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Abstract

Quantitative easing conducted by European central bank to fight persisting risks of deflation is drawing an attention of increasing number of empirical studies. Moreover, effectiveness of monetary policy at near zero inflation rates reveals lot of issues on whether interest rates really have a lower bound around zero percent. As a result, traditional views on the role of inflation expectations and expected real interest rates in the long-term interest rates determination face the challenge of fundamental revision. In the paper we analyze relative contributions of inflation expectations and expected real interest rates to long-term interest rates on government bonds leading path as well as their responses to both types of shocks in the Euro Area member countries using SVAR methodology. We also decompose long-term interest rates into transitory and permanent components. Our research revealed considerable differences in the role of inflation expectations and expected real interest rates shocks in determining long-term interest rates between core and periphery countries of the Euro Area. The crisis period even intensified this trend.

Keywords: interest rates, inflation expectations, economic crisis, SVAR, variance decomposition, impulse-response function

JEL Classification: C32, E43, F41

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1. Introduction

Risks of deflationary spiral in the Euro Area together with low nominal interest rates policy conducted by European Central Bank (ECB) are drawing attention of increasing number of empirical studies. Changes in the relative importance of inflation expectations and expected real interest rates in determining nominal interest rates are generally induced implications of the zero inflation environment (Labadie, 1994; Evans, 1998; Den Haan, 1995). Moreover, deflationary pressures and tightened financial conditions provided contradictory effects on the determination of long-term interest rates and even emphasized changed market fundamentals during the crisis period (Christensen, Lopez and Rudebusch, 2008).

Recent macroeconomic development in the Euro Area, characterized by persisting deflationary pressures, induces fundamentally different background for the economic policy framework and related institutions experimenting with a convenient policy mix to provide growth incentives and improve growth perspectives in the Euro Area. While governments seek optimum compromise between growth stimulation and consolidation efforts that would provide crucial incentives to boost domestic demand while maintaining conditions for fiscal sustainability of public budgets, European central bank (ECB) conducts another wave of quantitative easing aiming an increase in the rate of inflation (Krishnamurthy and Vissing-Jorgensen, 2011). While increased inflation would reduce persisting risks of deflationary spiral, it should also stimulate an increase in the nominal interest rates from near zero levels nowadays and improve the traditional signaling function of the price of money (Gürkaynak, Sack and Wright, 2007). Moreover, higher nominal interest rates should also help to boost real interest rates that are nowadays occasionally falling to unprecedentedly negative levels (Campbell and Shiller, 1991; Bindseil and Winkler, 2012).

Nominal interest rates in the Euro Area member countries followed generally criticized decreasing and mutually converging trend since the beginning of the Euro Area establishment (Acharya and Steffen, 2015). Introduction of single currency on a very heterogeneous group of countries induced undesirable convergence especially in the long-term interest rates on the government bonds. Reduction of differences among interest rates of the Euro Area member countries resulted from decreased expected risk premium recognized by financial markets being supported by (un)conventional operations of ECB that many economists criticized and indicated as one of the key design failures of the Euro Area (De Grauwe, 2013).

In the paper we examine influence of inflation expectations and expected real interest rates on the long-term nominal interest rates of government bonds with 10-year maturity in the Euro Area member countries by employing SVAR (structural vector autoregression) methodology. We also decompose nominal interest rates on government bonds into inflation expectations and expected real interest rates components. Our results indicate that both components significantly determined main trends in the development of interest rates on government bonds since 2000. At the same time, the role of both types of shocks in determining sovereign debt yields differs when comparing our results for periphery countries with those of core of the Euro Area.

2. Relationship between Interest Rates and Inflation

Questions associated with fundamental determinants of nominal interest rates are widely discussed in the recent empirical literature. Considering already mentioned deflationary pressures and near zero levels monetary policy conducted by ECB there exist a large number of research studies examining a relative importance of inflation expectations and expected real interest rates in the nominal interest rates determination (Vayanos and Vila, 2009; Christensen, Lopez and Rudebusch, 2012; Haubrich, Pennacchi and Ritchken, 2012). Key characteristics and implications resulted from the relationship between inflation and interest rates provide crucial information for monetary authorities.

Inflation and interest rates are mutually interconnected. Traditional linkage between inflation and interest rates refers the causal (bi-directional) relationship well documented by both theoretical and empirical literature that operates via transmission mechanism. As a result, changes in inflation induce adjustments in interest rates (Crowder and Hoffman, 1996; Rudebusch, 2002). During the periods of high inflation high interest rates may result from the public's anticipation of continued high inflation (Taylor, 1982). Decrease in inflation followed by discretionary policy changes or market-driven shocks is generally followed by a drop in interest rates.

Causal linkage between inflation and interest rates is regularly examined by central banks that preserve price stability and purchasing power of domestic currency by increasing interest rates during the periods of higher inflation following particular monetary policy rule (Fendel, 2009). On the other hand, inflation pressures are not necessarily associated with imbalanced demand driven economic growth where increased interest rates would prevent the economy from overheating. Increased inflation accompanies not just highly performing economies but may be also fueled by internal distortions or external shocks that the economies may experience even during the recession (Emiris, 2006). Deflationary environment provides quite specific fundamental background for the interest rates determination (Peersman, 2011). Near zero levels of nominal interest rates combined with increasing real interest rates induced by decreasing price level reduces maneuverability within existing operational framework of monetary authorities. As a result, central banks tend to employ unconventional instruments to accelerate inflation (Borio and Disyatat, 2009). Low interest rate environment clearly increases the role of management of inflation expectations by central bank (Arouba, 2014). Moreover, monetary economists emphasize the containment of long-term inflation expectations is the most important objective in conducting monetary policy (Tobias and Wu, 2010).

