shock completely died out in the long-run period.

Figure 1.9 summarizes responses of the nominal short-term interest rates to the positive one standard deviation monetary policy shock for the model with time series for the pre-crisis period (model A) and extended period (model B) in the European transition economies.

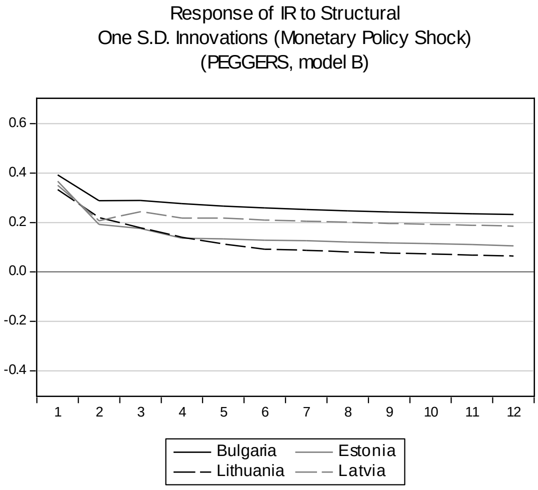
Figure 1.9 Responses of Interest Rates to Monetary Policy Shock

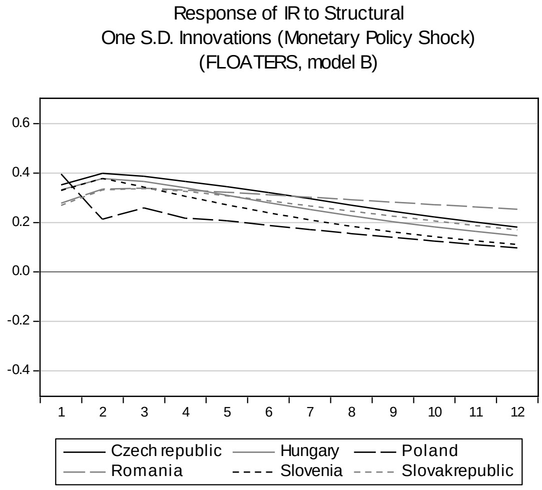
Model A





Model B





Note: Curves represent responses of interest rates (IR) to the positive one standard deviation monetary policy shock in each country from the group of the European transition economies.

Source: Author’s calculation.

Figure 1.9 shows estimated responses of short-term interest rates to the structural positive one standard deviation monetary policy shock in the European transition economies during the pre-crisis period (model A, 2000-2007) and extended period (model B, 2000-2012). Monetary policy shock was followed by an immediate nominal interest rates increase in all ten countries though we examined some differences in the short-term interest rates response patterns according to the exchange rate regime that was employed by individual countries.

As a direct response to the positive monetary policy shock, short-term interest rates immediately increased in the countries with pegged exchange rate arrangement. Our results thus reveal high responsiveness of interest rates to the discretionary changes in the monetary policy stance. On the other hand, initial dynamic response of the short-term interest rates culminated within first two months and then steadily decreased. However, the overall effect of the monetary policy shock did not completely died out, even in the long-run period that is why we consider its effect on the short-term interest rates as permanent. It seems that interest rates adjustments combined with their flexibility in the short run and stability in the long run are crucial for maintaining exchange rate stability and thus pegged exchange rate arrangement sustainability.

We provided clear evidence that discretionary changes in the interest rates (proxied in our model by the unexpected monetary policy shock) in countries with nominal exchange rate anchoring are followed by immediate and dynamic increase in the short-term interest rates while the reduced effect of the shock seems to be generally persisting even permanent in the long-run period.

Similar scenario was investigated in countries with flexible exchange rate arrangement. However, we observed some distinct differences in the short-term interest rates response patterns. Positive monetary policy shock was followed by the immediate short-term interest rates increase in the countries with relative exchange rate flexibility (in this case results are quite similar in both groups - “peggers” and “floaters”). The effect of the shock culminated similarly within first two months after the shock. The only difference was examined in case of Poland where the short-term interest rates steadily decreased immediately after the initial increase. Following the initial negative response to the monetary policy shock, the short-term interest rates steadily and continuously decreased. Convergence toward pre-shock levels is clear with increasing lag. As a result, effect of the monetary policy shock to the nominal short-term interest rates is just a temporary and thus neutral in the long run in countries with flexible exchange rate arrangement.

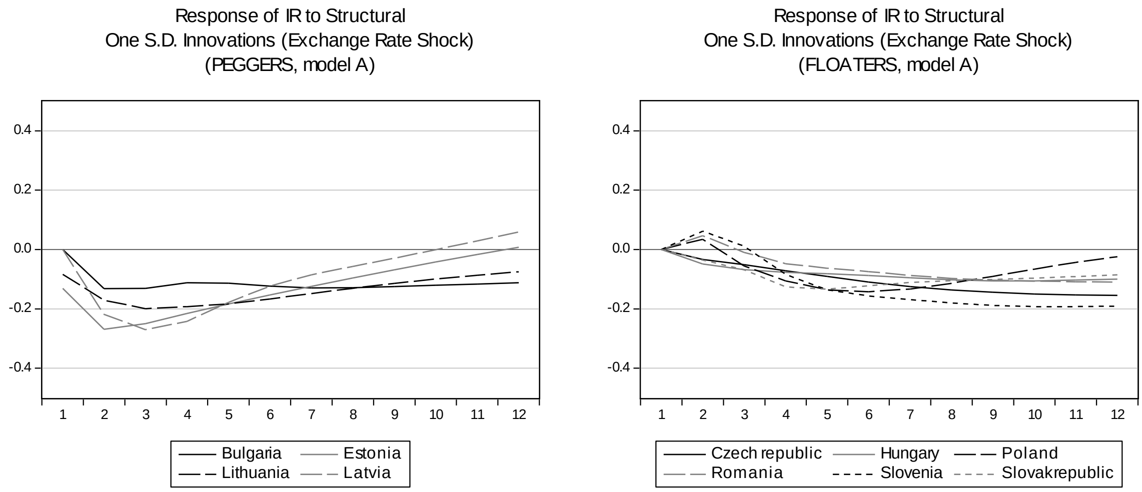
Crisis period affected responsiveness of the short-term interest rates to the positive one standard deviation monetary policy shock in both groups of countries. The overall effect of the shock clearly changed in countries with nominal exchange rate anchoring especially in the short run. Immediate response of the short-term interest rates was slightly reduced. As a result, we observed less dynamic increase in the interest rates within the period of first two month since the shock hit the model. Initial effect of the shock then subsequently decreased and the negative effect of the monetary policy shock was steadily reduced over time. However, the short-term interest rates never fully converged back to their pre-shock levels. Effect of the shock seems to be permanent (similarly just like in the model A with pre-crisis data).

Responses of the short-term interest rates in countries with flexible exchange rate arrangement in the model for extended period seem to be also affected by the effects of the crisis period. However, we observed just a minor change in the overall response pattern of the short-term interest rates in the individual countries. While the overall intensity of the immediate change in the interest rates, in comparison with the pre-crisis period, seems to be just a negligible, subsequent converging path toward pre-shock levels is slightly lagged. As a result, the overall durability of the negative effect of the monetary policy shock to the nominal short-term interest rates slightly increased revealing higher medium-term responsiveness of short-term interest rates to the unexpected discretionary changes (in the key interest rates) conducted by monetary authorities. Short-term interest rates seem to be neutral to the effects of the monetary policy shock in the long run because the negative effect of the shock steadily died out and interest rates retuned back to their pre-shock levels in all countries from the group.

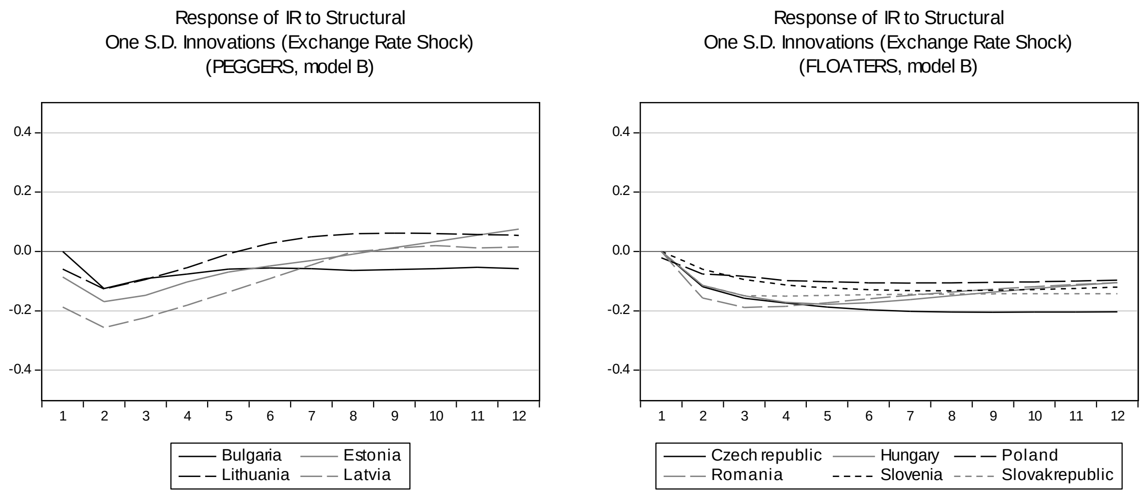
Figure 1.10 summarizes responses of the nominal short-term interest rates to the positive one standard deviation exchange rate shock for the model with time series for the pre-crisis period (model A) and extended period (model B) in the European transition economies.

Figure 1.10 Responses of Interest Rates to Exchange Rate Shock

Model A



Model B



Note: Curves represent responses of interest rates (IR) to the positive one standard deviation exchange rate shock in each country from the group of the European transition economies.

Source: Author's calculation.

Figure 1.10 shows estimated responses of short-term interest rates to the structural positive one standard deviation exchange rate shock in the European transition economies during the pre-crisis period (model A, 2000-2007) and extended period (model B, 2000-2012). Exchange rate shock was followed by an immediate interest rates decrease in all ten countries from both groups. However, we observed some differences in short-term and long-term response patterns according to the relative diversity in the adopted exchange rate regime in individual countries.

In the countries with the nominal exchange rate anchoring we investigated that positive exchange rate shock (exchange rate appreciation) was followed by the interest rate drop with around one month lag. However, we observed some different patterns with regard to the intensity of the interest rate decrease even among countries from the same group ("peggers"). Regardless of this it seems that the short-term interest rates are likely to be responsive to the unexpected exchange rate shocks in countries with the nominal exchange rate targeting.

Initial dynamic decrease in interest rates followed by the exchange rate shock culminated during the second month since the shock. After reaching the peak, interest rates tend to converge to their pre-shock levels following the path of steady and continuous though slight increase. However, the speed of interest rates adjustment in the medium term differs. As a result, the overall effect of the positive exchange rate shock was neutralized between tenth (Estonia and Latvia), eighteenth (Lithuania) and twenty-fourth (Bulgaria) month since the shock in group of countries with pegged exchange rate regime.

Following our results we suggest that high short-term (or even immediate) responsiveness of interest rates to the unexpected exchange rate shocks in countries with exchange rate targeting is associated with an increased stabilization role of interest rates to maintain exchange rate stability affected by exchange rate volatility (i.e. due to exchange rate shocks). Immediate higher responses of short-term interest rates in these countries should operate as a convenient vehicle to support the exchange rate on its way back to per-shock equilibrium levels.

Quite different response patterns of the short-term interest rates to the positive exchange rate shock were observed in the group of countries with flexible exchange rate arrangement. In comparison with the previous group of countries it seems that the immediate responsiveness of interest rates is lagged (by one to three months). Initial load of the exchange rate effect to the short-term interest rates is quite moderate. Interest rates reacted to the unexpected exchange rate shock by a moderate decrease. Effect of the shock intensified during next months. Despite relatively similar features in immediate responses of the short-term interest rates to the positive exchange rate shock in countries with flexible exchange rate arrangement we observed some differences in medium-term responsiveness patterns among individual countries.

Negative effect of the exchange rate shock to the short-term interest rates leading path completely died out within one year after the shock only in Poland. In remaining countries we observed longer response path on the way to the pre-shock equilibrium. As a result, interest rates returned back to their pre-shock levels till end of the second year since the shock hit the model in Hungary, Romania and Slovak Republic. However, negative effect of the exchange rate shock to the short-term interest rates seems to be permanent even in the long run in the Czech Republic and Slovenia.

We suggest that lower immediate responsiveness of interest rates to the unexpected exchange rate shock in countries with flexible exchange rate arrangement results from generally expected interest rates response patterns under interest rate parity conditions. As a result, interest rate differentials affect associated exchange rate adjustments in the medium-term horizons that is why the overall effects of exchange rate shock on interest rates are more durable under flexible exchange rates.

Crisis period affected substantial features in short-term interest rates responsiveness to the unexpected positive exchange rate shock in countries with nominal exchange rate anchoring. Differences in the immediate effects of the shock seem to be biased (in comparison with model A) according to the intensity of the response patterns within first three months. Immediate response path reflects slightly higher vulnerability of interest rates to the shock in some countries, though in some cases it does not change. However, we observed clear reduction in the overall durability of the immediate effect of the shock. As a result, interest rates converged to their pre-shock levels within reduced time period in all countries from the group but Bulgaria (though medium-term interest rate response trajectory reveals slightly reduced vulnerability). At the same time, we investigated increased volatility of interest rates on their medium-term converging path toward long-run equilibrium. Finally, effects of the exchange rate shock died out in the long run and thus short-term interest rates are neutral to the distorting effect of the shock.

Different patterns in the short-term interest rates responsiveness to the exchange rate shock during the crisis period was also recognized in the group of countries with flexible exchange rate regime. Following our results we realize that in comparison with the pre-crisis period there is slightly reduced lag in the immediate response (within first three months) of interest rates during the initial loading phase. At the same time, short-term responsiveness of interest rate clearly increased in all countries from the group of “floaters” emphasizing increased role of the short-term interest rate differentials for exchange rate determination under expectation of higher uncertainty.

The overall durability of the exchange rate shock related interest rate effects slightly increased in all countries. However, similarly to our results for the model with a pre-crisis time series, we received mixed results about the overall durability of the exchange rate shock. The negative effect of the shock seems to be permanent in the Czech Republic, Poland, Slovenia and Slovak Republic while it is just a temporary in Hungary and Romania.

1.1.6. Conclusion

Exchange rates determined main macroeconomic indicators in all ten European transition economies in the line with the general empirical investigations though we observed some specific implications of the distorting effects caused by the unpredicted exchange rate shifts during the crisis period that may be a subject of further academic discussion focusing on the wide causalities of the economic crisis. At the same time our results suggest some plausible causality between exchange rate regime and the way that the exchange rate shock affects industrial production and inflation. Thus, our investigations may be a relevant contribution to the fixed versus flexible exchange rate dilemma that seems to a crucial part of the discussion related to the possible implications of sacrificing monetary sovereignty in the eurozone candidate countries.

Following our results we observed that the <u>demand shock</u> had just a temporary effect on the short-term interest rates and resulted in long-term neutrality of the shock in both groups of countries (“peggers” and “floaters”). As a result, our analysis of the short-term interest rates responsiveness to the positive demand shock did not provide clear evidence about postulated empirical expectation about its permanent effects on the nominal interest rates. However, negative effect of the demand shock seems to be much more persistent and durable in countries that conducted monetary policy based on nominal exchange rate anchoring. We suggest that higher persistency of the interest rates increase is associated with stabilization effects of higher interest rates according to the distorting effects of demand shocks on the exchange rate stability. We suggest that less dynamic response of the short-term interest rates to the demand shock in countries with flexible exchange rate arrangements originates in associated exchange rate adjustments followed by the demand shock that intensified the process of convergence toward equilibrium restoration and thus put less intensive pressure on the interest rates increase. Exchange rate flexibility seems to be a convenient precondition for the nominal interest rates stability.

Liquidity shock in our sample of countries with nominal exchange rate targeting seems to be channeled more likely to the external (current account) disequilibrium. As a result, associated nominal interest rates adjustments are less dynamic, moderate and temporary. In comparison with group of "peggers" of results for the countries with flexible exchange rate arrangement reflect that the initial load of the effect was intensified revealing more dynamic immediate responsiveness of interest rates to the liquidity shock. Short-term path of the response patterns also revealed slightly reduced loading phase of negative effect to the nominal interest rates. The overall durability of negative effect of the liquidity shock to the nominal interest rates was slightly reduced.

We suggest that higher responsiveness of the short-term interest rates to the inflation shock under pegged exchange rate regime is caused by increased role of interest rates in maintaining price stability when nominal exchange rate anchoring is adopted. As a result, immediate interest rates increase followed by increased inflation pressures should prevent monetary instability and thus help to preserve exchange rate stability. On the other hand we observed that inflation shock was followed by slightly lagged response of the short term interest rates in countries with flexible exchange rate regime.

Long-run effect of the inflation shock to the short-term interest rates leading path seems to be neutral in countries with pegged exchange rate arrangement. However, in countries with smaller economies (Central European countries) from the group of "floaters" the negative effect of the inflation shock seems to be quite persisting even in the long run. We suggest that exchange rate flexibility together with high external openness represents more challenging combination of crucial determinants for monetary authorities that affects the overall price stability in comparison with countries employing pegged exchange rate regime. It seems that for countries with flexible exchange rate arrangement combined with inflation targeting it is necessary to determine interest rate curve on both short-term and long-term sides to preserve price stability and meet inflation target. As a result, unexpected positive inflation shock (unexpected increase in inflation) may cause a permanent increase in the short-term interest rates with subsequent effects to the long-term interest rates.

Discretionary changes in the interest rates (proxied in our model by the unexpected monetary policy shock) in countries with nominal exchange rate anchoring were followed by immediate and dynamic increase in the short-term interest rates while the reduced effect of the shock seems to be generally persisting even permanent in the long-run period. It seems that interest rates adjustments combined with their flexibility in the short run and stability in the long run are crucial for maintaining exchange rate stability and thus pegged exchange rate arrangement sustainability. Initial dynamics in the interest rate responses to the monetary policy shock in countries with flexible exchange rate arrangement is in general comparable with the results for the previous group of countries. However, effect of the monetary policy shock to the short-term interest rates is just a temporary and thus neutral in the long run in countries from the group of “floaters”.

We suggest that high short-term (or even immediate) responsiveness of interest rates to the unexpected exchange rate shocks in countries with exchange rate targeting is associated with an increased stabilization role of interest rates to maintain exchange rate stability affected by exchange rate volatility (i.e. due to exchange rate shocks). Immediate higher responses of short-term interest rates in these countries should operate as a convenient vehicle to support the exchange rate on its way back to per-shock equilibrium levels. On the other hand, lower immediate responsiveness of interest rates to the unexpected exchange rate shock in countries with flexible exchange rate regime results from generally expected interest rates response patterns under interest rate parity conditions. As a result, interest rate differentials affect associated exchange rate adjustments in the medium-term horizons that is why the overall effects of exchange rate shock on interest rates are more durable under flexible exchange rates.

Crisis period affected responses of nominal interest rates to demand shocks in both groups of countries. In general, we observed some different short-term interest rates responsiveness patterns in both groups of countries. It seems that responses of interest rates to structural shocks during the crisis period follow different path according to their initial change as well as following adjustment on the way to their long-run equilibrium. Observed changes in the interest rates responsiveness patterns differ not only according to the baseline period but also from the exchange rate arrangement perspective. Our investigation and estimated results thus contribute to highlighting both crisis related implications in the area of the short-term interest rates determination as well as exchange rate arrangement bias (i.e. fixed versus flexible exchange rates dilemma) particularly in the countries from the past Eastern block (European transition economies).

Estimated results of the interest rates impulse-response functions revealed quite distorting effects of the unexpected exchange rate shock to the responsiveness and durability of short-term interest rates according to the employed exchange rate regime as well as baseline period. We suggest that a relative diversity in results according to the exchange rate arrangement provides important evidence about crucial patterns of adjustment processes under fixed and flexible exchange rates. Our results thus may be contributive to the discussion about side effects associated with the process of monetary integration of the European transition economies. On the other hand, comparison of results for pre-crisis and extended periods revealed unique crisis related effects. However, origins of examined crisis related effects in the area of the interest rates determination and distortions in particular contribution of identified shocks to the interest rates leading path may be a subject of further investigation and academic discussion.

1.2. Interest Rates Determination and Inflation Expectations

1.2.1. Introduction to Inflation and Interest Rates Relationship

Obvious trend in the exchange rate regimes development and low inflation environment, together with increased sensitivity of commercial banks to the interest rates development in the European transition countries in the pre-crisis period during the last decade, enabled monetary authorities to successfully harmonize national monetary policy frameworks with the eurozone legal and operative pillars. Exchange rates stability during the preparation phase on the road to euro adoption was clearly associated with capabilities of national monetary authorities to maintain a monetary stability via interest rates transmission channel.

Gradual transition toward implementation of the qualitative approach mechanisms to the monetary policy decision-making in the European transition economies significantly increased the role of short-term interest rates adjustments. Operative fine-tuning of money market interest rates provides crucial information for commercial banks about intentions of monetary authority and thus enhancing signal function of key interest rates. However, desired effects of interest rate changes may be weaken especially in non-stable inflation environment. Sudden inflation shifts may cause misleading interpretation of interest rates adjustments and thus provide spurious signals to agents.

Linkage between inflation and nominal interest rates seems to be well observed. There is a strong interconnection in development of both categories. Traditional channel of impulses transmission provides clear suggestion about causal relationship between inflation and nominal interest rates - changes in the rate of inflation forces changes in the nominal interest rates due to changes in inflation premium. Following this assumption, central banks raises interest rates as the response to the inflation increase (this practice is known as monetary policy rule), trying to stabilize (maintain) purchasing power of the money. On the other hand, inflation increase doesn’t necessarily reflect unreasonably fast economic growth signalizing overheating. In such a case, increased interest rates should not contribute to the inflation drop. Therefore, raising inflation is not necessarily associated with fast economic growth, but may be a result of market failures or exogenous shocks and thus affect economies even in the recession or stagnation.

Nominal interest rates are not necessarily determined just by the rate of inflation. It is due fact that nominal interest rates consists of two components - real value of money and inflation premium. As a result, changes in nominal interest rates may be caused not only by forces determining the rate of inflation, but also by a number of variables affecting real interest rates (expectations of agents included). Nominal price of money is determined by a wide variety of determinants, that is why it may not seem to be clear, whether nominal interest rates volatility is caused by changes in inflation expectations or expected real interest rates.

Correct identification of (especially short-term) nominal interest rates volatility seems to be a crucial aspect for successful monetary policy decision-making. For example, an increase in the nominal interest rates caused by higher inflation expectations of agents represents a right signal for monetary policy tightening. Corresponding increase in the rate of interest seems to be well suited decision for reduction of excessive inflation pressures. On the other hand, an increase in the nominal interest rates caused by higher expected real interest rates is usually associated with different monetary policy consequences.

In the section we analyze sources of nominal interest rates volatility in the European transition economies to identify a contribution of inflation expectations and expected real interest rates to the nominal interest rates volatility by estimating the structural vector autoregression (SVAR) model. From constructed model we estimate the relative contribution of both determinants to the conditional variability (variance decomposition) of short-term money market interest rates. At the same time we estimate responses (impulse-response functions) of short-term nominal money market interest rates to one standard deviation inflation expectations and expected real interest rates shocks. Effects of economic crisis on our results are considered by estimating two models for every single economy from the group of the European transition economies employing monthly data for two different time periods 2000-2007 and 2000-2012. Comparison of results for both models is crucial for analysis the economic crisis contribution to the nominal interest rates volatility in ten European transition economies.

1.2.2. Overview of the Literature

Inflation versus interest rates nexus seems to be widely discussed area in the empirical literature. St-Amant (St-Amant, 1996) employed bivariate SVAR model to analyze the impact of expected inflation and ex-ante real interest rates on the nominal interest rates volatility of government bonds with maturity one year and ten years in the U.S.A. Following author's results we may conclude that inflation expectations seems to prevailing determinant of nominal interest rate volatility since the beginning of 1970s till the middle of 1980s, whereas shifts in expected real interest rates substantially contributed to the nominal interest rates volatility during the first half of the 1990s.

Deacon and Derry (Deacon and Derry, 1994) provided a variety of methods for identification of market interest rate and inflation premium from the interest rates associated with government bonds. Engsted (Engsted, 1995) implemented cointegration analysis and VAR methodology to examine properties of interest rates and inflation time series. Neely and Rapach (Neely and Rapach, 2008) analyzed time series for real interest rates employing growth equilibrium model. Authors dedicated extra effort to investigate a presence of persistence patterns especially in medium and long time period. Ragan (Ragan, 1995) analyzed time structure of nominal interest rates to estimate inflation expectations of agents. Results of his empirical investigation provided interpretation of the real interest rate volatility over time.

Crowder and Hoffman (Crowder and Hoffman, 1996) analyzed mutual interconnections between inflation and interest rates. Implemented SVAR methodology helped authors to isolate permanent and temporary sources of volatility for nominal interest rates and inflation time series. Lai (Lai, 2004) examined properties of time series for real interest rates. Author investigated conditions to maintain a time series stacionarity under changing length of base period.

Garcia and Perron (Garcia and Perron, 1996) analyzed long-run features of time series for real interest rates in the U.S.A. Lanne (Lanne, 2002) verified a validity of Fisher effect following the results of lung-run interconnections testing between inflation and nominal interest rates in the U.S.A.

1.2.3. Econometric Model

Employed methodology to analyze sources of nominal interest rates volatility is based on technique pioneered by Blanchard and Quah (Blanchard - Quah, 1988) who estimated bivariate model with two types of exogenous shocks. To identify structural shocks authors implemented identification scheme based on decomposing effects of the shocks into permanent and transitory components. Long-run identifying restrictions were applied on the variance-covariance matrix of reduced form VAR residuals.

Following our objective we estimate a model consisting of the vector of endogenous variables X_t and the same number of primitive (structural) shocks. Unrestricted form of the model is represented by the following infinite moving average representation:

$$X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + ... = \sum_{i=0}^{\infty} A_i\varepsilon_{t-i} = \sum_{i=0}^{\infty} A_i L^i \varepsilon_t \quad (1.7)$$

or

$$\begin{bmatrix} ir_{n,t} \\ p_t \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_{p^e,t} \\ \varepsilon_{ir_r^e,t} \end{bmatrix} \quad (1.8)$$

where X_t is a vector of the endogenous macroeconomic variables, A_i is a polynomial variance-covariance matrix of lag-length *l*, *L* is lag operator and ε is a vector of identically normally distributed, serially uncorrelated and mutually orthogonal white noise disturbances (vector of reduced form shocks in elements of *X*). Vector X_t of the endogenous variables of the model $\left(X_t = \left[ir_{n,t}, p_t\right]\right)$ consists of the following two elements: nominal interest rates $\left(ir_{n,t}\right)$ and rate of inflation $\left(p_t\right)$. Vector ε_t of the past primitive shocks is represented by the following two shocks: inflation expectations shock $\left(\varepsilon_{p^e,t}\right)$ and expected real interest rates shock $\left(\varepsilon_{ir_r,t}\right)$.

Structural exogenous shocks from equation (1.7) are not directly observable (cannot be correctly identified) due to the complexity of information included in true form VAR residuals. As a result structural shocks cannot by correctly identified. It is necessary to transform true model into following reduced form

$$X_t = e_t + C_1 e_{t-1} + C_2 e_{t-2} + ... = \sum_{i=0}^{\infty} C_i e_{t-i} = \sum_{i=0}^{\infty} C_i L^i e_t \quad (1.9)$$

or

$$\begin{bmatrix} ir_{n,t} \\ p_t \end{bmatrix} = \begin{bmatrix} c_{11i} & c_{12i} \\ c_{21i} & c_{22i} \end{bmatrix} \begin{bmatrix} u_{i^e,t} \\ u_{ir_r^e,t} \end{bmatrix} \tag{1.10}$$

From equations (1.7) and (1.9) we clearly observe relationship between primitive shocks ε_t and reduced form VAR residuals e_t:

$$e_t = A_0 \varepsilon_t \tag{1.11}$$

Matrices C_i we obtain from estimated equation (1.7). Considering $A_i = C_i A_0$, we can now identify matrix A_0. To estimate coefficient of matrix A_0, it is necessary to impose four restrictions. Two restrictions are simple normalizations, which define the variance of the shocks $\varepsilon_{p^e,t}$ and $\varepsilon_{ir_r,t}$ (it follows the assumption that each of the disturbances has a unit variance, $\mathrm{var}(\varepsilon) = 1$). Third restriction comes from an assumption that identified shocks are orthogonal. Normalization together with an assumption of the orthogonality implies $A_0^{'} A_0 = \Sigma$, where Σ is the variance covariance matrix of $e_{p^e,t}$ and $e_{ir_r,t}$. The final restriction, which allows the matrix C to be uniquely defined, represents the long-run identifying restriction providing that a cumulative effect of expected real interest rate shock to the nominal interest rates variability is zero:

$$\sum_{i=0}^{\infty} a_{12i} = 0 \tag{1.12}$$

Long-run identifying restrictions enable us to isolate temporary and permanent sources of nominal interest rates volatility and thus to distinguish effects of both structural shocks on endogenous variables of the model.

In terms of our vector autoregression model it implies

$$\begin{bmatrix} ir_{n,t} \\ p_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ . & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{i^e,t} \\ \varepsilon_{ir_r^e,t} \end{bmatrix} \tag{1.13}$$

Correctly identified model can be finally estimated employing SVAR methodology. Variance decomposition and impulse-response functions are computed to observe a relative contribution of inflation expectations and expected real interest rates shocks to the nominal interest rates conditional variance as well as response of nominal interest rates to one standard deviation inflation expectations and expected real interest rates shocks. Effects of economic crisis on our results are considered by estimation of two models (with data sets for two different time periods 2000-2007 (model A) and 2000-2012 (model B)) for every country from the group of the European transition economies. Comparison of results for both models is crucial for evaluation of the economic crisis contribution to the nominal interest rates volatility in ten European transition economies.

1.2.4. Data and Results

To estimate a sources of the nominal interest rates volatility in ten European transition economies (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia) we employ monthly data with period 2000M1-2007M12 (model A) consisting of 96 observations and with period 2000M1-2012M12 (model B) consisting of 156 observations for following endogenous variables - nominal interest rates (interbank offered rates with 3 months maturity[8]) and inflation (core inflation). Estimation of two models corresponds with the primary objective of the chapter that is to evaluate effects of inflation expectations and estimated real interest rates on nominal interest rates development considering possible implications of economic crisis on presented results. Time series for all endogenous variables were drawn from theIMF database (International Financial Statistics, November 2013). Time series for the rate of inflation were seasonally adjusted.

We also emphasize a relative importance of exchange rate regime choice on the results providing suggestion about potential effects of breakdown in mutual interconnections between macroeconomic development and flexible exchange rates leading path (as one of the key implications after euro adoption). The beginning of the period for time series included in both models is related the continuous strengthening of qualitative features in the monetary policy decision-making since the beginning of the past decade.

Correct estimation of both models and precise identification of exogenous shocks hitting the model it is necessary VAR model to be stationary. To test the stationarity of both models it is necessary to test the time series for unit roots and cointegration. To test the stability of the VAR model we have also applied a number of diagnostic tests of the VAR residuals (normality, serial correlation, heteroskedasticity).

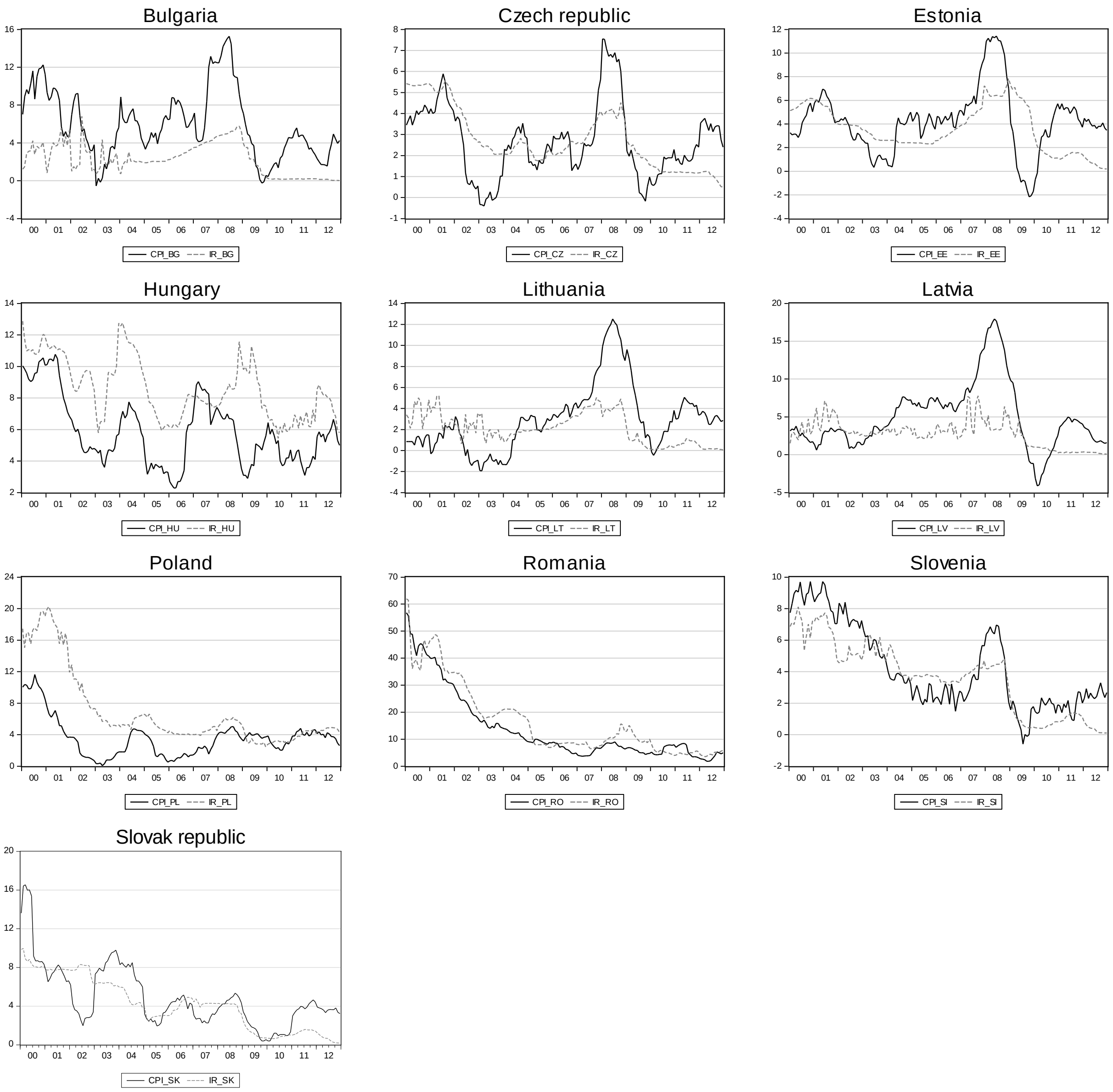
Overview of interest rates and inflation development in the European transition economies is provided in the figure 1.11. As we have expected, most countries experienced obvious trend in inflation decrease during the first half of the past decade. Adverse impacts of external (oil and gas markets) and internal (seasonal food, indirect taxes) price development together with spurious price effects of euro adoption (in respective countries) and economic crisis contributed to ceasing or slowing down of positive inflation trend in most of countries from the group. On the other hand interest rate development seems to be affected by exchange rate regime choice. Countries with currency board arrangements (Bulgaria, Estonia and Lithuania) and conventional fixed peg (Latvia) experienced relatively stable trend in the interest rates development during the pre-crisis period. In countries with flexible exchange rate arrangements[9] interest rates seem to be much more determined by main trends in the development of inflation.

In both groups of countries interest rates did not precisely follow a leading path of inflation. At the same time, adjustments in interest rates seem to be lagged following changes in inflation with up 6 months delay. Countries with hard pegs also experiences repetitive

[8] Interbank offered rates in Estonia, the Slovak Republic and Slovenia were replaced by EURIBOR since the eurozone membership.
[9] Although Hungary employed fixed exchange rate pegged to euro till May 2008, due to wide horizontal bands (±15%) exchange rate floated in de facto flexible exchange rate arrangement.

periods with negative real interest rates in the recent years due to excessive inflation pressures.

Figure 1.11 Inflation and Interest Rates (2000M1-2012M12)



Note: Endogenous variables - inflation (CPI), short-term interest rates (IR) are expressed in percentage.

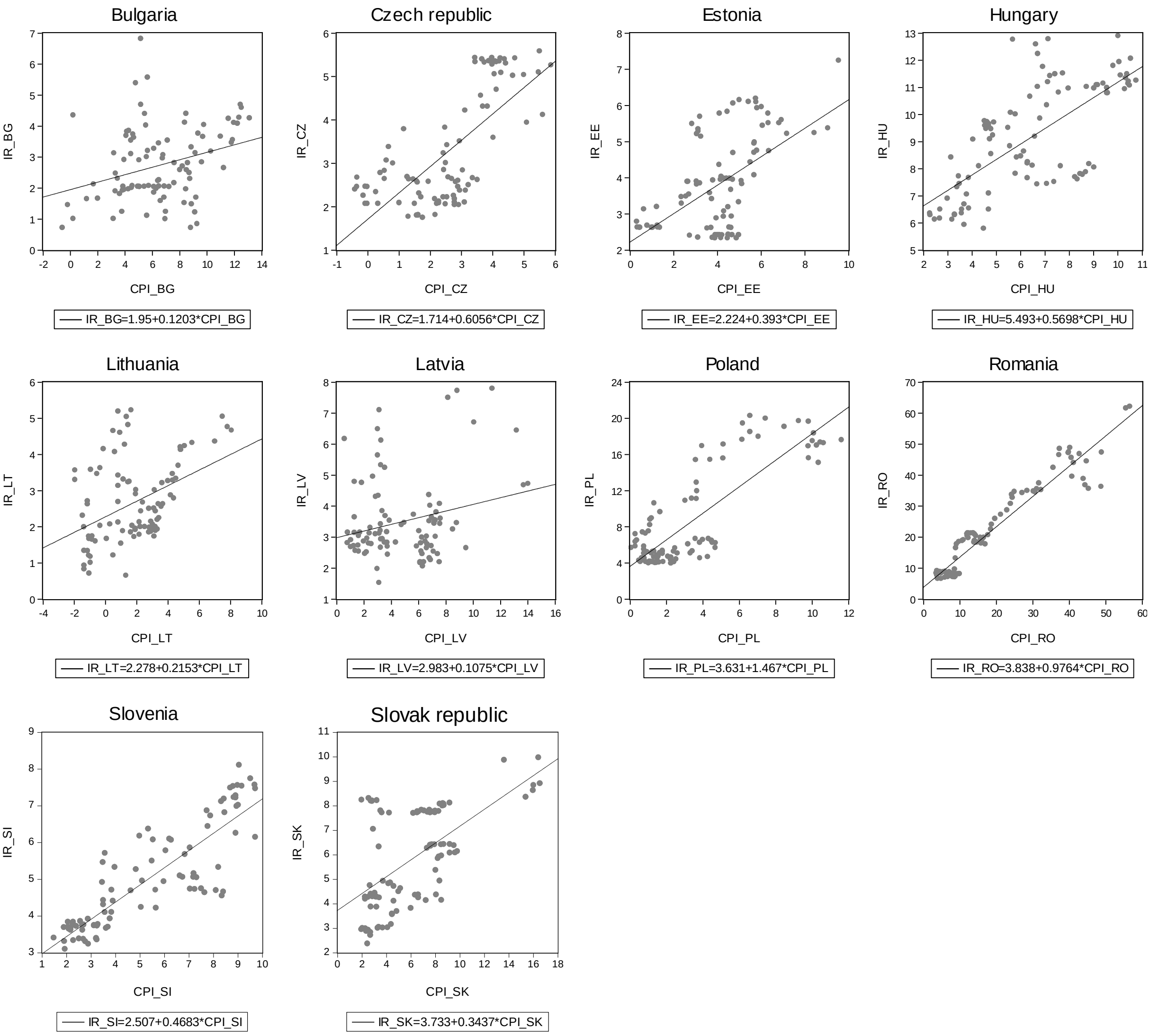
Source: Compiled by author based on data taken from IMF - International Financial Statistics (IFS) (November 2013).

Crises period affected interest rates and inflation in all countries. Inflation rates in all ten European transition economies reached its local maximum (for the period of last few years) shortly before negative effects of ongoing economic crisis revealed. Although the rate of inflation seems to differ at the end of pre-crisis period in each individual country, all economies subsequently experienced rapid disinflation as a result of recession. In all countries interest rates adapted to changes in inflation with just moderate intensity causing high volatility and instability of real exchange rates. Moreover, Hungary experienced the period of asymmetric development of inflation and interest rates leading path. Strong divergence effect in Hungary was associated with sharp increase in real interest rates emphasizing crisis related internal and external macroeconomic imbalance in the country.