Nominal interest rates are not necessarily determined just by the rate of inflation (Booth and Ciner, 2000). 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) (Eijffinger, Schaling and Verhagen, 2000; Cochrane and Piazzesi, 2005). Nominal price of money is determined by a wide variety of determinants, that is why it may not seem to be clear, whether the volatility of nominal interest rates is caused by changes in inflation expectations or expected real interest rates (Kim and Orphanides, 2012; Wood, 1983). Correct identification of the sources of the volatility of nominal interest rates is a crucial part of successful monetary policy decision-making (McGough, Rudebusch and Williams, 2005). For example, an increase in the nominal interest rates caused by higher inflation expectations of agents represents a correct 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.

3. Interest Rates Determination in Empirical 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 10-year government 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.

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 a Derry (Deacon a 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 a Hoffman (Crowder a 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 long-run interconnections testing between inflation and nominal interest rates in the U.S.A.

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 the true form representation into the 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.

In the paper we employ methodology introduced by Blanchard a 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 true form of the model is represented by the following infinite moving average representation:

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

or

$$\begin{bmatrix} ir_{n,t} \\ p_t \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_{p^e,t} \\ \varepsilon_{ir_r^e,t} \end{bmatrix} \quad (2)$$

where $X_t = \left[ir_{n,t}, p_t\right]$ is n x 1 vector of the endogenous macroeconomic variables ($ir_{n,t}$ - long-term nominal interest rate, p_t - rate of inflation), $A(L)$ 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 $\left(\varepsilon_t = \left[\varepsilon_{p^e,t}, \varepsilon_{ir_r^e,t}\right]\right)$ 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):

$$E(\varepsilon_t) = 0, \quad E(\varepsilon_t \varepsilon_t') = \Sigma_\varepsilon = \mathrm{I}, \quad E(\varepsilon_t \varepsilon_s') = [0] \quad \forall t \neq s \quad (3)$$

we assume two exogenous shocks that contemporaneously affects endogenous variables - 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) 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:

$$X_t = u_t + C_1 u_{t-1} + C_2 u_{t-2} + ... = \sum_{i=0}^{\infty} C_i u_{t-i} = \sum_{i=0}^{\infty} C_i L^i u_t \quad (4)$$

or

$$\begin{bmatrix} ir_{n,t} \\ p_t \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} u_{i^e,t} \\ u_{ir_r^e,t} \end{bmatrix} \quad (5)$$

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

$$E(u_t) = 0, \quad \Sigma_u = E(u_t u_t') = A_0 E(u_t u_t') A_0' = A_0 A_0', \quad E(u_t u_s') = [0] \quad \forall t \neq s \qquad (6)$$

Relationship between reduced-form VAR residuals (u_t) and structural shocks (ε_t) can be summarized from equations (1) and (4) as follows: $u_t = A_0 \varepsilon_t$. Matrices C_i we obtain from estimated equation (1). 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, $\operatorname{var}(\varepsilon) = 1$). 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 $\varepsilon_{p^e,t}$ and $\varepsilon_{ir_r,t}$. SVAR methodology decomposes the series into its permanent and temporary components. 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. 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.

The equation (2) we can now rewrite to the following form:

$$\begin{bmatrix} ir_{n,t} \\ p_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ . & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{i^e,t} \\ \varepsilon_{ir_r^e,t} \end{bmatrix} \qquad (7)$$

Correctly identified model can be finally estimated employing SVAR methodology as the system is now just-identified. 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 the overall responsiveness of nominal long-term interest rates to one standard deviation inflation expectations and expected real interest rates shocks.

5. Data and Results

We've estimated bi-variate SVAR model for the individual Euro Area member countries to estimate the responsiveness of their long-term nominal interest rates to the positive one standard deviation inflation expectations and expected real interest rates shocks. Monthly data for the period of 2000M1-2007M12 (model A) consisting of 96 observations and for the period of 2000M1-2015M4 (model B) consisting of 184 observations were employed for the interest rates on government bonds with 10-year maturity and inflation based on consumer prices. Estimation of two models for each individual country should be helpful in examining crisis related effects on calculated results. Time series for inflation were seasonally adjusted. Time series for all endogenous variables were collected from IMF database (International Financial Statistics, September 2015).

A. Testing Procedures

Estimation of both models and correct identification of structural shocks affecting both endogenous variables it is necessary to preserve stationarity of the VAR model. To test the stationarity of both models it is necessary to check 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).

Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were computed to test endogenous variables for the unit roots presence. Both ADF and PP tests indicate that all variables are non-stationary on values. As a result, the null hypothesis of a unit root presence cannot be rejected for any of time series. Testing variables on first differences indicates that time series are stationary. We may conclude that variables are integrated of order 1 I(1).

Because all endogenous variables have a unit root it is necessary to test time series for cointegration using the Johansen and Juselius cointegration test. The test for the cointegration was calculated using three lags as recommended by the AIC (Akaike Information Criterion) and SIC (Schwarz Information Criterion).