A. Correlation Analysis

Mutual relationship between inflation and interest rates in the European transition economies during the pre-crisis period depicts the figure 1.12. Coefficients of correlation between core inflation and short-term interest rates revealed plausible implications of exchange rate regime choice. In the group of countries so called “peggers” (countries with currency board arrangement or conventional fixed peg with narrow horizontal bands) the coefficients of correlation between inflation and interest rates seem to be lower (in some cases even much lower) than in the group of countries so called “floaters” (countries with free or managed floating or intermediate pegs).

Figure 1.12 Inflation and Interest Rates Correlation Coefficients (2000M1-2007M12)



Note: Endogenous variables - inflation (CPI), short-term interest rates (IR) are expressed in percentage. Correlation coefficients between inflation and interest rates: BG (0.310), CZ (0.715), EE (0.556), HU (0.700), LT (0.428), LV (0.235), PL (0.825), RO (0.957), SI (0.864), SK (0.595).

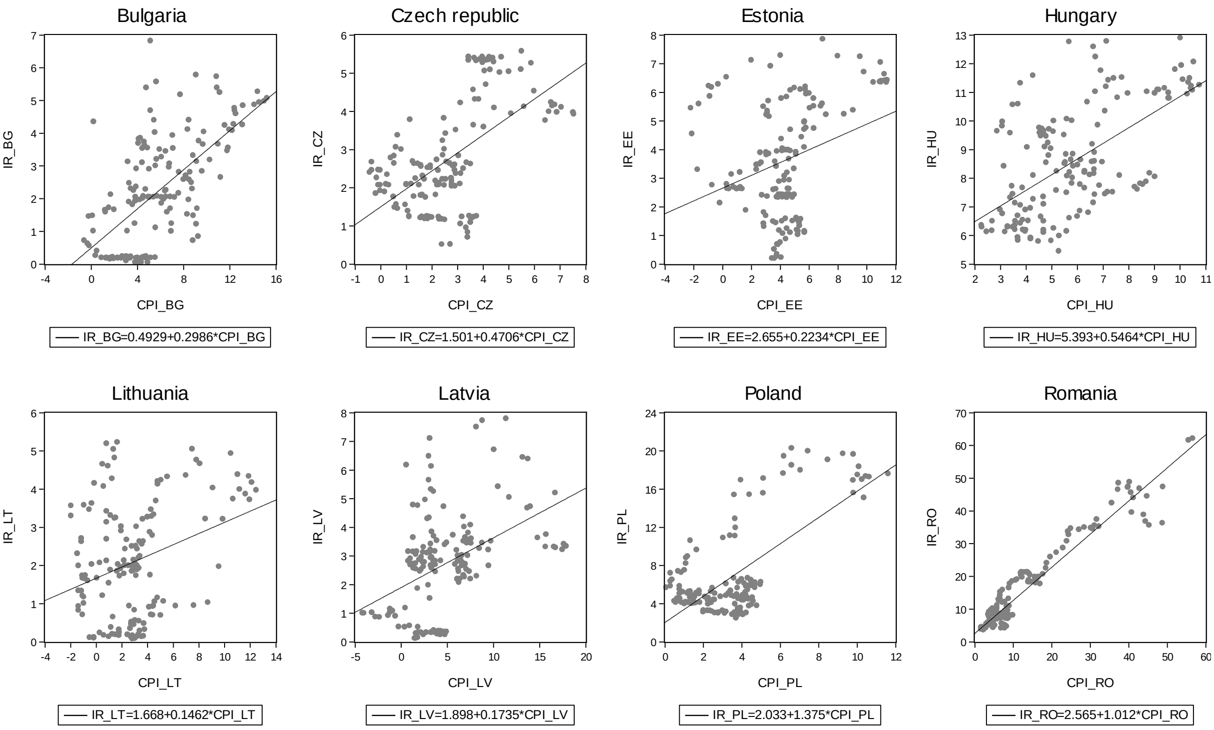
Source: Author’s calculations.

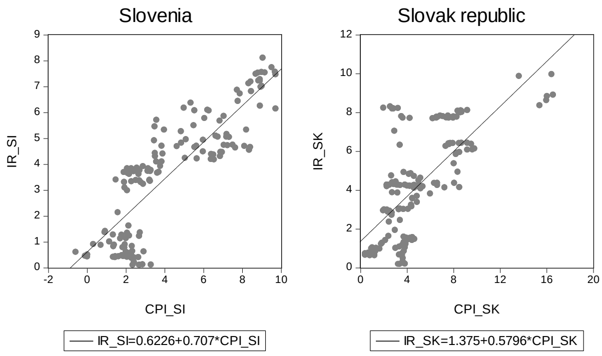
Following the results of correlation analysis we may conclude that in countries with exchange rate as the nominal anchor, non-autonomous monetary policy is obviously associated with low interest rates (irrespective of inflation) while the nominal exchange rate target contributes to successful disinflation process. On the other hand interest rates leading path doesn't seem to be directly affected by domestic rate of inflation proving a substantial source of real exchange rate volatility. Even though, stabilized expectations of economic agents due to exchange rate targeting significantly contributes to the overall macroeconomic stability.

Countries with inflation targeting and no predetermined path for the exchange rate achieved higher correlations between interest rates and inflation especially due to increased flexibility of short-term interest rates. In such countries, autonomous monetary policy obviously contributes to higher mutual interconnections between the rate of interest and the rate of inflation. Signal function of interest rates adjustments seems to be more significant and thus providing more precise information to agents about the price stability associated with the overall macroeconomic performance of the country.

Mutual relationship between inflation and interest rates in the European transition economies during the extended period depicts the figure 1.13. Coefficients of correlation between core inflation and short-term interest rates revealed curious effects of the crisis period.

Figure 1.13 Inflation and Interest rates Correlation Coefficients (2000M1-2012M12)





***Note**:* Endogenous variables - inflation (CPI), short-term interest rates (IR) are expressed in percentage. Correlation coefficients between inflation and interest rates: BG (0.646), CZ (0.589), EE (0.313), HU (0.607), LT (0.320), LV (0.435), PL (0.693), RO (0.958), SI (0.846), SK (0.698).

Source: Author's calculations.

Economic crisis significantly affected results of correlation analysis between inflation and interest rates. The strength of mutual interconnections between both categories weakened in most of countries from the group irrespective of the exchange rate arrangement. Increased uncertainty on the markets resulted in drop of information value resulted from associated changes in prices especially due to exogenous character of prices related initial determinants causing decreased efficiency of allocative efficiency of the markets.

Lower predictability of inflation trend during the recession together with higher discretion in the monetary policy decision-making following the principle of low interest rate policy and quantitative easing that monetary authorities implemented to fight a crisis, contributed to higher volatility in the real exchange rates development in most of the countries from our group. The only exception in the group of "peggers" we found in two countries with currency board arrangements - Bulgaria and Lithuania and in the group of "floaters" - Slovak Republic (country joined the eurozone in 2009).

Despite decreased interconnection between interest rates and inflation development during the extended period, correlation coefficients between both categories generally remained higher in the group of "floaters". Moreover, the overall decrease in correlation coefficients was not significant in this group of countries. Spurious effects of the crisis period are more evident in the group of "peggers" considering much more significant changes in the coefficients of correlation between the rate of inflation and short-term interest rates.

Summarizing overview for correlation analysis of mutual relationship between inflation and interest rates in the European transition economies in the pre-crisis and extended period provides Table 1.7.

Table 1.7 Summary of Correlation Analysis for Pre-crisis and Extended Period

	2000-2007	2000-2012	Δ
Bulgaria	0.310	0.646	↑
Czech Republic	0.715	0.589	↓
Estonia	0.556	0.313	↓
Hungary	0.700	0.607	↓
Latvia	0.235	0.435	↑
Lithuania	0.428	0.320	↓
Poland	0.825	0.693	↓
Romania	0.957	0.958	=
Slovak Republic	0.595	0.698	↑
Slovenia	0.864	0.846	↓

Source: Author's calculations.

B. Unit Root Test

Table 1.8 Unit Root Tests

Country	**Model**	**Order of integration of endogenous variables**			
		CPI		**IR**	
		ADF	PP	ADF	PP
Bulgaria	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Czech Republic	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Estonia	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Latvia	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Lithuania	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Hungary	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	**I(0)**	I(1)
Poland	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	**I(0)**	I(1)	I(1)
Romania	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Slovak Republic	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)
Slovenia	A	I(1)	I(1)	I(1)	I(1)
	B	I(1)	I(1)	I(1)	I(1)

Source: Author's calculations.

Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were computed to test endogenous variables for the presence of a unit root. Results of unit root tests are summarized in the Table 1.8 (detailed results of unit root are not reported here to save space. Like any other results, they are available upon request from the author).

Both ADF and PP tests indicate that all variables are not stationary on the values so that the null hypothesis of a unit root cannot be rejected for any of the series (with exception of interest rates in Hungary (ADF, model B) and inflation in Poland (PP, model B). Testing variables on the first differences indicates that the time series are stationary. We may conclude that all variables are I(1).

C. Cointegration Test

Because endogenous variables have a unit root on the values it is necessary to the test the time series for cointegration using the Johansen and Juselius cointegration test. The test for cointegration was calculated using three lags as recommended by AIC (Akaike Information Criterion) and SIC (Schwarz Information Criterion). Results of cointegration tests are summarized in the Table 1.9 (detailed results of cointegration tests are not reported here to save space. Like any other results, they are available upon request from the author).

Table 1.9 Johansen and Juselius Cointegration Tests

Country	**Number of cointegrating equations**			
	Model A		**Model B**	
	trace stat.	max eigvalue stat.	trace stat.	max eigvalue stat.
Bulgaria	0	0	0	0
Czech Republic	0	0	0	0
Estonia	0	0	0	0
Latvia	0	0	0	0
Lithuania	0	0	0	0
Hungary	0	0	0	0
Poland	0	0	0	0
Romania	0	0	0	0
Slovak Republic	0	0	0	0
Slovenia	0	0	0	0

Source: Author’s calculations.

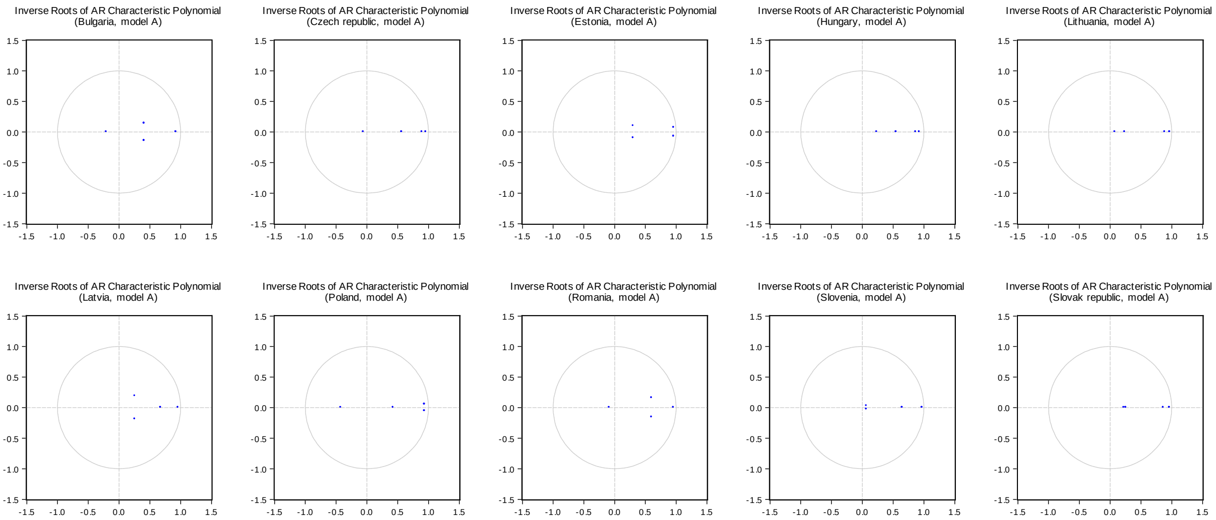
The results of the Johansen cointegration tests confirmed the results of the unit root tests for both models (models A and B) in all ten countries providing that any linear combination of two variables is nonstationary process. Trace statistics and maximum eigenvalue statistics (both at 0.05 level) in each individual country indicated that there is no cointegration among endogenous variables of both models.

D. VAR Stability

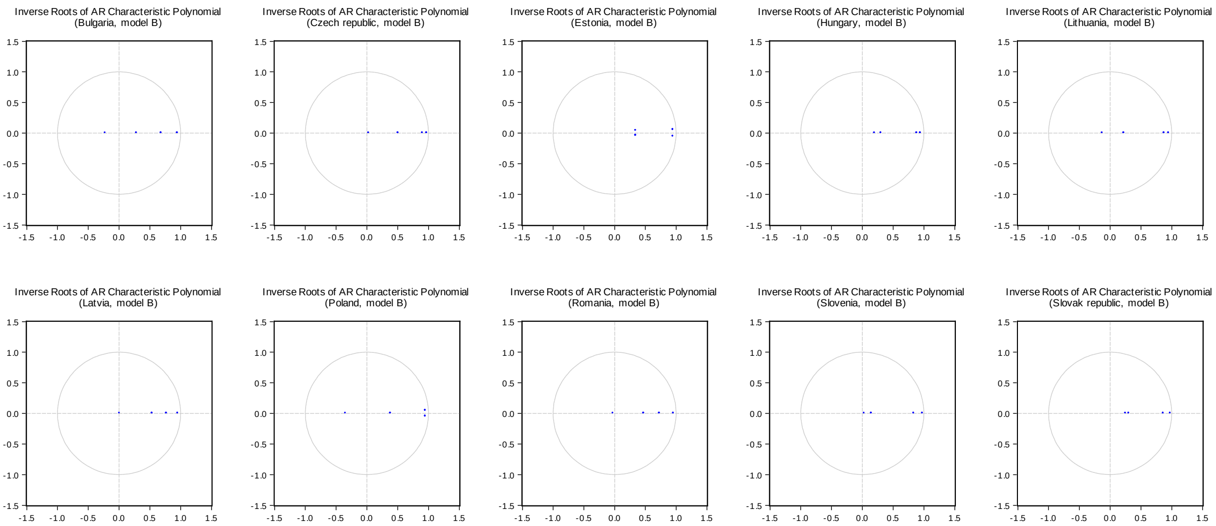
To test the stability of VAR model we also applied a number of diagnostic tests. We found no evidence of serial correlation, heteroskedasticity and autoregressive conditional heteroskedasticity effect in the disturbances. Model also passed the Jarque-Bera normality test, so that errors seem to be normally distributed. VAR models seem to be also stable because inverted roots of the model for each country lie inside the unit circle (Figure 1.14).

Figure 1.14 VAR Stability Condition Check

Model A



Model B



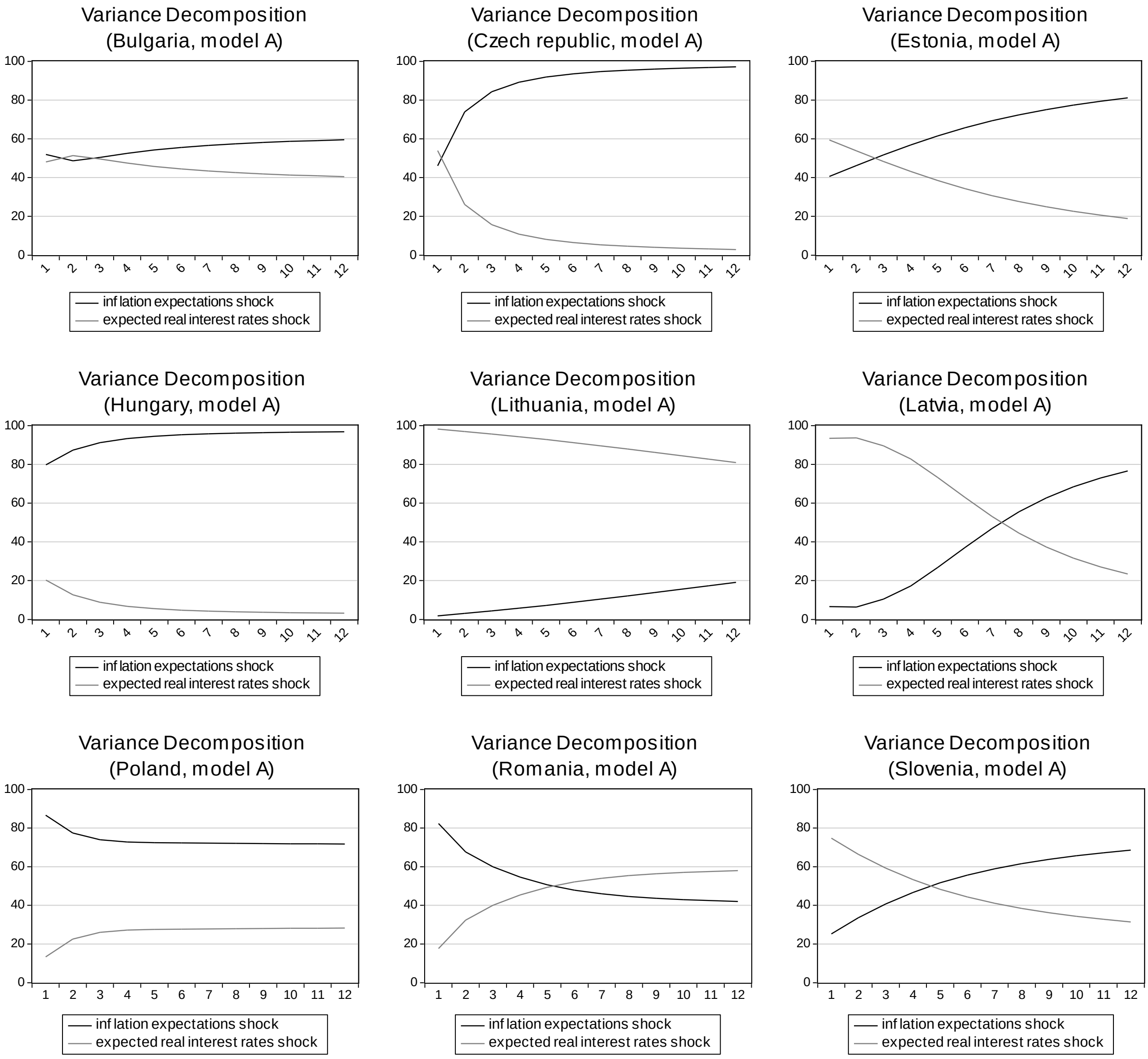
Source: Author's calculation.

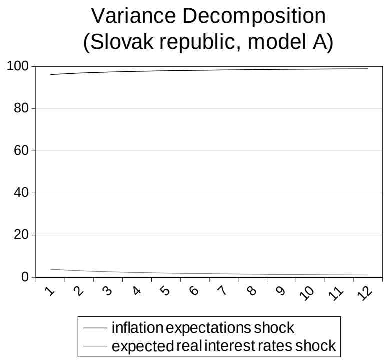
Following results of the unit root and cointegration tests we estimated both models using variables in the first differences so that we can calculate variance decompositions and impulse-response functions for all ten countries from the group of the European transition economies. Following the main objective of the chapter we summarize the relative importance of inflation expectations and expected real interest rates shocks in the nominal interest rates conditional variance. We also analyze individual responses of nominal interest rates to the positive one standard deviation inflation expectations and expected real interest rates shocks. Effects of the crisis period on sources of the nominal interest rates volatility in the European transition economies is observed by comparing the results for estimated models employing time series for two different periods - model A (2000M1-2007M12) and model B (2000M1-2012M12).

E. Variance Decomposition

Figure 1.15 shows the estimated contribution of inflation expectations and expected real interest rates shocks to nominal interest rates conditional variance in the European transition economies during the pre-crisis period (2000M1-2007M12) in model A.

Figure 1.15 Variance Decomposition of Nominal Interest Rates (2000M1-2007M12)





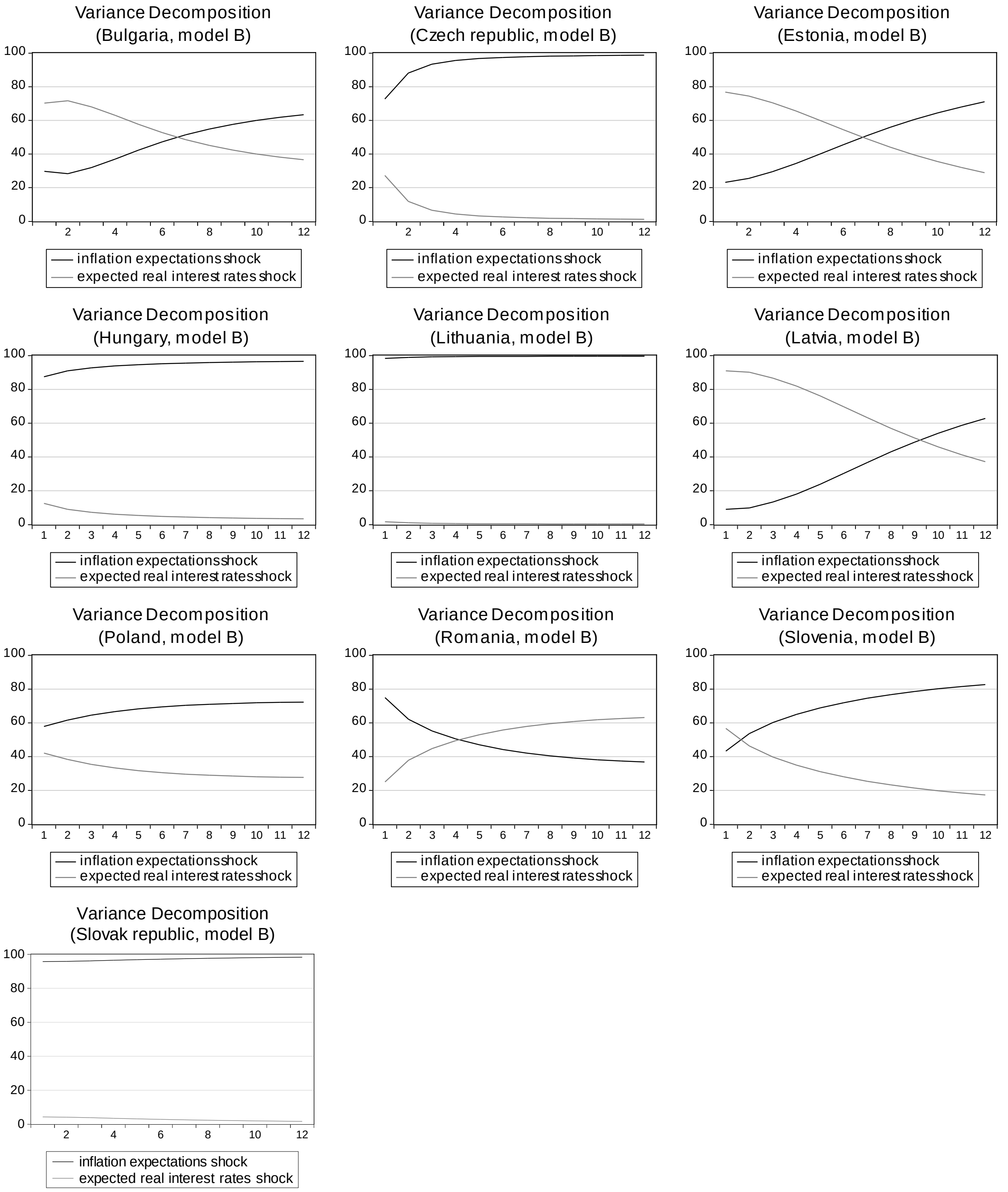
Source: Author’s calculations.

Overview of structural shocks contributions to the nominal interest rates unpredicted shifts revealed remarkable implications of the exchange rate regime choice. Immediate contribution of the expected real interest rates shock is significantly higher in countries with currency board arrangement (Bulgaria, Estonia, Lithuania) and conventional fixed peg (Latvia) though the size of initial contribution differs in all four economies. It seems like exchange rate as the nominal anchor contributes to the stability of inflation expectations (especially in the short-run). Exchange rate targeting thus provides a suitable vehicle for reducing short-run effects of inflation expectations on the price mechanism on the money market. Higher contribution of expected real interest rates to the nominal interest rates variance also reduces distorting effects of money markets imperfections resulting from false price signals related to sudden inflation shifts. It also seems to be obvious that the relative contribution of the expected real interest rates shock decreases over time followed by increasing role of the inflation expectations shock.

The relative immediate importance of the expected real interest rates shock in the group of countries, so called floaters, seems to be significantly smaller reflecting crucial role of inflation expectations in determining the nominal interest rates leading path (with exception of Slovenia). Despite the absence of apparent nominal anchor (explicit exchange rate target with no predetermined path for the exchange rate), explicit inflation targeting (monetary policy strategy implemented by all six countries with floating exchange rate regimes during the first half of the 2000s) delivered similarly successful results in disinflation process. Thus, a substantially higher role of the inflation expectations in this group of countries seems to be reasonable. The overall impact of inflation expectations on interest rates even rises in the long-run (with exception of Poland and Romania).

Figure 1.16 shows the estimated contribution of inflation expectations and expected real interest rates shocks to the nominal interest rates conditional variance in the European transition economies during the extended period (2000M1-2012M12) in model B.

Figure 1.16 Variance Decomposition of Nominal Interest Rates (2000M1-2012M12)



Source: Author's calculations.

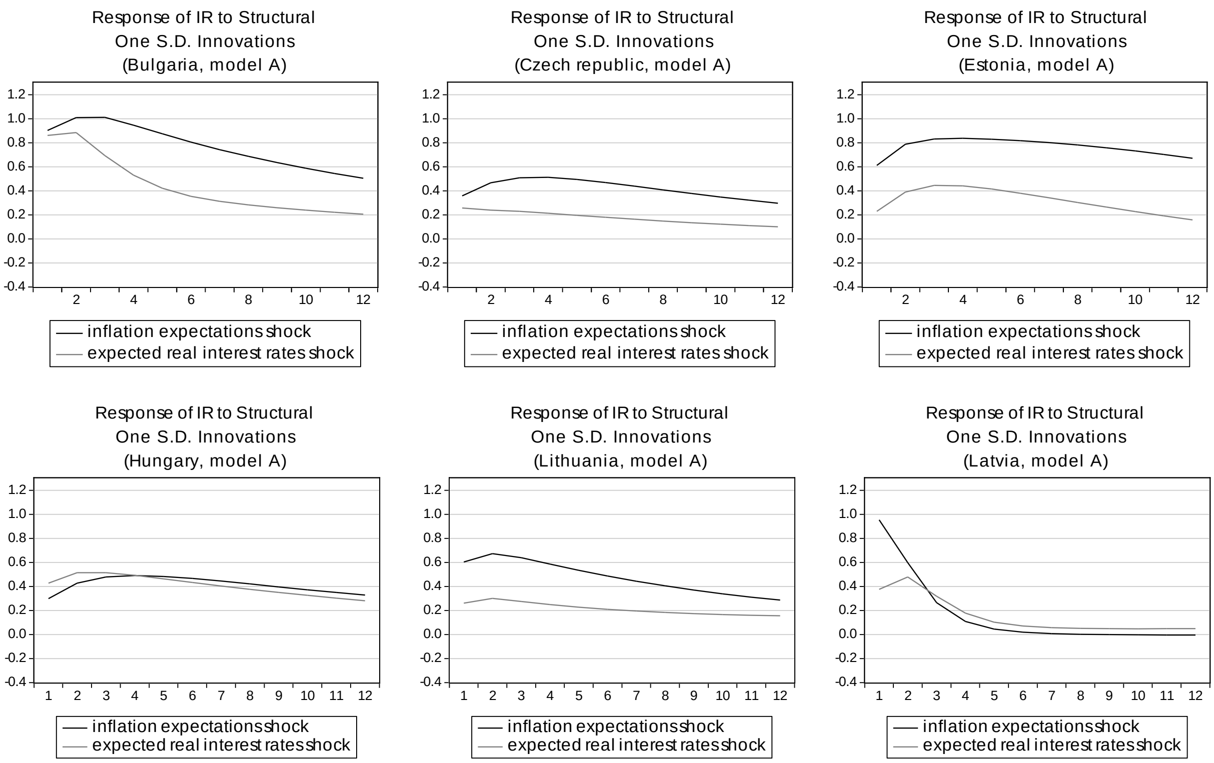
In general, economic crisis predominately confirmed main character of identified potential sources determining the short-term nominal interest rates volatility in the European transition economies. In the group of countries, so called "peggers" we experienced an increased immediate contribution of expected real interest rates shock to the conditional variability of nominal interest rates. Even the price effects of economic crisis seem to be spurious and hardly predictable, immediate role of inflation expectations in determining nominal interest rates generally decreased in this group of countries. It seems that a credible nominal target operating as a key pillar of the monetary policy strategy provides a crucial anchor for stable inflation expectations of agents, especially in the short-run.

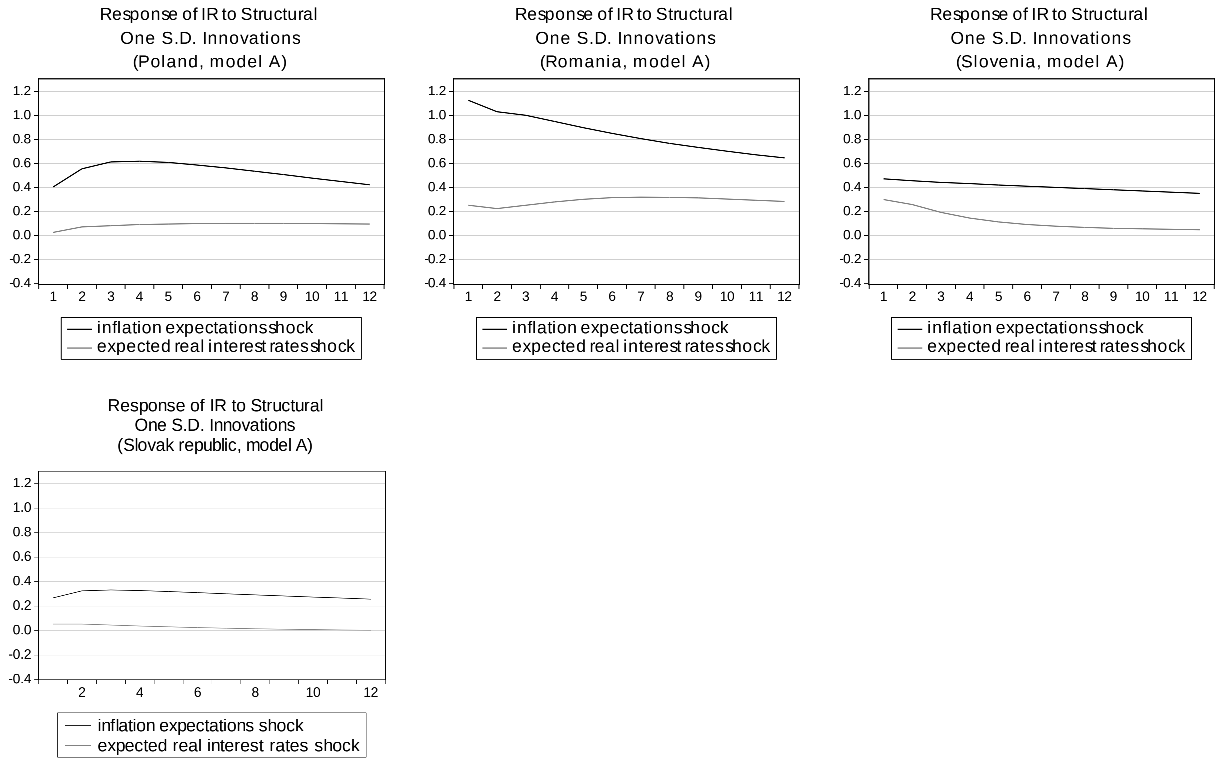
In the group of countries, so called "floaters", immediate contribution of inflation expectations shock to the nominal interest rates variance predominately increased (with exception of Poland and Romania in the short-run). Despite overall success of inflation targeting we suggest that inflation expectations tend to suffer from low level of self-persistence and become quite vulnerable to sudden changes caused by unexpected exogenous shocks. Related nominal interest rates volatility and associated real interest rates instability reflects relatively low success of monetary authority to regain price stability providing the absence of a credible nominal anchor.

F. Impulse-Response Function

In the figure 1.17 we summarize responses of nominal interest rates to one standard deviation positive inflation expectations and expected real interest rates shocks in the European transition economies during the pre-crisis period (2000M1-2007M12) in model A.

Figure 1.17 Impulse-Response Functions of Nominal Interest Rates (2000M1-2007M12)





Source: Author's calculations.

Nominal interest rates responded to both inflation expectations and expected real interest rates shocks during pre-crisis period in line with empirical expectations. One standard deviation positive shock of inflation expectations caused immediate increase in nominal interest rates in all ten European transition economies. On the other hand we observed some differences in intensity as well as durability of the effect.

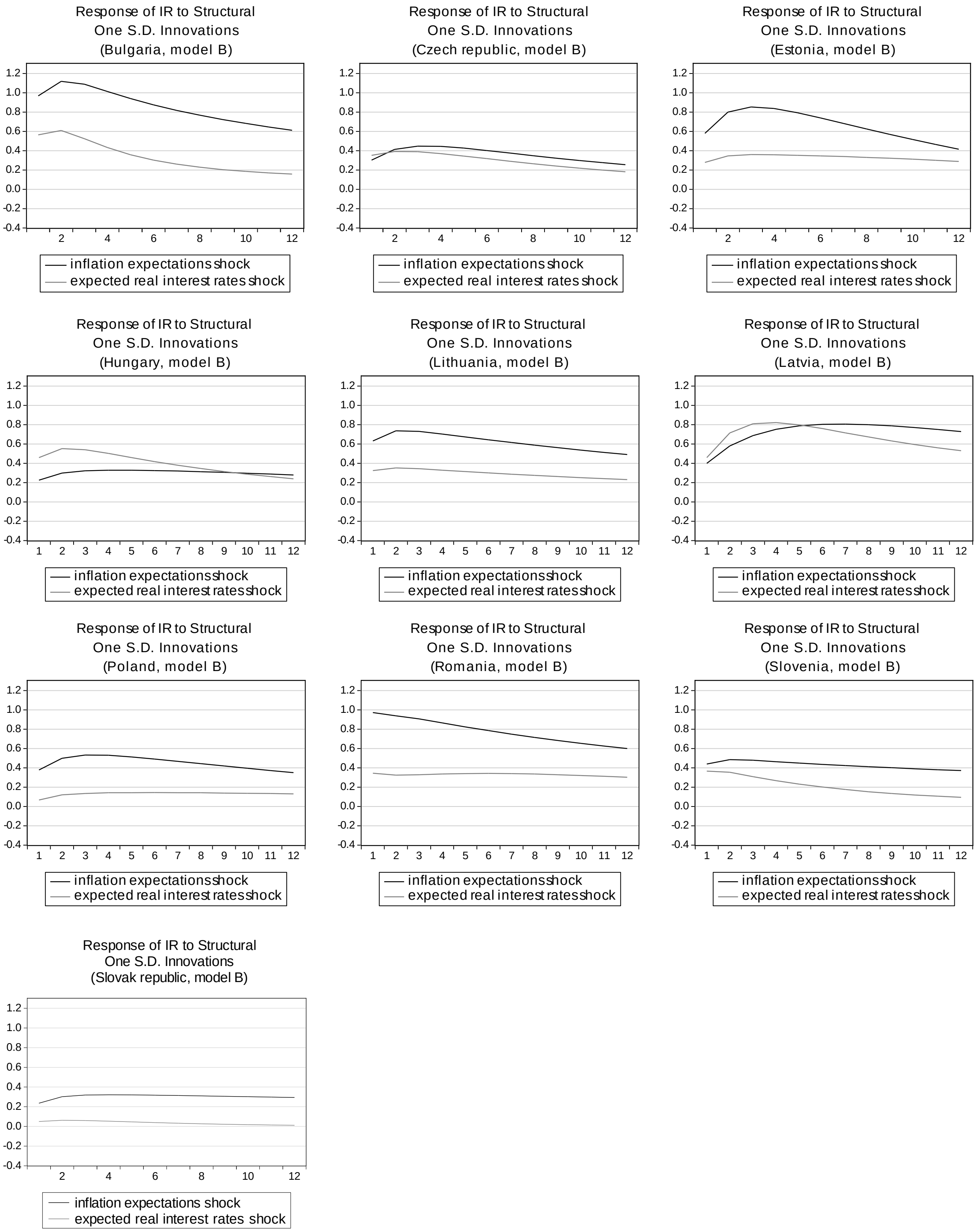
Immediate response of nominal interest rates to unpredicted sudden positive one standard deviation real interest rate shock in the group of countries, so called "peggers" as well as in Hungary, seems to be noticeably higher. Provided that Hungarian forint operated during the pre-crisis period in the intermediate exchange rate regime[10], similarity of results seems to be convenient.

Effects of both shocks seem to be just temporary in determining short-time variability of nominal interest rates. Negative impact of inflations expectations and expected real interest rates shocks steadily died out confirming long-run neutrality of nominal interest rates to their effects.

In the figure 1.18 we summarize responses of nominal interest rates to one standard deviation positive inflation expectations and expected real interest rates shocks in the European transition economies during the extended period (2000M1-2012M12) in model B.

[10]Hungarian forint operated during pre-crisis period in de facto fixed peg regime, but due to substantial range for fluctuations provided by wide horizontal bands it was included in the group of countries, so called "floaters".

Figure 1.18 Impulse-Response Functions of Nominal Interest Rates (2000M1-2012M12)



Source: Author's calculations.

Crisis period affected responses of nominal interest rates to positive inflation expectations and expected real interest rates shocks with spurious results. In three countries from the group of so called "peggers" (Bulgaria, Latvia and Lithuania) we experienced slight increase in the durability of the negative effect imposed by the inflation expectations shock.

An exception in this group of countries is Estonia (anticipated eurozone membership might cause changes in effects of inflation expectations). At the same the negative effect of expected real interest rates shock seems to be durable in all countries of so called “peggers” with expectation of Bulgaria. At the same we experienced an increased durability of the expected real interest rates shock in Estonia and Latvia.

Changes in effects of inflation expectations shock on the nominal interest rates during the extended period in the group of so called “floaters” seems to be just negligible. At the same time we experienced a slight increase in durability of expected real interest rates positive shock (especially in the Czech Republic and Poland).

1.2.5. Conclusion

Exchange rate regime choice in the European transition economies affected corresponding monetary policy strategy framework. Countries (“peggers”) with exchange rate as the nominal anchor (hard pegs or soft pegs with narrow horizontal bands) successfully implemented exchange rage targeting. Countries (floaters) with soft pegs (pegs with wide horizontal bands or crawling pegs) and floating regimes employed monetary targets as intermediate criteria of monetary policy (monetary targeting) later (continuously since the end of the 1990 in respective countries) followed by adoption of direct (explicit) inflation targeting.

Regular monetary policy anchors operates well as stabilizing pillars under turbulent conditions in domestic (open) economy considering relative stability on the markets of main trading partners as well as of the country providing nominal anchor (i.e. exchange rate). Following our results in the model with time series for pre-crisis period it seems that exchange rate as the nominal anchor contributed to the stability of inflation expectations in the group of countries, so called “peggers” (especially in the short-run). Exchange rate targeting thus provided a suitable vehicle for reduction of short-term effects of inflation expectations on the price mechanism on the money market. Higher contribution of expected real interest rates to the nominal interest rates conditional variance also reduced distorting effects of money markets imperfections resulting from false price signals related to sudden inflation shifts.

Despite the absence of an apparent nominal anchor, explicit inflation targeting delivered similarly successful results in disinflation process in the group of countries, so called “floaters”. Substantially higher role of the inflation expectations in this group of countries seemed to be reasonable. The overall impact of inflation expectations on nominal interest rates in the long-run mostly rose.

Overall effects of the crisis period related to the respective responses of nominal interest rates to the inflation expectations and expected real interest rates shocks seem to be puzzled. Redistributive impacts followed by increased asynchronous effects of local crisis are obviously associated with selective and irregular changes in expectations of agents though still well anchored by credible indicator. Economic crisis, as a typical exogenous shock and global phenomenon, affected economies especially through the external trade or/and financial flows channel, quickly spreading across a region of neighboring and interconnected economies. It seems to be convenient to expect that a relative importance of external nominal anchors during the crisis period became less successful in stabilizing inflation expectations, providing distorting effects of the crisis on the economy of anchoring country. However, our results indicates that a relative importance of inflation expectations in determining nominal interest rates generally decreased in the group of countries, so called “peggers”. Even the price effects of economic crisis seem to be spurious and hardly predictable, a credible nominal anchor provided a crucial vehicle for stabilization of inflation expectations of agents, causing a relative drop in the role of inflation expectations in determining nominal interest rates during the crisis period.

Despite overall success of inflation targeting during the most of the 2000s we suggest that inflation expectations tend to suffer from low level of self-persistence and become quite vulnerable to sudden changes caused by unexpected exogenous shocks in the group of countries, so called “floaters”. Related nominal interest rates volatility and associated real interest rates instability reflected relatively low success of monetary authority to regain price stability proving the absence of a credible nominal anchor.