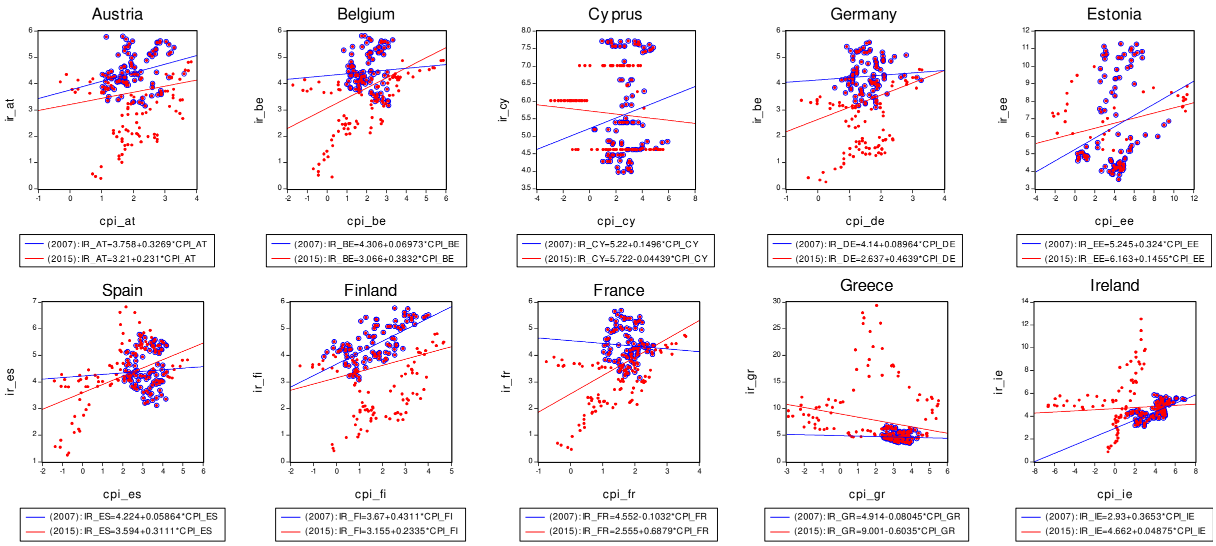
The results of Johansen cointegration tests confirmed our results of unit root tests. Both the trace statistics and maximum eigenvalue statistics (both at 0.05 level) indicate that there is no cointegration among endogenous variables of the model.

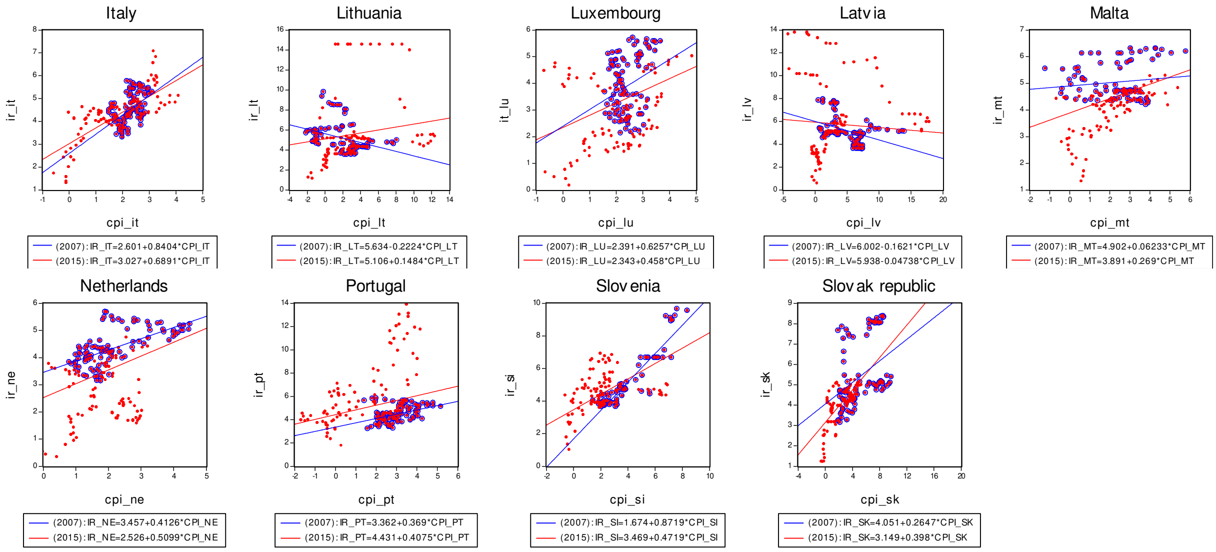
To test the stability of VAR models we also employed a number of diagnostic tests. We found no evidence of serial correlation, heteroskedasticity and autoregressive conditional heteroskedasticity effect in disturbances. The model also passes the Jarque-Bera normality test, so that errors seem to be normally distributed. VAR models seem to be stable also because inverted roots of the model for each country lie inside the unit circle. Detailed results of time series testing procedures are not reported here to save space. Like any other results, they are available upon request from the author.

B. Relationship between Interest Rates and Inflation

Figure 1 depicts mutual relationship (simple linear regression) between the price level dynamics and the long-term nominal interest rates on 10-year government bonds in the Euro Area member countries. The results are presented for both per-crisis and extended periods. In most countries higher rates of inflation are associated with higher interest rates. However, mutual relationship between both variables does not provide a clear picture of effects of inflation on long-term interest rates according to the size and performance of the country.

Figure 1 Correlation between Interest Rates and Inflation





Note: Inflation (CPI) and long-term nominal interest rates (IR) are expressed in percentage. Regression equation 2007 is calculated for the period 2000-2007 and regression equation 2015 for the period 2000-2015. Correlation coefficients between inflation and interest rates:

<u>2000-2007:</u> AT (0.285), BE (0.062), CY (0.122), DE (0.072), EE (0.228), ES (0.049), FI (0.657), FR (-0.061), GR (-0.049), IE (0.662), IT (0.487), LT (-0.360), LU (0.292), LV (-0.414), MT (0.133), NE (0.631), PT (0.421), SI (0.918), SK (0.405).
<u>2000-2015:</u> AT (0.158), BE (0.441), CY (-0.069), DE (0.248), EE (0.182), ES (0.479), FI (0.242), FR (0.483), GR (-0.219), IE (0.076), IT (0.718), LT (0.171), LU (0.344), LV (-0.078), MT (0.403), NE (0.397), PT (0.278), SI (0.660), SK (0.662).

Source: Author's calculations.

Relatively strong positive relationship between both variables was examined in both smaller (i.e. Austria, Luxembourg, Netherlands) and larger (i.e. Finland) economies from the core as well as the periphery (i.e. Portugal and Italy) of the Euro Area. The same results were obtained for the new Euro Area members from the Central and Eastern Europe (except for Latvia and Lithuania) that operated outside the currency union during the pre-crisis period. In the remaining countries the correlation between interest rates and inflation was generally lower, though in some cases we have also observed a negative correlation between both variables (France and Greece). While generally lower or even negative relationship between both variables indicate reduced role of inflation premium in determining long-term interest rates, examination of possible causal relationship requires a further investigation.

Crisis period significantly strengthened the relationship between long-term interest rates and inflation in some countries (i.e. Belgium, Germany, Spain, France and Malta). However, divergent trend was observed in countries that suffered the most during the crisis period (i.e. Cyprus, Greece and Ireland) and few examples of reduced correlations was also identified (i.e. Austria, Finland, Italy, Luxembourg). New Euro Area member countries also provide mixed evidence about the effects of the crisis on the mutual relationship between interest rates and inflation.

Table 1 summarizes detailed information on correlation relationship between long-term interest rates and inflation in the Euro Area member countries decomposed into three years long sub-periods.

Table 1 Correlation between Inflation and Interest Rates

	2000-2002	2003-2005	2006-2008	2009-2011	2012-2014
Austria	0.2019	-0.4750	0.7303	-0.5902	0.6771
Belgium	0.5055	-0.6665	0.5457	0.2313	0.8654
Cyprus	0.0519	-0.0643	0.4877	0.4394	0.8541
Germany	0.0231	-0.2183	0.5790	-0.6271	0.7778
Estonia	0.3424	-0.5284	0.9054	-0.4541	
Spain	0.0824	-0.3351	0.2112	0.7889	0.8938
Finland	0.6124	-0.3054	0.6774	-0.5040	0.6583
France	-0.0981	0.6149	0.3924	-0.5614	0.8315
Greece	-0.3009	-0.4949	0.3010	0.3560	0.8266
Ireland	0.2958	0.0978	0.1760	0.8065	0.9282
Italy	-0.1273	0.6325	0.5472	0.7319	0.9120
Lithuania	0.1963	-0.8343	1.0000	1.0000	0.8942
Luxembourg	0.6316	-0.3415	0.2038	-0.7921	0.6679
Latvia	0.3388	-0.5848	0.5600	-0.4272	0.6823
Malta	0.5320	-0.8068	0.0858	0.2901	0.7399
Netherland	-0.4452	0.0258	0.5790	-0.4265	0.6666
Portugal	-0.5097	0.2965	0.1900	0.8370	0.9125
Slovenia	0.4861	0.9478	0.5955	0.1689	0.8289
Slovakia	0.6982	0.9443	0.3261	0.3914	0.9193
average	**0.1851**	**-0.1103**	**0.4786**	**0.0973**	**0.8076**

Note: Data represents coefficients of mutual correlations between inflation (CPI based) and interest rates (10-year government bonds).
Source: Author's calculation.

Early stage (2000-2002) followed by the establishment of the Euro Area indicates positive though generally weak relationship between long-term nominal interest rates on 10-year government bonds and inflation in the group as a whole. This period was characterized by a convergence in long-term interest rates that especially in the periphery and less performing countries of the Euro Area induced decreasing trend in the yields from government bonds. At the same time, most countries experienced a reduced dynamics in the prices (during 2001 and 2002) affected by the recession in European Union during 2000 and 2001 while later new Euro Area members from Central and Eastern Europe were recovering from the end of 1990s recession. As a result, five countries from the group experienced a negative while other five countries strong positive correlation between interest rates and inflation.