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Chapter 2

Monetary Rules and their Importance in the Context of Monetary Union

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2.1 Introduction
2.2 Literature Overview
2.3 Theoretical and Practical Background of Monetary Rules Implementations
2.4 Rules versus Discretion
2.5 Monetary Rules versus Monetary Policy Strategies
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2.7 The Taylor Rule Quantification for the Slovak Republic
2.8 Conclusion
2.9 References

MONETARY RULES AND THEIR IMPORTANCE IN THE CONTEXT OF MONETARY UNION

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Abstract
Monetary rules help to quantify reaction function of monetary authorities of particular countries. One of the most important monetary rules is the Taylor rule. Thanks to its simplicity, it has been applied to many countries. However, its relevance was shattered by financial and economic crisis. The application can be complicated even questionable within a monetary union consisting of very asymmetric countries. The main objective of this chapter and the monograph as a whole is to investigate importance of the monetary rules in the context of monetary union and economic crisis and to quantify such a rule for Slovakia before and during crisis, before and after its integration into the European Monetary Union.

Keywords: monetary rules, interest rates, inflation, monetary union, economic crisis,

2.1. Introduction

Monetary rules help to quantify reaction function of monetary authorities of particular countries. One of the most important monetary rules is the Taylor rule. Thanks to its simplicity, it has been applied to many countries. However, its relevance was shattered by financial and economic crisis. The application can be complicated even questionable within a monetary union consisting of very asymmetric countries. The main objective of this chapter and the monograph as a whole is to investigate importance of the monetary rules in the context of monetary union and economic crisis and to quantify such a rule for Slovakia before and during crisis, before and after its integration into the European Monetary Union.

2.2. Literature Overview

The idea of monetary rules is in line with time consistency problem and discussion on rules versus discretion that was significantly treated by Lucas (1973); Kydland and Prescott (1977); later by Barro and Gordon (1983). This theory was fundamental for analysis of monetary strategies comprehensively researched, e.g. by Mishkin (1992, 1999, 2009).

The basic source of inspiration for large literature on monetary rules is John B. Taylor (1993, 1999, 2001) who suggested the best known central bank´s reaction function so called the Taylor rule. Bernanke and Mishkin (1997); Clarida, Galí, and Gertler (1998); Orphanides (2001) were among the first who developed original Taylor rule to various Taylor-type rules applicable in practice. Ball (1999) focused on open economy aspects. Kozicki (1999) evaluated monetary rules from the point of view of their economic policy utility. Gerlach and

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Schnabel (2000); Gerlach-Kristen (2003); Gerdesmeier and Roffia (2004) made first estimations of Taylor-types rules for the euro area. Golinelli and Rovelli (2005); Horváth (2006, 2009); Ziegler (2012) suggested monetary rules for new European Union member states considering their transition process. Rudebusch (2009); Belke and Klose (2011) studied monetary rules in the context of financial and economic crisis.

Specific contributions of the above mentioned authors are gradually described throughout the following sections and sub-sections.

2.3. Theoretical and Practical Background of Monetary Rules Implementations

Monetary rules implementations are from the theoretical and practical point of view implied by monetary policy principles, consequent requirements for central banks and time (in)consistency problem.

2.3.1. Current Principles of Monetary Policy Application

Last three-four decades are marked by an important turnover of monetary policy application. This change was implied mostly by significant rise of inflation in 1970s in most of the countries of the world. On the contrary, at present, most of the countries reach comparatively low level of inflation or as it is named by Mishkin (2009); countries are in *low inflation environment*. In 2006, 193 countries out of all 223 countries in the world had annual inflation rate below 10% and 149 had inflation even less that 5%. In 2012, 197 countries out of 224 had inflation lower that 10% and inflation in 139 countries was under 5% level (Central Intelligence Agency, 2012). Successful disinflation process was influenced by opinions that were fundamental for monetary authorities in 1970s. Gradually, these opinions were transformed into seven principles of efficient monetary policy application (Mishkin, 2009):

1) Price stability implies several important benefits for economy. On the other hand, inflation represents high costs for economy, in addition, it leads to uncertainty in the field of relative prices and future price level. This complicates decisions about investments and decreases economic efficiency (Briault, 1995). There is no a trade-off between sufficient economic growth and low inflation especially in long run perspective. On the contrary, price stability is an indispensable assumption for economic growth (Fisher, 1993).

2) Fiscal policy should be in line with monetary policy. Irresponsible fiscal policy obstructs monetary policy application even if the latter one is very reasonable (Woodford, 1995).

3) Time inconsistency is a serious problem that should be avoided. Monetary policy is endangered by monetary policy especially if monetary authorities prefer short time objectives to long term ones (Kydland, Prescott, 1977; Calvo, 1978; Barro, Gordon, 1983).

4) Monetary policy should be based on a *forward looking* approach. A measurement applied at present will lead to a result with a certain lag, i.e. in time when economic

fundamentals will have been changed. Thus, monetary policy setting should be able to react flexibly to possible future changes. Otherwise measurement will always miss its target.

5) Monetary policy makers have to be independent, responsible and their activities have to be transparent. This principle is not only a pre-condition of every democratic society but at the same time it increases monetary policy efficiency. According to some authors (Mishkin, 2009), it is possible to increase responsibility of monetary authorities through a penalty system in the case of missed monetary policy goals. This system should lead to a natural replacement of less competent policy makers by more competent ones.

6) Monetary policy should focus on evolution of inflation and GDP, too. Central bankers should not exclusively aim only price stability (King, 1997). They should strive for minimal fluctuations in the field of output as well (Taylor, 1999). This principle is important especially if there is no a trade-off or *arbitrage* between output (employment) and inflation.

7) Financial instability should be avoided as it causes economic drop, increases inflation and output fluctuations. Consequences of financial instability in times of the Great depression are demonstrated e.g. by Bernanke (1983). These impacts are described by Corsetti, Pesenti, and Roubini (1998), too, but on the example of currency crises in Asia, and Latin America.

These seven principles of monetary policy application imply certain requirements for central banks:

1) Price stability should be a paramount long run monetary policy objective.

2) It is necessary to apply an explicit nominal anchor. A strong nominal anchor is crucial for favourable economic results (Woodford, 2003). An explicit nominal anchor can be under some form of fixed peg exchange rate regime (e.g. *currency board* in Argentina, Bulgaria, etc.), targeted growth of money supply (e.g. *monetary targeting* in Germany in 1980s), targeted inflation rate (e.g. *inflation targeting* in New Zealand and later on in many other countries). An explicit nominal anchor implementation helps to eliminate time inconsistency problem.

3) Central bank independence should not be applied in respect to primary objective determination. On the contrary, activities of central bankers should be subordinated to this objective. Debelle and Fischer (1994) distinguish between independence at the level of monetary policy objectives and monetary policy tools. Monetary tools independence is based on free choice of monetary instruments. Mishkin (2009) prefers monetary tools independence to independence in monetary objective setting. According to his opinion, monetary objective should be chosen and specified by government having the mandate from electors, i.e. by public will. However, in case of short and medium term goals determination, central bank should be more independent.

4) Central bank independence in the field of monetary tools should be insured. In general, the higher central bank independence is, the more successful inflation targeting is. These conclusions can be found in works by Alesina and Summers (1993); Cukierman (1992, 2006). Consequently, central bank independence has been significantly rising in developed as well as emerging countries since 1990s. Before 1990, only the German Bundesbank, Swiss central bank and partially the Federal Reserve System in the U.S. had sufficient level of

independence (Mishkin, 2009). Some authors (Posen, 1995) study causality whether central bank independence leads to low inflation or whether another factor, such as preference of residents for lower inflation, contributes to higher central bank independence and lower inflation.

5) A central bank should be responsible for its activities to government and public control. This fact also underlines relevance of an explicit nominal anchor. Through a nominal anchor, it is easier to verify and quantify efficiency of the central bank.

6) A central bank should focus on transparency and communication with public. Clearly formulated monetary policy is more efficient and it contributes to price stability. Frequent change of instruments and targets decreases transparency and increases incertitude of economic agents, which negatively influences overall economic evolution.

7) A central bank should supervise financial stability, too. Its mandate as a lender of last resort naturally contributes to financial stability. On the other side, this generally applied institute creates conditions for moral hazard of numerous commercial banks. Thus, a central bank has to find a compromise between lender of last resort and the possibility of moral hazard. Consequently, the institute of lender of last resort should be applied only in very particular cases, e.g. when an institution is facing a liquidity problem but it does not suffer from insolvency. In addition, the central bank should supervise financial market regularly. This will provide central bank with information whether employ lender of last resort institute or not (Mishkin, 1992; Bernanke, 2000).

Monetary policy can influence economy through various channels (interest rate, credit, exchange rate, and wealth ones). This is so called transmission process of monetary policy. An interest rate transmission process seems to be dominant in the euro area.

2.3.2. Time Inconsistency Problem in Monetary Policy Application

Due to failures of monetary targeting (i.e. targeting of monetary aggregates), inflation targeting have been implemented in several countries since 1990s. This targeting takes into account *time inconsistency* problem in economic policy application. The research works by Kydland and Prescott (1977); Calvo (1978); Barro and Gordon (1983) dealt with time inconsistency problem. According to their findings, discretionary approach in monetary policy with the eventual possibility of every day change leads to weak macroeconomic result in long run perspective. Implementation of a stable nominal anchor can reduce time inconsistency problem. Nominal anchor should be a guarantee that a central bank will focus on long run targeting and will resist to political pressures in favour of short run goals.

Time inconsistency in economic policy is narrowly linked to two principal possibilities of a monetary authority; monetary policy based on discretion or on a monetary rule that is determined in advance.

Monetary authority has two basic possibilities in conduct of economic policy:

1) To apply discretionary approach: monetary authority decides according to actual situation. For instance, central bank adapts volume of money in circulation without any rule known in advance.

2) To apply a rule based policy: the rule of monetary authority is known in advance. The rule can be under the form of a Gold standard, k-rule, Taylor rule, etc. Measurements of policy makers are known in advance and market players can adopt and prepare to these procedures.

Existence of an optimal economic policy is supposed in time *t*. It is believed in time *t* that the predetermined policy is efficient. However, if policy makers in time *t+1* change their strategy, it means that their policy is time inconsistent. Time inconsistency decreases central bank credibility. The Bundesbank is the most often mentioned example of a credible monetary authority after the Second World War.

If the predetermined rule is not respected, short term advantages can be achieved. Nevertheless, such a time inconsistent behaviour is at the expense of long term positive effects.

Economic policy is time consistent, if a measurement planned in time t for period t+i is implemented and optimal also in time t+i.

Time inconsistency problem can be explained through the inflation theory. We distinguish between demand-pull inflation and supply-push inflation. Inflation can be caused by shocks. It can be generated also by deficit and consequent debt monetization. High inflation or deflation were very seldom observed up to 1970s. Thereafter, price level started to rise significantly. A new idea appeared: Is inflation deeply ingrained in institutional behavior of economic agents? Inflation targeting strategy can be a response to this hypothesis.

Assumingly, there is a central bank in economy that respects and objective function (2.1) (Barro, Gordon, 1983).

The first equation expresses goals of economic policy makers.

$$U = \lambda * (y - y_n) - \frac{1}{2}\pi^2 \qquad (2.1)$$

where U is utility, y is aimed economic output, y_n is potential output, π is inflation rate.

Function (2.1) is maximized. If λ is higher than ½, we prefer output targeting. λ is weight of macroeconomic objectives. The second part of equation (2.1) expresses objective of price stability (minus inflation squared as we want to stabilise inflation around 0) and ½ will be eliminated through derivation.

The second equation describes state of an economy. It is the modern function of output by Lucas (1973).

$$y = y_n + \alpha * (\pi - \pi^e) + e \qquad (2.2)$$

where e is offer shock, π^e is expected inflation, $\pi - \pi^e$ is difference between real and expected inflation, i.e. so called inflation shock.

Inflation is an important variable, however, it is known only at the end of period. Consequently, expected inflation is applied. Several economic agents, e.g. investors, tripartite, etc., make their decisions according to expected inflation. For instance, nominal wage contracts between employers and employees are contracted one year in advance. Nevertheless, economic agents are interested rather in real wage. They have to consider influence of inflation that they do not know, therefore they include expected inflation.

The third equation expresses monetary policy instruments (regulation of volume of money in circulation - *m*)

$$\pi = \Delta m + v \tag{2.3}$$

where Δm is change of money in circulation, v is inflation shock.

Regulation of volume of money in circulation is considered as the central bank monetary policy instrument in the model.

Institutional framework and other conditions are required in this model:

1. Nominal wages are based on expected inflation.
2. Offer shock *e* occurs - equation (2.2).
3. Offer shock is observed at the beginning of the period.
4. Central bank determines change of Δm only when offer shock *e* occurs.
5. Thereafter inflation shock occurs - *v*: equation (2.3).

Consequently, we have a model with three equations. Basic equation is (2.1):

$$U = \lambda * (y - y_n) - \frac{1}{2}\pi^2 \tag{2.1}$$

Equations (2.2) and (2.3) will be integrated into equation (2.1). y and π will be replaced by their equations.

$$U = \lambda * \left(y_n + \alpha * \left(\pi - \pi^e\right) + e - y_n\right) - \frac{1}{2}(\Delta m + v)^2$$

π will be replaced by equation (2.3):

$$U = E\left\{\lambda * \left[\alpha * \left(\Delta m + v - \pi^e\right) + e\right] - \frac{1}{2}(\Delta m + v)^2\right\}$$

The new equation will be modified as it follows:

$$U = E\left\{\lambda * \left[\alpha * \left(\Delta m + v - \pi^e\right) + e\right] - \frac{1}{2}\left(\Delta m^2 + v^2 + \Delta m v\right)\right\}$$

$$U = \alpha * \lambda\left(E\Delta m + Ev - E\pi^{e}\right) + E\lambda e - \frac{1}{2}\left(E\Delta m^{2} + Ev^{2} + E\Delta mv\right)$$

$$U = \alpha * \lambda\left(\Delta m - \pi^{e}\right) - \frac{1}{2}\left(\Delta m^{2} + \delta_{v}^{2}\right)$$

Modified function will be maximized according to the central bank instrument (we will perform first derivation of the function according to Δm, which will be equaled to zero).

$$\frac{\partial U}{\partial \Delta m} = \lambda\alpha - \frac{1}{2} * 2\Delta m = \lambda\alpha - \Delta m$$

$$\frac{\partial U}{\partial \Delta m} = 0$$

$$\lambda\alpha - \Delta m = 0$$

$$\Delta m = \lambda\alpha > 0$$

We will substitute an optimal inflation (rise of volume of money in circulation Δm) to y:

$$y = y_{n} + \alpha * \left(\pi - \pi^{e}\right) + e$$

$$y = y_{n} + \alpha * \left(\Delta m + v - \lambda\alpha\right) + e$$

$$y = y_{n} + \alpha * \left(\lambda\alpha + v - \lambda\alpha\right) + e$$

$$y = y_{n} + \alpha * v + e$$

The result is an equation of output, where y_{n} is a potential i.e. optimal output, $\alpha * v$ are shocks.

What is an optimal inflation (change of volume of money in circulation Δm)? It is a result of optimisation in a certain situation. The equation (2.4) describes an optimal change of money supply Δm.

$$\Delta m = \lambda\alpha > 0 \tag{2.4}$$

If the central bank targets inflation, which equals zero, the same output y would be achieved while inflation would be zero. Comparison of the results implies that in both cases output *(y)* would be the same.

These findings lead us to conclusion that it is more advantageous to apply a monetary rule that represents a commitment for the monetary authority. The approach based on discretion creates costs under the form of higher inflation. Application of a rule generates a higher utility U^{c} than is utility of a discretionary policy U^{d} for society as a whole. We can summarize it:

$$E\left[U^{c}\right] > E\left[U^{d}\right] \tag{2.5}$$

where U^c is utility implied by a commitment (rule) and U^d is utility implied by a discretion.

Barro and Gordon (1983) conclude that time inconsistency is problematic. Discretion creates cost. Thus monetary authority should peg its policy to a rule.

Central bank management should consist of conservative economists, who usually expect lower inflation than others. The idea of independent central banks has been promoted since 1980s. Appropriate legislation has been implemented in favor of this independence in most of countries. Prior to these changes, central banks were dependent from ministry of finance. At present, most of central banks are independent and their mandate is to maintain price stability. The question is which part of inflation can be influenced and which part is beyond central bank´s impact.

Research of Barro and Gordon (1983) confirms that monetary strategies based on a rule lead to better economic results than monetary policy based on discretion. Despite the fact, these conclusions are often contested and especially in the context of economic crises and integration movements as it will be discussed here after.

Time inconsistency analysis is in fact a theoretical basis for monetary rules including Taylor ones.

2.4. Rules versus Discretion

The polemics among economists for and against rules or discretion in monetary policy is up to date. Discretionary strategy means that monetary authority does not apply its policy according to a predetermined publicly known rule or procedure. Thus, central bank can profit from the advantage of flexibility. It can react without any commitment to actual situation. On the other hand, central bank has a possibility to realise its monetary policy on the basis of a rule which is more or less exactly specified in advance. Financial markets as well as the general public can estimate future reactions of the central bank and changes in monetary instrument settings with a lead. Therefore, central bank´s activities are not a surprise but an expected measurement. These findings imply different opinions of economists, too. It may seem that financial markets need a surprise for an efficient application of instruments and successful elimination or at least minimisation of undesired macroeconomic effects. However, Carlstrom and Fuerst (2008) and others claim that only expected monetary policy can be beneficial and mainly if economic agents in financial markets are forward-looking. Monetary policy transmission channels are then more performing. Economic agents that are ready to central bank´s measurements will respond quicker to changes and will contribute significantly to their fulfilments.

2.4.1. History and Evolution of Monetary Policy Rules

Up to 19th century merely discretionary policy was applied. Rules existed only under the form of a gold standard or exchange rate stability (Lewis, 2010). Gold standard was in fact a rule, because one unit of account consisted of fixed volume of gold.

Wicksell (1896) suggested a very simple rule, yet without sufficient dissemination of its application. The main advantage of this rule was its simplicity. According to the Wicksell rule, interest rate was explained by the only parameter - price stability. On the other side, this simplification faced much criticism (Orphanides, 2007).

Much known worldwide is the k-percent Friedman´s rule (Friedman, Schwartz, 1963). This rule is often interpreted also as a *golden rule of money stock growth*. Friedman claimed that rate of money supply growth should be equal to real GDP growth rate. Under the similar formulation, the rule was implemented in 1935 when a statistician Snyder (Orphanides, 2007) estimated 4% trade growth rate in the U.S. and constant velocity of money in circulation. Considering this estimation, he suggested that a 4% money growth per year would lead to macroeconomic stability. Later on, in 1960s and 1970s, Friedman himself defended money growth rate of 4% as this level corresponded to average rate of annual GDP growth in the U.S. during those decades.

Importance of monetary policy measurement rose in 1970s and 1980s. Kydland and Prescott (1977) brought several interesting analyses and underlined problem of time inconsistency. They confirmed that time inconsistent monetary policy can satisfy economic agents only in short run and monetary rules application can reduce the problem.

Monetary rules were defended also by Buchanan and Brennan (Buol, Vaughan, 2003). They were convinced that discretionary policy generates inflation over its optimal level. Barro and Gordon (1983) extended the theory in 1980s. They claimed that monetary authority will always have a tendency to diminish unemployment at the expense of higher inflation. McCallum (1988) suggested a rule later known as the McCallum one. Author focused on monetary base as a central bank objective. This parameter is influenced by inflation rate, real GDP growth and money velocity:

$$\Delta m_t = \Delta y^* - \Delta v_t^a + 0.5(\Delta y^* - \Delta y_{t-1}) \tag{2.6}$$

where m and y represent a monetary aggregate and nominal GDP respectively, Δv_t^a is an average rate of money velocity during the previous year. According to McCallum, American economy would reach better results if respecting these rules mainly in 1930s and 1970s.

In 1990s, importance of rules based on interest rate regulation arose. J. B. Taylor presented a very simple rule in 1993. The rule became soon popular and wide spread. Many countries have already implemented the rule in their monetary policy decision making process since that time.

2.4.2. The Taylor Rule

J. B. Taylor, professor at the Stanford University suggested a simple guide for monetary policy application in 1993. He adopted his rule to conditions of American economy:

$$i = \pi + gy + h\,(\pi - \pi^*) + r^f \tag{2.7}$$

where *i* represents a short term nominal rate in %, which is set by a central bank, π is inflation rate in %, π^* is inflation goal of the country in question, y is output gap and r^f is neutral real interest rate which corresponds to null inflation and null output gap. Coefficients g and h express weights of the both gaps. π^*, r^f, g and h are positive values.

Some authors mention slightly modified version of the Taylor rule (Blanchard, 2006):

$$i_t = i^* + a(\pi_t - \pi^*) - b\,(u_t - u_n) \tag{2.8}$$

where π plus r^f are replaced by another parameter i^*. This is a targeted nominal interest rate. Weights are a and b. The most important change in this equation is unemployment gap, which is substituting output gap. This substitution is stemming from the usual phenomenon in economy that higher output is in general linked to lower unemployment and vice versa. Consequently, the sign of this element in equation is negative.

The both equations imply that if actual (current) inflation rate is equal to targeted inflation and actual output rate has the same value as potential output (in other words, inflation and output gap are zero), nominal interest rate set by the central bank should be equal to targeted nominal interest rate (i^* or $\pi + r^f$).

If current inflation rate exceeds targeted value, monetary authority should increase interest rate above its neutral level. Rise of interest rates will probably slow down economic growth, increase unemployment and inflation will reach again its targeted value. Interest rate growth is expressed by the coefficient h or a.

On the contrary, in the case of a negative output gap (if unemployment is higher than its natural rate), the central bank should apply an expansive monetary policy and to decrease interest rate. Consequently, the overall economic output should rise up to its potential value. It will be associated with drop of unemployment to its natural rate.

Nevertheless, Taylor (1993) warns that if inflation rises, nominal interest rate should be increased more than proportionally. Otherwise, the measurement is not efficient. This is so called the Taylor principle (Taylor, 1999b; Carlstrom, Fuerst, 2008); according to which real interest rate should be higher than natural interest rate if inflation is over its targeted value. Thus, the simplest version of the rule implies, if inflation rises by one percentage point, real interest rate should increase by half of percentage point and nominal interest rate should rise by 1.5 of percentage point.

If the central bank attributes to inflation gap lower weight than one, it is applying so called *accommodating policy behavior* that can lead to destabilization from the point of view of inflation. This was typical for pre-Volcker period in the U.S., when the Federal Reserve System was attributing to inflation gap the weight lower than one (Taylor, 1999). If the inflation gap coefficient is higher than one, it is so called *stabilization monetary policy* (Sauer, Sturm, 2003).

During the last two decades, certain specifications were involved into the Taylor rule to minimize monetary policy failure. In general, we distinguish between *forward-* and *backward-looking* Taylor rules. Forward-looking rules employ forecasted data, while backward-looking rules operate with actual (current) data. Difference between them is obvious in the case of the U.S. in year 1997 (Asso et al., 2007). Backward-looking rule did not suggest any change of interest rate, however forward-looking one recommended interest rate rise. More detailed analysis proved that unchanged rates would lead to higher costs. Thus, application of forward-looking rule has been preferred in the U.S. since that time. This approach corresponds with monetary policy intention to influence positively future and not current situation, which actually, cannot be changed. Yet, according to Taylor (1999), backward-looking rule can be also appropriate because it helps economists to evaluate current situation and to provide them with information for better decisions in future. All in all, he assumes that a monetary authority should not apply results of the rule automatically. Different particular factors have to be often taken into account.

Sauer and Sturm (2003) consider the Taylor rule as a process of monetary policy evaluation that enables us to compare real interest rate setting with the rates quantified by the rule.

The Taylor rule is in conflict with the Tinbergen one (1952), according to which one economic policy goal should be targeted using one instrument. The Taylor-type rules suppose that one tool (interest rate) can influence positively evolution of several macroeconomic objectives (output, inflation, exchange rate – as it is suggested by some Taylor-type rules mentioned here after, etc.).

2.4.3. The Taylor Rule Criticism

After 2007, the period of financial and economic crisis brought much instability in financial markets and discredited significantly the Taylor rule. Results of Rudebusch (2009), vice-president of the Federal Reserve System in San Francisco, have shown that interest rates calculated by the Taylor rule should be approximately at the level of -5% in the period of crisis. Of course, the value is not realistic in practice. As real interest rate (*federal funds interest rate*) was 0% in 2009, difference between calculated rate and real one was 5%. On the other hand, in the pre-crisis period, quantified and really applied interest rates were almost equal (see Comparison of calculated and real interest rates in the U.S. from 1988 to 2010 by Rudebusch, 2009).

Yet, Taylor objected that the Federal Reserve System (FED) does not employ the Taylor rule under its original form and the modified version generates errors. While in the original version of the rule for the U.S. inflation and output gap coefficients should be the same, i.e. at the level of 0.5; the FED implemented a higher coefficient for output gap than for inflation. In addition, the Taylor rule is based on current data but the FED uses predictions. Taylor unlike Rudebusch (2009) argues that his rule is adequate also in times of crisis.

Gerlach and Schnabel (2000), who suggested the Taylor rule for the newly created euro area, also confirmed that the Taylor rule application during the crisis is problematic. They quantified nominal interest rate for the future euro area. Their results corresponded very well to reality apart from years 1992 and 1993, i.e. years when several European countries were touched by currency crisis.

Opinions on the Taylor rules differ significantly. Generally speaking, the Taylor rule is a supplement or support to monetary strategy based on inflation targeting. The rule focuses on inflation target achievement in medium term. In addition, it reacts to GDP evolution. Some economists as e.g. Mishkin (2009) argue that inflation targeting monetary strategy should be based on discretion and not on a rule.

The Taylor rule is evaluated positively thanks to its intuitiveness and simplicity (Orphanides, 2007). The rule describes situation in the past and at the same time it provides us with recommendation how to proceed in future.

Critics of the Taylor rule allege that it is little flexible and it limit decision making process of the central bank. Nevertheless, Taylor himself defends his rule (Adema, 2004). He assures that the rule responds appropriately to macroeconomic changes and its results do not have to be respected at any price. One of the critics is Svensson (2003), who considers two parameters as insufficient to determine monetary policy. Another problem is specification of the right level of neutral interest rate and output gap or choice of their relevant indicators and data.

On the other side, Gerlach and Schnabel (2000) tested application of other variables in the equation, e.g. M3 aggregate growth rate, real exchange rate of euro to dollar, etc. Despite the fact, they did not obtain better results for the euro area as the original Taylor rule suggested.

2.5. Monetary Rules versus Monetary Policy Strategies

Monetary policy can be applied in practice via four main monetary strategies. It is exchange rate targeting, monetary targeting, inflation targeting or monetary policy with an implicit and not explicit nominal anchor (Mishkin, 2009). The first three strategies assume existence of an explicit nominal anchor, e.g. a rule, which enables us to face time inconsistency problem.

2.5.1. Principles of Monetary Strategies

Advantages and disadvantages of particular monetary policy strategies are summarized for instance by Neupauerová and Vravec (2007). Exchange rate targeting can be a good instrument for countries with rather low central bank credibility how to stabilize inflation expectations in future. However, monetary crises in 1990s seriously endangered especially emerging economies in Latin America and Asia that applied the targeting (Mishkin, 2009). Nevertheless, Mishkin (1998) recommends implementing of the strategy only in case if there is no other possibility how to tame high inflation.

Most of industrialized countries had been employing monetary aggregate targeting since 1970s. The main principle of the targeting is a statistically significant correlation between monetary aggregates and inflation. Yet, the relation is not always obvious. This finding is implied also by equation expressing money demand:

$$m_t - p_t = \gamma y_t - \kappa i_t + v_t \tag{2.9}$$

where m_t is logarithm of money equilibrium, υ_t is error term, p_t is price level logarithm, y_t is output gap (logarithm of current and potential output), i_t is nominal interest rate. In the case of a significant error term or instable parameters in the equation, the relation between monetary aggregate and inflation will be statistically insignificant. Monetary aggregate targeting will lead to important deviations of calculated interest rates from optimal ones. This will result in high output, inflation and interest rate volatility (Clarida et al., 1999).

The relation between monetary aggregate and inflation used to be more important in the past as higher inflation well corresponded to changes in volume of money in circulation. However, this signal is weaker in the case of low one-digit inflation. Thus at present, application of the targeting in countries with low inflation is problematic (Estrella, Mishkin, 1997).

Consequently, despite its relative success in Germany, Switzerland and other countries, the strategy was gradually abandoned.

In the following part we will focus on inflation targeting as it is considered to be a precondition of monetary rules employment by several authors (e.g. Maria-Dolores, 2005).

2.5.2. Inflation Targeting in the Context of Monetary Rules

Inflation targeting has been implemented since 1990s due to above-mentioned monetary targeting failures. Inflation targeting takes into account *time inconsistency* problem in conduct of economic policy via fixed nominal anchor.

Inflation targeting stems from monetary aggregate targeting principles. However, instead of monetary aggregates targeted values it announces publically numeric medium-term inflation target. In addition, the role of intermediate objectives such as volume of money in circulation, interest rates, etc. is less crucial. Only final objectives (inflation) are important.

The first central bank that started to employ such a strategy was the Reserve Bank of New Zealand in 1990. Inflation targeting implementation was accompanied by significant rise of central bank independence. Price stability became a unique and exclusive monetary policy goal. Consequently, inflation rate dropped remarkably (Mishkin, 2009). The example of New Zealand was followed by Canada in 1991 and later on by other countries.

Inflation targeting requires certain economic assumptions (Schaechter, Stone, and Zelmer, 2000):

1) favorable fiscal position,
2) sufficiently known and analyzed monetary policy transmission mechanism between monetary instruments and inflation,
3) well-developed financial system,
4) central bank independence and its evident mandate for price stability achievement,
5) ability to predict inflation evolution,
6) absence of other nominal anchors apart from inflation,
7) transparent and responsible monetary policy.

If a country fulfils all these conditions, so called full-fledged explicit inflation targeting can be applied. If these assumptions are met only partially, semi-fledged inflation targeting under its implicit form is realized. Brazil can be one of the examples that started to employ immediately full-fledged inflation targeting since 1999, while Chile, Israel, Great Britain or Slovakia preferred more gradualist approach.

Inflation targeting consists of several crucial **elements**:

1) public announcement of a mid-term inflation target using a numeric form,
2) price stability is an institutional commitment and long-term as well as paramount monetary policy target,
3) the role of intermediate objectives as e.g. volume of money in circulation or its growth is limited. Final goal is primordial,
4) high monetary policy transparency through clear and regular communication with general public,
5) high responsibility and central bank independence in the field of targeted goal achievement.

Inflation targeting advantages can be summarized in the following manner:

1) inflation targeting takes into account domestic macroeconomic conditions (this fact is in line with monetary targeting, yet it differs from exchange rate targeting),
2) inflation targeting respects several variables in monetary policy setting and not just one parameter as monetary targeting (a particular monetary aggregate),
3) accountability and thus transparency of inflation targeting is very high (this is the same as in exchange rate targeting but different from monetary targeting),
4) thanks to its accountability and transparency it enables us to avoid time inconsistency problem rather successfully,
5) central bankers do not have to neglect other goals as e.g. output and unemployment. This is true especially in the case of gradual inflation targeting, i.e. successive disinflation process,
6) flexible approach allows deviations from targeted inflation e.g. in the case of offer shocks occurrence. Inflation targeting does not have to be applied as a strict monetary rule, it enables changes according to current economic situation of a country,
7) under inflation targeting conditions, various asset price bubbles are less probable (Bernanke, Gertler, 1999).

Despite the fact that central bank declarations refer often to central bank stability, it is never in line with null inflation. In practice, certain inflation is targeted instead of a price level. Mean value of targeted inflation is always above 0% as null inflation represents a risk of deflation. Consequences of deflation can be much more serious than higher inflation. According to Mishkin (1996), too low inflation leading to deflation causes financial instability equally as too high inflation. Another reason why not to target null inflation is that according to several researches (Boskin et al., 1996; Shapiro and Wilcox, 1997), main indicator of inflation - consumer price index - is often overvalued by 0.5 or even by 2 percentage point. Overvaluation of inflation stems also from the fact that price indices do not consider qualitative progress of products. Several authors (Akerlof et al., 1996) found out on the basis of various simulations that inflation approaching to zero increases continually natural level of unemployment. Consequently, not only upper boundary - ceiling but also lower limit - bottom are very important for inflation targeting. Some authors, e.g. Mishkin (2009), suggest inflation targeting at the level of 1-3%. This interval corresponds to the idea of price stability. At the same time, an interval targeting enables certain flexibility. The interval is e.g. 0-3% in New Zealand, 2-3% in Australia, etc.

Targeted rate of inflation can be adjusted according particular characteristics of a country. It can exclude prices of energy and food, impacts of indirect taxes, etc. Thus, apart from consumer price index or harmonized index of consumer prices, core or clear inflation can be targeted as well. In respect to sufficient monetary policy transparency, the central bank should justify and explain to general public the choice of a particular indicator of inflation and its relation to overall inflation.

As it has been already mentioned, significant advantage of inflation targeting is that monetary authorities can consider several variables not only inflation. E.g. the central bank can but is not obliged to observe evolution of output or exchange rate. We can apply the Svensson model (Svensson, 1997) to demonstrate our considerations. The model is based on two main equations, i.e. aggregate supply curve:

$$\pi_t = \pi_{t-1} + \alpha_1 y_{t-1} + \varepsilon_t \tag{2.10}$$

and aggregate demand curve:

$$y_t = \beta_1 y_{t-1} - \beta_2 (i_{t-1} - \pi_{t-1}) + \eta_t \tag{2.11}$$

where $\pi_t = p_t - p_{t-1}$ is inflation rate in time t (and p_t is logarithm of price level), y_t is output gap (logarithm of current and potential output), i_t is nominal interest rate, ε_t and η_t are supply and demand shocks.

Under these conditions, an optimal monetary policy should determinate interest rates in order to minimize loss function:

$$E_t \sum_{\tau=t}^{\infty} \delta^{\tau-t} L_\tau \tag{2.12}$$

where $\delta < 1$ is a discount monetary authority rate (or base rate) and loss function is:

$$L_\tau = (\pi_\tau - \pi^*)^2/2 + \lambda y_\tau^2/2 \tag{2.13}$$

If central bank will not ponder output gap evolution, coefficient $\lambda = 0$ and the result will be equation (2.14):

$$E_t \pi_{t+2} = \pi^* \tag{2.14}$$

Monetary policy setting to achieve targeted inflation in two year horizon will be optimal under these conditions. If $\lambda > 0$, evolution of output will be also respected. Interest rate setting will correspond to equation (2.15) and this formulation will represent a gradualist approach to inflation targeting:

$$E_t \pi_{t+2} - \pi^* = c(E_t \pi_{t+1} - \pi^*) \tag{2.15}$$

Svensson (1997) calls the strategy as a „flexible inflation targeting“ and Bernanke et al. (1999) clarifies that the model is a realistic approximation of central bank activity in practice.

If the central bank takes into account exchange rate evolution, aggregate demand and supply equations would be under the form (Ball, 1999):

$$\pi_t = \pi_{t-1} + \alpha_1 y_{t-1} + \alpha_2 e_{t-1} + \varepsilon_t \quad (2.16)$$

$$y_t = \beta_1 y_{t-1} - \beta_2(i_{t-1} - \pi_{t-1}) + \beta_3(e_{t-1} - e_{t-2}) + \eta'_t \quad (1.17)$$

These equations would be in line with open economy conditions and exchange rate would be determined as:

$$e_t = \phi i_t + u_t \quad (2.18)$$

where e_t is logarithm of real exchange rate expressed as a deviation from its „normal“ (mid-term) value, u_t is error term, ϕ stands for positive relation between interest rates and value of currency (e.g. via capital flows and appreciation).

Optimal monetary policy setting should correspond to the following equation in this modified model:

$$i_t = \pi_t + b_1(\pi - \pi^*) + b_2 y_t + b_3 e_t \quad (2.19)$$

This Taylor rule modification, which takes explicitly into account exchange rate in monetary tools setting, is in line with inflation targeting. As demonstrated here above, if $\lambda = 0$, monetary policy strives to achieve inflation target in two-year horizon. If $\lambda > 0$, long-term inflation goal is targeted in a gradual way in longer horizon. According to findings by Cecchetti and Ehrmann (2000), all countries targeting inflation assume non-null weight to output gap. These conclusions can be applied also to the adjusted Taylor-rule with exchange rate.

However, in practice, inflation targeting is connected with certain **disadvantages**. The targeting is not suitable in countries without insufficient credibility of their monetary authorities. It is not easy to reach high credibility, yet it is easy to lose it. Developing countries and countries in transition prefer different strategies prior to implementation of inflation targeting. This was also the case of the Czech Republic, Hungary, Poland and Slovakia in 1990s.

Disadvantages and inflation targeting critiques can be summarised in seven points:

1) inflation targeting allows to apply a discretionary approach to a certain extent (Calvo and Mendoza, 2000),
2) higher probability of output volatility,
3) strict inflation targeting can reduce overall economic growth especially in short-term,
4) inflation targeting is very demanding also due to slow-paced transmission between monetary policy instruments to monetary policy goals, thus, central bank responsibility is very limited (Masson et al., 1997),

5) inflation targeting efficiency depends also from fiscal policy or its dominance within economic policy as a whole. Expansionary fiscal policy or public debt monetization endanger inflation targeting (Masson et al., 1997),
6) required exchange rate flexibility (as just one nominal anchor is recommended) can lead to financial instability.

First three disadvantages are contested by Mishkin (1999) and Bernanke et al. (1999). Rigorous fulfilment of above-mentioned inflation targeting assumptions leads automatically to elimination of these disadvantages. In addition, Mishkin and Savastano (2009) claim that output and employment rate regained their previous positive levels in comparatively short time after inflation targeting implementation. Other three disadvantages concern mainly developing countries and economies in transition.

Monetary conditions index (MCI) calculation can be a useful instrument for inflation targeting. MCI comprises exchange rate evolution, short-term interest rates, monetary and credit aggregates, commodity prices, wages, etc. This index enables us to predict overall macroeconomic situation or to estimate how monetary conditions influence aggregate demand. Monetary policy setting can be adjusted accordingly (Freedman, 1994). Nevertheless, Mishkin and Schmidt-Hebbel (2001) warn that monetary condition index cannot be employed automatically. It is important to distinguish what is the source of appreciation/depreciation. For instance, in case of depreciation index suggests to increase interest rate to fortify exchange rate again. However, if exchange rate depreciation is implied by portfolio shocks, interest rate rise, i.e. restrictive policy, would not be favorable in this case. On the other hand, if depreciation is caused by negative foreign-trade shocks stemming from export price drop, interest rate rise would not be appropriate. This would probably limit economic growth even more.

Generally speaking, inflation targeting seems to be rather successful monetary strategy. However, Hall and Mankiw (1994) remark that nominal GDP could be more suitable final goal instead of inflation. Nominal GDP comprises economic growth and inflation at the same time. Though, Mishkin (2009) argues that inflation rate is announced on monthly basis while nominal GDP is declared only quarterly. These intervals are not sufficient for monetary policy makers. Inflation targeting is more understandable and transparent to general public than nominal output targeting. In addition, any of the central banks has not chosen nominal GDP targeting in practice due to these arguments.

2.6. Methodology of the Taylor Rule Quantification

Relatively frequent approach of the Taylor rule estimation is linear regression. This methodology was applied e.g. by Maria-Dolores (2005), Ziegler (2012) and others. Klose (2011) employs generalized method of moments (GMM) with Newey-West weighted covariance matrix. As the Taylor rule parameters are considered to be stationary, some authors employed cointegration methodology, see e.g. Gerlach-Kristen (2003) or Frömmel et el. (2009).

However, particularities of different countries inspired many authors to various modifications of standard methods as it will be gradually depicted here after.

2.6.1. Original Methodology of the Taylor Rule Quantification

Originally, Taylor (1993) suggested the formula for the U.S. Coefficients were based on empirical study, they were not econometrically estimated:

$$i = 2.0 + \pi + 0.5y + 0.5(\pi - 2.0) \tag{2.20}$$

Inflation target and real neutral interest rate equals 2%. Moreover, according to Taylor, both inflation gap and output gap have the same influence on interest rate; therefore, both these components have the same weights of 0.5%.

Mathematic interpretation sounds: If actual inflation rate equals targeted one and the economy has achieved potential product, real interest rate is 2.0%. For each percentage point by which inflation rises above (decreases under) 2.0%, interest rate will increase/lessen by 0.5 percentage points. And each 1-percentage rise/fall of output above its potential level means rise/fall of interest rate by 0.5%.

Economic interpretation emphasizes that both inflation and output growth (or low unemployment) are two equivalent goals. This fact corresponds to official announcements of the FED.

The Taylor rule describes economic evolution in the U.S. during the past 30 years very truly, especially since 1985. In periods, when real interest rate was equal to the one given by the formula, the economy was growing. On the contrary, during the years, when those values were different, macroeconomic parameters were not ideal.

Kong and Kamoike (2006) compared and evaluated the Taylor rule with federal funds rate on quarterly basis from 1970 to 1998, the period of three FED governors - Burns, Volcker and Greenspan. During Burns period, interest rate in the economy was lower than that given by the formula. Still, their evolution was highly correlated. Those years were connected with significant increase of inflation. If the FED had followed the Taylor rule (with inflation target of 2%), inflation would have been lower.