Second stage (2003-2005) was characterized by the boost in performance of most countries that induced slight increase in inflation while interest rates on government bonds followed continuously decreasing trend. As a result, correlation between interest rates and inflation decreased in all Euro Area member countries and increased only in Slovak republic and Slovenia operating outside the Euro Area at this stage. During the third period (2006-2008) the correlation between interest rates and inflation significantly strengthened due to increasing trend in the interest rates development and accelerated inflation caused by higher real output dynamics at the end of this sub-period. Early crisis sub-period (2009-2011) revealed a substantial decrease in the mutual relationship between long-term interest rates and inflation due to divergent trajectory in the path of both variables. Recession caused a significant drop in the dynamics of the price level (2009) followed by less dynamic boost (2010) while interest rates on government bonds tend to rise in almost all countries especially in the last year of this sub-period (Cyprus, Spain, Greece, Ireland, Italy, Portugal and Baltic countries as well). The last sub-period (2012-2014) brought a substantial increase in the mutual relationship between both variables. Disinflation and associated deflationary pressures and the end of this sub-period were associated with a reduction in the rate of interest on government bonds in all countries thought in Cyprus and Greece due to bailout programme.

C. Variance Decomposition

Instability of the correlation between long-term interest rates and inflation as well as changing patterns in the price level dynamics during the pre-crisis and crisis periods reveals questions associated with a stability of long-term inflations expectations (Chernov and Mueller, 2012). Moreover, the relative importance of inflation expectations in determining long-term interest rates requires rigorous investigation. Increasing importance of this objective is even highlighted considering that near zero inflation environment makes the relative importance of inflation expectations quite ambiguous. Moreover, expected real interest rates do not seem to be the only (though still significant) driver of the nominal interest rates movements during the deflationary periods (Arouba, 2014). However, increased uncertainty on the financial markets, excessive liquidity fueled by the conduction of the unconventional monetary policy and time deformation of the yield curves provide mixed suggestions on the relative importance of expected real interest rates in determining long-term nominal interest rates (Rudebusch and Swanson, 2012).

Table 2 summarizes relative contributions of the inflation expectations and expected real interest rates shocks to the conditional variance of long-term nominal interest rates on 10-year government bonds in the Euro Area member countries during pre-crisis (model A) and extended (model B) periods. Variance decomposition enables us to examine the relative importance of both structural shocks in explaining long-term nominal interest rates fluctuations over different time horizons. Because we have employed bi-variate VAR model and employed scheme to identify just two (mutually uncorrelated) structural shocks the sum of both shocks in each particular horizon in both models for all countries is equal to 100 per cent. Moreover, following our identification scheme considering that shock of expected real interest rates is neutral in determining nominal interest rates in the long run, the contribution of this shock to the variance of nominal interest rates gradually approaches zero percent.

Our results indicate that expected real interest rate clearly dominates in explaining immediate and short-term fluctuations of the long-term nominal interest rate in models for both pre-crisis and extended period in all countries. However, over increasing time horizon its contribution the variability in nominal interest rate clearly decreases and is equal to zero in long run as we have assumed. It also implies that the role of inflation expectations in explaining short-term movements of nominal interest rate is quite low thought their importance continuously raises with increasing time horizon and dominates in the long run.

Table 2 Variance Decomposition of Long-term Nominal Interest Rates (in per cent)

Austria					Belgium					Cyprus				
Horizon (months)	Expected real interest rates		Expected inflation		Horizon (months)	Expected real interest rates		Expected inflation		Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B		A	B	A	B		A	B	A	B
1	73.24	71.75	26.76	28.25	1	72.56	70.12	27.44	29.88	1	74.56	70.18	25.44	29.82
6	68.87	65.22	31.13	34.78	6	69.23	66.19	30.77	33.81	6	70.17	64.12	29.83	35.88
12	60.36	57.23	39.64	42.77	12	61.49	59.35	38.51	40.65	12	53.76	51.09	46.24	48.91
24	41.70	36.29	58.30	63.71	24	42.70	40.22	57.30	59.78	24	35.56	34.75	64.44	65.25
48	24.09	22.62	75.91	77.38	48	22.10	21.76	77.90	78.24	48	18.90	21.59	81.10	78.41
long-term	0.00	0.00	100.00	100.00	long-term	0.00	0.00	100.00	100.00	long-term	0.00	0.00	100.00	100.00

Germany					Estonia					Spain				
Horizon (months)	Expected real interest rates		Expected inflation		Horizon (months)	Expected real interest rates		Expected inflation		Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B		A	B	A	B		A	B	A	B
1	76.29	73.53	23.71	26.47	1	78.71	60.03	21.29	39.97	1	70.51	74.29	29.49	25.71
6	73.15	69.36	26.85	30.64	6	69.38	53.56	30.62	46.44	6	65.84	70.41	34.16	29.59
12	65.88	62.28	34.12	37.72	12	59.45	48.21	40.55	51.79	12	52.25	57.14	47.75	42.86
24	45.05	42.45	54.95	57.55	24	40.49	35.69	59.51	64.31	24	33.68	36.27	66.32	63.73
48	24.17	22.16	75.83	77.84	48	21.86	20.54	78.14	79.46	48	16.22	17.42	83.78	82.58
long-term	0.00	0.00	100.00	100.00	long-term	0.00	0.00	100.00	100.00	long-term	0.00	0.00	100.00	100.00

Finland				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	71.33	68.49	28.67	31.51
6	67.09	63.24	32.91	36.76
12	50.14	58.98	49.86	41.02
24	41.77	35.63	58.23	64.37
48	23.32	19.44	76.68	80.56
long-term	0.00	0.00	100.00	100.00

France				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	74.21	71.33	25.79	28.67
6	71.18	68.08	28.82	31.92
12	64.23	60.56	35.77	39.44
24	42.32	41.29	57.68	58.71
48	22.89	21.24	77.11	78.76
long-term	0.00	0.00	100.00	100.00

Greece				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	79.08	81.16	20.92	18.84
6	73.22	75.72	26.78	24.28
12	66.90	68.57	33.10	31.43
24	45.47	46.23	54.53	53.77
48	25.04	27.31	74.96	72.69
long-term	0.00	0.00	100.00	100.00

Ireland				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	73.29	76.26	26.71	23.74
6	69.23	71.49	30.77	28.51
12	61.43	64.11	38.57	35.89
24	42.56	45.81	57.44	54.19
48	22.79	23.09	77.21	76.91
long-term	0.00	0.00	100.00	100.00

Italy				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	73.54	75.02	26.46	24.98
6	68.42	71.79	31.58	28.21
12	54.29	60.92	45.71	39.08
24	36.16	41.11	63.84	58.89
48	20.44	22.63	79.56	77.37
long-term	0.00	0.00	100.00	100.00

Luxembourg				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	71.17	68.56	28.83	31.44
6	67.64	62.15	32.36	37.85
12	58.22	56.38	41.78	43.62
24	41.83	38.27	58.17	61.73
48	22.07	20.19	78.93	79.81
long-term	0.00	0.00	100.00	100.00

Lithuania				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	77.21	64.18	22.79	35.82
6	70.44	60.37	29.56	39.63
12	56.22	45.29	43.78	54.71
24	32.74	31.36	67.26	68.64
48	18.16	16.22	81.84	83.78
long-term	0.00	0.00	100.00	100.00

Latvia				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	74.29	67.29	25.71	32.71
6	68.98	59.21	31.02	40.79
12	51.14	48.61	48.86	51.39
24	31.05	29.40	68.95	58.60
48	22.45	23.26	77.55	76.74
long-term	0.00	0.00	100.00	100.00

Malta				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	75.29	70.88	24.71	29.12
6	69.07	66.49	30.93	33.51
12	51.80	54.21	48.20	45.79
24	32.31	37.04	67.69	62.96
48	16.66	20.45	83.34	79.55
long-term	0.00	0.00	100.00	100.00

Netherlands				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	74.29	70.22	25.71	29.78
6	71.15	66.29	28.85	33.71
12	64.27	61.71	35.73	38.29
24	40.15	38.14	59.85	61.86
48	18.78	18.06	81.22	81.94
long-term	0.00	0.00	100.00	100.00

Portugal				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	69.56	72.15	30.44	27.85
6	65.12	69.54	34.88	30.46
12	54.26	60.03	45.74	39.97
24	37.09	42.77	62.91	57.23
48	22.15	23.51	77.85	76.49
long-term	0.00	0.00	100.00	100.00

Slovak republic				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	73.15	71.23	26.85	28.77
6	69.53	65.67	30.47	34.33
12	62.67	56.22	37.33	43.78
24	43.18	38.12	56.82	61.88
48	17.97	16.95	82.03	83.05
long-term	0.00	0.00	100.00	100.00

Slovenia				
Horizon (months)	Expected real interest rates		Expected inflation	
	A	B	A	B
1	71.49	68.11	28.51	31.89
6	65.24	61.27	34.76	38.73
12	58.56	50.14	41.44	49.86
24	39.16	35.05	60.84	64.95
48	15.17	14.77	84.83	85.23
long-term	0.00	0.00	100.00	100.00

Note: Relative contributions of structural shocks to the conditional variance of long-term nominal interest rates on 10-year government bonds in models A (2000M1-2007M12) and B (2000M1-2015M4).
Source: Author's calculations.