The period of Volcker brought opposite evolution. Real-time data interest rate moved under the level determined by the rule. These years were also connected with a sharp reduction of inflation that was more aggressive than the one suggested by the formula.

Greenspan´s period meant compliance of values in real economy and those calculated from the rule. High correlation continued till 2002. Following four years of Greenspan´s governance were under sharp critique. Taylor accused the FED of stimulating monetary policy too much that have caused housing bubble. In the beginning of year 2010, a vehement discussion started after Bernanke, current governor of the FED and successor of Greenspan, defended the US monetary policy in years 2002-2006. He pointed out the differences between the Taylor rule results based on actual data and those based on predicted data.

2.6.2. The Extensions of the Original Approach

Despite various discussions on adequacy of the Taylor rule during crisis, the rule is quite wide spread in the world. As the rule was originally suggested for American economy, it is necessary to adopt it to local conditions when it is applied in other countries. Several specifics occur when the rule is implemented.

Inflation target can be expressed as π^* or π_t^* depending on eventual changes in time. However according to literature, it is supposed that the target is constant in long term (Belke, Klose, 2009).

On the other hand, change in real interest rate can occur in time. According to the Fisher´s equation real interest rate (r_t) is equal to nominal interest rate (i_t) minus inflation in time *t* (π_t). Consequently, it is possible to employ a filter, e.g. the Hodrick-Prescott filter (HP-filter) (Hodrick, Prescott, 1997) to calculate real interest rates. The HP-filter enables to estimate potential output. Chagny and Döpke (2001) or Belke and Klose (2009) mention various manners of potential output quantifications. Inter alia they indicate potential output measurement on the basis of linear $y_{t\,lin}^* = y_{0\,lin}^* + \alpha * t$ and quadratic trend $y_{t\,qua}^* = y_{0\,qua}^* + \beta * t^2$. Where α and β are coefficients of propensity of the functions. In case of monthly data, smoothing parameter is 14 400, for quarterly data the value of parameter is 1 600. It is important to determinate an adequate length of time series for potential output estimation. Belke and Klose (2009) mention 10-year period as a standard one for this calculation.

Original version of the Taylor rule considers an equilibrium real interest rate that is characterised also as a neutral one as it corresponds to null inflation and output gap. In line with the early version of the rule, real interest rate is constant in long run perspective for each country. Taylor (1993) sets the rate at the level of 2% for the U.S. Obviously, it is not evident how to determinate the constant. Belke and Klose (2009) suggest calculating of a multi-year average of gaps between nominal interest rates and inflation rates. The result is in this case rather sensitive to the length of chosen period for calculation of average. In addition, it is crucial to consider use of expected rate of return of tangible fixed assets, overall propensity to save, overall evaluation of incertitude in economy, degree of central bank credibility. If these factors are not inspected, resulting real interest rate can be questionable. Nevertheless, these reflections imply that real interest rate cannot be constant in practice.

In practice, lower interest rate volatility is observed in comparing with interest rates calculated by the rule. Consequently, smoothing parameter is very frequently involved into the Taylor rule:

$$i_t = \lambda i_{t-1} + (1-\lambda)[i^* + \gamma(\pi_t - \pi^*) + \beta(y_t - y_t^*)] \qquad (2.21)$$

were λ is interest rate smoothing parameter and its values are from <0;1> interval. This enables us to reduce high volatility of interest rates responding to economic shocks. In addition, the right value of the parameter is not known in advance, thus it is not possible to estimate precisely its impact on interest rates. If $\lambda = 1$, interest rates depend exclusively on previous interest rates. If $\lambda = 0$, interest rates are independent from their own values in the previous period. It means that original version of the Taylor rule without any smoothing parameter is valid. Nevertheless, both these cases are extreme and not applicable in practice, thus in reality the interval ($0 < \lambda < 1$) holds. Calculated interest rates should be implied also by their own precedent values.

Carlstrom and Fuerst (2008) focused on the factor of inertia (smoothing) in the Taylor rule application. They found out that the Federal Reserve System in the U. S. modifies interest rates more slowly than recommended by the Taylor rule. They evaluated efficiency of the standard Taylor rule and compared it with the Taylor rule including inertia factor. They found out that the rule including inertia is more successful under the condition of price and wage rigidity. Carlstrom and Fuerst (2008) tested price and wage rigidity on the basis of price shock (oil price) impact. The success was according to them manifested by low inflation and higher output. Nevertheless, if only prices are rigid and wages are rather flexible, the standard rule leads to lower inflation in short run than a rule with inertia factor. Consequently, they integrated factor of inertia in the case of the U.S. as it follows (Kozicki, 1999; Carlstrom, Fuerst, 2008):

$$i_t^{PA} = 0{,}76 * i_{t-1} + 0{,}24 * i_t \tag{2.22}$$

where i_{t-1} is federal interest rate as for the last day in the month of particular quarter, i_t is interest rate calculated by the Taylor rule without inertia factor, i_t^{PA} is the Taylor rule with inertia factor (PA - persistence actor), i.e. interest rate that should be applied by monetary authority. Interest rate i_t is a long term objective and interest rate i_t^{PA} should be gradually adopted to the objective i_t . Instead of sudden achievement of the targeted interest rate, the FED will move to this level only by 24% quarterly. The authors demonstrated that real evolution of interest rates in the U.S. from 1989 to 2007 was almost entirely in line with the Taylor rule based on inertia principle.

Another way how to implement inertia into a monetary rule is to respond to weighted average of current and past inflation and output gap.

An alternative version of an original rule employs forward-looking perspective. According to Clarida and Gertler (1996), the forward-looking approach is necessary if a central bank does not want to react to changes of monetary policy conditions too late. Thus, it is important to involve expected future values of inflation and/or output into the equation. Such an equation could have a following form:

$$i_t = i^* + \gamma[E(\pi_{t+j/t}) - \pi^*] + \beta[E(y_{t+k/t}) - y_t^*] \tag{2.23}$$

where *E* is expectation operator and *j*, *k* are positive values expressing horizon of forecasting. However, j and k do not have to be equal as various horizons for inflation and output forecasting are possible. Expectation factor *E* can be associated also to potential output y_t^*, as the one can be also changeable in time.

Certainly, the Taylor rule version consisting of smoothing factor and forward-looking approach at the same time is also possible.

$$i_t = \lambda i_{t-1} + (1-\lambda)\{\gamma[E(\pi_{t+j/t}) - \pi^*] + \beta[E(y_{t+k/t}) - y_t^*]\} \tag{2.24}$$

Amato and Gerlach (2002) recommend involving of exchange rate to the central bank reaction function in the case of developing countries as well as countries in transition. According to Mohanty and Klau (2004) central banks in developing countries respond more sensitively to exchange rate changes than to changes of inflation and output. Frömmel et al. (2009) suggest exchange rate in the Taylor rule mainly in the case of small and open economies. They test the modified Taylor rule in new European Union member states (Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia) as future or already existing euro area member states. Ball (1999) emphasizes that pure inflation targeting without explicit exchange rate observations can be very dangerous for open economies. This could cause large exchange rate and output fluctuations. Impact of exchange rate changes on inflation via imported prices is the quickest monetary policy transmission channel in small and open economies (Frömmel et al., 2009). Exchange rate can be involved in the equation depending on exchange rate regime. If it is a fixed peg regime, monetary policy has to react to exchange rate changes to maintain its credibility. Reaction is non-linear because the more exchange rate approaches intervention boundaries the more monetary authority has to respond. Frömmel et al. (2009) recommend employing of exchange rate in the form of a growth rate for the whole observed period Δs_t or as a position of exchange rate within a fluctuation band b_t, if the currency is pegged to another currency. Eventually, it is possible to involve both variables in the equation. Thus, the equation will be as it follows:

$$i_t = \lambda i_{t-1} + (1-\lambda)[i^* + \gamma(\pi_t - \pi^*) + \beta(y_t - y_t^*) + \delta \Delta s_t + \vartheta b_t] \tag{2.25}$$

Equation (2.25) involves both ways of exchange rate changes quantifications. Exchange rate growth Δs_t represents more general approach that can be applied for all countries. It is supposed that interest rate will rise, if currency depreciates, ceteris paribus. The second possibility is to measure distance from boundaries of fluctuation band. The approach is convenient mainly for countries with their currency pegged to another one or to a currency basket. It is appropriate to assume a non-linear equation as mentioned above. Distance of exchange rate from upper or lower boundary is transformed via exponential function:

$$b_t = \begin{cases} max[\exp(s_t - l), \exp(u - s_t)] & if \quad \exp(s_t - l) > \exp(u - s_t) \\ -max[\exp(s_t - l), \exp(u - s_t)] & if \quad \exp(s_t - l) < \exp(u - s_t) \end{cases} \tag{2.26}$$

where *l* and *u* are lower and upper boundaries of fluctuation band respectively. Boundaries are officially determined by monetary authority. However, calculation of b_t is not simple as central parities as well as fluctuation bands can often change especially in countries in transition.

Kahn and Parrish (1998) demonstrated in case of New Zealand and Great Britain that monetary strategy change (expressed through structural breaks) can influence significantly monetary policy reaction function. It is therefore significant to identify structural changes, which can be verified through several tests, e.g. the Chow test (1960). Presence of other break points that are unknown in the very beginning can be detected e.g. via the Quandt - Andrews test (Andrews, 1993). Identification of break points enables us to employ time varying coefficients. The approach was chosen and confirmed by Assenmacher and Wesche (2006) for Germany, Great Britain, and the U.S. Thus, monetary policy changes have to be taken into account.

These extensions of the original approach enable us to apply the rule to such specific conditions as in the European Monetary Union are.

2.6.3. The Taylor Rule Quantification Methodology in the European Monetary Union

The Taylor rule inspired several authors to apply it to the European Monetary Union conditions. Gerlach and Schnabel (2000) confirmed that the rule calculated by them corresponded well with real-data interest rate evolution. The only exception was period 1992-1993 due to currency crises and consequent turbulences in foreign exchange markets in several countries of the European Exchange Rate Mechanism (ERM). Gerlach and Schnabel (2000); Peersman and Smets (1999) or others, quantified the Taylor rule according to data prior the European Central Bank creation. Later relevant analyses were realised by Belke and Polleit (2007) or Fendel and Frenkel (2009). Nevertheless, these calculations are based on ex-post data. However, ex-post data are not available for the central bank in time of decision making process on interest rates setting, etc. Among the others, Orphanides (2001) drew attention to the problem. Consequently, real time data implementation (i.e. data available in time of decision making process) seems to be more appropriate (Belke, Klose, 2009). In addition, Belke and Klose (2009) quantified differences in results in the case of ex-post and real time data. Differences stem from several reasons. Inflation and output gaps are at our disposal only with a certain lag, data are gradually revised, etc. Another problem is if a central bank employs only past and current data. Interest rates will always respond too late to macroeconomic evolution because monetary impulse is efficient only with a certain delay (Svensson, 2003). Thus, predicted data are very important.

Some authors (Sauer, Sturm, 2003) divide Taylor-type rules to two main groups: I) so called backward-looking or contemporaneous rules, which can be divided again to a) ex-post data rules or b) real-time data rules, II) forward-looking rules, which can be divide to a) rules employing industrial growth indicator instead of output gap or b) survey data rules.

Application of backward-looking rules may seem to be easier at first sight, however an important difference can occur in the case of ex-post data that are often revised comparing to data available in time of decision making process of monetary authorities. Revisions of data are often very important and consequently results can very a lot accordingly (Orphanides, 2001).

Implementation of forward-looking rules leads to better results as it is mentioned in several researches (Sauer, Sturm, 2003) and it is more relevant from the point of view of practical application. In addition, it helps us to avoid some methodological problems that are frequent in backward-looking rules. For instance, backward-looking rules usually employ the Hodrick-Prescott filter for output gap calculation. Nevertheless, the Hodrick-Prescott filter requires stationarity of time series which is quite problematic in practice. If time series are not stationary, the Hodrick-Prescott filter can create false economic cycles. Thus, it is necessary to make them stationary e.g. through the first or second differences. In addition, end-of-sample bias exists. If we want to filter end-of-sample data, we have to add other data to our sample e.g. via extrapolation (Belke, Klose, 2009).

Forward-looking elements can be involved in monetary rules through several possibilities. Sauer and Sturm (2003) found out that output growth rate application instead of output deviations from its trend value (i.e. output gap), ensures forward-looking approach in monetary rules. According to their observations, production growth rate is always leading output gap in the euro area. Others, e.g. Gerdesmeier and Roffia (2004) or Ullrich (2003) prefer annual industrial production growth, too, because of the same reason.

Besides output growth rate, forward-looking character of the rule can be ensured through survey data, which approximate overall economic growth and its perspective in the nearest period. These data are more available than standard statistic ones and they express expectations of economic agents, which have often self-fulfilling character. They are leading indicators of the near future (Sauer, Sturm, 2003). Since 1985, the European Commission has been publishing *Economic Sentiment Indicator* (ESI) on the monthly basis. Several authors have confirmed relevance of this indicator in term of economic cycles in the European Union countries (Goldrian et al., 2001).

Forward-looking perspective can be involved into the central bank reaction function even via forecasted inflation that is usually published monthly either in central bank monthly bulletins or in other expert periodicals and surveys. Sauer and Sturm allege (2003) that forecasted inflation has roughly a half-year lead before statistically observed inflation. Consequently, it ensures sufficient forward-looking nature of the rule.

Equilibrium real interest rate (i_t^*) can be calculated using the Fisher equation in regard to adaptive expectations, i.e. as a difference between nominal interest rate (i_t) and inflation rate (π_t).

$$i_t^* = i_t - \pi_t \tag{2.27}$$

Thereafter the Hodrick-Prescott filter can be applied to eliminate a possible trend. Wu (2005) recommends the formula for equilibrium real interest rate calculation especially in the period of stable inflation and steady economic growth.

Gerlach and Schnabel (2000) considered real interest rate in the euro area countries as constant. On the other hand, they admitted that countries with lower credibility of their monetary authority used to have rather high real interest rates in the past. Calculation of equilibrium real interest rate was hence overvalued for the whole euro area. Consequently, they decided to adjust the time series and to eliminate too high interest rates caused by low credibility. They deducted inflation and average depreciation of nominal exchange rate towards German mark from nominal interest rate. Equilibrium real interest rate was 3.55%, which was considered as a constant value for the whole newly created euro area.

Quantification of a monetary rule for a group of several countries as it is in the case of the euro area requires time series aggregation. Aggregation is possible on the basis of weights associated to particular countries. The weights are calculated according to a country GDP taking into account purchasing power parity to the overall euro area GDP. That aggregation led them to conclusion that long-term inflation and output gap coefficient was 1.5 and 0.5 respectively. These values are in line with the European Central Bank monetary policy setting and mandate as it targets inflation as its primary goal.

Many authors, e.g. Sauer and Sturm (2003), employ *Euro Overnight Index Average* (EONIA) as a nominal interest rate for the Taylor rule in the European Monetary Union. EONIA is equivalent of federal funds rate that is applied in the U.S. Taylor rule. These interest rates capture current monetary policy setting. They aggregate naturally through market restrictive or expansive monetary instruments character. EONIA is overnight interbank interest rate for the euro area. In other words, it is an interest rate of interbank credits with one day maturity. Consequently, EONIA is in fact an overnight EURIBOR. Some authors, e.g. Perez-Quiros and Siciliae (2002) contest application of EONIA in the euro area Taylor rule due to its large daily fluctuations. On the other hand, Sauer and Sturm (2003) prefer implementation of EONIA as monetary rules calculate with monthly or quarterly data and average of EONIA daily data on monthly or quarterly basis significantly reduces its volatility.

Gerlach and Schnabel (2000) tested apart from standard variables alternative ones in the case of the euro area. They suggested e.g. growth rate of aggregate M3, federal funds rate, real exchange rate ratio of euro to dollar, etc. Nevertheless, they results were less significant as it was in the case of standard model.

2.6.4. The Taylor Rule Quantification Methodology in the New European Union Member States

Most of the researches on the Taylor rules focus on large industrialized countries. Analysis in the case of small open countries in transition or post-transition economies is less frequent and rather brief. Shorter time series are one of the limiting elements in this field. The data are available mostly since the second half of 1990s. In addition, monetary policy strategies have been more changeable in these countries. Fixed peg exchange rate regimes changed to more flexible ones. It is not obvious to determine targeted inflation in these countries as inflation targeting has been implemented since 1997 and later on. Formulation of a monetary rule is complicated also due to less stable macroeconomic environment which is a typical feature of countries in transition.

Frömmel et al. (2009) quantified the Taylor rule for the new European Union member states, i.e. the Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia. They involved exchange rate in their formula as all these economies are small and open ones. They assumed significant impact of exchange rates.

Their results were in line with expectation and theory, e.g. the Taylor principle, in all countries but Slovakia. Nevertheless, their rule does not comprise an inertia factor, i.e. a *smoothing parameter*. As evolution of real interest rates corresponded the least with the calculated Taylor rule in case of Slovakia, the authors concluded that the National Bank of Slovakia applied rather discretionary approach in comparison with other analysed central banks.

Maria-Dolores (2005) estimated the Taylor rule for the Visegrad countries (V4 - the Czech Republic, Hungary, Poland, and Slovakia) in the period from 1998 to 2003 and he concluded that the Taylor rule matches with actual interest rates in all countries but Slovakia. He supposes that the difference is implied by different exchange rate regimes. While the Czech Republic, Hungary, and Poland applied rather floating regimes, Slovakia had more fixed peg. In the Czech Republic, managed floating was applied from 1997 to 2000 and independent floating was practiced from 2001 on. Hungary has been employing managed floating since 2000. Poland has been practicing independent floating since 2000. Slovakia implemented managed floating in 1998. Nevertheless, Maria-Dolores (2005) judges the regime in Slovakia as rather inflexible. Consequently, the Taylor rule for Slovakia does not correspond with existing interest rates. However, more important is the fact that flexible exchange rate regime should be accompanied by explicit inflation targeting. Only under these two conditions, the Taylor rule can be quantified and compared with existing interest rates. Inflation targeting has been implemented in the Czech Republic, Hungary and Poland since January 1998, June 2001, and October 1998 respectively. Slovakia practiced implicit inflation targeting from 2000 to 2004. Since 2005, it has been employing explicit inflation targeting.

Paez-Farell (2007) analyses the same group of countries. He confirms significant reaction of interest rates to exchange rates. Angeloni et al. (2007) as well as Yilmazkuday (2008) estimate the Taylor rule only for the Czech Republic, Hungary, and Poland. The Slovak Taylor rule is problematic also in other studies. Moons and Van Poeck (2008) found out that new European Union member states do not differ much from existing euro area member states in the field of interest rate setting on the basis of data from 1999 to 2003. Horváth (2009) determines neutral interest rate from the point of view monetary policy in the Czech Republic with time varying parameter. His results imply that neutral interest rate decreases and approaches more and more to the one of the euro area.

All above mentioned analyses concluded that the Taylor principle is not often fulfilled in these countries. This fact can have several reasons. Frömmel et al. (2009) indicate that if exchange rate is involved in the rule, it can react to inflation as well as interest rates. Another argument is brought by Golinelli and Rovelli (2005), according to which reaction of interest rates to inflation can be moderate if calculated interest rates were set too highly. In comparison with the standard Taylor rule, central bank reaction function in open economies responds to more types of information and also to external influences.

Nevertheless, Taylor (2001) argues that rules comprising exchange rate do not function well. Involving of exchange rate can cause chaotic volatility of interest rate. Yet, later on, Taylor (2002) admits that open economies have certain particularities and application of exchange rate can be justified in their case. He opens discussion if exchange rate should be on the left or right side of the equation, i.e. if interest rate or *monetary condition index* should be perceived as a monetary instrument.

Christina Ziegler (2012) quantified several Taylor-type rules for new European Union countries (the Czech Republic, Hungary, Poland, Slovakia, and Romania mostly during the period from 1995 to 2008. She excluded countries applying different types of fixed arrangements e.g. currency board (Bulgaria, Estonia, and Lithuania) but also Latvia that was applying very strict fixed peg with maximal oscillation towards euro of +/-1%. Her objective was to evaluate via *General Method of Moments* (GMM) to which extend central banks of those countries behaved time inconsistently and preferred exchange rate targeting to officially declared inflation targeting. Ziegler (2012) proved this assumption for all observed countries. Thus central bank behavior was time inconsistent.

Particularities of Monetary Rules Implementation in the New European Union Member States

As it was mentioned, monetary rules enable us to deal with time inconsistency problem. Time inconsistency has its particular features in transitive or post-transitive countries. One of the reasons of time inconsistent behaviour can be an effort to reduce appreciation pressures on domestic currency stemming from the Balassa-Samuelson effect (Balassa, 1964; Samuelson, 1964). Central bank usually decreases interest rates in these economies to limit local currency appreciation (Ziegler, 2012). Relatively weaker currency is important for competitiveness of these economies within international markets. On the other hand, central bank credibility is reduced as central bank reacts discretionary to changes of exchange rates. Nevertheless, monetary authority credibility is definitely crucial in the case of transitive and post-transitive countries. Consequently, such a policy leads to uncertainty and forecasting of future output and inflation becomes more difficult.

2.7. The Taylor Rule Quantification for the Slovak Republic

The objectives of this chapter will be:

1) To estimate various Taylor-type rules for Slovakia and to describe central bank reactions throughout observed periods. Our approach will be rather positive (descriptive) and less normative (based on recommendations). This is in line with the contribution by Peersman and Smets (1999), who underlines positive (descriptive) role of the Taylor rule.
2) Unlike previous studies, to estimate an optimal Taylor rule for Slovakia including period of crisis, i.e. from January 2000 to May 2013 and excluding period prior to implicit inflation targeting. The time series comprising 161 observations based on monthly data will be treated via linear regression with Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors approach.
3) To evaluate respecting of the Taylor principle in various versions of estimated rules. If the inflation gap coefficient is higher than one, so called *stabilization monetary policy* is applied. If the inflation gap coefficient is lower than one, so called *accommodating policy behavior* is typical for the central bank. The second case can lead to destabilization from the point of view of inflation.
4) To analyze if the National Bank of Slovakia policy was rather *passive*, i.e. reacting to contemporaneous inflation and output gap; or *active*, i.e. reacting to expected inflation and output gap.
5) To identify if the central bank´s policy was pro-cyclical one, i.e. negative output gap coefficient; or whether it was anti-cyclical due to positive output gap coefficient.

6) To evaluate central bank strategy from the point of view of time consistency, i.e. if central bank focused more on exchange rate evolution than on inflation in spite of inflation targeting.
7) To decide if the central bank´s strategy was really based on inflation targeting as officially declared, i.e. if central bank responded mostly to inflation gap.
8) To compare the Taylor rule for Slovakia with the Taylor rule for the euro area and other V4 countries.

This chapter as well as the monograph as a whole extends previous researchers from several aspects. Therefore, main contributions are:

1) Inspiration how to calculate the Taylor rule or other monetary rules for transition or post-transition countries.
2) Involvement of monetary union integration aspect in the Taylor rule quantification.
3) Evaluation of the Taylor rule in the context of financial and economic crisis.

2.7.1. Particularities of the Slovak Economy and Slovak Monetary Strategy

The Taylor rule quantification in the context of Slovakia has to take into account particularities of Slovak transition and integration process. According to Frömmel et al. (2009), new member states of the European Union including Slovakia have to follow so called *twin inflation target*. On one level, these countries have their own internal inflation targets, which correspond to the situation of their economy. But on another level, during their accession period to the euro area, they have to respect external inflation target formulated by Maastricht criteria or to follow the mid-term and long-term European Central Bank goal (inflation under or close to 2%).

Up to 2005, Slovakia pursued its own target in line with its disinflation process. Since 2005, when Slovakia implemented the European Exchange Rate Mechanism II, external target corresponding with Maastricht criteria has become crucial one. Since 2009, inflation below 2% has been primary goal.

Table 2.1 Participation of Slovak koruna in the European Exchange Rate Mechanism II

November 2005	Entry to the ERM II, Initial central parity determination	44.2233 SKK/EUR 38.4550 SKK/EUR 32.6868 SKK/EUR	upper boundary central parity lower boundary	+/-15%	+/- 27%
March 2007	First revaluation of central parity	40.7588 SKK/EUR 35.4424 SKK/EUR 30.1260 SKK/EUR	upper boundary central parity lower boundary	+/-15%	
May 2008	Second revaluation of central parity	34.6449 SKK/EUR 30.1260 SKK/EUR 25.6071 SKK/EUR	upper boundary central parity lower boundary	+/-15%	
July 2008	Final setting of the conversion rate by the Council of the EU	30.1260 SKK/EUR			

Source: Own representation according to the National Bank of Slovakia (2009).

An important assumption for the Taylor rule quantification is free floating exchange rate regime and inflation targeting at the same time. These conditions are in line with Maria-Dolores (2005), Frömmel et al. (2009), and others. According to Maria-Dolores (2005), the Taylor rule performance is higher in countries with inflation targeting as in practice, the loss function is calculated only on basis of deviation of actual inflation from targeted one.

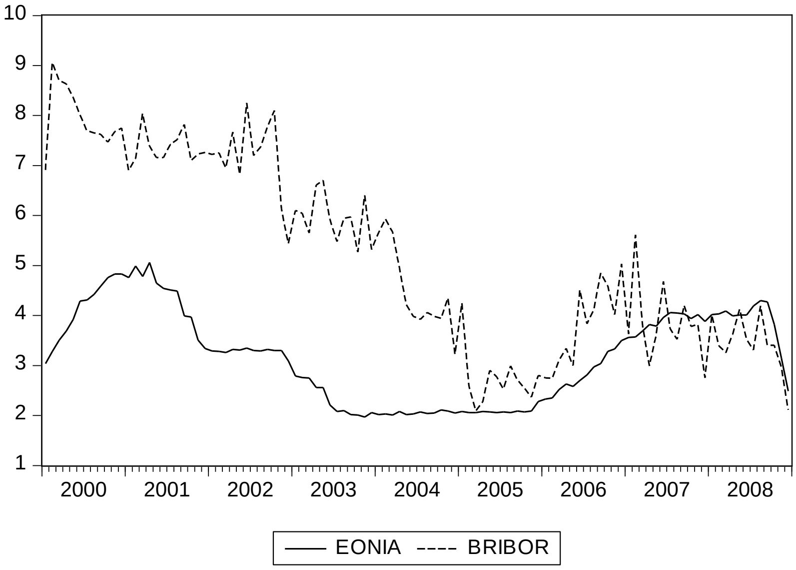
The Slovak Republic implemented managed floating in 1998 which represented relatively flexible exchange rate arrangements. However, explicit inflation targeting was introduced only in 2005. In the same year in November 2005, the Slovak Republic entered to the ERM II, which is officially rather fixed peg. From this point of view, it would seem that the Taylor rule formulation for Slovakia is not possible. Nevertheless, Frömmel et al. (2009) argue that participation in the ERM II with +/-15% fluctuation bands is sufficiently flexible and can be regarded as relatively flexible exchange rate regime. Overall possible change of exchange rate can be by 30% and this is sign of important flexibility. This statement is true particularly in the case of Slovakia as Slovak koruna´s central parity was moved towards its appreciation even twice, so overall possible change of exchange rate could be much more than 30%. In reality it was almost 54% (+/- 27%) as throughout all this period exchange rate of koruna could vary from 25.6071 SKK/EUR to 44.2233 SKK/EUR. Both revaluations were justified by positive economic evolution of Slovak economy strongly influenced by significant inflow of foreign direct investments. Both central parity changes were approved by the euro area ministers of finance, the European Central Bank president and several ministers of finance and governors from other EU countries beyond the euro area (National Bank of Slovakia, 2009).

2.7.2. Data and Methodology for the Taylor Rule Estimation in the Slovak Republic

In line with other relevant researches (Clarida et al., 1998; Sauer and Sturm, 2003; and others), output gap will be calculated using the Hodrick-Prescott filter with the smoothing parameter of $\lambda = 14\,400$ as we work with monthly data[2]. The filter will be applied on Slovak industrial production index (IPI). Output gap will be calculated as deviation of current industrial production logarithm from its trend. Despite the fact that ratio of services is rising in overall economy, it is still assumed that industrial sector is a cycle maker as it leads other sectors and influences them (Sauer and Sturm, 2003). Disadvantage is that data on industrial production are often ex-post revised, thus they are not convenient in application of real-time data. Thus, our objective is to estimate just the ex-post backward-looking rule. From January 2000 to May 2013, 161 seasonally adjusted data are available (Eurostat, 2013).

[2] Smoothing parameter for monthly, quarterly and annual data is $\lambda = 14\,400$, 1 600 and $\lambda = 6.25$ respectively (Hodrick and Prescott, 1997).

Figure 2.1 Evolution of EONIA and BRIBOR (2000-2008)



Source: Own representation according to Eurostat (2013).

Harmonized index of consumer prices (HICP), precisely its year-on-year rate of change, will be used as an inflation indicator π_t. From January 2000 to May 2013, 161 seasonally unadjusted[3] data are available (Eurostat, 2013). In model "ECB", targeted inflation (π^*) for Slovakia will be the same as the one set by the European Central Bank, i.e. 2%, as Slovakia strives to converge to this level in long-term perspective. In alternative model "NBS"; we will consider targeted inflation particularly determined for Slovak economy by the National Bank of Slovakia after explicit inflation targeting implementation in 2005. This double approach corresponds with the idea of Frömmel et al. (2009) on twin inflation target in transition countries with integration ambitions. In 2005, inflation target interval is from 2.5 to 4.5%, thus we will calculate with the value of 3.5%. In 2006, inflation target was under 2.5% and since the following year it has been in line with the European Central Bank target (< 2%) (National Bank of Slovakia, 2004). Before 2005, in times of implicit inflation targeting, we will consider gradual disinflation process in Slovakia.

Overnight BRIBOR (Bratislava Interbank Offered Rate) will be used as nominal interest rate up to 2008. EONIA (Euro Overnight Index Average) has been applied since 2009. This approach is analogical with other studies (Sauer and Sturm, 2003). From January 2000 to May 2013, 161 seasonally unadjusted data based on monthly averages will be employed (National Bank of Slovakia, 2013; Eurostat, 2013). We can observe that evolution of EONIA and BRIBOR was significantly correlated due to integration process. This fact allows us to employ BRIBOR instead of EONIA in the period from 2000 to 2008.

Equilibrium real interest rate (i_t^*) will be calculated according to the above-mentioned Fisher equation in respect to adaptive expectations, i.e. as a difference between nominal interest rate (i_t) and inflation rate (π_t):

$$i_t^* = i_t - \pi_t \tag{2.28}$$

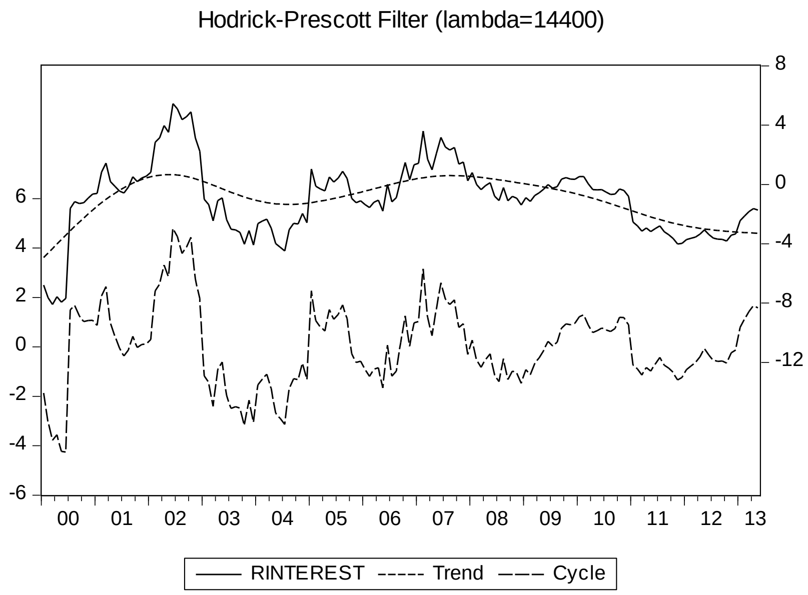
[3] This is in line with recommendations by Sauer and Sturm (2003).

Some authors including Taylor (1993) suggest application of constant equilibrium real interest rate. However, we assume that equilibrium real interest rate is changing in time especially in countries in transition. Horváth (2006) developed the idea on time-varying equilibrium interest rates on the example of the Czech Republic. Via the figure 2.2, we confirm the relevance of time-varying real interest rates for Slovakia. In fact, absolute deviation is 13.55% during observed period. Similar deviations were found out e.g. by Belke and Klose (2009) or Garnier and Wilhelmsen (2009) on the sample of other countries.

We want to calculate output gap as a difference between actual output and its potential value. Potential output is often in literature quantified using the Hodrick-Prescott filter; however this methodology requires stationary data. Our output measured through industrial production index IPI is not stationary as for level values according to standardly used Augmented Dickey-Fuller test. Nevertheless, first differences are stationary, consequently, we can apply the Hodrick-Prescott filter and calculate output gap.

Instead of output gap, it is possible to employ also *Economic Sentiment Indicator* (ESI), which is calculated in Slovakia from January 1997 on. As it is calculated via moving average, first available data are available since March 1997. ESI expresses economic agents' mood and thus it has forecasting attributes. ESI is weighted arithmetic average of five components: a) industrial confidence indicator 40%, b) construction confidence indicator 5%, c) retail-trade confidence indicator 5%, d) services confidence indicator 30%, and e) consumer confidence indicator 20%. We will involve 161 seasonally adjusted data on ESI from January 2000 to May 2013 to our calculations (Statistical Office of the Slovak Republic, 2013).

Figure 2.2 Equilibrium Real Interest Rate and Hodrick-Prescott Filtered Rate



Source: Own calculation according to data from Eurostat (2013).

Real effective exchange rate (REER) is applied as Slovakia is small and open economy and presence of exchange rate should be tested in the central bank´s reaction function. REER is weighted average of country´s currency relative to an index or basket of other relevant currencies adjusted for the effects of inflation. 161 data will be involved in our estimation covering the period from January 2000 to May 2013. We will apply $REER_t$ and lagged $REER_{t-1}$ similarly with Obstfeld and Rogoff (1995) and Taylor (2001). They suggest application of $REER_{t-1}$ to involve dynamics into reaction function.

Table 2.2 Descriptive statistics of data from January 2000 to May 2013

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Observations
ACTINFL	4.629	3.800	16.800	-0.200	3.383	1.386	5.559	161
EINFLGAP	2.629	1.800	14.800	-2.200	3.383	1.386	5.559	161
ESI	104.521	107.800	119.000	71.900	9.827	-1.215	4.226	161
ETARGETINFL	2.000	2.000	2.000	2.000	0.000	NA	NA	161
NINFLGAP	1.288	1.300	8.800	-2.200	2.223	1.010	4.415	161
NINTEREST	3.656	3.520	9.060	0.070	2.727	0.217	1.739	161
NTARGETINFL	3.342	2.500	8.000	2.000	1.782	1.391	4.060	161
OUTPUT	83.780	83.940	125.200	50.030	21.701	0.074	1.646	161
OUTPUTGAP	0.000	-0.310	24.950	-8.270	5.064	2.377	11.664	161
REER	107.777	104.930	136.240	72.970	21.977	-0.203	1.513	161
RINTEREST	-0.973	-0.800	5.450	-8.100	2.476	-0.173	3.868	161

Note: ACTINFL – actual inflation, EINFLGAP - inflation gap based on the European Central Bank inflation target, ESI - economic sentiment indicator, ETARGETINFL - the European Central Bank inflation target, NINFLGAP - inflation gap based on the National Bank of Slovakia inflation target, NITEREST - nominal interest (BRIBOR up to 2008, EONIA since 2009), NTARGETINFL - the National Bank of Slovakia inflation target, OUTPUT - output determined according to industrial production index, OUTPUTGAP - output gap, REER - real effective exchange rate, RINTEREST - equilibrium real interest rate.

Source: Own calculations according to data from the Eurostat (2013), NBS (2013), Statistical Office of the Slovak Republic (2013).

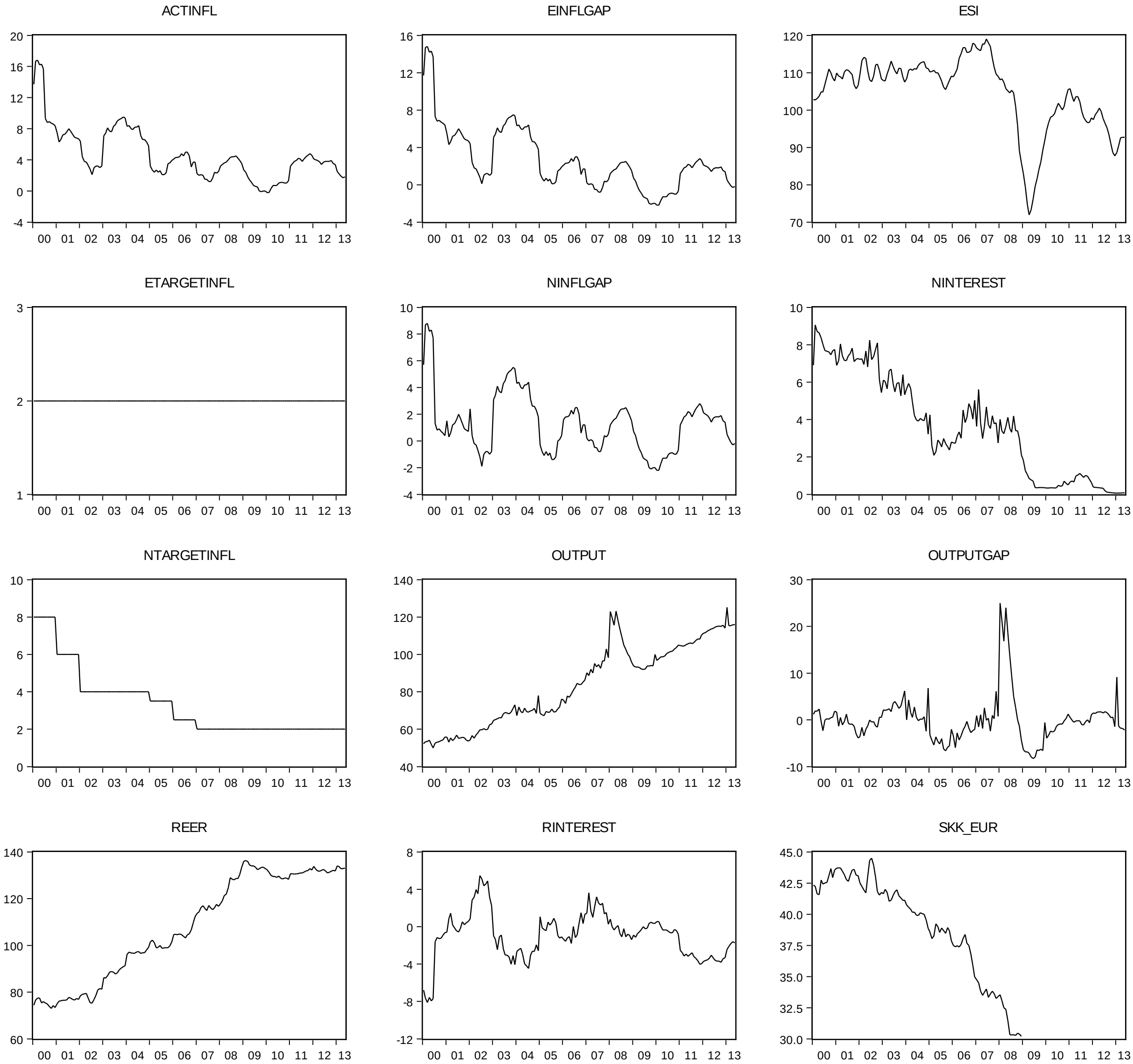
Descriptive statistics of data involved in our calculations is captured in Table 2.2. Overview of above mentioned data is depicted in the figure 2.3.

The Taylor-type rules covering the period from January 2000 to May 2013 (161 observations) will be estimated via linear regression with Newey-West standard errors approach to overcome potential problems with heteroskedasticity and autocorrelation (HAC). It is recommended e.g. by Ziegler (2012) and others. The overall sample will be divided into two sub-samples. The first sub-sample will be from January 2000 to December 2008, the second one, i.e. the Taylor rule estimation uniquely during crisis, will cover data from 2009[4] to 2013.

We will try to estimate several backward-looking and forward-looking rules for Slovakia. As it was mentioned, backward-looking rules can be divided into rules based on ex-post available data (i.e. revised data) and rules determined according to real-time data (i.e. without any revisions). Disadvantages of real-time data rules were described in previous sub-section. Thereafter we will try to estimate the ex-post Taylor rule for Slovakia.

[4] Unlike old European Union member states and other industrialised countries, Slovakia has been touched by crisis only since 2009. In 2008 economic growth was 6.4%; in 2009 it dropped to -4.7% (Eurostat, 2013).