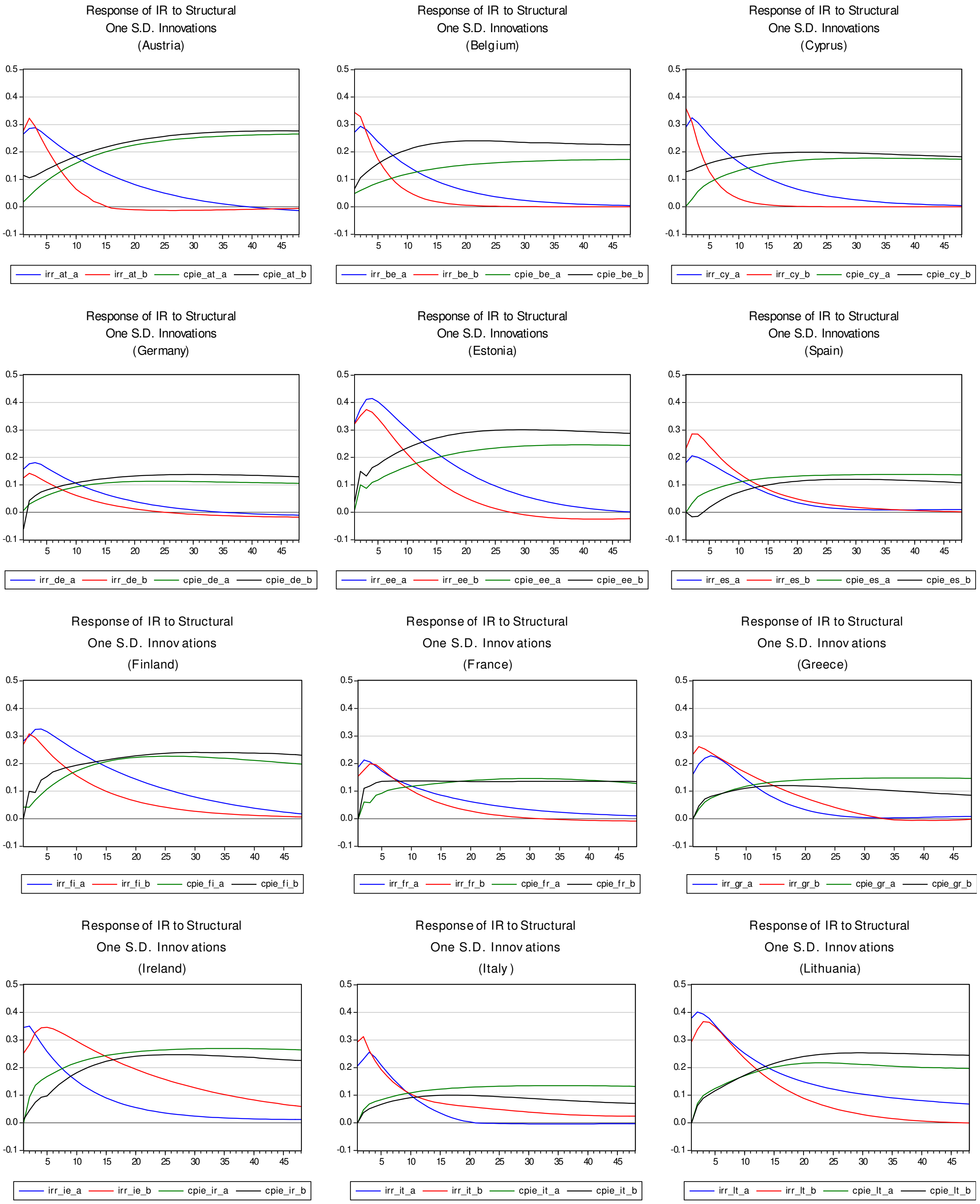
While the response patterns of the long-term nominal interest rates followed quite similar scenario in all Euro Area member countries we have observed some differences in the relative contributions of both shocks to the nominal interest rates determination in individual countries. Results seem to be also sensitive to the underlying period as the contribution of both shocks to the nominal interest rates determination has slightly changed when comparing models for pre-crisis and extended period. However, differences between both models are less considerable because the model for the extended period includes time series for the pre-crisis period.

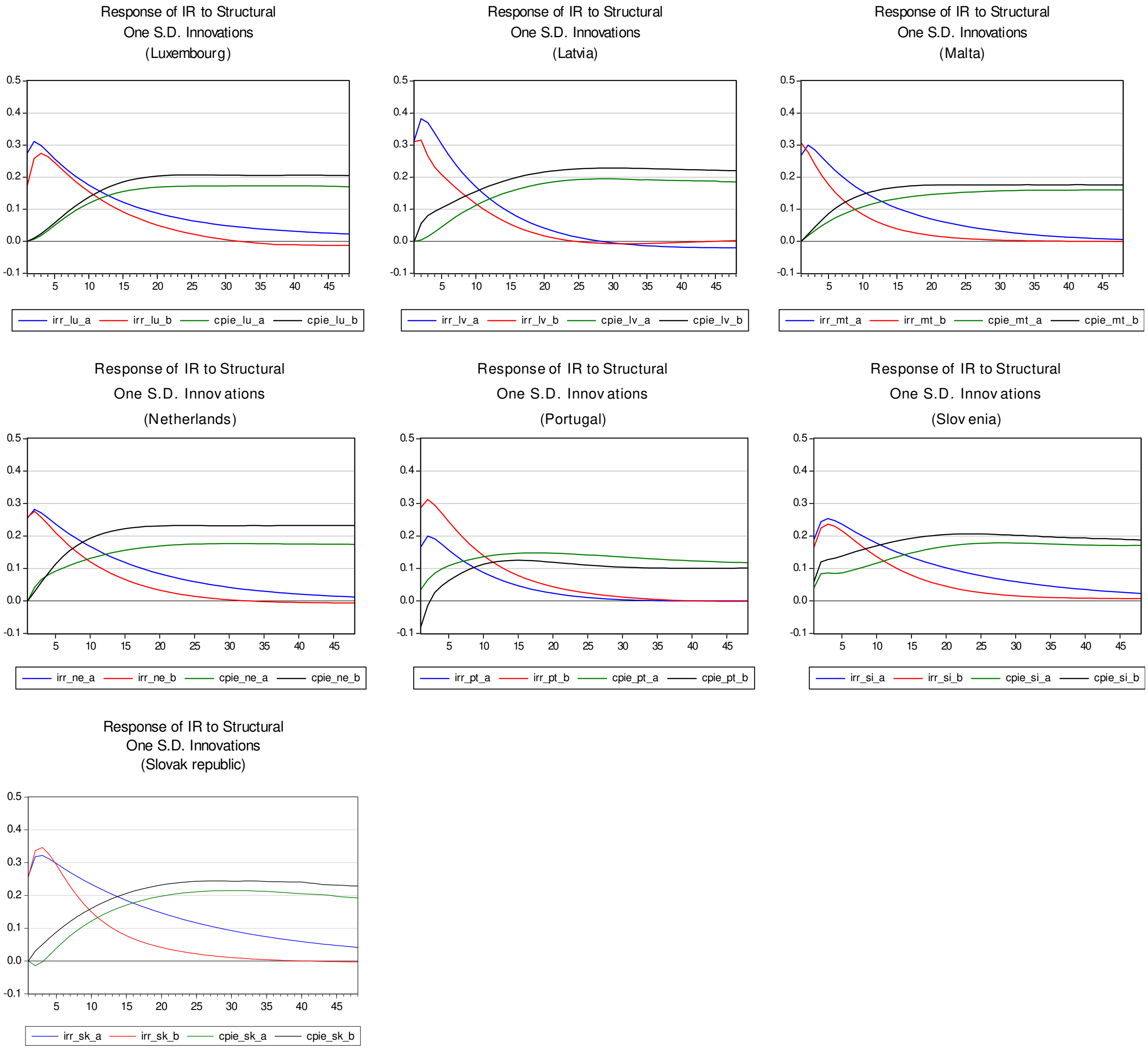
Relative importance of expected real interest rates during the first year since the shock in explaining unexpected movements in nominal interest rates clearly dominated during the pre-crisis period in all countries. However, the role of inflation expectations continuously increased and generally dominated since the sixteenth month since the shock. It seems that inflation expectations are more persistent and sudden changes in inflation expectations requires more time to induce changes in the long-term interest rates. While the relative contribution of both shocks to the unexplained fluctuations in the nominal interest rates followed a rather similar pattern in all countries from the group, crisis period brought some changes to the determination of nominal interest rates. Results for the extended period indicate a slight reduction in the relative importance of the expected real interest rates in all countries but periphery economies (Greece, Italy, Portugal, and Spain). We suggest that crisis induced reduction in the role of inflation expectations and increased role of expected real interest rates in the periphery countries reflects well known problems with liquidity (and associated increase in the risk premia) on the markets with their government bonds in the early stage of the crisis period. Second important implication of the effects associated with the crisis period is represented by the more significant increase in the relative importance of inflation expectations in determining long-term nominal interest rate in Baltic countries in comparison with the core countries of the Euro Area. Estonia, Latvia and Lithuania experienced the most significant drop in the dynamics of the price level during the early stage of the crisis period that is why the more significant increase in the more significant increase in the role of inflation expectations seems to be reasonable.