Figure 2.3 Overview of Data Relevant for Slovak Taylor-type Rules Estimations (2000-2013)



Note: ACTINFL - actual inflation, EINFLGAP - inflation gap based on the European Central Bank inflation target, ESI - economic sentiment indicator, ETARGETINFL - the European Central Bank inflation target, NINFLGAP - inflation gap based on the National Bank of Slovakia inflation target, NITEREST - nominal interest (BRIBOR up to 2008, EONIA since 2009), NTARGETINFL - the National Bank of Slovakia inflation target, OUTPUT - output determined according to industrial production index, OUTPUTGAP - output gap, REER - real effective exchange rate, RINTEREST - equilibrium real interest rate, SKK_EUR - exchange rate SKK/EUR

Source: Own representation and calculation according to data from the Eurostat (2013), NBS (2013), Statistical Office of the Slovak Republic (2013).

Our estimations will be based on above-mentioned function applied e.g. by Frömmel et al. (2009) that apart from standard elements comprises factor of inertia and exchange rate, which should not be neglected in the case of such an open and small economy as Slovakia is:

$$i_t = \lambda i_{t-1} + (1-\lambda)[i^* + \gamma(\pi_{t.k} - \pi^*_{t.\ k}) + \beta(y_t - y_t^*) + \delta_1 s_t + \delta_2 s_{t-1}] + \varepsilon_t \quad (2.29)$$

Taylor (2001) proposes intuitive interpretation of exchange rate coefficients δ_1 and δ_2:

1. if $\delta_1 < 0$ and $\delta_2 = 0$, then higher nominal real exchange rate will imply pressure to lower short term interest rate, this is so called "relaxing monetary policy";

2. if $\delta_1 < 0$ and $\delta_2 > 0$ and $\delta_1 + \delta_2 < 0$, then initial interest rate reaction will be partially compensate next period;

3. if $\delta_1 < 0$ and $\delta_1 = -\delta_2$, then interest rate reacts to the change of exchange rate;

4. if $\delta_1 < 0$ and $\delta_2 < 0$, then weight given to exchange rate stability is important, this condition is in fact compatible with exchange rate targeting.

2.7.3. Results and Discussions

Gradually we will estimate:

a) backward-looking simple form of the rule with inflation gap, output gap and equilibrium real interest rate;

b) backward-looking open economy rule with real effective exchange rates $REER_t$ and $REER_{t-1}$;

c) backward-looking simple rule with factor of inertia, i.e. interest rate smoothing;

d) backward-looking open economy rule with factor of inertia;

e) forward-looking simple rule with inflation gap with forecasting for k=1-12 months gradually, industrial production index (IPI) that leads traditional output gap, and equilibrium real interest rate;

f) forward-looking rule as in e) but in addition with factor of inertia;

g) forward-looking rule as in e) but in addition with open economy aspect, i.e. with $REER_t$ and $REER_{t-1}$;

g) open economy forward-looking rule as in e) with factor of inertia;

h) forward-looking simple rule with inflation gap with forecasting for k=1-12 months gradually, economic sentiment index (ESI) that leads traditional output gap, and equilibrium real interest rate;

i) forward-looking rule as in h) but in addition with factor of inertia;

j) forward-looking rule as in h) but in addition with open economy aspect, i.e. with $REER_t$ and $REER_{t-1}$;

k) open economy forward-looking rule as in h) with factor of inertia;

All these Taylor-type rules will be estimated for two alternatives of inflation targets. Inflation target determined by the National Bank of Slovakia, model "NBS", i.e. inflation target will vary throughout the period in line with disinflation process in the country. Inflation target set by the European Central Bank, model "ECB", i.e. inflation target will be always 2%.

Table 2.3 Taylor-type rules estimations for Slovakia (2000-2013)

	infl. target	γ	β	δ_1	δ_2	λ	$1-\lambda$	Adj. R^2
Simple TR	NBS	1.497***	0.006				1.214***	0.663
	ECB	1.317***	0.008				1.057***	0.659
Open economy TR	NBS	0.699***	-0.014	-0.080*	-0.005		0.568***	0.944
	ECB	1.128***	0.003	-0.012	0.028***		1.122***	0.998
TR with interest smoothing	NBS	0.246***	0.012			0.871***	0.203***	0.959
	ECB	0.200***	0.011			0.855***	0.178***	0.961
Open economy TR with interest smoothing	NBS	0.369***	0.001	-0.046^	0.011	0.553***	0.302***	0.970
	ECB	1.030***	0.004	-0.010	0.025**	0.088***	1.025***	0.998
Forward-looking TR – IPI	NBS	1.743*** 0.296* k=12	-0.064***				1.427***	0.833
	ECB	1.132*** 0.023^ k=12	-0.005**				1.093***	0.998
Forward-looking TR with interest smoothing – IPI	NBS	0.470*** 0.099** k=12	-0.013*			0.744***	0.403***	0.963
	ECB	1.064*** 0.023^ k=12	-0.004*			0.064***	1.026***	0.998
Open economy forward-looking TR – IPI	NBS	1.831** 0.312** k=12	-0.062***	-0.087	0.156**		1.454***	0.837
	ECB	1.140*** 0.024^ k=12	-0.004*	-0.005	0.025***		1.096***	0.998
Open economy forward-looking TR with interest smoothing – IPI	NBS	0.519** 0.108* k=12	-0.012*	-0.051	0.066*	0.737***	0.425***	0.963
	ECB	1.072*** 0.024^ k=12	-0.064*	-0.006	0.025***	0.064***	1.029***	0.998
Forward-looking TR – ESI	NBS	1.339*** 0.249** k=12	0.023***				1.211***	0.870
	ECB	0.924*** 0.006 k=12	0.019***				0.942***	0.996
Forward-looking TR with interest smoothing – ESI	NBS	0.432*** 0.096* k=12	0.007***			0.699***	0.399***	0.966
	ECB	0.887*** 0.009** k=12	0.018***			0.061***	0.888***	0.997
Open economy forward-looking TR - ESI	NBS	0.955*** 0.175*** k=12	0.055***	-0.061	0.033		0.877***	0.915
	ECB	1.043*** 0.018*** k=12	0.008***	-0.004	0.014***		1.036***	0.998
Open economy forward-looking TR with interest smoothing - ESI	NBS	0.435*** 0.065*** k=12	0.018***	-0.046	0.038	0.616***	0.406***	0.968
	ECB	1.010*** 0.016*** k=12	0.007***	-0.005	0.015***	0.034***	1.004***	0.999

Note: *, **, *** correspond to 10%, 5% and 1% significance level respectively, k=12 is 12- month horizon, TR - Taylor rule, IPI - Industrial production index, ESI - Economic sentiment index, NBS - National Bank of Slovakia, ECB - European Central Bank.

Source: Own calculation according to data from the Eurostat (2013), NBS (2013), Statistical Office of the Slovak Republic (2013).

Our sample will be treated as a whole, i.e. from 2000 to 2013, and it will be divided also into two sub-samples from 2000-2008 and 2009-2013. We have three reasons for such division. Firstly, we want to estimate situation before integration to the euro area and after adoption of euro. Secondly, we strive to compare reaction function before financial and economic crisis and during the crisis. Finally, this sub-sampling is justified also by the Quandt-Andrews break point test (Andrews, 1993) that identified especially year 2009 as a significant rupture in macroeconomic indicators. This result was confirmed also by the Chow break point test (Chow, 1960) at 1% significance level.

Monetary policy reaction functions covering the period from 2000 to 2013 are captured in Table 2.3. Evidently higher weight was attributed to inflation gap than to output gap. This observation is in line with inflation targeting in Slovakia. It is probable that even during the period of implicit inflation targeting (2000-2004); inflation was more in the centre of attention than other variables. In forward-looking rules, we applied forecasting horizon from 1 to 12 months for inflation. Nevertheless, only the 12-month horizon was statistically significant in all alternative rules. However, the Taylor principle (inflation gap coefficient >1) was maintained only in half of cases (13 out of 24). Consequently, it seems that higher inflation was not always evidently offset by sufficient rise of interest rate. Especially, forward-looking Taylor rules based on ESI were seldom in line with the Taylor principle. Thus, we cannot clearly conclude, if Slovakia experienced accommodative or stabilization monetary policy.

Very interesting is finding that output gap was statistically significant only in forward-looking rules. Nevertheless, value of its coefficient is very low in all cases. Negative sign implies pro-cyclical character of monetary policy (drop of output led to rise of interest rate and vice-versa). On the other hand, in the most of cases, policy was rather anti-cyclical. Pro-cyclical tendency appeared only in case of forward-looking rules based on IPI. Yet, very low coefficients indicate that monetary policy was in general rather neutral from the point of view of economic growth.

From the point of view of expected inflation, central bank´s policy is rather passive. It pays more attention to actual inflation than to inflation expected in 12-month horizon. Regarding expected output, central bank´s policy is more active. Relevance of output gap is higher in forward-looking rules than backward-looking ones.

Interest rate did not react much to actual exchange rate. Impact of lagged exchange rate was more significant. As $\delta_1 < 0$ and $\delta_2 > 0$ almost in all cases, we can investigate a certain compensation effect. Appreciation of exchange rate will lead to drop of interest rates in short term but it will increase interest rate in the following period. Central bank should not maintain loosing of monetary policy in long run because it is not compatible with its anti-inflationary policy and inflation targeting as a whole. Still, after 2000, we cannot observe exchange rate targeting in Slovakia.

Interest rate smoothing is obvious in Slovakia. Impact of previous interest rate on actual rate is always significant. Coefficient is usually very high. In some cases, interest rates are explained by their previous values by more than 80%. This fact supposes relatively small fluctuations in interest rate evolution.

Table 2.4 Taylor-type Rules Estimations for Slovakia (2000-2008)

	infl. target	γ	β	δ_1	δ_2	λ	$1-\lambda$	Adj. R^2
Simple TR	NBS	2.669***	0.006				1.894***	0.632
	ECB	1.456***	-0.007				1.435***	0.707
Open economy TR	NBS	1.435***	0.005	-0.331**	0.363**		1.015***	0.944
	ECB	1.127***	0.002	-0.013	0.029**		1.120***	0.993
TR with interest smoothing	NBS	0.274***	0.013			0.917***	0.219***	0.883
	ECB	0.515***	0.006			0.652***	0.522***	0.924
Open economy TR with interest smoothing	NBS	0.284***	0.012	-0.036	0.037	0.908***	0.227***	0.881
	ECB	1.030***	0.003	-0.009	0.024**	0.091***	1.025***	0.995
Forward-looking TR - IPI	NBS	1.827*** 0.495*** k=12	0.017***				1.519***	0.387
	ECB	1.109*** 0.051*** k=12	-0.019***				1.078***	0.984
Forward-looking TR with interest smoothing – IPI	NBS	0.549*** 0.117*** k=12	0.001			0.764***	0.477***	0.888
	ECB	0.984*** 0.040*** k=12	0.017***			0.122***	0.960***	0.987
Open economy forward-looking TR - IPI	NBS	1.788*** 0.338*** k=12	-0.085***	-0.053	0.136		1.540***	0.573
	ECB	1.108*** 0.018*** k=12	-0.008***	0.001	0.022		1.096***	0.995
Open economy forward-looking TR with interest smoothing – IPI	NBS	0.646*** 0.109*** k=12	-0.022**	-0.039	0.059	0.703***	0.568***	0.897
	ECB	1.050*** 0.015*** k=12	-0.008*	-0.001	0.021**	0.057***	1.039***	0.996
Forward-looking TR - ESI	NBS	1.369*** 0.306*** k=12	0.022***				1.191***	0.629
	ECB	1.001*** 0.001 k=12	0.018***				0.992***	0.997
Forward-looking TR with interest smoothing - ESI	NBS	0.559*** 0.110*** k=12	0.005***			0.691***	0.496***	0.897
	ECB	0.975*** -0.001 k=12	0.018***			0.028**	0.968***	0.997
Open economy forward-looking TR - ESI	NBS	1.057*** 0.155*** k=12	0.073***	-0.013	-0.037		0.909***	0.830
	ECB	1.034*** 0.009*** k=12	0.012***	0.004	0.002		1.024***	0.998
Open economy forward-looking TR with interest smoothing - ESI	NBS	0.628*** 0.091*** k=12	0.032***	-0.027	0.005	0.517***	0.548***	0.921
	ECB	1.009*** 0.009*** k=12	0.011***	0.003	0.003	0.027***	1.001***	0.998

Note*:* *, **, *** correspond to 10%, 5% and 1% significance level respectively, k=12 is 12- month horizon, TR - Taylor rule, IPI - Industrial production index, ESI - Economic sentiment index, NBS - National Bank of Slovakia, ECB - European Central Bank.

Source: Own calculation according to data from the Eurostat (2013), NBS (2013), Statistical Office of the Slovak Republic (2013).

Finally, impact of equilibrium real interest rate on short term nominal rate is indisputable in all cases. Interestingly, its coefficient is usually lower, if the coefficient of inflation gap is lower, and it is over one, if later one is more than one.

Monetary policy reaction functions covering the period from 2000 to 2008 are captured in Table 2.4. This period is typical for inflation targeting and for preparations to the euro area integration. As expected, evidently higher weight was attributed to inflation gap than to output gap. However, the Taylor principle is maintained in more cases than it was in previous table (15 out of 24). Consequently, there is a higher probability that higher inflation could be offset by sufficient rise of interest rate. Forward-looking Taylor rules based on ESI are now more in line with the Taylor principle. Nevertheless, we cannot clearly conclude, whether Slovakia experienced accommodative or stabilization monetary policy.

Very interesting is, once again, finding that output gap was statistically significant only in forward-looking rules. Nevertheless, value of its coefficient is still very low in all cases. Interest rate was not very sensitive to changes in output. In the most of cases, policy was rather anti-cyclical (positive sign of coefficient). Pro-cyclical tendency appeared mainly in case of forward-looking rules based on IPI. Yet, very low coefficients indicate that monetary policy was in general rather neutral from the point of view of economic growth.

From the point of view of expected inflation, central bank´s policy is rather passive. It pays more attention to actual inflation than to inflation expected in 12-month horizon. Regarding expected output, central bank´s policy is more active. Relevance of output gap is higher in forward-looking rules than backward-looking ones.

Interest rate did not react much to actual exchange rate. Impact of lagged exchange rate was only little bit more significant. As $\delta_1 < 0$ and $\delta_2 > 0$ almost in all cases, we can investigate a certain compensation effect. Appreciation of exchange rate led to drop of interest rates in short term but it increased interest rate in the next period. Still, after 2000, we cannot observe exchange rate targeting in Slovakia.

Interest rate smoothing is obvious in Slovakia also in the sub-sample 2000-2008. Impact of previous interest rate on actual rate is always significant. Coefficient is usually very high. In some cases, interest rates are explained by their previous values by more than 90%. This fact supposes relatively small fluctuations in interest rate evolution.

Finally, impact of equilibrium real interest rate on short term nominal rate is evident in all cases and as expected, it is always positive. Analogically with previous table, equilibrium real interest rate coefficient tends to behave similarly as inflation gap coefficient.

These results indicate that the National Bank of Slovakia realized time consistent monetary policy focusing on officially declared inflation targeting.

Monetary policy reaction functions covering the period from 2009 to 2013 are captured in Table 2.5. This period is influenced by financial and economic crisis and by Slovak integration into to the euro area. Thus, estimations for inflation target set independently by the National Bank of Slovakia are missing.

As expected, evidently higher weight was attributed to inflation gap than to output gap. However, the Taylor principle is maintained in fewer cases than it was in previous tables (4 out of 12). Consequently, we can suppose that during the period 2009-2013 inflation was not sufficiently offset by interest rate changes. We can conclude that behavior of common interest rate in the euro area had rather accommodative character in regard to Slovak inflation. Common interest rate did not contribute sufficiently to stabilization of Slovak inflation.

Table 2.5 Taylor-type Rules Estimations for Slovakia, 2009-2013

	infl. target	γ	β	δ_1	δ_2	λ	$1-\lambda$	*Adj. R^2*
Simple TR	ECB	0.026	-0.098				-0.160***	0.453
Open economy TR	ECB	1.008***	0.007**	0.004	0.012**		1.017***	0.996
TR with interest smoothing	ECB	-0.025	0.009*			0.895***	-0.019***	0.898
Open economy TR with interest smoothing	ECB	1.070***	0.006**	0.004	0.012**	-0.059***	1.078***	0.996
Forward-looking TR - IPI	ECB	1.222*** 0.006 k=12	0.024***				1.319***	0.938
Forward-looking TR with interest smoothing - IPI	ECB	0.672*** -0.012 k=12	0.013			0.391***	0.724***	0.970
Open economy forward-looking TR - IPI	ECB	0.961*** -0.015*** k=12	0.001	0.009***	0.005**		0.961***	0.998
Open economy forward-looking TR with interest smoothing - IPI	ECB	0.988*** -0.015*** k=12	0.001	0.009***	0.005**	-0.026*	0.988***	0.998
Forward-looking TR - ESI	ECB	1.192*** 0.106*** k=12	0.025***				1.237***	0.916
Forward-looking TR with interest smoothing – ESI	ECB	0.581*** 0.036*** k=12	0.012***			0.449***	0.603***	0.969
Open economy forward-looking TR - ESI	ECB	0.976*** -0.008*** k=12	0.001***	0.008***	0.005***		0.978***	0.999
Open economy forward-looking TR with interest smoothing - ESI	ECB	0.989*** -0.008*** k=12	0.001***	0.008***	0.006***	-0.013	0.992***	0.999

***Note**:* *, **, *** correspond to 10%, 5% and 1% significance level respectively, k=12 is 12- month horizon, TR - Taylor rule, IPI - Industrial production index, ESI - Economic sentiment index, NBS - National Bank of Slovakia, ECB - European Central Bank.

Source: Own calculation according to data from the Eurostat (2013), NBS (2013), Statistical Office of the Slovak Republic (2013).

Output gap was statistically significant in more variants of rules. Nevertheless, value of its coefficient is still very low. Interest rate was not very sensitive to changes in output. Almost in all cases, policy was rather anti-cyclical (positive sign of coefficient). Yet, very low coefficients indicate that monetary policy was in general rather neutral from the point of view of economic growth.

Exchange rate coefficients are always positive and often significant. Exchange rate appreciation leads to interest rate rise. However, very small values of parameters indicate that this impact is minor. Interest rate did not react to actual nor lagged exchange rate. This statement is in line with free floating exchange rate regime in the euro area.

Interest rate smoothing is much less present in the sub-sample 2009-2013. Impact of previous interest rate on actual rate is usually not so significant even it is sometimes negative. This fact supposes relatively small impact of central bank smoothing of interest rate. It seems that EONIA (unlike e.g. BRIBOR) evolves more independently at financial markets. However, this can be implied also by crisis when fluctuations of interest rates are more frequent.

Finally, impact of equilibrium real interest rate on short term nominal rate is evident in all cases and as expected, but is not always positive. This can be again explained by financial and economic crisis. Analogically with previous tables, equilibrium real interest rate coefficient tends to behave similarly as inflation gap coefficient.

2.7.4. Comparisons of the Taylor Rules within the V4 Countries and the Euro Area Rule

Ziegler (2012), Frömmel et al. (2009) and others estimated Taylor rules for countries in transition. They focused on countries with official inflation targeting (the Czech Republic, Hungary, Poland, Romania, and Slovenia) and excluded countries with exchange rate targeting (Bulgaria, Estonia, Latvia, and Lithuania). According to them, estimation for Slovakia was limited by the fact that Slovakia implemented explicit inflation targeting only since 2005 and at the same time Slovakia adopted the ERM II mechanism which is some kind of fixed peg within the euro area. However, we believe that also period of implicit inflation targeting starting in 2000 is inflation targeting and the ERM II is rather flexible mechanism as it was explained here above. Consequently, we estimated several Taylor-type rules for Slovakia and we will compare them with the results of other authors for the Czech Republic, Hungary, and Poland, which experienced similar transition process as Slovakia. We will focus on results of Slovak rules from the sub-sample from 2000 to 2008 due to several reasons: i) Czech, Hungarian, and Polish rules are based on the period from late 1990s to 2008, ii) following period (2009-2013) is influenced by crisis, and iii) adoption of euro in Slovakia unlike other countries.

Central banks in the Czech Republic, Hungary, and Poland applied sometimes time inconsistent monetary policy. Despite officially declared inflation targeting they preferred from time to time interest rate modifications in regard to exchange rate evolution in favor of output growth. They switched from inflation targeting to exchange rate or output targeting. They priority was anti-cyclical monetary policy mainly in case of the Czech Republic and Poland. Their policy was therefore occasionally based on discretion.

National bank of Slovakia behaved much more time consistently. Despite the period of so called implicit inflation targeting (2000-2004), it seems that is was a full-fledged targeting. Inflation was in the center of central bank´s attention. Output gap was not significant, and in addition, central bank´s policy was sometimes pro-cyclical as output was not at all monetary policy priority. Exchange rate evolution did not have significant impact on interest rate. Even during the period of the ERM II mechanism, central bank did not intervene importantly against Slovak koruna appreciation. Finally, central parity was revaluated twice. It seems that monetary policy was time consistent mainly with the aim to build sufficient central bank credibility. It was important to build and to maintain the credibility due to Slovak integration ambitions within the euro area.

Table 2.6 Monetary Policy Reaction Functions in the V4 Countries

	Czech Republic	Hungary	Poland	Slovakia
Monetary policy	strongly time inconsistent	strongly time inconsistent	little time inconsistent	time consistent
Discretion/rule	discretion	discretion	discretion	rule
Interest smoothing	not significant	significant	not significant	significant
Equilibrium real interest rate	not significant	not significant	not significant	significant
Inflation gap	significant	significant	significant	significant
Output gap	significant, mainly anti-cyclical	not significant	significant, mainly anti-cyclical	partially significant, small coefficients, sometimes pro-cyclical
Exchange rate	significant	significant	significant	not significant

Source: Own representation based on Ziegler (2012), Frömmel et al. (2009), and own results.

Table 2.7 captures comparison of reaction functions in the euro area and Slovakia in pre-crisis period and after crisis. Break point for the euro area is year 2008 and for Slovakia it is 2009 as crisis influenced Slovakia several months later and in addition year 2009 is linked to Slovak integration to the euro area.

Table 2.7 Monetary Policy Reaction Functions in the Euro Area and Slovakia

	Euro area before 2008	Slovakia before 2009	Euro area after 2008	Slovakia after 2009
Monetary policy	time consistent	time consistent	time inconsistent	time consistent
Discretion/rule	rule	rule	rule	rule
Taylor principle	maintained	maintained	violated	violated
Interest smoothing	significant	significant	significant	less obvious
Equilibrium real interest rate	significant but with negative sign	significant	little significant	significant
Inflation gap	significant	significant	significant	significant
Output gap	significant, anti-cyclical	partially significant, small coefficients, sometimes pro-cyclical	significant, higher weight than inflation gap, anti-cyclical	significant, but small coefficients, anti-cyclical
Exchange rate	NA	not significant	NA	significant, but small coefficients

Note: Exchange rates were not involved in reaction functions of the euro area as it is not small and open economy

Source: Own representation based on the ECB research by Blattner and Margaritov (2010), Belke and Klose (2011), and own results.

Comparison between monetary rules for euro area and Slovakia indicates several differences. Some of these differences are obviously implied by crisis. While the ECB behavior is time consistent before the crisis, it is time inconsistent after 2008. The ECB is during the crisis more attentive to output gap than to inflation gap evolution. During the crisis Slovak reaction function is little bit more attentive to output gap than before and has anti-cyclical character. However, inflation gap is still in the center of attention. The most important difference is in the Taylor principle. While it was maintained before crisis in the euro area as well as in Slovakia, it is violated after 2008 or 2009. It means that interest rate change is not sufficient to maintain inflation target.

In conclusion, despite official declarations about priority of inflation target over other targets, it seems that during crisis, monetary authorities pay more attention to output gap than assumed. Consequently, we can observe time inconsistency of the European Central Bank monetary policy. During the crisis, the Taylor principle is violated in the euro area as well as in Slovakia. It means that monetary policy is rather accommodative, which can have destabilization effect on inflation in long-term.

Differences between Slovak and the euro area reaction functions exist especially in the field of output gap. The National Bank of Slovakia focused more on inflation gap which can be explained by: i) disinflation process in Slovakia; ii) integration effort of Slovakia to fulfil Maastricht criteria including inflation one; iii) evident inflation targeting monetary strategy in Slovakia unlike the euro area where money supply is targeted, too.

However, we assume that monetary reaction functions will be more symmetric in future as Slovakia will not have to continue in disinflation process and mainly due to so called endogenous argument. It is possible to expect improving of the situation due to this endogenous argument (Frankel, 2009). Frankel explained that monetary integration would lead to gradual symmetry among business cycles and economic fundamentals in general.

2.8. Conclusion

The chapter explains relevance of the monetary policy rules in the context of monetary integration and economic crisis. It underlines importance of the Taylor rule and alternative Taylor-type rules. The time consistency problem is researched in line with the discussion rules versus discretion. Advantages and disadvantages of particular monetary strategies are summarized with special accent on inflation targeting as a usual pre-condition of the Taylor rule quantification.

Several Taylor-type rules are estimated for Slovakia since 2000 to 2013. The results are compared within the Visegrad countries and the euro area in connection with the period of financial and economic crisis. Estimations of the rules enable us to describe character of monetary policy application in Slovakia and other countries as well as asymmetry and compatibility of Slovak monetary conditions with the euro area setting.

Pre-crises period reveals clear time consistent policy in Slovakia and the euro area. Crisis leads to violation of certain pre-determined principles. We can observe more important focus on output gap and the Taylor principle is shattered.

Nevertheless, crucial is the question, whether after-crisis period will lead to higher symmetries in monetary policy conditions in the euro area and higher compatibility of monetary rules among member states.

2.9. References

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Chapter 3

Effectiveness of the Interest Rate Channel in the Context of Monetary Union and Economic Crisis

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3.1 Introduction
3.2 Overview of the Literature
3.3 Econometric Model
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EFFECTIVENESS OF THE INTEREST RATE CHANNEL IN THE CONTEXT OF MONETARY UNION AND ECONOMIC CRISIS

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Abstract
Monetary policy represents one of the most important policies of each country's policy mix. Understanding how monetary policy works and affects real economy is essential in understanding how changes in the settings of monetary instruments such as interest rate increase or decrease will affect the real economy and which variables will react. In this chapter we analyze the implications of monetary policy shocks in countries of monetary union in Europe. This chapter is focused on analysis of the transmission process of monetary policy in euro area in general as well as for the EMU countries and selected transition economies such as the V4 countries. We estimated vector autoregression model using the Cholesky decomposition of innovations in order to identify the effect of the monetary shocks on selected variables.

Keywords: interest rate, monetary policy transmission mechanism, VAR, Cholesky decomposition, impulse-response function

3.1. Introduction

Monetary policy influences economic situation via various transmission channels. Its main focus nowadays is on achieving price stability with base interest rates usually serving as the primary monetary instrument. Impact of monetary policy may change with changing economic conditions or monetary policy framework. For central bankers, it is essential to know how and when the changes in the settings of their monetary instruments will affect the real economy and which variables will react. They must be equally aware of possible time lags with which the various effects will manifest themselves. Thus policy makers face uncertainty about the extent of the changes in the settings of their monetary tools.

Generally, transmission processes act faster in open economies that are more exposed to external influences. (Šmídková, 2002) However, the choice of the main channels should also mirror the changes in the overall economic conditions so as to reflect structural changes that many economies are still undergoing nowadays. This is especially the case of the former so-called transition economies, such as e.g. central European economies. Their case proves

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that monetary policy cannot simply follow a standard theory with explicitly defined monetary anchor. Dynamically changing environment requires a certain degree of freedom whether is it in objectives or instruments of monetary policy. Many countries such as e.g. the V4 countries switched from traditionally used monetary or exchange rate targeting to inflation targeting.

The case of the European Economic and Monetary Union (EMU) confirms the attempt of the monetary policy in the domain of price stability that has been its sole mandate since the beginning. The objective of the European Central Bank is to maintain price stability in all member states of the euro area through the single monetary policy. The last four years reviewed whether the single European monetary policy is able to achieve its main objective and thus create a stable economic environment for overall macroeconomic situation in the euro area and for its individual members. Recent economic crisis and the further economic evolution including debt crisis revealed many problematic domains especially lasting asymmetries and divergent economic development. Main asymmetries arise from the still missing detailed framework for common fiscal policy. As a result, national governments are allowed to issue debt in a currency over which they exert no control, increasing even more existing divergences in macroeconomic development. (De Grauwe, 2012).

This chapter is focused on analysis of the transmission process of monetary policy in euro area in general as well as for the EMU countries and selected transition economies such as V4 countries. We estimated vector autoregression model using the Cholesky decomposition of innovations in order to identify the effect of the monetary shocks on selected variables. This analysis allows computing impulse-response functions for estimation of interest rate pass-through to macroeconomic variables. The recent crisis significantly affected the evolution of the euro area and that is why we divided our analysis into two periods - the first one covers the period from the first quarter of 2002 to the fourth quarter 2007. The second period covers also the years of the economic crisis (2002Q1-2011Q4). Countries are divides in to two groups: group no. 1 - Germany, France, Netherlands, Belgium and Luxembourg and group no. 2 - Portugal, Italy, Greece, Spain and Ireland (countries often designated by an acronym PIIGS or PIGS), group no. 3 - Czech Republic, Hungary, Poland and Slovakia. The choice of countries in the first group reflects either the size and importance or the influence of these economies in the euro area. The second group of so-called PIIGS countries regroups the most heavily-indebted economies. They became the focus of various analyses with regards to the European sovereign-debt crisis in 2009. The third group, former transitive countries represents either possible future members of euro area (Czech Republic, Hungary and Poland) or former transitive country that became member of monetary union (Slovakia).

The transmission process of the EMU's monetary policy, carried out by the European Central Bank (ECB), is represented by the changes in short-term interest rates. Subsequently, these changes are transmitted by various channels to real economy and affect macroeconomic variables, such as gross domestic product, exchange rate and price level, etc. In our analysis we will be interested in comparing the responses of the EMU countries variables to monetary policy shocks, i.e. transmission via interest rate channel (monetary shock) and its impact on inflation, gross domestic product and nominal effective exchange rate. The estimated model should verify whether changes in the interest rate setting have a desirable impact on selected macroeconomic indicators. The results will be compared with general results computed for average euro area variables.

3.2. Overview of the Literature

Over the last thirty years there have been many important shifts in monetary policy strategies as well as the instruments that are used. It can be mainly viewed as a reaction to changes in traditional monetary transmission channels due to e.g. structural changes in economy and the interaction between changes in monetary policy actions and the way expectations are formed. (Mishkin, 2009; Boivin, 2010) Most central banks use their key interest rates to indicate the changes in their monetary stance. By doing so, they also influence the expectations of the market subjects and direct those towards a desired level of inflation what is the basis of the monetary regime of inflation targeting. (Ďurčová, 2008) Modifications in key short-term interest rate are transmitted to money market rates and consequently to banking sector and the real economies.

Even though nowadays there is a general agreement on the fact that monetary policy can influence significantly real economy, the debates on the particular mechanism, the channels of transmission or time lags remain. Various opinions can be found especially in the studies focused on single monetary policy of ECB. They imply that the influence of monetary policy on real economy in EMU countries depends on a number of external factors (economic structure, competitiveness, presence of various shocks, etc.) (Égert, Moons, Garretsen, Aarle, Fornero, 2007) That is why some authors suggest that it is important to take into consideration also the national characteristics of the member countries, especially with regards to possible future enlargement of EMU. (Brissimis, Skotida, 2008)

The monetary transmission processes are often analyzed using vector autoregression models (VAR or VEC model). The standard VAR approach assumes that the dynamics of the economy can be described by a set of macroeconomic variables. Some authors may argue that this approach cannot be considered realistic as the real economic activity and economic processes might not be perfectly measured by any observable macroeconomic indicators. Despite many debates, the VAR model remains one of the most often used in modelling of monetary transmission processes.

A Vector autoregression approach enables to study impacts of monetary shocks on selected variables and allows a cross country comparison. Even though monetary conditions and thus transmission processes may be different in various countries, the studies show that these differences were not significant in 1990s. (Gerlach and Smets, 1995; Baran, Coudert and Mojon, 1996) The methods used by these authors were based on different estimation strategies but their findings are rather similar. They showed that the response of output to interest rate shocks was not completely identical for a group of EU countries. However, the differences in transmission of monetary policy among the countries (such as Germany, France, Italy and United Kingdom) were not very large. (IMF, 1997) Paper by Angeloni et al. (Angeloni, Mojon, Kashyap and Terlizzesee, 2003) shows that out of the three monetary channels (interest rate channel, asset price channel and credit rate channel) the interest rate channel is the most important for monetary policy transmission in the euro area as it enables the direct pass-through of the monetary shocks (such as tightening or loosening of the monetary policy). Their results also show that the effects of the monetary policy on the output and the prices of the euro area aggregate are consistent with the effects of monetary policy shocks identified within each country. The reaction of the output to an unexpected increase in the short-term interest rate is only temporal and the response of prices is delayed up to four quarters.

In case of the V4 countries, analyses confirm the importance of the interest rate channel in comparison with other transmission channels. (Crespo-Cuaresma, Reininger, 2007) E.g. Hurník and Arnoštová (Hurník and Arnoštová, 2005) used vector autoregression approach in order to analyze transmission mechanism in case of the Czech Republic over the period 1994-2004. Their results show that the unexpected tightening of the monetary policy leads to a fall in output, whereas the prices remains persistent for a certain time and start to fall after approximately two quarters. The exchange rate reacts by immediate appreciation.

Generally, the economic theory suggests that after a monetary contraction output as well as the prices should fall and the exchange rate is expected to appreciate shortly after. However, as noted by various authors, the evidence for opposite behavior of prices or exchange rate can be found in many studies. In case of exchange rates, the reaction may be dependent on the monetary regime. The changes of exchange rates systems or currency crisis may also cause the unusual behavior of exchange rate, when the monetary contraction leads to immediate depreciation instead of appreciation of the exchange rate. This unusual response is sometimes regarded to as the "exchange rate puzzle". (Hurník and Arnoštová, 2005; Popescu, 2012; Mirdala, 2009) As for the behavior of the prices, the atypical behavior appears quite often and is documented by many studies analysing the impact of monetary policy shocks on the price level. This "anomaly" was first noted and "named" price puzzle by Sims and Eichenbaum in 1992. (Castelnuovo and Surico, 2006) Here, the studies offer several possible explanations to the problem of price puzzle; one of them being the misidentification of the monetary policy shock during the regimes associated with a weak response of interest rates to inflation. In other words, what is referred to as a policy shock is actually a combination of a genuine policy shock and some endogenous policy reaction. The other approach by Balke and Emery (Balke and Emery, 1994) explains the existence of the price puzzle in case of the United States by the fact that the FED systematically responds to signals of higher future inflation by raising federal funds rate, but the scope of this reaction is not important enough to prevent inflation from actually rising.

The interest in analyzing transmission processes of monetary policy has increased in recent years especially with regards to recent financial and debt crises. For example Lyziak (Lyziak, 2011) and Demchuk (Demchuk, 2012) use the VAR approach to test the impacts of the crisis on the effectiveness of transmission of monetary policy in case of Poland. One of the most important findings is the fact that the traditional, interest rate channel can be considered as the most affected by the crisis. Effects of financial crisis on interest rates pass-through are also analyzed in the IMF's Global Financial Stability report (IMF, 2012). The report compares the interest rate pass-through to the short-term interest rates as well as to the long-term interest rates in case of euro area and the United States. According this report, the financial crisis marked the transition from the short-term interest rates to the long-term interest rates in both the United States and the euro area. Badarau, Levieuge (Badarau, Levieuge, 2011) analyzed how financial heterogeneity can accentuate the cyclical divergences inside a monetary union. They showed that a common monetary policy contributes to worsening cyclical divergences, in comparison with monetary policies that would be nationally conducted.

Other studies analyze monetary policy with regards to the use of monetary rules. Some authors point out that due to the effect of the crisis it is no longer possible to fully rely on the monetary rules of the Taylor-type. (Sinicakova, Pavlickova, 2011) The main problem seems to be the effectiveness of the short-term interest rate in the times of the crisis when these rates were reduced to levels close to zero. As a result, the transmission to real macroeconomic variables has proved to be relatively insignificant. Even before crisis, some authors stressed the possibility of the problems and lower effectiveness of the interest rate channel using short-term interest rate. They suggested the use of long-term interest rate. (Rudebusch, McGough, Williams, 2005; Mankiw, 2011) However, followers of monetary rules continue supporting the theory of long-term interest rates dependent from short-term interest rates. These rates are determined by the central bank’s estimates of future economic development that is relatively well mirrored by monetary rules. (Taylor, 2009)

Many authors point out that the use of short-term interest rate within the strict monetary rule can be less effective than its management within the inflation targeting framework. They highlight especially the advantages of strategy of inflation targeting such as a transparency and the greater emphasis on medium a long term time horizon. (Mishkin, 2009) Analyzing of the monetary rules together with the interest rate transmission channel in case of countries undergoing convergence process has become more popular only recently. Authors point out that despite the widespread use of the inflation targeting strategy; central banks are still monitoring the evolution of exchange rate. (Frömmel et al. 2011; Zamrazilová, 2011; Mandel, Arlt, 2012)

That is why we tried to apply the vector autoregression approach to member countries of the EMU as well as the EMU candidate countries so as to monitor the transmission via interest rate transmission channel. As for the selected variables of the model we chose gross domestic product, inflation and exchange rate, i.e. the variables that central banks typically use within their monetary rules.

3.3. Econometric Model

In order to analyze the transmission of the interest rate shocks, we will use the Vector autoregression approach. The vector autoregression model is an approach commonly used for modelling the effects of monetary policy on the set of endogenous variables over the sample period of time. For our analysis we estimate the following model:

$$CY_t = A(L)Y_{t-1} + u_t \tag{3.1}$$

where a vector $Y_t = [y_t, e_t, p_t]$ is a N x 1 vector of the contemporaneous endogenous variables with y_t corresponding to GDP, e_t representing nominal effective exchange rate (NEER) and p_t denoting consumer price index. C is a N x N matrix that includes all the coefficients describing the simultaneous relations among endogenous variables of the model, *A(L)* corresponds to a N x N polynomial with coefficients representing relationships among endogenous variables on lagged values. Shocks are represented by $u_{t,}$ - a N x 1 normalized vector of shocks to the model.

Contrary to standard VAR models used to identify monetary shocks we did not include money aggregates in the model. The tested contractionary monetary policy shock is commonly followed by a fall in money for most of the countries. What is more, analyses of other authors indicate that the inclusion or omission of money aggregate in a model did not affect the impact of the short-term interest rate shock on output and prices. (For more see Mojon and Peersman, 2001)

By multiplying equation (3.1) by an inverse matrix C^{-1} we obtain the reduced form of the VAR model (this adjustment is necessary because the model represented by the equation (3.1) is not directly observable and structural shocks cannot by correctly identified). Thus the VAR model described by the equation (3.1) can be rewritten to following representation:

$$Y_t = C^{-1}A(L)Y_{t-1} + C^{-1}u_t = B(L)Y_{t-1} + e_t \tag{3.2}$$

where

$$B = C^{-1}A \tag{3.3}$$

$$e_t = C^{-1}u_t \tag{3.4}$$

B(L) is a matrix describing the relationship among variables on lagged values and e_t is a N x 1 vector of serially uncorrelated errors of the model.

To verify the soundness and accuracy of our results, we estimated and compared two Vector autoregression models. Models were identified through the restriction resulting from the recursive Cholesky decomposition of the residuals for each of the analyzed countries. Final causal impacts of unexpected shocks on the examined variables were summarized in the impulse response functions (IRF functions).

Before staring analysis, it is necessary to test selected time series for stationarity as well as to verify the existence of long-run equilibrium. It is also important to test the model for residual autocorrelation, heteroscedasticity and normality.

3.4. Data and Results for the EMU12 Countries

For the purpose of estimating the effect of the interest rate exogenous shocks on economy of the country we have used the quarterly data from 2002Q1 to 2011Q4 (40 observations) for macroeconomic indicators - gross domestic product, inflation (measured by domestic consumer price index), NEER (nominal effective exchange rate) and interbank offered interest rates for each analyzed country. Time series for the gross domestic product were seasonally adjusted in order to eliminate possible seasonal factors.

Data used in our model were obtained from the International Financial Statistics of the International Monetary Fund, European Central Bank Database, Eurostat as well as from the Bank for International Settlements Database.

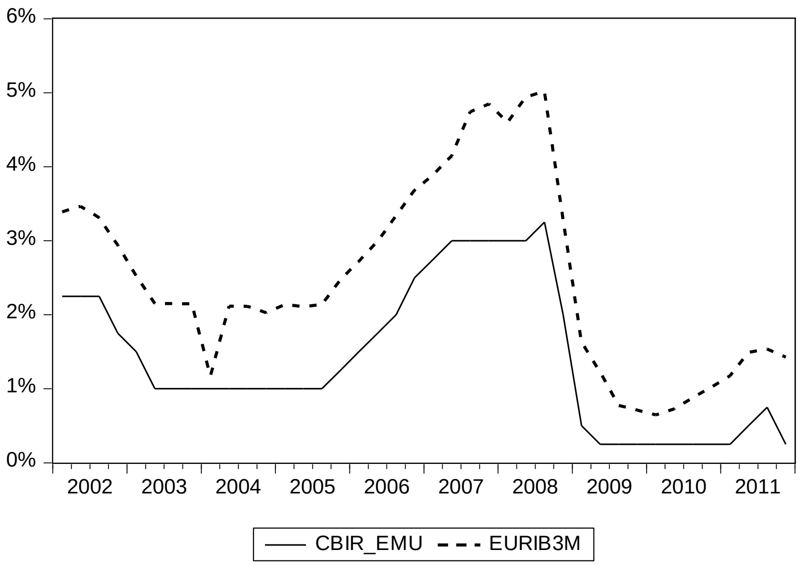
As mentioned before, we estimated two models (A and B) corresponding to two time periods: model A (2002-2007), model B (2002-2011). By applying same method on a time periods of various length we were able to analyze possible impacts of the economic and financial crisis on the transmission process of monetary policy.

3.4.1. Endogenous Variables

In our model we supposed that the monetary decisions concerning the variations of the European key interest rate (two-week interest rate for main refinancing operations) are transmitted to market interest rates, thus the evolution of 3-month EURIBOR rate mirrors the evolution of ECB's monetary policy stance (see the figure 3.1). When compared, the 3-month EURIBOR rate shows high level of correlation to ECB's two-week key interest rate; therefore it can be used for an estimation of the evolution of monetary policy decisions without posing any problem for the analysis.

Figure 3.1 indicates that base interest rate reached the highest level right before the economic crisis. Year 2009 brought about the reversal in the character of monetary policy, changing the stances of central bankers which adopted rather expansionary policies.

Figure 3.1 Interest Rates

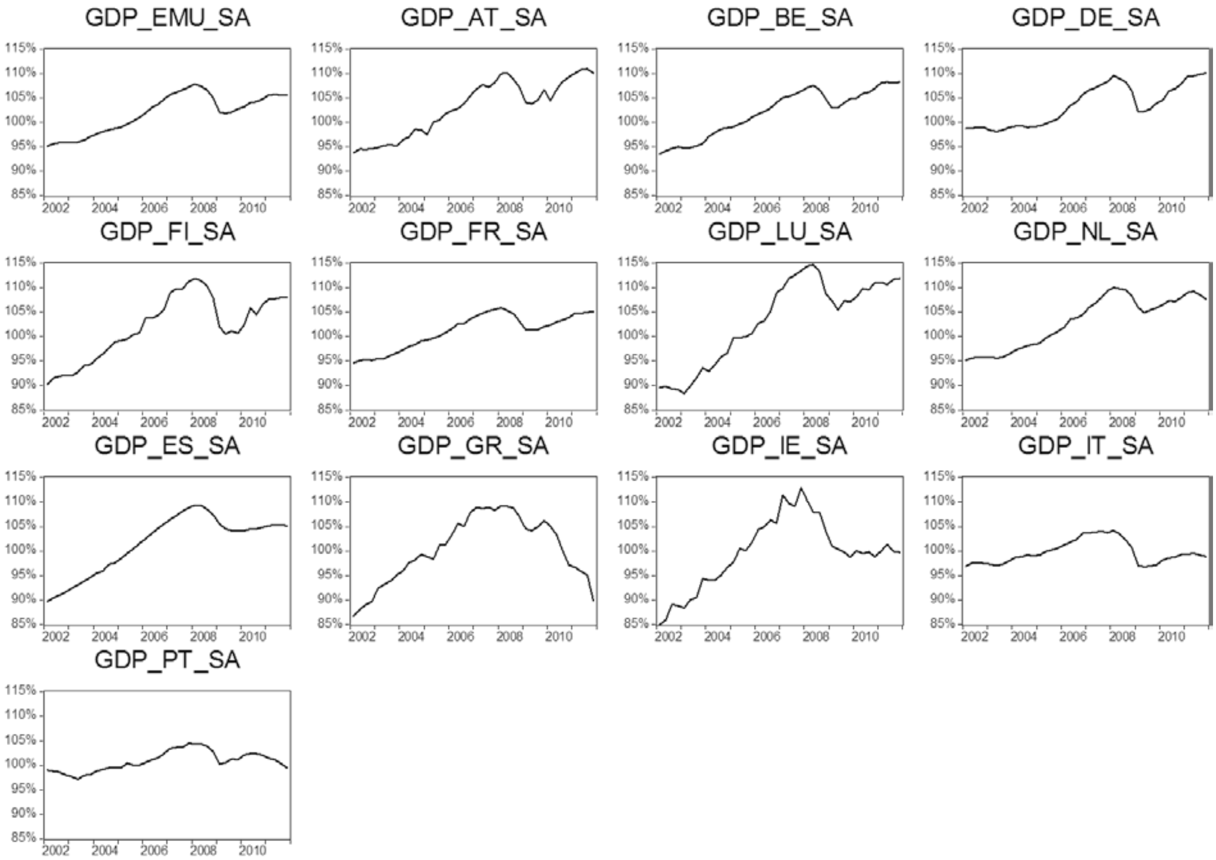


Source: ECB.

The evolution of tested variables used in the model, i.e. GDP, inflation and NEER is presented in Figures 3.2 - 3.4. These figures present evolution of the variables for all of the EMU12 countries separately as well as for the whole EMU12. The countries are ordered as follows: firstly EMU12, then countries of the group n°1 (Germany, France, Netherlands, Belgium and Luxembourg) and lastly the countries of the group n°2 (Portugal, Italy, Greece and Spain, Ireland). As can be seen, the evolution of variables of the countries within groups may be considered similar to some extent. However, when we compare two groups we may notice some differences. Generally, time series of variables by individual countries within each group are following the same trend, mirroring the economic cycle, the crisis in 2008-2009 and the further after-crisis development.

The first analyzed variable was gross domestic product. The development of GDP in the countries of the first group during the observed period 2002 -2011 was very similar to that of the entire euro zone (see figure 3.2, where 2005=100%). Until 2007, GDP globally grew. In certain countries such as Luxembourg or Finland we can follow a stronger growth, in others such as France or Germany, the growth was slower. In 2008, the growth of GDP was stopped by the crisis and GDP slumped considerably. Some countries registered even a decline of GDP compared to 2007. After this year, the GDP growth trend re-establishes.

Figure 3.2 Evolution of GDP



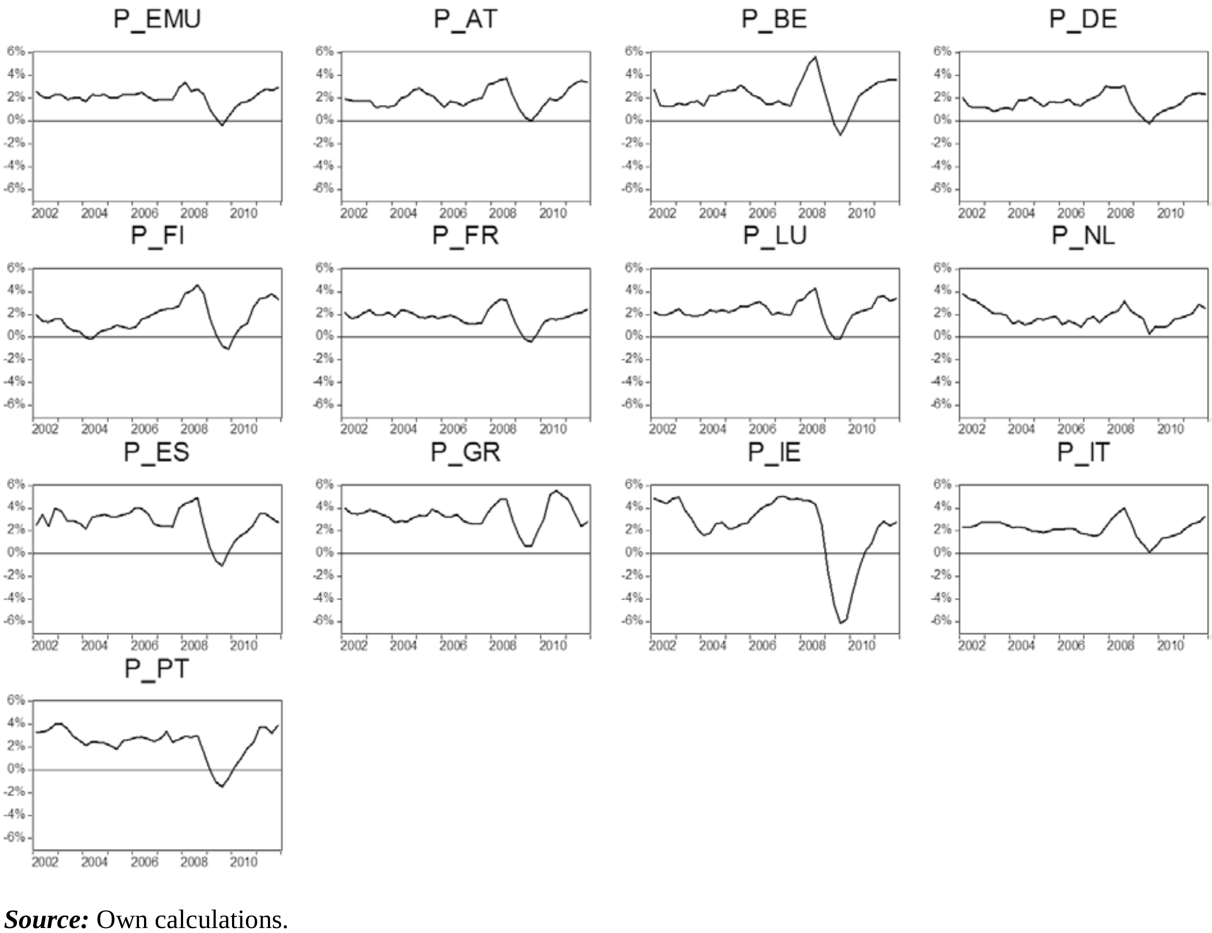
Source: Own calculations.

The second group consists of highly indebted EMU countries that are often, not very favorably, denoted as "PIIGS" countries. Here again we can see a growing trend over the period 2002-2007 that came to a halt in 2008. The slump in GDP was the most prominent in case of Greece and Ireland. Italy and Portugal recorded also a decline in their GDP growth but in their case the previous evolution of their GDP was less pronounced.

Currently, there are many debates going on concerning so-called "PIIGS" countries. Many critics point out that the deepening economic disparities among the euro area economies weaken the common currency and threaten to cause a breakup of monetary union. Despite the continuous attempts to bring and keep all euro area members at the same economic level, differences and asymmetries among countries still persist. The financial and economic crisis expanded these asymmetries while unveiling other, more severe problematic areas. These issues seem to be the most visible in so-called “PIIGS” countries that account collectively for approximately 25% of GDP of the European Union. Many of the current most serious problems may be contributed to previous years of expansionary fiscal policies creating high levels of indebtedness. Since the crisis was accompanied by declines in national incomes and at the same time increasing governmental expenditures, fiscal positions of these countries deteriorated dramatically with the rapidly increasing general government debt. The overall economic situation worsened and unemployment rates increased considerably over the last few years (with some of the countries seeing their rates to triple). However, variables such as unemployment rate or general government debt expressed as a percentage of GDP were not included in our model.

Behavior of inflation in the euro area over the period 2002 - 2007 can be described as relatively stable. Since the end of 2007 to the end of the reporting period the development of inflation has been more volatile. A similar trend can be observed in all surveyed countries with the most volatile inflation behavior in the case of Belgium (see figure 3.3). Some countries registered even slight deflation of prices.

Figure 3.3 Evolution of Price Level

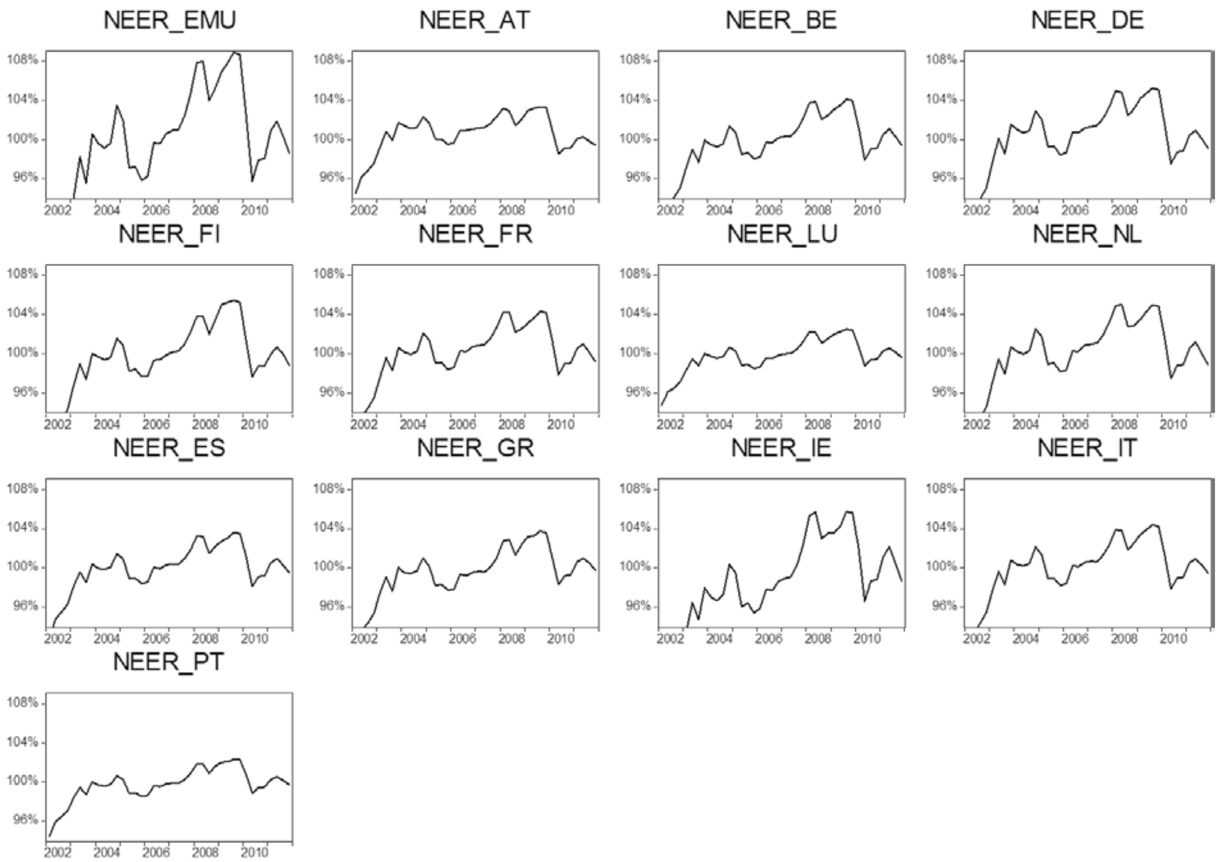


Source: Own calculations.

As for the second group of countries, it is evident that crisis caused inflation to drop. We can see that some of these countries (e.g. Spain or Portugal) equally recorded a slight deflation. Prices were most significantly affected in Ireland with the deflation nearing 6%. Later on prices assumed their initial path.

Generally, countries’ basic instrument in the battle against inflation is monetary policy is the key interest rate. By changing its setting, central bankers influence also the inflation level. However, countries that are members of monetary union are no longer able to employ a proper monetary policy that could help in case of situation such as the economic downturn. On the contrary, they are all exposed to same monetary measures. That is why, considering the existing differences among the EMU12 economies the ECB’s policy may be too strict or inversely too loose depending on the particular situation. Nevertheless, this chapter will not focus on the analyzing whether the monetary measures adopted by the ECB were appropriate or did bring expected results but rather will focus on the differences in process of monetary policy transmission to selected economic variables in two groups of countries.

Figure 3.4 Evolution of NEER



Source: Own calculations.

The last surveyed variable was a nominal effective exchange rate, NEER. NEER is a weighted average value of a country's bilateral exchange rate to all the currencies of the relevant trade partners of a country. The weights are determined by the importance a home country places on all other currencies traded within the pool, as measured by the balance of trade. Based on the figure 3.4, we can follow the evolution of NEER in two groups of countries as well as for the whole EMU12. Here again, it can be concluded, that the development of individual countries is very similar to that of the whole euro area. However, there are no such distinctive differences among two groups as for the GDP and prices. Interestingly, the evolution of NEER by individual countries over the surveyed period seems to be relatively more stable than the evolution in case of overall EMU12. Generally, we can observe a trend of gradual appreciation with the shorter periods when NEER depreciated, then resumed its previous course. As expected, the years of economic crisis are marked with the most prominent depreciation of the surveyed period of 2002-2011. This can be seen in all countries.

3.4.2. Results of the Tests

Before estimation of the model it is important to test selected time series for stationarity and cointegration. Stationarity of time series is an important precondition for a quality of an econometric analysis. To determine the stationarity or non-stationarity of time series we used unit root tests, the Augmented Dickey-Fuller Test (ADF test) and the Phillips – Perron Test (PP test). Both tests verify the zero hypothesis of non-stationarity of time series. In our case, ADF and PP tests indicated that some of the series were stationary at the values. However, testing variables on the first differences indicated that the series were stationary. We can conclude that the variables are I (Table 3.1, 3.2).

As most of the endogenous variables were not stationary on the values and thus had the unit root, it was necessary to test these time series for cointegration. The existence of the cointegration relations between variables was verified by Johansen cointegration test (using two lags as recommended by the Akaike Information Criterion and Schwarz Information Criterion). Johansen´s cointegration test verifies the existence of possible long-term relationships between variables. The results of the cointegration test by both trace and maximum eigenvalue statistics indicated no cointegration among the endogenous variables of the model (Table 3.3).

Table 3.1 Results of the Unit Root Tests for the Whole EMU12 (2002Q1-2011Q4)

EMU	**EURIBOR**		**GDP**		**NEER**		**P**	
	ADF	**PP**	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**
Level	-1.836	-1.679	-1.667	-1.467	-2.886***	-3.465**	-2.789***	-2.351
1st diff.	-4.029*	--4.055*	-2.697***	-2.773***	-5.161*	-5.106*	-4.455*	-4.479*

Note: Data represent results of t-statistics. Null hypothesis cannot be rejected at 1% significance level (*), at 5% significance level (**), at 10% significance level (***).

Source: Own calculations.

Table 3.2 Results of the Unit Root Tests for Selected Countries (2002Q1-2011Q4)

		GDP		NEER		P	
		ADF	PP	ADF	PP	ADF	PP
AT	level	-1.064	-1.081	-2.920***	-3.443**	-4.796*	-2.296
	1st diff.	-5.191*	-5.191*	-4.086*	-4.984*	-4.796*	-3.843*
BE	level	-1.154	-2.814***	-3.538**	-3.538**	-4.514*	-2.356
	1st diff.	-3.936*	-5.205*	-5.180*	-5.180*	-4.939*	-3.645*
DE	level	-1.158	-2.956**	-3.550**	-3.550**	-3.986*	-2.386
	1st diff.	-3.475**	-5.101*	-5.046*	-5.046*	-4.757*	-4.820*
FR	level	-1.475	-1.467	-2.904***	-3.593**	-4.097*	-2.486
	1st diff.	-3.032*	-3.071**	-5.140*	-5.103*	-4.862*	-3.714*
NL	level	-1.511	-1.274	-2.906***	-3.541**	-3.844*	-2.978**
	1st diff.	-2.620***	-2.769***	-5.103*	-5.047*	-3.313*	-6.507*
FI	level	-1.583	-1.648	-2.744***	-3.347**	-3.260**	-2.031
	1st diff.	-4.177*	-4.251	-4.999*	-4.964*	-4.420*	-3.282**
LU	level	-1.267	-1.254	-2.736***	-3.272**	-3.657*	-2.027
	1st diff.	-4.388*	-4.432*	-5.081*	-5.018*	-5.110*	-4.074*
GR	level	-0.496	-1.539	-2.884***	-3.466**	-5.518*	-2.238
	1st diff.	0.630	-2.747***	-5.414*	-5.398*	-7.224*	-3.424**
	2nd diff.	-7.398*					
ES	level	-2.023	-2.191	-2.911***	-3.614***	-2.957**	-2.450
	1st diff.	-1.763	-1.898	-5.230*	-5.223*	-5.299*	-4.580*
	2nd diff.	-7.213*	-7.125*				
IT	level	-1.864	-1.763	-2.997**	-3.717*	-3.128**	-2.332
	1st diff.	-3.524**	-3.642*	-5.199*	-5.161*	-2.188	-2.988**
PT	level	-1.575	-2.856**	-2.856**	-3.566**	-2.329	-1.915
	1st diff.	-4.084*	-5.275*	-5.275*	-5.249*	-3.605**	-3.623*
IE	level	-1.922	-2.143	-3.220**	-3.341**	-3.615**	-1.981
	1st diff.	-1.882	-6.151*	-5.254*	-5.202*	-3.632*	-2.711***
	2nd diff	-10.31*					

Note: Data represent results of t-statistics. Null hypothesis cannot be rejected at 1% significance level (*), at 5% significance level (**), at 10% significance level (***).

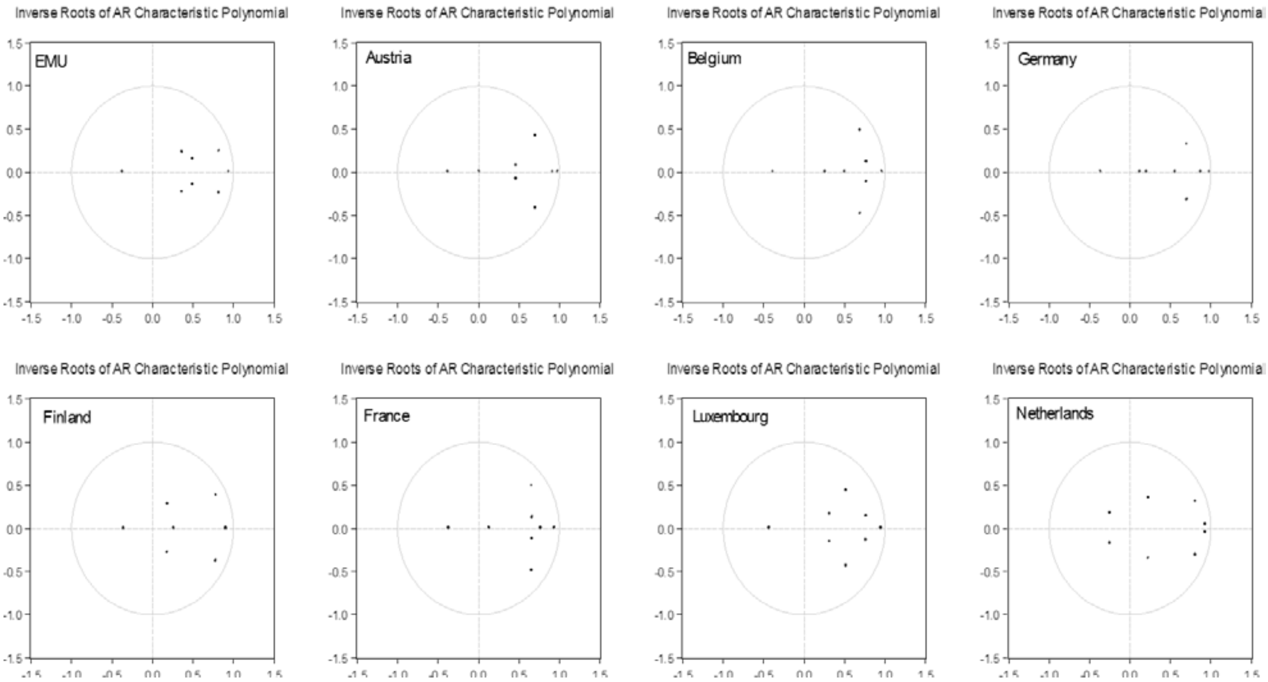
Source: Own calculations.

Table 3.3 Results of the Cointegration Tests (2002Q1-2011Q4)

	Number of equations	Trace Statistics	0.05 Critical Value	Eigenvalue	0.05 Critical Value
EMU	none	46.99179	47.85613	25.29037	27.58434
AT	none	34.73298	47.85613	20.73323	27.58434
BE	none	40.68194	47.85613	22.66434	27.58434
DE	none	38.73502	47.85613	23.95584	27.58434
FR	none	52.72919	47.85613	29.49587	27.58434
NL	none	43.56354	47.85613	19.33443	27.58434
FI	none *	49.62818	47.85613	23.33043	27.58434
	at most 1	26.29775	29.79707		
LU	none	46.42373	47.85613	22.86221	27.58434
GR	none	53.56961	55.24578	29.04483	30.81507
ES	none *	66.34219	55.24578	35.70091	30.81507
	at most 1	30.64127	35.01090	18.78474	24.25202
IT	none *	68.39192	54.07904	35.02508	28.58808
	at most 1	33.36683	35.19275	16.81875	22.29962
PT	none *	68.27519	63.87610	31.05840	32.11832
	at most 1	37.21679	42.91525		
IR	none *	32.69974	24.15921	32.69974	24.15921
	at most 1	12.78933	17.79730	12.78933	17.79730

Source: Own calculations.

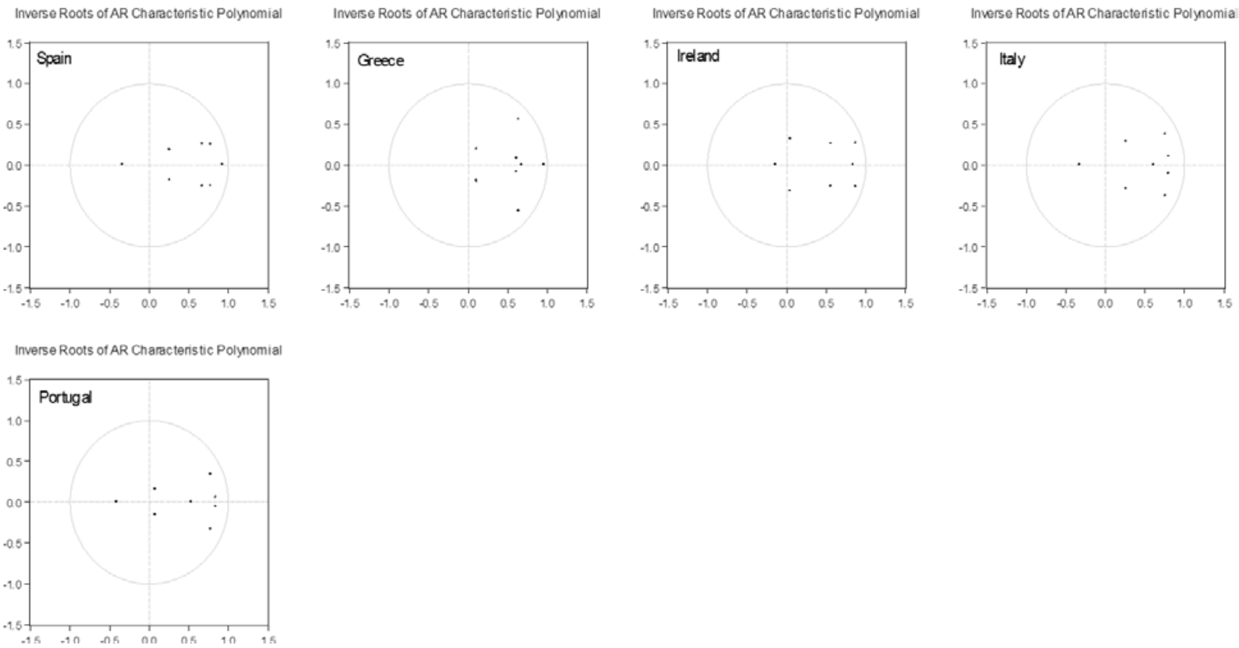
Figure 3.5 AR Roots Test for the First Group of Countries



Source: Own calculations.

The stability of the model was tested with the help of AR roots test. This test verifies whether the inverted roots of the models for each country lie inside the unit circle. Using the graph for AR roots test (Figure 3.5, 3.6) we can see that none of the points exceeds the circle, even though some of the roots are near unity in absolute value. Nevertheless, the estimated VAR models for each of the selected countries were considered stable.

Figure 3.6 AR Roots Test for PIIGS Countries



Source: Own calculations.

Following the results of the unit root and cointegration tests we estimated the model using the variables in the first differences. We calculated the impulse-response functions for each EMU country. The results are presented in following sections and summarized in the tables as well as the figures.

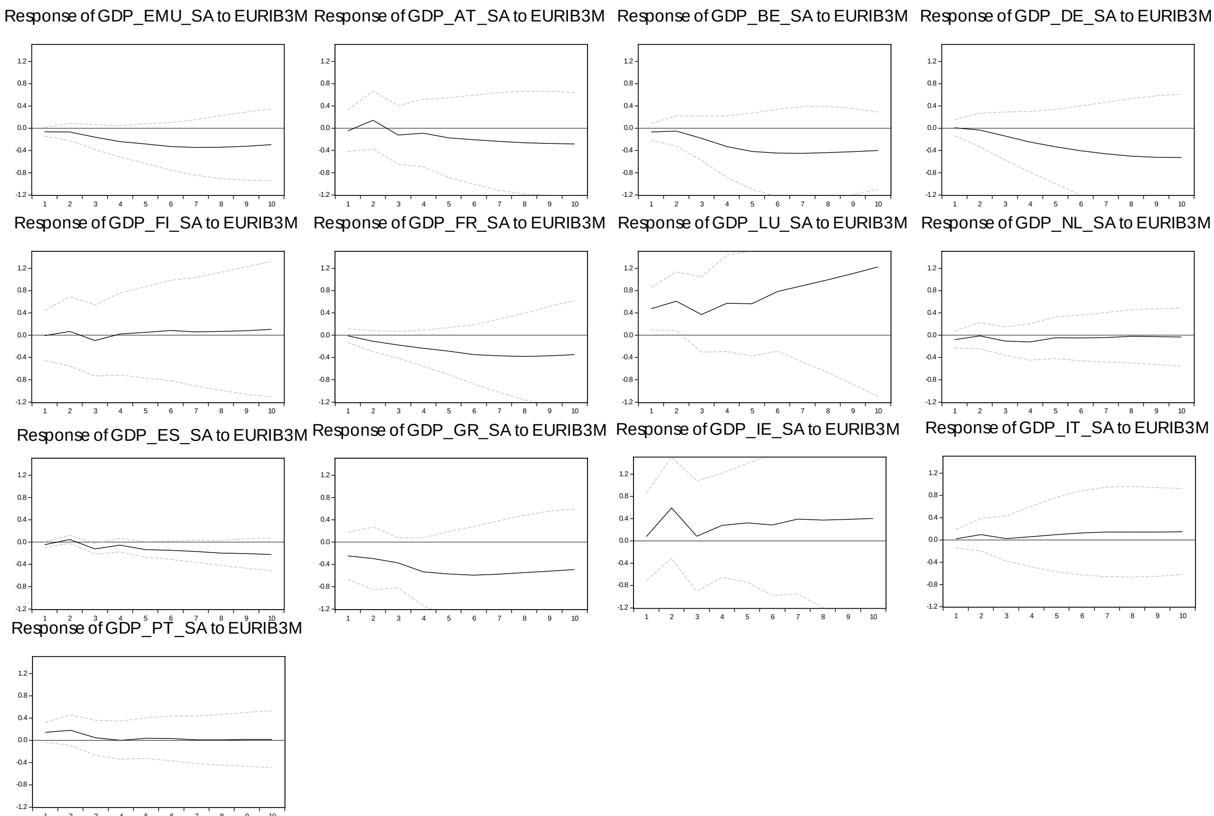
3.4.3. Impulse-Response Functions

Estimated vector autoregression model enables to analyze impulse response functions for selected endogenous variables. The results are grouped by variables so as to be able to compare the similarities or differences in responses for each country. We focused solely on the response of endogenous variables to changes in interest rate. The estimated response of variables on monetary policy shock is observed over the period of 10 quarters after initial shocks.

As mentioned previously, in case of unexpected monetary tightening (monetary policy shock in the form of sudden increase of interest rate) the theory suggests the following behavior of surveyed variables over the short time: an output decline, a price level decline (with possible time lags) and the appreciation of the country's exchange rate.

Model A - Reaction of GDP, Period of 2002-2007

Figure 3.7 Impulse-Response Function for GDP (2002-2007)



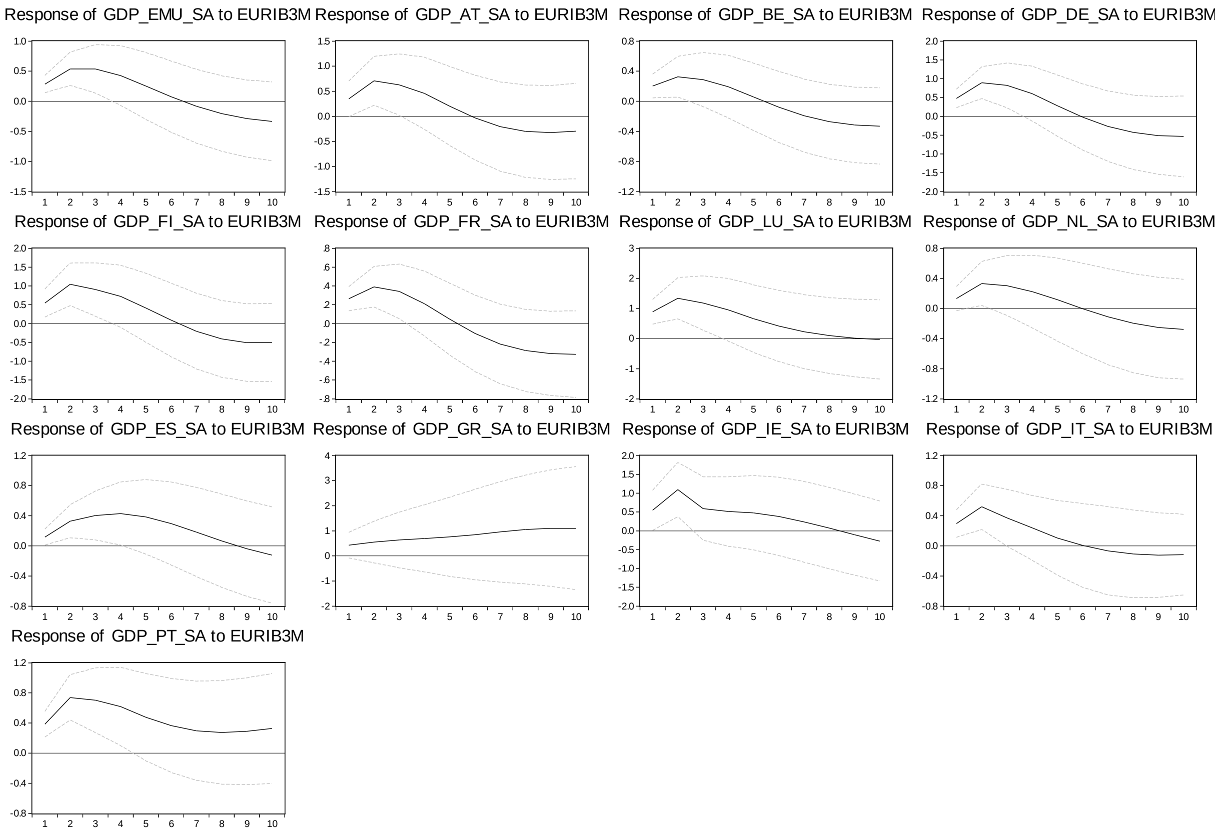
Source: Own calculations.

Next graphs (Figure 3.7) depict IRF function for GDP over shorter time period of 2002-2007. As for the evolution of GDP, its response to interest rate shock is expected to follow a downward trend in short term. It can be explained by the adverse reaction of the major GDP components (demand and investment) which usually start to decline after short-term interest rate increase. Subsequently a total GDP is affected as well. This evolution was equally confirmed by the tests for most of the countries. We can therefore say that the unexpected monetary tightening in the form of the short-term interest rate increase generally caused a fall in GDP.

Firstly we focused on the shorter period with countries' data up to 2007. In some countries the reaction of GDP was slightly lagged. When we compare the response of GDP in the EMU12 and in its member countries, we can see it is similar. These results confirm that the tightening of the monetary policy in the EMU did constrict the GDP growth and can be considered as being effective over the surveyed period. However the differences can be found in the intensity of the response. A weak response can be observed e.g. in Finland or the Netherlands. The reaction that was a most different from that of the EMU12 or member countries in general was that of Luxembourg's GDP. Here we can see a positive reaction. It may be related to the fact that Luxembourg is a small and very open economy that is tightly linked to all neighboring countries which may cause the independence of its GDP development from the course determined by the ECB.

Model B - Reaction of GDP, Period of 2002-2011

Figure 3.8 Impulse-Response Function for GDP (2002-2011)



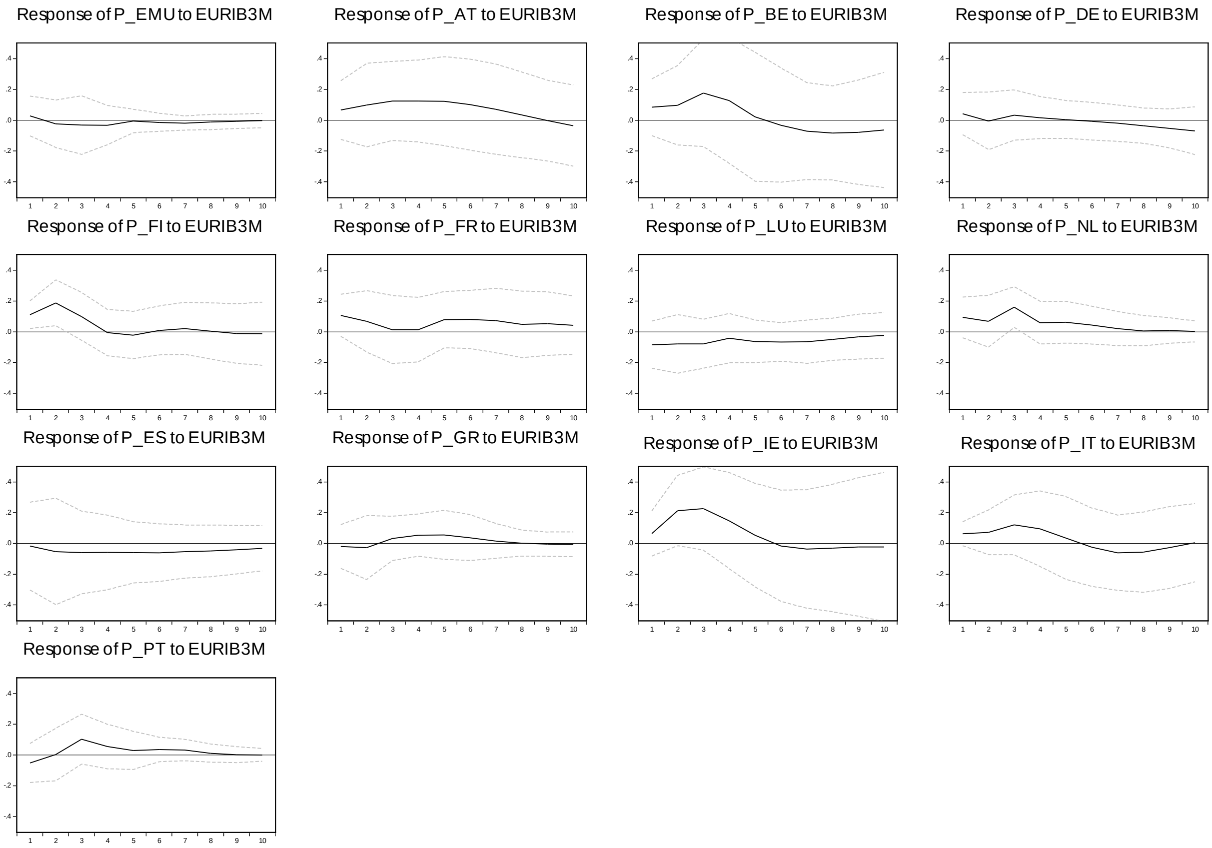
Source: Own calculations.

We also tested the response of GDP over the longer period so as to compare whether this reaction would indicate an impact of economic crisis. Contrary to a period of 2002-2007, here we see a much higher similarity in a reaction of individual countries as well as between these countries and the EMU12. All graphs (Figure 3.8) show firstly an initial increase in GDP that is replaced by its decline after approximately two quarters. This can be observed in all member countries with the exception of Greece.

Model A - Reaction of Prices, Period of 2002- 2007

We also tested the response of the prices to interest rate shock. Here the theory indicates that the increase of interest rate should slow down the increase of prices causing the inflation rate to drop down. However, as explained previously, sometimes an unusual behaviour (such as a sluggish or even positive response of prices after an unexpected monetary tightening) can appear. However, a price puzzle, as it is denoted by various authors, is not a completely atypical result.

Figure 3.9 Impulse-Response Function for Prices (2002-2007)



Source: Own calculations.

The following figure 3.9 depicts the impulse-response functions for price level over the period 2002-2007. We can see that the expected downward trend appears but not immediately as for the output series and not in all analyzed countries. The expected reaction was confirmed in the euro area with the lag of one quarter but in the mid-term these effects disappear. A slightly lagged reaction can also be observed in the case of France and Luxembourg; for Belgium, the reaction is lagged by five quarters. It should be noted that in all cases the reaction is relatively weak. As for the countries of the second group, there again we can observe certain lag for a price decline. In most countries the lag was within an average interval of 1-4 quarters (Portugal, Italy, Greece and Ireland).

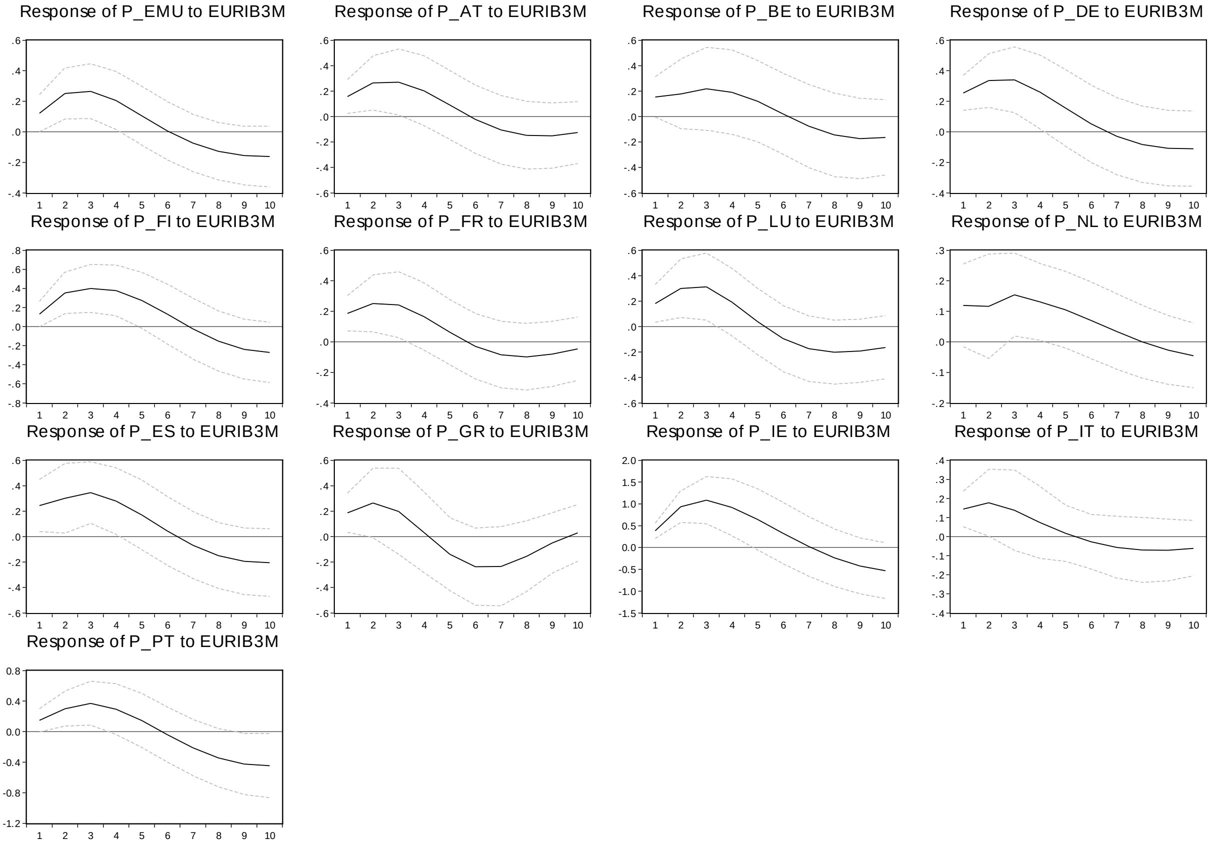
Lagging reactions of macroeconomic variables to policy measures can be generally explained by time delays in the transmission mechanism of monetary policy. They are rather common and may cause that the changes in interest rates settings manifest themselves in some countries sooner than in the others. As a result, transmission processes in countries of monetary union cannot be considered as entirely identical in speed and exact results which was confirmed also by our analysis.

The ECB's sole monetary objective is the price stability with a clearly defined target level of the inflation. In times when key monetary indicators show an upward trend in European inflation, the ECB always reacts by adjusting the short-term interest rate equally upward. Balke and Emery point out that such a behavior of central bank in some cases may not be important enough to prevent inflation from actually rising. (Balke and Emery, 1994) Using this logic we can argue that due to existing differences and asymmetries among the EMU countries, the ECB's restrictive monetary policy may not be restrictive enough to really assure the expected response in price level (or on the contrary, may be too restrictive given the country‘s particular economic situation). This explanation seems to be valid for example in case of Ireland (after year 2000) that experienced high levels of economic growth accompanied with inflation levels exceeding the ECB's inflation target of 2%. The ECB's monetary policy with low short-term rates might have been thus considered as counterproductive for Ireland.

Model B - Reaction of Prices, Period of 2002- 2011

Model B represents the reaction of prices over the longer period. Similarly to model B for GDP, we can observe a different as for the shorter period (model A). Figure 3.10 for the EMU12 as well as for individual countries indicate almost identical development. In this case we expect that monetary tightening will cause a decline in price level. This reaction is lagged and appears only approximately after three quarters. There are no significant differences in the reaction of the countries. The higher similarity of the reaction in the longer period suggests that the differences between countries are getting less prominent in the long-run.

Figure 3.10 Impulse-Response Function for Prices (2002-2011)



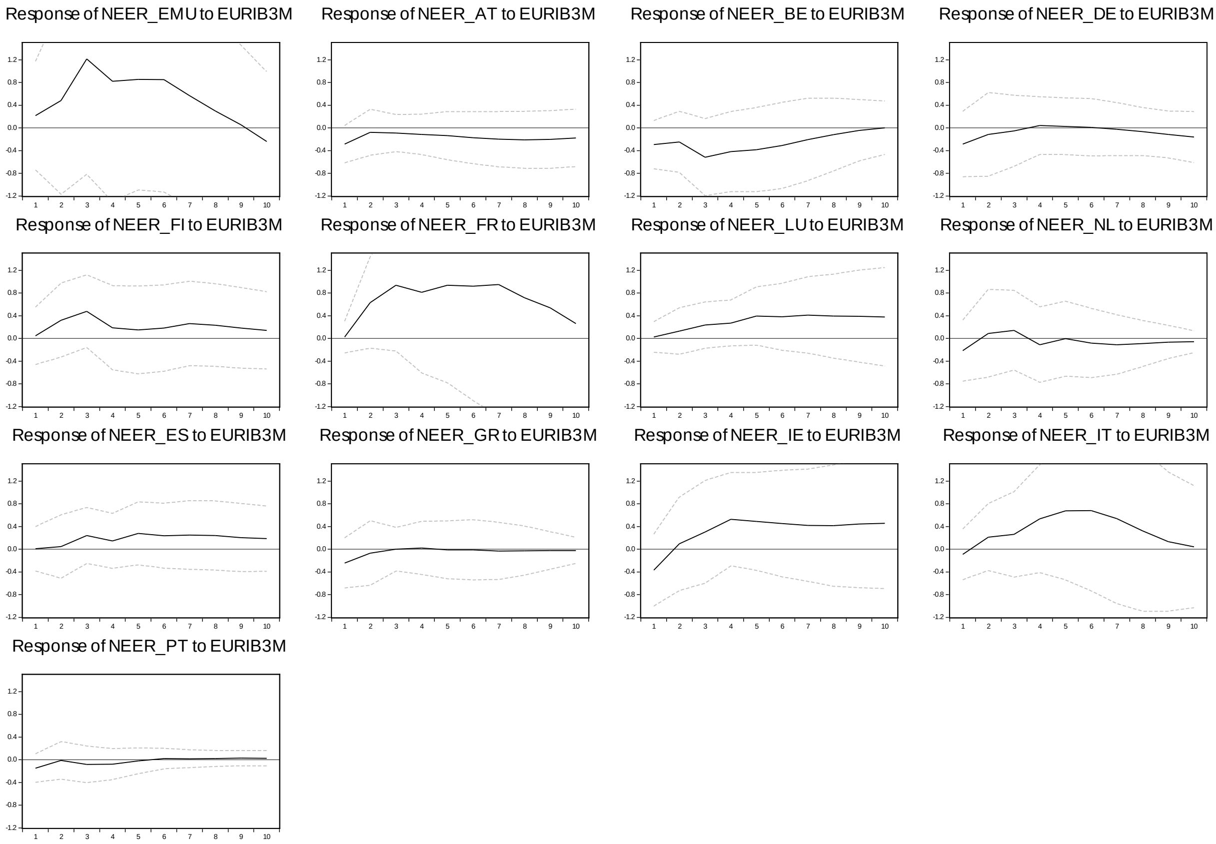
Source: Own calculations.

Model A - Reaction of NEER, Period of 2002-2007

The last variable tested for impulse-response functions was exchange rate. Here the theory indicates that the increase of interest rate should be accompanied by the inflows of foreign capital causing the country‘s exchange rate to appreciation. Based on the figure 3.11, we can follow the evolution of NEER after the positive interest rate shock in the individual countries and for the whole EMU12. Here again, we can see that the development in individual countries, despite not being identical, is very similar to that of the whole euro area. In some cases the appreciation of the exchange rate is lagged by several quarters. What is more, the reactions differ in their volume.

The development of NEER for the EMU12 corresponds with expected positive reaction of NEER. The intensity of the initial reaction increases even more after two quarters. Impulse is lost after nine quarters. Similar but not as strong reaction can be observed in the case of France and Luxembourg. The basic hypothesis was not verified in the case of Germany, Belgium and the Netherlands. As for the second group of countries, most of them recorded an appreciation of NEER though it was slightly lagged. The weakest reaction was observed for Greece and Portugal.

Figure 3.11 Impulse-Response Function for NEER (2002-2007)

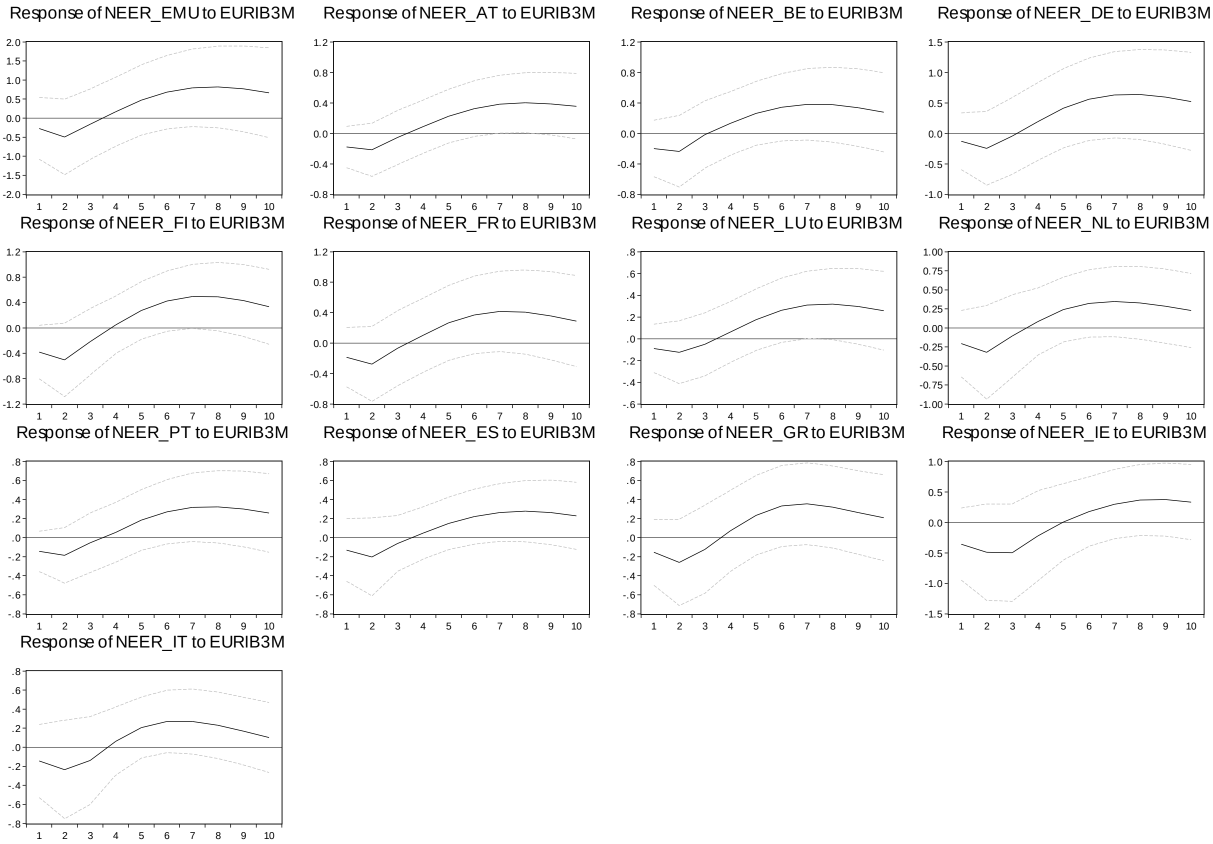


Source: Own calculations.

Model B - Reaction of NEER, Period of 2002-2011

Model B monitors a reaction of NEER to the interest rate shock over the longer period of 2002-2011. As mentioned before, the increase in short-term interest rate is supposed to cause an appreciation of exchange rate (or an increase of NEER). Even though this expected appreciation appears, it is not directly after the initial impulse. In most cases it appears after two quarters. However, we must also point out that the intensity of the reaction is not identical for all member countries (Figure 3.12).

Figure 3.12 Impulse-Response Function for NEER (2002-2011)



Source: Own calculations.

3.4.4. Variance Decomposition - Endogenous Variables

Based on the estimated model it was possible to make a variance decomposition of endogenous variables - GDP, prices and NEER. Table 3.4 shows the contributions of changing interest rate EURIBOR to variability of GDP, prices and nominal effective exchange rate in case of overall EMU12 as well as in case of individual countries.

The results for the euro area indicate a significant influence of EURIBOR on GDP over the period of 2002-2007 (35.9%). This influence increases over time. When compared to results for individual countries it is obvious that such a significant impact cannot be observed in all EMU12 members. Countries such as Netherlands, Austria, Finland, Italy, Ireland and Portugal showed lower influence. On the other hand, France and Spain recorded even stronger contribution of EURIBOR to variability of GDP (France: 63.47%, Spain: 51.04%).

As for the price level, here we expected a high sensibility to changes of interest rate. However, the variance decomposition showed surprisingly only small contribution of EURIBOR to variability of GDP (3.27%). Again, these findings were not confirmed for individual countries and the results indicated a higher influence within the interval of 15-25% for e.g. France, Netherlands, Italy, Ireland, Finland and Luxembourg. The most often, the reaction was getting stronger with the passing time.

The last analyzed variable was nominal effective exchange rate. In case of the EMU12 it is possible to observe the most significant influence after 12 quarters from the initial change in EURIBOR (19.88%). This result was not confirmed for Netherlands, Germany, Finland, Greece and Portugal. Here the influence remained within the interval 3-10%.

Generally we can conclude that out of the analyzed variables, the strongest impact (in %) of the change in EURIBOR was observed in case of a country's GDP. Nevertheless, as it is evident from the Table 3.4, a variability of GDP, prices and NEER can be caused and affected equally by other variables, not included in our model.

Table 3.4 Variance Decomposition of Endogenous Variables (2002Q1-2007Q4)

EMU	**GDP_SA**	**P**	**NEER**	**AT**	**GDP_SA**	**P**	**NEER**
1	10.76932	0.850188	0.935507	1	0.315510	2.149208	12.80155
3	14.98055	1.914235	10.00401	3	1.915533	5.818480	10.22759
6	36.11129	2.850700	17.77033	6	3.041534	11.14459	8.924976
12	35.96022	3.273967	19.88475	12	8.472873	7.719731	13.51186
BE	**GDP_SA**	**P**	**NEER**	**DE**	**GDP_SA**	**P**	**NEER**
1	3.685254	3.727871	8.468942	1	0.026985	1.750807	4.314819
3	5.602542	9.408313	22.63734	3	1.975114	1.544776	3.346991
6	22.10867	10.15335	29.51107	6	8.688519	1.556404	3.042997
12	35.55139	10.75195	27.84862	12	16.17737	6.541666	5.057710
FR	**GDP_SA**	**P**	**NEER**	**FI**	**GDP_SA**	**P**	**NEER**
1	0.125695	10.45832	0.138655	1	0.004246	23.91415	0.151140
3	17.95770	9.811315	23.64141	3	0.507280	37.00290	11.53996
6	46.72336	15.01866	39.60682	6	0.431422	25.40234	9.119693
12	63.47415	20.27808	45.00869	12	0.600214	12.85580	10.64948
NL	**GDP_SA**	**P**	**NEER**	**LU**	**GDP_SA**	**P**	**NEER**
1	4.756261	8.691005	2.842685	1	24.71025	5.306369	0.160611
3	4.016074	25.73854	2.162061	3	24.72314	10.16507	6.464291
6	3.352385	26.98489	2.499934	6	26.10766	12.61422	25.58227
12	1.332252	24.72688	3.189836	12	38.23862	15.30257	46.66870
GR	**GDP_SA**	**P**	**NEER**		**GDP_SA**	**P**	**NEER**
1	6.170433	0.342297	5.308979	1	14.57933	0.066557	0.007572
3	14.40609	0.972945	3.569682	3	31.03238	1.239094	3.292637
6	23.60240	3.695327	2.933272	6	34.66976	3.073383	9.016880
12	29.00831	3.747031	3.071050	12	51.04473	4.502910	16.17270
IT	**GDP_SA**	**P**	**NEER**	**PT**	**GDP_SA**	**P**	**NEER**
1	0.259952	11.05393	0.736372	1	10.91922	3.087405	6.024828
3	1.505936	15.29359	5.428450	3	9.427063	8.231131	4.528543
6	2.389492	12.95653	22.03772	6	3.648285	9.059045	4.091169
12	6.622171	11.02200	16.87595	12	1.375775	8.955587	3.856285
IE	**GDP_SA**	**P**	**NEER**				
1	0.189205	3.398598	5.985605				
3	6.496150	22.00614	5.054261				
6	6.811609	13.32476	14.74780				
12	9.729595	9.173848	25.07190				

Note: Cholesky ordering: EURIB3M GDP_SA, P, NEER.

Source: Own calculations.

The next step was to extend the analysis so as to cover the years of economic crisis of 2008-2011 (Model B). Adding of these years led to a change in contributions of interest rate shocks to variability of analyzed variables. (Table 3.5)

Table 3.5 Variance Decomposition of Endogenous Variables (2002Q1-2011Q4)

EMU	**GDP_SA**	**P**	**NEER**	AT	**GDP_SA**	**P**	**NEER**
1	33.88845	9.987223	1.173817	1	9.596934	13.56455	4.491298
3	34.95727	33.59046	2.893923	3	24.64752	23.30497	5.730960
6	22.30419	36.55599	7.307510	6	17.01191	25.04084	13.63698
12	26.25392	44.09607	17.95679	12	16.02578	29.69203	35.65291
BE	**GDP_SA**	**P**	**NEER**	DE	**GDP_SA**	**P**	**NEER**
1	15.98634	9.411988	3.016519	1	33.42066	41.11222	0.807415
3	16.21210	8.675137	3.600847	3	46.57506	58.19813	1.953764
6	9.660438	9.521135	8.963796	6	30.72127	60.62856	11.54421
12	20.98284	12.77649	18.13770	12	29.41877	61.68127	31.62451
FR	**GDP_SA**	**P**	**NEER**	FI	**GDP_SA**	**P**	**NEER**
1	36.33843	23.99959	2.360260	1	20.29583	9.729598	8.248336
3	36.15795	29.26168	3.894431	3	38.59984	41.53320	13.04402
6	21.58172	29.73843	9.034039	6	23.84283	38.95870	16.98198
12	35.67195	29.22801	19.18046	12	24.12158	41.95738	23.92424
NL	**GDP_SA**	**P**	**NEER**	LU	**GDP_SA**	**P**	**NEER**
1	6.952596	7.869653	2.344427	1	39.23616	14.60447	1.678284
3	13.33392	16.81599	4.070060	3	46.15036	29.88136	2.845411
6	13.33392	22.26252	7.006688	6	38.30633	30.69222	11.29876
12	7.134303	22.83350	10.69791	12	31.14042	40.19025	31.75853
GR	**GDP_SA**	**P**	**NEER**		**GDP_SA**	**P**	**NEER**
1	6.997997	14.35717	2.079216	1	11.42927	13.76321	1.645953
3	7.768034	14.17949	4.868480	3	22.62743	25.56153	3.353067
6	8.083747	17.43874	10.26646	6	16.38477	23.91013	6.649040
12	11.00237	19.14625	15.32978	12	13.38268	26.73821	14.96525
IT	**GDP_SA**	**P**	**NEER**	PT	**GDP_SA**	**P**	**NEER**
1	24.12205	22.44637	1.489339	1	41.98260	9.390400	4.750997
3	32.89228	16.20589	3.642456	3	63.13084	30.22776	6.391109
6	13.58452	14.74266	6.955506	6	56.66740	29.86409	13.90999
12	13.58452	13.72608	8.905907	12	54.02334	54.95883	33.44129
IE	**GDP_SA**	**P**	**NEER**				
1	10.44411	40.39077	3.770709				
3	25.51197	68.60431	9.478530				
6	17.10577	56.61740	9.701887				
12	15.23679	56.45230	13.34478				

Note: Cholesky ordering: EURIB3M GDP_SA, P, NEER
Source: Own calculations.

The results for the whole EMU12 show a significant increase of influence of EURIBOR in case of prices (44.09%) and the slightly less pronounced reaction for GDP (33.88%) and NEER (17.95%) after passage of 12 quarters. When we look at the results by countries, we can see the impact of interest rate on GDP decreased considerably only in Greece (11%) and in France (36.33%). All other countries registered a reaction that was stronger than that of shorter period. It was especially case of Portugal (63.13%), Germany

(46.57%), and Finland (38.59%). The biggest change occurred for prices. Here the influence increased for all analyzed countries, namely in case of Ireland (68.60%), Germany (61.67%) and Portugal (54.95%). The variance decomposition of NEER indicated a less pronounced effect of the change in EURIBOR that was getting stronger with the passing quarters e.g. for Belgium (18.13%), France (19.18%), Italy (8.9%) and Ireland (13.34%). Countries like Austria (35.65%) or Portugal (33.44%) saw the stronger influence almost immediately. For the extended period, our analysis indicated the strongest impact on price level.

Findings of variance decomposition of variables enable to draw several conclusions. In case of the EMU 12, the interest channel seemed effective in influencing selected variables. This was evident especially when we compared two periods (models A and B). The most important change was registered for prices in the extended period. The results also showed a significant impact on the variability of GDP.

When we compared the overall results with results for individual countries it can be stated there are significant differences. We can find countries with the reactions that are rather similar to those of the EMU12. However, this was not confirmed in most of the cases. Therefore we can conclude that the effectiveness of monetary policy interest rate channel in influencing particular variables is considerably different in various EMU12 countries.

3.5. The V4 Countries

The four Central European countries, the Slovak Republic, Czech Republic, Hungary and Poland, are often referred to as the so-called Visegrad countries, or briefly the V4 countries. When we look closer at their macroeconomic policies and the evolution of their economies over the last two decades, it is possible to find many similar or identical features. Each of these countries had to overcome the so-called transformational depression that had been brought about by the change of orientation of their national macroeconomic policies from command economy to market economy. This initial economic situation had been very similar with many common features including the fall of GDP growth rates, considerable rise in consumer prices as well as in unemployment rates which resulted in the necessity to stabilize the economy.

During the first years of transformation V4’s central bankers opted for traditional monetary or exchange rate targets as the main monetary anchors. However, liberalized markets together with gradually liberalized capital flows and strong foreign trade links between countries have reduced considerably the efficiency of traditional transmission channels. This caused the shift of monetary policy to “new strategies” based on direct or indirect targeting of the inflation rates. Increased capital mobility and gradually improving macroeconomic situation of these four countries also led to modification of exchange rate regimes; from some form of pegged regime to less strict ones, such as the managed floating. The constantly changing environment, together with the ever-growing volumes of foreign capital inflows, either in the form of the long-term foreign direct investment or the short-term speculative capital, are weakening, or even eliminating the impacts of adopted monetary policy measures. Thus monetary policy makers need to monitor and take into consideration not only domestic but also the foreign factors. Especially in small open economies, the impact of foreign factors can be even more important than that of domestic factors what reduces considerably the autonomy of national monetary policy.

3.5.1. Data and Results for the V4 Countries

For the purpose of estimating the effect of the interest rate exogenous shocks on economies of the V4 countries we have again used the quarterly data from 2002Q1 to 2011Q4 (40 observations). Data covered the evolution of three macroeconomic indicators analyzed also for EMU countries that is gross domestic product, inflation (measured by domestic consumer price index) and nominal effective exchange rate for each analyzed country. Time series for the gross domestic product were seasonally adjusted in order to eliminate possible seasonal factors. Data used in our model were obtained from the International Financial Statistics of the International Monetary Fund, databases of national Central Banks and Bank for International Settlements as well as from the European Central Bank Database.

The structure of this section will be the same as for the EMU countries. Here again, we estimated two models (A and B) corresponding to various time periods: model A (2002-2007), model B (2002-2011). By applying same method on time periods of various lengths we were able to analyze possible impacts of the economic and financial crisis on the transmission process of monetary policy. The V4 countries, unlike the EMU members, still have a possibility to carry on their own monetary policies even though it may be limited to some extent by their high levels of openness. In case of Slovak Republic the last years of the analyzed period (from 2009 onward), the country became member of the EMU and the National Bank of Slovakia became integrated to the Eurosystem.

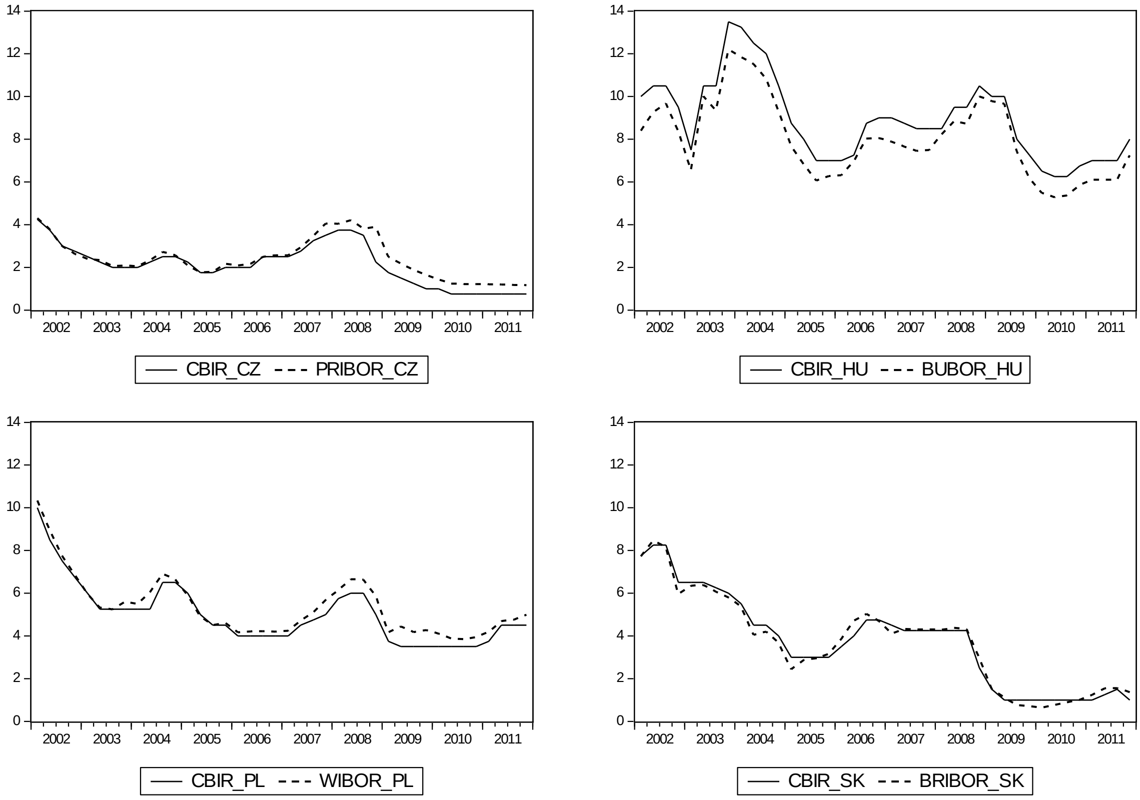
3.5.2. Endogenous Variables

Same as for the EMU members, we started with an assumption that monetary policy decisions concerning the variations of key interest rates are transmitted to market interest rates. Central banks of the V4 countries usually use two-week interest rate for main refinancing operations as a key interest rate. Changes in its setting affect short-term money market rates, such as 3-month rates, in particular PRIBOR in the Czech Republic, BUBOR in Hungary, WIBOR in Poland and BRIBOR in Slovakia (BRIBOR was replaces by EURIBOR rate for the period of 2009-2011 as Slovakia entered a monetary union).

Following figures illustrate the evolution of key interest rate of central banks together with the 3- month money market interest rate for each of the V4 counties. We can see that there were no significant deviations in the evolution of 3-month rate. For all four countries it copies the trend of the key interest rate that is determined for 2-weeks period. As these two rates show high levels of correlation, we used 3-month interest rate to estimate the evolution of monetary policy decisions and its overall stance (see figure 3.13).

Figures for the V4 countries do not indicate a same evolution in all four countries. There is a discernible downward trend in case of Slovakia and to some extent also in Poland and the Czech Republic. The evolution of interest rates in Hungary was the most volatile with two important peaks. However we can find two common characteristics almost in all four graphs: there was a decrease of interest rates at the beginning of the observed period that ended around 2004-2005.

Figure 3.13 Interest Rates (2000-2011)

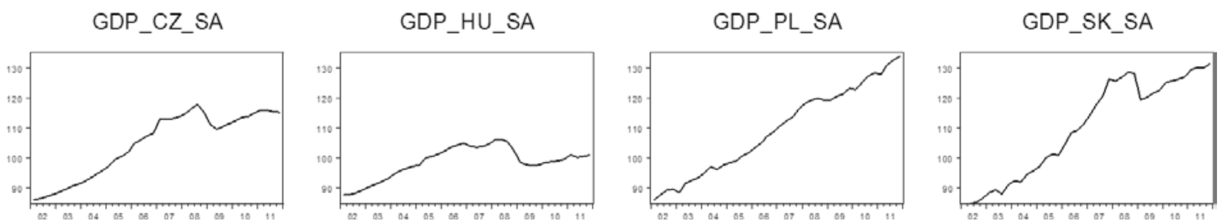


Source: National central banks, ECB.

In years of economic crisis interest rates increased and reached their maximums around 2008. After this year they were adjusted to lower levels in order to stimulate economic activity. However, the case of Hungary is a bit specific. We can see two “peaks” in the evolution of interest rates, i.e. 2003 and 2008. While the second can be connected to economic crisis, the first one is specific only for this country. A soaring in interest rate was a response of Hungarian central bank to previous speculative attack of investors.

Evolution of three analyzed variables over 2002-2011 was marked with considerable volatility and in some cases we cannot find a common trend for all four countries.

Figure 3.14 Evolution of GDP in the V4 Countries (2005=100)



Source: IMF.

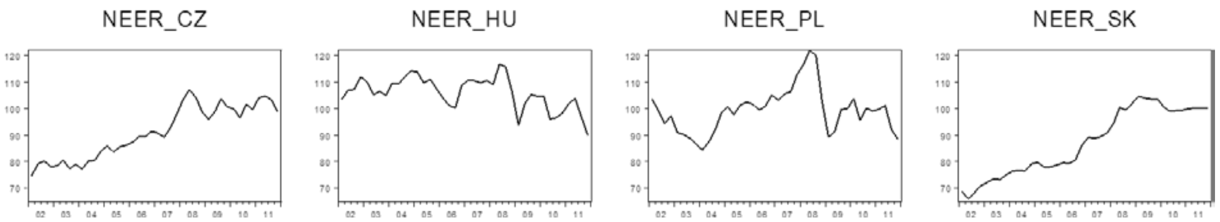
Firstly we looked at the evolution of gross domestic product (Figure 3.14). We can see that the highest growth occurred in case of Slovakia and Poland, followed by the Czech Republic. The economy of Hungary was similar to other three countries in the first half of the observed period even though the growth was less pronounced. In 2008, GDP slumped and the next years brought only a slight recovery. In 2011 the GDP was still at lower level than it was before crisis. The crisis marked GDP growth also in Slovakia and the Czech Republic leaving Poland as the only "unaffected" country. In this case, the GDP growth was only slowed down and Poland was the only European Union country that managed to avoid a recession.

Nominal exchange rate was the next analyzed variable (Figure 3.15). A similar evolution of NEER can be observed for two countries, namely the Czech Republic and Slovakia. In these two cases, NEER appreciated continually until the 2008. Since then the evolution of NEER can be described as a rather volatile. Nevertheless, the appreciation that appeared after 2008 was not as strong as before 2008 and the exchange rate did not surpassed its levels from before crisis. After 2008, Slovakia saw its nominal effective exchange rate depreciate. Later on it was followed by only a very slight appreciation.

Evolution of NEER in Hungary was marked by several appreciations and depreciations. However, the overall trend over the analyzed period can be described more as a depreciating than an appreciating. Here again we can observe a most significant slump in the evolution of NEER in the time of economic crisis. Following years brought some amelioration but the NEER was still "weaker" than before the crisis.

As for the evolution of Poland, we can distinguish two important periods. Firstly there is a period of 2004-2008 which can be described by strong appreciation. This trend was reversed by crisis; NEER fell to its levels 4 years prior. Similarly to Hungary, since 2008, there were periods of appreciations and depreciations without any clear upward or downward trend.

Figure 3.15 Evolution of NEER in the V4 Counties (2008=100)

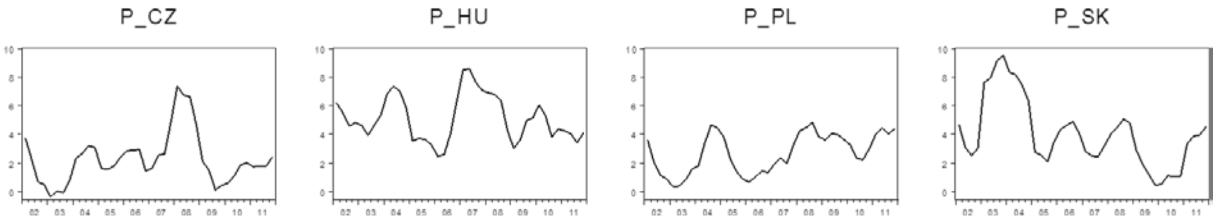


Source: BIS.

Evolution of price levels in these countries was the most volatile out of all analyzed variables. It was marked by repeated increases and decreases. This volatility can be connected to continuing process of price deregulation and to various administrative measures especially at the beginning of the observed period. The impact of the economic crisis was visible mostly at the end. Generally, we can say that crisis brought a turnabout in evolution of price level for all countries as we can observe a common feature - more or less prominent slumps in prices (Figure 3.16). It is visible especially in case of the Czech Republic, Hungary and Slovakia. However, prices fell the most significantly in the Czech Republic. Evolution of price level in

Hungary was marked with an increase before crisis and a slump in the following years. Slovakia recorded an important increase at the beginning of the observed period. This evolution was influenced predominantly by domestic factors, especially by administrative measures (increase in excise taxes as well as TVA) and price deregulations that explain up to 75% of price level increase. Other important turnabout came after the crisis. Prices fell considerably but after few quarters they returned to pre-crisis level. And lastly, in case of Poland the increase of price level did not exceed 5% and the impact of the crisis was the least prominent.

Figure 3.16 Evolution of Price Level in the V4 Countries (%)



Source: IMF.

3.5.3. Results of the Tests

Table 3.6 Results of the Unit Root Tests (2002Q1-2011Q4)

		IR (3m)		**GDP**	
		ADF	**PP**	**ADF**	**PP**
CZ	level	-1.900416	-2.086908	-1.676031	-1.753671
	1st diff.	-4.147079*	-4.127920*	-3.753081*	-3.695753*
HU	level	-2.059239	-2.132583	-3.120515**	-2.097672
	1st diff.	-5.778706*	-5.775436*	-3.120515**	-3.206547**
PL	level	-3.279173**	-3.991206	0.122162	0.122162
	1st diff.	-3.625562*	-3.502639**	-6.709337*	-6.712962*
SK	level	-2.302531	-1.603150	-0.965763	-0.957064
	1st diff.	-5.044862*	-5.058568*	-5.382526*	-5.367136*
		NEER		**P**	
		ADF	PP	ADF	PP
CZ	level	-1.520625	-1.491732	-1.759866	-2.519334
	1st diff.	-5.256253*	-6.893745*	-5.589619*	-3.966264*
HU	level	-1.520625	-1.491732	-1.759866	-2.519334
	1st diff.	-5.256253*	-6.893745*	-5.589619*	-3.966264*
PL	level	-1.782970	-1.802298	-3.832310*	-2.420608
	1st diff.	-5.157588*	-6.218456*	-4.299772*	-3.240775**
SK	level	-2.553088	-2.086649	-2.762881	-2.145945
	1st diff.	-4.634968*	-4.505182*	-3.942391*	-3.972840*

Note*:* Data represent results of t-statistics. Null hypothesis cannot be rejected at 1% significance level (*), at 5% significance level (**), at 10% significance level (***).

Source: Own calculations.

Before we estimated model for the V4 countries, we needed to test selected time series for stationarity and cointegration. As for the EMU countries, we used unit roots test - Augmented Dickey-Fuller Test and Phillips-Perron Test to verify the stationarity of time series. In case of V4 countries, ADF and PP tests indicated that only some of the series were stationary at the values. Testing on the first differences showed the stationarity of time series. We can conclude that the variables are I (Table 3.6).

As most of the endogenous variables were not stationary on the values and thus had the unit root, it was necessary to test these series for cointegration. The existence of the cointegration between variables was verified by Johansen cointegration test (using two lags as recommended by the Akaike Information Criterion and Schwarz Information Criterion). The results of the cointegration tests by both trace and maximum eigenvalue statistics indicated in almost all cases no cointegration among the endogenous variables of the model (Table 3.7).

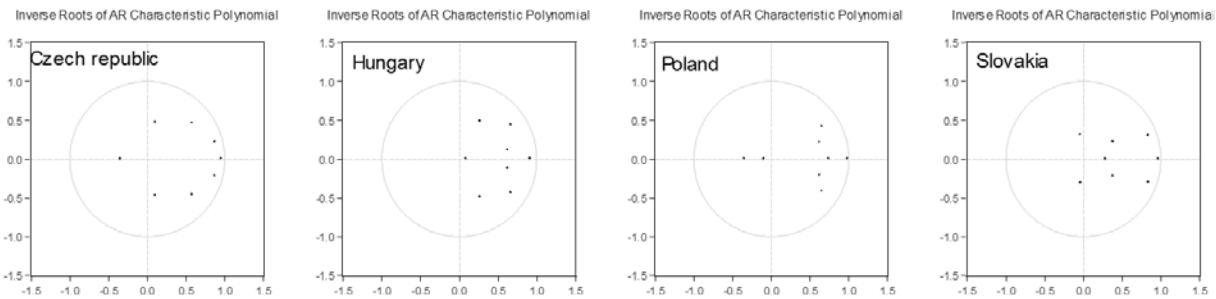
Table 3.7 Results of the Cointegration Tests (2002Q1-2011Q4)

	Number of equations	Trace Statistics	0.05 Critical Value	Eigenvalue	0.05 Critical Value
CZ	none	61.26312	54.07904	28.22967	28.58808
	at most 1	33.03345	35.19275		
HU	none	47.10558	47.85613	24.70808	27.58434
PL	none	40.28425	47.85613	17.05212	27.58434
SK	none	62.77215	47.85613	33.16675	27.58434
	at most 1	29.60540	29.79707	16.95593	21.13162

Source: Own calculations.

In order to verify the stability of the model we used the AR roots test. The graphs (Figure 3.17) show that none of the points exceeds the circle, thus the estimated VAR models for each of the V4 countries were considered stable.

Figure 3.17 AR Roots Test for V4 Countries



Source: Own calculations.

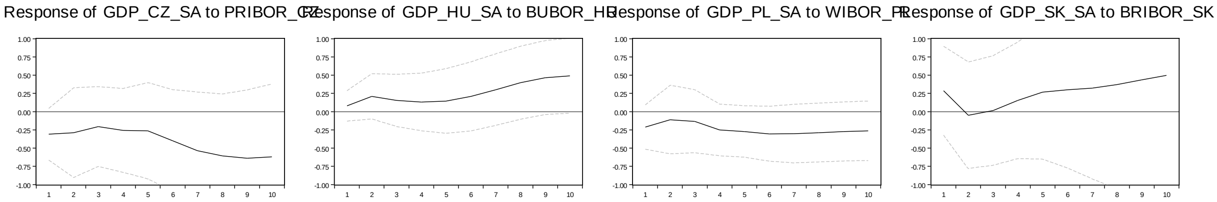
3.5.4. Impulse-Response Functions

Estimated vector autoregression model enabled to analyze impulse response functions for selected endogenous variables also in case of the V4 countries. The results are grouped by variables so as to be able to compare the similarities or differences in responses for each country. We focused solely on the response of endogenous variables to changes in interest rate. The estimated response of variables to a monetary policy shock is observed over the period of 10 quarters after initial shocks.

As mentioned previously, in case of unexpected monetary tightening (monetary policy shock in the form of sudden increase of interest rate) the theory suggests: an output decline, a price level decline (with possible time lags) and the appreciation of the country's exchange rate.

Model A - Reaction of GDP, Period of 2002-2007

Figure 18 Impulse-Response Function for GDP (2002-2007)



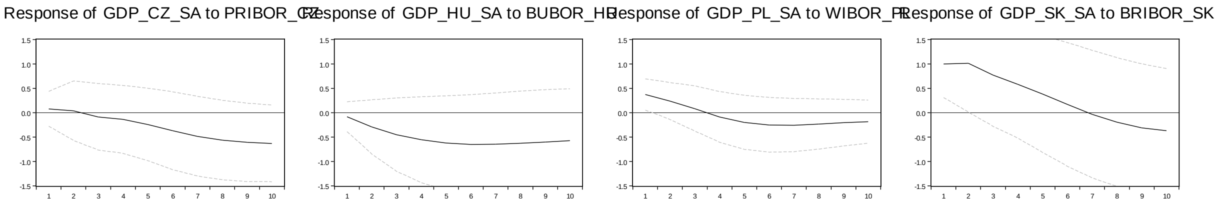
Source: Own calculations.

Figure 18 shows that the response of endogenous variables to sudden fluctuations in short-term interest rate was sensitive. Despite positive shock in interest rate the reaction of GDP is only slightly positive in case of Hungary and Slovakia. This behavior may be related to the fact that GDP growth in Slovakia is largely determined by other factors. High trade openness and connection to other countries as well as domestic fiscal policy played also an important role. In the case of Hungary, monetary policy faced several unfavorable events that tested its efficiency. We can mention for example a speculative attack on domestic currency as one of the most significant. Central bank had to choose between stability of price level and stability of Forint. As a result, transmission of monetary policy measures to real economic variables such as GDP might have been weakened as indicates next graph.

Model B - Reaction of GDP, Period of 2002-2011

Over the longer period of 2002-2011 GDP responded, as expected, by a decrease in all monitored countries. For the Czech Republic and especially Poland and Slovakia, this reaction was not immediate, but with time lags of around three quarters (Figure 3.19).

Figure 3.19 Impulse-Response Function for GDP (2002-2011)



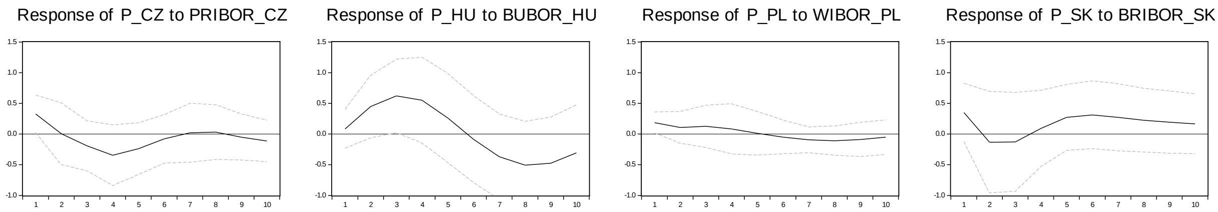
Source: Own calculations.

Model A - Reaction of prices, Period of 2002-2007

We also tested the response of the prices to interest rate shock. Here the theory indicates that the increase of interest rate should slow down the increase of prices causing the inflation rate to drop down. However, as explained previously, sometimes an unusual behavior in the form of sluggish or even positive response of prices can appear after an unexpected monetary tightening (so-called price puzzle).

The next Figure 3.20 depicts the impulse-response function for price level over the period of 2002- 2007. We can see that the expected downward trend appears but not immediately and not in all analyzed countries. In most cases, the reaction is lagged by 4 quarters and in the case of Poland and Slovakia the reaction is less sensitive.

Figure 3.20 Impulse-Response Function for Prices (2002-2007)

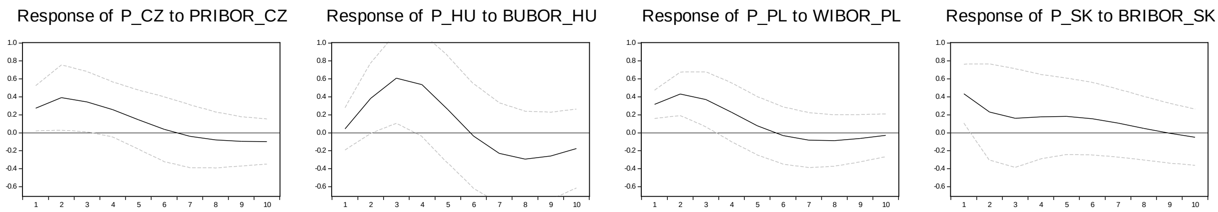


Source: Own calculations.

Model B Reaction of Prices, Period of 2002-2011

The figure 3.21 shows that in the period of 2002-2011 prices reacted positively to a shock in the short-term interest rates. This could be explained by the fact that within this period the inflation in the V4 countries varied substantially. There were period of higher inflation even during monetary policy tightening. Similarly, declines in interest rates during crisis (2008-2010) did not result in the growth of the price level but reduced inflation rates. During this period inflation was still strongly influenced by many reforms, such as changes in taxes and price deregulations. High openness of these countries (notably the Czech Republic, Hungary and Slovakia) and the impact of the imported commodities prices (ex. oil prices) equally affected the evolution of the inflation. All these factors reduce the possibility of monetary policy to influence price developments in these countries.

Figure 3.21 Impulse-Response Function for Prices (2002-2011)

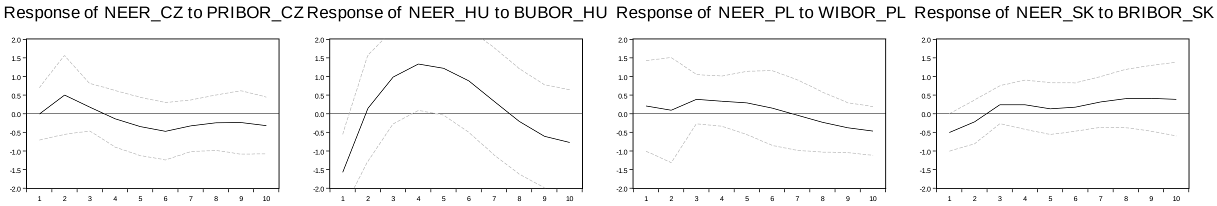


Source: Own calculations.

Model A - Reaction of NEER, Period of 2002-2007

The exchange rate was a last variable tested for impulse-response functions. Here the theory indicates that the increase of interest rate should be accompanied by the inflows of foreign capital causing the appreciation of country‘s exchange rate.

Figure 3.22 Impulse-Response Function for NEER (2002-2007)



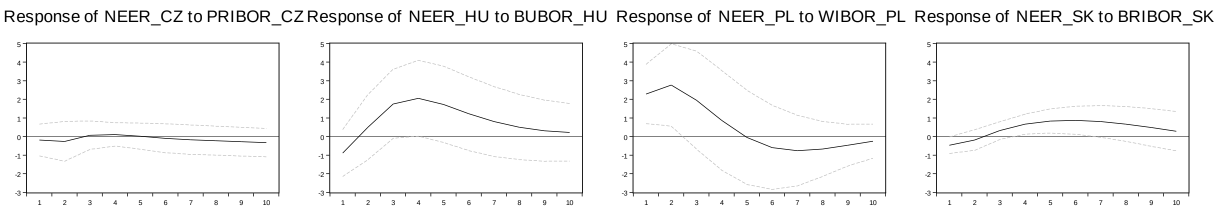
Source: Own calculations.

Based on the figure 3.22, we can follow the evolution of NEER after the positive interest rate shock in V4 countries. In all cases the appreciation of the exchange rate is lagged by several quarters. What is more, the reactions differ in their volume. The weakest reaction was observed for Czech Republic, Poland and Slovak Republic.

Model B - Reaction of NEER, Period of 2002-2011

Model B monitors a reaction of NEER to the interest rate shock in the longer period of 2002-2011. As mentioned before, the increase in short-term interest rate is supposed to cause an appreciation of exchange rate that is represented by an increase of NEER. Even though this expected appreciation appears, it is not directly after the initial impulse. In the case of Hungary and Slovakia it appears after two quarters. However, we must also point out that the intensity of the reaction is not identical for all monitored countries. The NEER responses to positive interest rate shock by its depreciation in the case of the Czech Republic which may be related to higher volatility of bilateral Czech crown exchange rate against foreign currencies since 2008 (Figure 3.23).

Figure 3.23 Impulse-Response Function for NEER (2002-2011)



Source: Own calculations.

The most of tested variables reacted not immediately or even not satisfy our expectations. The reactions are often lagged, or very weak even if the period 2002-2007. So we continue our analysis with the variance decomposition.

3.5.5. Variance Decomposition - Endogenous Variables

Based on the estimated model it is possible to continue with a decomposition of variance of endogenous variables. Table 8 shows contributions of changing interest rate (PRIBOR, BUBOR, WIBOR and BRIBOR or EURIBOR respectively) to the variability of GDP, price level and nominal effective exchange rate for the Czech Republic, Hungary, Poland and Slovakia. The results for shorter period i.e. that is until 2007 indicate that variations of interbank interest rates had a significant impact on variability of GDP in Hungary (39%), the Czech Republic (24%) at the end of analyzed period. This reaction was lower in case of Poland (24%) and rather weak in case of Slovakia (3.9%).

For price level, it is possible to observe a stronger reaction at the beginning of the analyzed period for the Czech Republic (19%) and Poland (19%). Out of all observed countries, the most significant reaction was observed in Hungary (39%) nearing the end of the period. Results for Slovakia indicate again the least significant impact (9.5%).

Out of all observed variables, the reaction of nominal effective exchange rate was a most prominent one. It could be observed especially for Hungary (43%). However, the impact for three remaining countries was significantly weaker and intensified only with passing time.

Based on these results we could conclude that the contributions of changing interest rates to variability of GDP, price level and NEER were lower in the period of 2002-2007 (especially in case of Poland and the Slovak Republic). We could therefore assume that there were also other channels that played an important role in the transmission of monetary policy measures. With the regards to high level of openness of analyzed countries and the selected monetary strategy (predominantly a targeting of inflation) we can assume an important position of other transmission channels, that is an exchange rate channel and a channel of inflation expectations. Their combined functioning can mean that the transmission via the interest rate is weakened.

Table 3.8 Variance Decomposition of Endogenous Variables (2002Q1-2007Q4)

CZ	GDP_SA	P	NEER	HU	GDP_SA	P	NEER
1	13.00653	19.06483	0.002192	1	2.540472	1.284213	35.77179
3	14.68488	12.62680	7.312109	3	9.824570	25.83959	31.46820
6	14.17493	19.68635	11.45182	6	10.77226	28.57453	42.75172
12	24.82843	17.74028	15.92685	12	39.31527	34.73937	43.20111
PL	**GDP_SA**	**P**	**NEER**	**SK**	**GDP_SA**	**P**	**NEER**
1	8.371598	19.31147	0.531479	1	3.933223	9.535905	16.82455
3	5.154862	7.750705	2.001080	3	1.755614	3.083910	13.64358
6	12.77357	4.931009	2.782869	6	2.256321	5.956170	8.119885
12	15.44656	5.420584	6.271231	12	3.436915	9.208415	7.819380

Note: Cholesky ordering: EURIB3M GDP_SA, P, NEER.
Source: Own calculations.

The decomposition of variations carried for the longer period of 2002-2011 (Table 9) that covers also the years of economic crisis showed certain differences. For some of the variables or the countries the reaction got stronger for others it weakened. The most visible difference was observed for GDP in case of Slovakia (from 4% to19.7%). It was similar for the price level (from 9.5% to 17%). We can therefore conclude that the effectiveness of the analyzed transmission channel of interest rate improved over the longer period that covered also the years of crisis as well as adoption of common European currency.

However, the similar conclusion cannot be drawn for Hungary where the results indicate an opposite trend – a weakening of reactions of analyzed variables to interest rate shock. The most important change could be observed for NEER (from 43% to 27%) and also for GDP (from 39% to 26%). Very similar conclusions could be also drawn for the Czech Republic where all analyzed variables reacted less strongly to sudden changes in interbank interest rates.

Results for Poland show stronger impact on variability of price level (change from 19% to 40%) and NEER (change from 6% to 21%). The reaction of GDP intensified only slightly and only at the beginning of the analyzed period. Overall, we could assume a higher effectiveness of monetary policy in this longer period, similarly as in case of the Slovak Republic.

Table 3.9 Variance Decomposition of Endogenous Variables (2002Q1-2011Q4)

CZ	**GDP_SA**	**P**	**NEER**	**HU**	**GDP_SA**	**P**	**NEER**
1	0.484235	11.65681	0.536140	1	0.803205	0.391505	5.136175
3	0.252917	18.39445	0.870319	3	5.864276	21.23768	11.67055
6	1.864567	14.32080	0.771068	6	14.48187	25.70894	26.00751
12	12.28084	13.22661	2.985048	12	26.66135	28.99200	27.42196
PL	**GDP_SA**	**P**	**NEER**	**SK**	**GDP_SA**	**P**	**NEER**
1	13.24544	35.39376	19.54685	1	19.74425	17.13064	10.82820
3	8.146368	40.00032	21.70215	3	18.14342	7.388900	9.702790
6	6.879981	32.41762	19.48854	6	11.64131	8.967516	23.93522
12	7.788567	27.77474	19.37068	12	9.433910	9.373209	15.45078

Note: Cholesky ordering: EURIB3M GDP_SA, P, NEER.
Source: Own calculations

Results of variance decomposition for the V4 countries point out that the reactions of variables to interest rate shock for individual countries are not entirely identic. In all cases it was confirmed that other transmission channels of monetary policy played an important role. Two interesting tendencies could be equally observed: a stronger reaction to interest rate shock in shorter period in case of Hungary and the Czech Republic. For these countries the influence of interest rate weakens with the passing time. An opposite trend, a stronger impact in the longer period could be seen in case of Slovakia and Poland. In these two countries, especially in Poland there were no important changes in reactions of analyzed variables over longer period.

3.6. Conclusion

The interest in exploring the transmission mechanism of the monetary policy has increased in recent years. Many authors have noted that out of the various transmission channels the traditional interest rate channel was the most affected by the financial and debt crisis. The crisis has also restarted a debate on the EMU accession and the advantages of own monetary policy as macroeconomic and anti-shock tool. A question that remains is whether it is now possible to talk about independent monetary policy in the condition of the EU member country. Recent negative developments after 2008 still verify the ability of monetary policy to mitigate its impacts. In the EMU, it can be seen in the case of the effects of single monetary policy and the deepening of the asymmetries between member countries. It is now possible to evaluate the monetary policy independence of small and open non-member country and its influence on macroeconomic developments. In current situation, central bank authorities of the countries such as the Czech Republic, Hungary or Poland still consider important to preserve an independent monetary policy.

The analysis focused on the monetary policy efficiency through interest rate transmission channel. The basic variables of the model were GDP, inflation and exchange rate, i.e. variables that are generally used in the central bank monetary rules. The aim of the analysis was to evaluate the efficiency of the interest rate channel in euro area in general as well as for the EMU countries and selected transition economies such as V4 countries. Our analysis was based on several expectations. We assumed that negative developments related to the crisis can distort the transmission of monetary policy effects on macroeconomic variables and that the impact of monetary policy changes are transmitted to the economic variables only partially or significantly lagged. The estimations were made using the vector autoregression model with the Cholesky decomposition of innovations.

Comparing the overall results for the whole EMU with results for individual countries it can be stated that the significant differences exist. We can find countries with the reactions that are rather similar to those of the EMU12. However, this was not confirmed in most of the cases. Therefore we can conclude that the effectiveness of monetary policy interest rate channel in influencing particular variables is considerably different in various EMU12 countries.

The reactions of variables to interest rate shock for the V4 countries are also not entirely identic. In all cases it was confirmed that other transmission channels of monetary policy played an important role. In regard to the high level of openness and applied monetary strategy in these economies, it is possible to assume the important role of exchange rate and inflationary expectations channel, which may weaken the transmission through the interest rate channel.

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Chapter 4

Forecasting Serbian Quarterly GDP

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4.1 Introduction
4.2 Methodology and Data
4.3 Model Specification and Diagnostics
4.4 Results
4.5 Conclusion
4.7 References

FORECASTING SERBIAN QUARTERLY GDP[1]

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Abstract

In this paper we have forecasted Serbian quarterly GDP data for 2013. We have used extended classical Box-Jenkins approach, also known as Seasonal Autoregressive Integrated Moving Average (SARIMA) stochastic model. We have identified the SARIMA (0,2,2)(2,1,0)[4] as the model which provides the best explanation of the data. According to our forecast, Serbian economy will grow by 1.3% in 2013 which is in line with predictions published by several commercial banks operating in Serbia. Our model shows that the largest GDP growth will be at the end of the year, i.e. in the last two quarters.

Keywords: GDP, SARIMA, Forecast

4.1. Introduction

Serbian GDP fell roughly by 2% in 2012. It is interesting to notice that recession was much more severe than forecasted by the International Monetary Fund (IMF). Even with several revisions, the economic drop was somewhat three times bigger than envisaged. Although it is relatively easy to identify causes for deviation ex-post, determination of realistic forecasts ex-ante represents a great challenge for economists all over the world. Inability to predict the future economic outcomes with certainty makes this topic always relevant for a research. Moreover, policymakers depend heavily on GDP statistics and forecasts to choose which course to take with economic, fiscal and investment policy.

In this chapter we have forecasted the Serbian quarterly GDP for the year of 2013 using extended classical Box-Jenkins approach, also known as Seasonal Autoregressive

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Integrated Moving Average (SARIMA) stochastic model. Our results may concern Serbian policy-makers as we are providing one additional possible scenario of economic growth, beside the forecasts of international financial institutions and their own predictions.

This whole group of Autoregressive Integrated Moving Average (ARMA) models has been widely used in various scientific fields for forecasting discrete time series processes, especially in business and economics (Maiti and Chatterjee, 2012). In the literature there are different examples of real application of ARMA machinery in the area of business/economics. Di Caprio et al (1983) forecasted electricity consumption, Hein and Spudeck (1988) studied daily federal funds rate, Pflaumer (1992) modeled population totals, du Prez and Witt (2003) analyzed truism demand and all of them used ARMA modeling strategy.

Dhrymes and Peristiani (1988) used this method to compare the performance of ARIMA models' to Wharton econometric model in forecasting quarterly macroeconomic variables. They have concluded that ARIMA methods are more precise for smaller forecast horizons. Many papers on forecasting GDP using ARMA method have been recently published. For instance, Ning et al (2010) forecasted GDP of Shaanxi region. They have observed yearly GDP values in the years 1952-2007 and specified ARIMA (1,2,1) model. Obtained results have performed very well in terms of relative error of actual and predicted values, making the model relatively effective in prediction.

In addition, Maiti and Chatterjee have applied a similar analysis to India. They have revealed ARIMA (1,2,2) model as a good fit on data (over a period 1959-2011). It is important to notice that in both papers authors have used annual GDP values, consequently determining the models without a seasonal component. Unfortunately, there are only a few papers dealing with this issue in our region. Jovanović and Petrovska (2010) studied several methods for short-term forecasting of Macedonian GDP, and one of them was ARIMA model. Their results indicate that including more data in the analysis (static factor model) yields significantly better performance. Surprisingly, they ranked a simple model that links domestic GDP to foreign demand as a second, concluding that the simple methods should not always be so easily dismissed.

Stoviček (2007) examined the applicability of various ARMA models in terms of length and seasonal adjustments for out-of-sample forecasting of Slovenian inflation. Overall, they have concluded that the standard in-sample model selection conditions are not reliable in determining the best model for out-of-sample forecasting. As mentioned earlier, the lack of papers in this area makes this topic very interesting for the case of Serbia.

4.2. Methodology and Data

We have used extended Box-Jenkins model (Box and Jenkins 1976) for forecasting Serbian quarterly GDP for 2013. Kleiber and Zeileis (2008) argue that several research studies have confirmed the model's flexibility in capturing volatility of a single variable over a period, hence becoming a classical approach to parametric modeling and forecasting. Furthermore, the general form of ARMA (p,d,q) equation can be defined as:

$$\varphi(\mathrm{B})(1-\mathrm{B})^{\mathrm{d}}\mathrm{Y}_{\mathrm{t}} = \theta(\mathrm{B})\varepsilon_{\mathrm{t}}$$

where the autoregressive part (AR) is given by the pth order polynomial $\varphi(B) = 1 - \varphi_1 B - \cdots - \varphi_p B^p$, the moving average part (MA) is determined by the qth order polynomial $\theta(B) = 1 + \theta_1 B + \cdots + \theta_q B^q$ and d is the differencing order. Furthermore, our methodology is based on Seasonal Autoregressive Integrated Moving Average (SARIMA) stochastic model. This important extension of ARIMA framework enables us to model a time series with seasonal pattern i.e. to incorporate seasonal behavior of our data set. Seasonal ARIMA models are defined by seven parameters ARIMA (p,d,q)(P,D,Q)s:

$$\left(1 - \varphi_1 B - \varphi_2 B^2 - \cdots - \varphi_p B^p\right)\left(1 - \Psi_1 B^s - \Psi_2 B^{2s} - \cdots - \Psi_p B^{ps}\right)(1 - B)^d (1 - B^s)^D y_t$$
$$= c + (1 - \theta_1 B - \theta_2 B^2 - \cdots - \theta_q B^q)(1 - \Theta_1 B^s - \Theta_2 B^{2s} - \cdots - \Theta_Q B^{Qs})\varepsilon_t$$

where the left hand side of the equation represents Autoregressive part of order p, Seasonal Autoregressive part of order P, differencing of order d and seasonal differencing of order D, respectively. On the right side there is Moving average part of order q and Seasonal Moving average part of order Q. Small letter s denotes the period of the seasonal pattern, in our case s = 4, as we observe the quarterly data.

In order to forecast Serbian GDP, we used chain-linked quarterly data over a period 2001Q1-2012Q3. The data are collected from Serbian Statistical Office's data base. Table 4.1 presents values of Serbian GDP that we have used in our analysis.

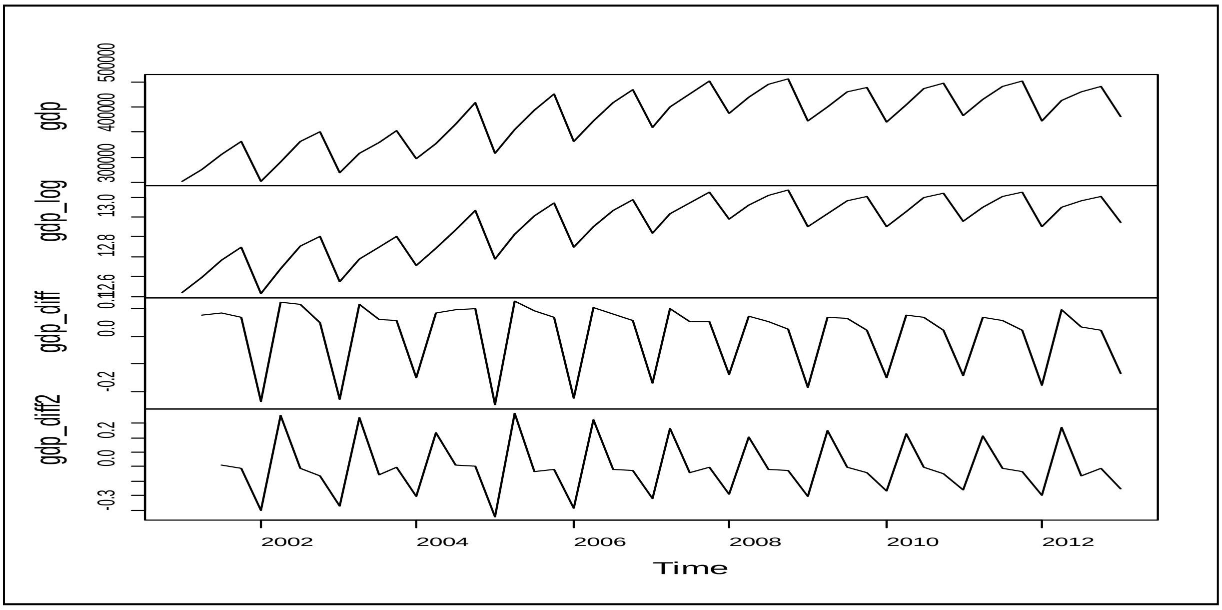
Table 4.1 Quarterly GDP Data, mill. RSD*

Year	Qtr1	Qtr2	Qtr3	Qtr4
2001	303107.2	326780.5	355345.0	380643.9
2002	301499.7	340909.8	382113.4	400643.0
2003	320098.9	358401.1	380270.2	402085.2
2004	346565.7	377336.4	415045.4	458232.8
2005	358239.8	405680.5	443944.0	475618.9
2006	380685.7	421694.1	457527.4	483450.0
2007	408548.7	450806.0	475839.8	501993.1
2008	437337.7	469442.7	494247.8	506323.0
2009	421157.3	450495.8	479542.6	489288.2
2010	421137.9	453784.8	486720.1	497369.3
2011	432642.6	464060.3	490289.4	501154.4
2012	421232.9	463502.1	479966.9	490471.4
2013	430133.5			

Note: * Chain-linked volume measures at relative prices of 2005, non-seasonally adjusted
Source: Statistical Office of the Republic of Serbia.

By plotting GDP data, we can observe the strong seasonal pattern. This is expected, especially having in mind that we used non-seasonally adjusted statistics. In addition, we notice that used GDP series does not have a stationary form. Therefore, we exploited the idea of differencing to reach the stationarity of the series.

Figure 4.1 Plotted GDP Data in Various Forms



Note: gdp - values in mill. RSD, gdp_log - values in logs, gdp_diff - first difference values, gdp_diff2 - second difference values.

Source: Statistical Office of the Republic of Serbia, Author's calculation.

Augmented Dickey-Fuller (ADF) test[5] results on different GDP series forms have proven that two-time differenced GDP (Δ^2GDP) follows a stationary pattern. The value of test statistics for Δ^2GDP is highly significant at the 1 percent level, therefore rejecting the unit-root null hypothesis. Hence, we conclude that Δ^2GDP series is stationary.

Table 4.2 Augmented Dickey-Fuller Test Results

Variable	Dickey-Fuller	p - value
GDP log	0.4146	0.99
ΔGDP	-4.1406	0.01
Δ^2GDP	-7.7059	0.01*

Note: *p-value smaller than reported.

Source: Author's calculation.

4.3. Model Specification and Diagnostics

We have used the penalty function approach to identify our model, since it is considered to be the most suitable method for model selection under the SARIMA framework (Saz, 2011). Based on the lowest values of both penalty function statistics, Akaike information criterion (AIC) and Bayesian information criterion (BIC) (Akaike 1973; Schwarz 1978), we identified the SARIMA (0,2,2)(2,1,0)[4] as the model which provides the best explanation of the data. The formal notation of our model is given by:

[5] For more details on ADF test, see: Saz, G. (2011)

$$(1-\Psi_1 B^4-\Psi_2 B^8)(1-B)^2(1-B^4)y_t=(1-\theta_1 B\ -\theta_2 B^2)\ \varepsilon_t$$

where the coefficient estimates are given below.

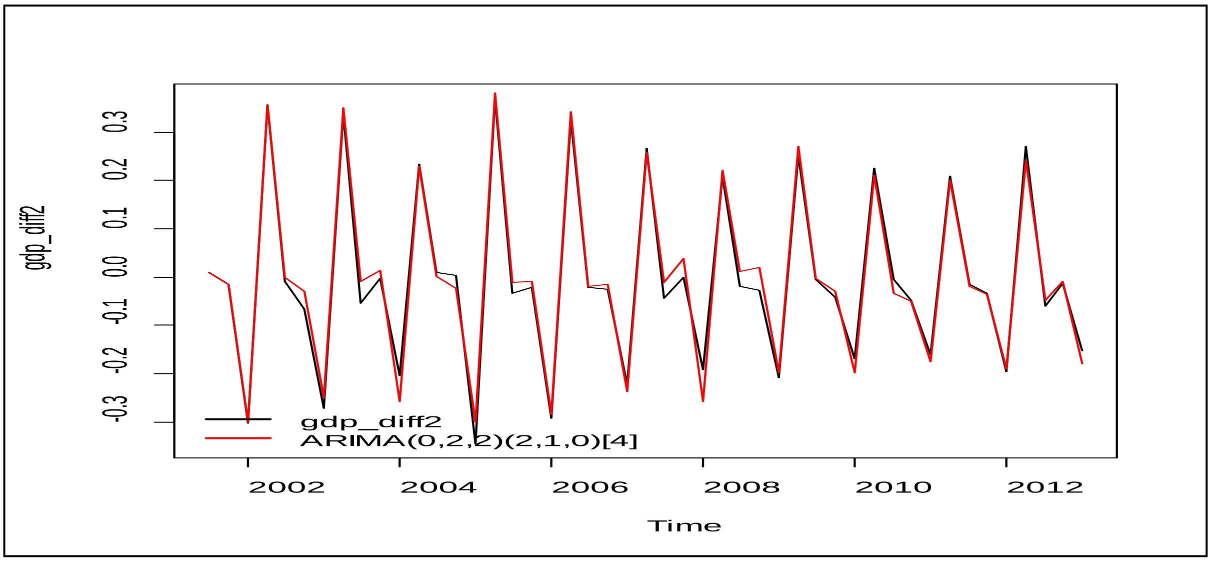
Table 4.3 The Estimates of SARIMA (0,2,2)(2,1,0)[4]

	MA1	MA2	SAR1	SAR2
Value	-1.3514	0.4531	-0.6498	-0.5306
Std. E.	0.1565	0.1727	0.1524	0.1571

Source: Author's calculation.

As the below chart demonstrates, SARIMA (0,2,2)(2,1,0)[4] provides a reasonably good fit to the data, closely following the historical pattern of the two-times differenced GDP values. However, in order to confirm the model's validity it is necessary to perform a residual diagnostics.

Figure 4.2 Second Difference GDP and SARIMA (0,2,2)(2,1,0)[4]



Source: Author's calculation.

Residuals from a correctly specified model should be similar to white noise, i.e. to have independent, zero mean and constant variance. We preformed Ljung- Box test (1978) to formally test for white noise by aggregating autocorrelation across lags. The test statistics is given by:

$$Q_m=n(n+2)\sum_{k=1}^{n}(n-k)^{-1}\,r_k^2\approx\chi^2_{m-r}$$

where r_k^2 is autocorrelation of residuals at lag k, n represents the number of residuals and m denotes the number of time lags.

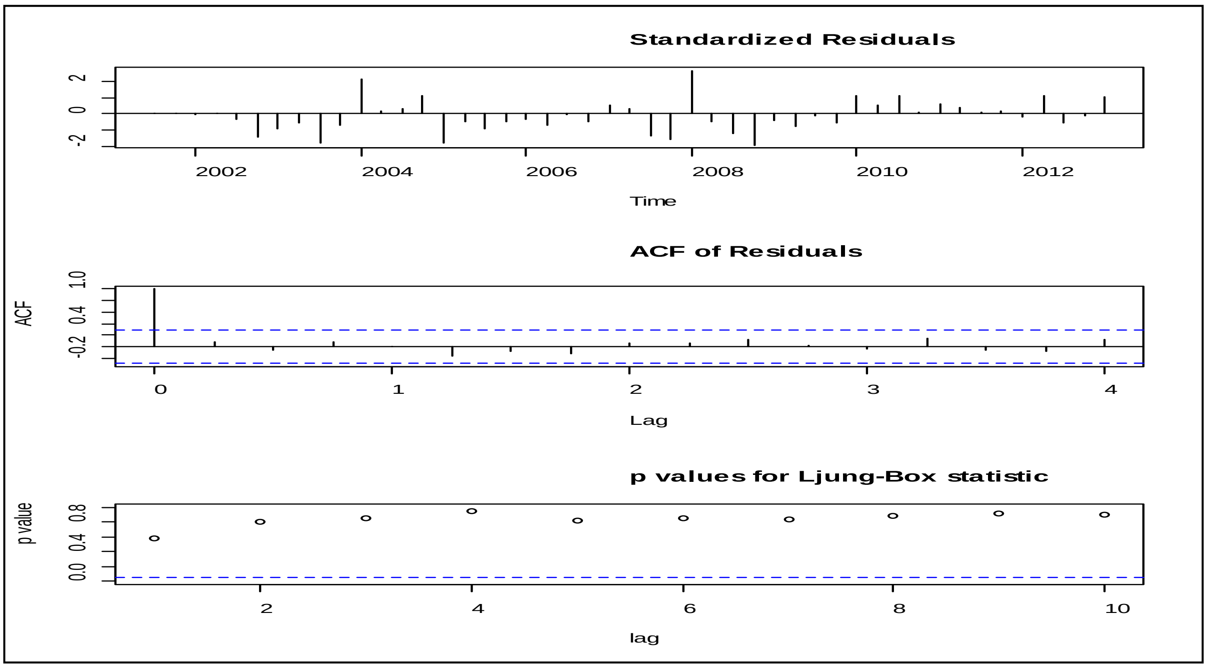
Table 4. Modified Box-Pierce (Ljung-Box) Chi-Square Statistics

Lag	Chi-Square Statistic	p value
4	0.78	0.8541
8	3.72	0.8112
12	4.95	0.9337
16	8.41	0.9064
20	17.17	0.5780
24	20.95	0.5841
28	22.26	0.7242
32	26.03	0.7201
36	28.25	0.7834
40	29.89	0.8526
44	30.39	0.9261

Source: Author's calculation.

In plane words, when the p-value of Q test statistics is large, the model is specified correctly. Our test results confirm the validity of the model, i.e. the Chi-square statistics is not significant at any lag, therefore confirming our SARIMA model as an adequate for capturing GDP trend in Serbia.

Figure 4.3 Residual Analysis - Summary



Source: Author's calculation.

4.4. Results

As we have fitted the model to the two-time differenced log data, it was necessary to perform certain output transformations in order to obtain reasonable quarter based growth rates. Differenced data can be expressed as $\Delta Y_t = Y_t - Y_{t-1}$ and the second difference as $\Delta^2 Y_t = Y_t - 2Y_{t-1} + Y_{t-2}$. The same logic is used when determening the second difference for future lag, $\Delta^2 Y_{t+1} = Y_{t+1} - 2Y_t + Y_{t-1}$. In order to obtain the log values we have applied $Y_{t+l} = \Delta^2 Y_{t+l} + 2Y_{t+l-1} - Y_{t+l-2}$, where l is number of time horizons ahead. After obtaining the log value forecasts, we used exponential function to attain values in RSD. Then, we calculated quarterly GDP growth rates comparing our forecasts with the same quarter last year.

Table 4.5 Quarterly GDP Growth Rate Forecasts, 2013 Q2 – 2014Q1*

Year	Quarter	PBFGR	LLBGR 80	ULBGR 80	LLBGR 95	ULBGR 95
2013	Q2	**-0.5%**	-3.6%	2.8%	-5.2%	4.5%
	Q3	**1.7%**	-3.6%	7.3%	-6.3%	10.4%
	Q4	**1.8%**	-3.7%	7.6%	-6.5%	10.8%
2014	Q1	**0.9%**	-4.5%	6.6%	-7.3%	9.8%

Note: *PBFGR - point based forecast growth rates, LLBGR 80 - lower limit (80%) based growth rates, ULBGR 80 - upper limit (80%) based growth rates, LLBGR 95 - lower limit (95%) based growth rates, ULBGR 95 - upper limit (95%) based growth rates.

Source: Author's calculation.

According to our forecast, Serbian economy will grow by 1.3% (having in mind 2.1% growth in Q1) in 2013 which is in line with predictions published by several commercial banks operating in Serbia. Our model shows that the largest GDP growth will be at the end of the year, i.e. in the last two quarters. This forecast is more pessimistic than one made by the IMF (2%). We believe that the recovery of the whole Western Balkan region will stay restricted because of undying eurozone crisis, although many argue that Fiat export will be enough to get back Serbian economy on the road to sound growth.

Yet, there is no doubt that the acceleration of export will have a substantial contribution to year-over-year GDP growth. This primarily refers to Fiat Automobili Srbija company and their suppliers in exporting cars and automotive components worldwide. Furthermore, this year we can expect the increase in agricultural production (after a great drop in 2012) and larger inflow of Foreign Direct Investments (FDI) resulting in improved GDP performance. Having in mind that the most of announced FDI will be in agriculture, we could expect lagged impact on GDP, most likely reflecting the growth in the following year.

4.5. Conclusion

In this chapter we have study the issue of forecasting Serbian quarterly GDP. The goal was to specify a SARIMA model which will describe the data well, respecting all diagnostic rules. We have given our contribution in developing methodology suitable for this purpose of research, given that the published papers dealing with this problem in Serbia are very rare. In addition, we provide one extra prognosis for such an important macroeconomic variable, which may serve as signal for policy makers when making economic, investment and political decisions. The performance of our model, and Box-Jenkins methodology overall, can be evaluated only after we have the final data for all quarters, but having said this, we believe that the results obtained in this chapter represent reliable indicator for Serbian GDP performance in 2013.

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CONCLUSION

Examination of the wide variety of aspects associated with mutual relationships between interest rates and macroeconomic fundamental variables is a key point to understand the complexity of the rules versus discretion dilemma. Nowadays, interest rates represent one of the most crucial variables in the widely used monetary rules employed by monetary authorities. It serves not only as a very effective vehicle for a transmission of monetary policy decisions by monetary authorities but also as a convenient indicator of monetary conditions. Interest rates determination represents key pillar in the rules versus discretion dilemma as well as quality (interest rates) versus quantity (money supply) dilemma. While both dilemmas may be considered as obsolete issue in the main streams of economic theory for decades, their relevancy clearly arises in the time of sudden, sharp, lasting and complex downturns in particular as well as world economy.

In our monograph we investigated reasonability and importance of monetary rules in the monetary policy decision making. We highlighted the relevancy and key obstacles of the most common used monetary rule - Taylor rule in the monetary policy strategy of the National bank of Slovakia and European central bank. Short-term interest rates, as a crucial vehicle in the transmission mechanism of monetary policy, have a prominent role in the Taylor rule. While generally under well managed control, examination of the interest rates determination obviously reveals unique and inevitable information for both discretionary short-term fine-tuning as well as long-term strategic decision-making of monetary authorities. Determinants of the short-term interest rates volatility, investigated in our monograph, affected interest rates responsiveness in line with theory and empirical evidence. However, relative contribution of structural shocks and inflation expectations to the storm-term interest rates leading path was investigated according to the exchange rate arrangements diversity in the European transition economies during pre-crisis and extended periods. Our approach thus contributes to both fixed versus flexible exchange rates dilemma as well as empirical evidence about distortionary effects of the crisis period in terms of interest rates determination under different particular (or country specific) conditions.

Implementation of monetary policy framework into long-term strategy and short-term day-to-day operations in particular country or monetary union is determined not only by the reliability of monetary policy objectives but also by the overall dynamics of economic process (good times versus bad times) as well as exposure of the country/countries to the large scale of endogenous and exogenous shocks. Effectiveness of monetary policy may vary due to changes in monetary policy framework or large scale of economic conditions. As a result, responsiveness of corresponding economic variables to the monetary policy incentives provides vital information about appropriateness of transmission mechanism. We examined the effectiveness of the interest rate channel of the monetary policy in the selected countries divided to three groups - northwest EU countries, south EU countries and Visegrad countries to improve empirical results and following discussion. Effects of the crisis period are also highlighted and rigorously interpreted.

One of the crucial objectives of the monograph was to evaluate compatibility of single monetary policy in the period of crisis and in regard to integration of new European Union member states (such as Slovakia) into the euro area. Comparison between monetary rules for euro area and Slovakia indicates several differences. Some of these differences are obviously implied by crisis. While the European Central Bank´s behavior is time consistent before the crisis, it is time inconsistent after 2008. The European Central Bank is more attentive to output gap than to inflation gap evolution during the crisis. During the same period, Slovak reaction function is little bit more attentive to output gap than before and has anti-cyclical character. However, inflation gap is still in the center of attention. The most important difference is in the Taylor principle. While it was maintained before crisis in the euro area as well as in Slovakia, it is violated after 2008 or 2009. It means that interest rate change is not sufficient to maintain inflation target. Despite official declarations about priority of inflation target over other targets, it seems that during crisis, monetary authorities pay more attention to output gap than assumed.

Nevertheless, there arises a crucial question of whether after-crisis period will lead to higher symmetries in monetary policy conditions in the euro area and higher compatibility of monetary rules among member states. We assume that monetary reaction functions will be more symmetric in future as Slovakia and other new member states will not have to continue in disinflation process and mainly due to so called endogenous argument. According to this argument, monetary integration should lead naturally to gradual symmetry among business cycles and economic fundamentals in general. However, only future will clearly confirm or reject validity of this argument.

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