D. Impulse-Response Functions

Figure 2 summarizes responses of nominal interest rates on 10-year government bonds to the positive one standard deviation shocks of inflation expectations and expected real interest rates in PIGS countries, Germany and France during pre-crisis (model A) and extended (model B) periods.

Figure 2 Responses of Long-term Interest Rates to Shocks of Inflation Expectations and Expected Real Interest Rates





Note: Curves represent responses of long-term nominal interest rates (IR) to the positive one standard deviation inflation expectations shock (CPIE) and expected real interest rates shock (IRR) in models A (2000M1-2007M12) and B (2000M1-2015M4).
Source: Author's calculations.

Impulse-response functions of long-term nominal interest rates revealed mostly similar response patterns of interest rates on 10-year government bonds to the underlying shocks across all countries though we have observed some differences between periphery economies (PIGS) and Euro Area core countries. Moreover, differences in the response patterns of nominal interest rates between both groups of countries are reasonable in both models covering both pre-crisis and extended periods.

Expected real interest rates dominated in determining long-term interest rates during almost whole first year since the shock in all Euro Area member countries. Nominal interest rates immediately increased after the positive expected real interest rate shock. However, responsiveness of nominal interest rates to the shock of expected real interest rates was slightly higher in the periphery countries. Effect of the shock culminated within first three months and then steadily died out during subsequent two years since the shock in the whole group of countries. Nominal interest rates in Baltic countries seem to be more responsive to the expected real interest rate shock in comparison with the rest of the group.

Comparison of the results for pre-crisis and extended periods revealed interesting differences between periphery and the core Euro Area member countries. Despite some minor differences, responsiveness of long-term interest rates to the shock of expected real interest rates in periphery countries during the extended period slightly increased (effect is clear especially during first months since the shock), while remaining countries experienced opposite trend. We suggest that investors required higher risk premium (associated with higher expected real interest rates) to hold risky government bonds of PIGS countries considering that these countries were exposed the most to the threat of default during the crises period.

Effects of the expected real interest rates shock on the long-term nominal interest rates gradually decreased with increasing time horizon and completely died out in the horizon of 2 to 4 years since the shock in the respective country. As a result, effect of this shock is neutral in the long run that corresponds to our assumptions in the model specification and structural shocks definition. However, Expected real interest rates remain a significant driver of the long-term nominal interest rates movements in the short run.

Immediate responsiveness of long-term interest rates to the positive inflation expectations shock was generally negligible (in comparison with expected real interest rates shock) though the intensity of the shock continuously increased over time. As a result, effects of inflation expectations on long-term nominal interest rates are much stable with increasing time horizon in all Euro Area member countries. While short-term (within first twelve months since the shock) response of interest rates to the shock of inflation expectations was generally lower than in case of expected real interest rates, it remained positive and stable with increasing time horizon and even permanent in the long run. Positive effect of the shock culminated till the end of the second year since the shock. The shock of inflation expectations clearly dominated in the medium term in determining long-term nominal interest rates and our results confirm its permanent effect on interest rates in the long run (though with reduced intensity in some countries, i.e. Greece and Italy).

Crises period affected responsiveness of interest rate on 10-year government bonds to the shock of inflations expectations in both groups of countries. While the vulnerability of long-term nominal interest rates to the shock of inflation expectations in periphery countries decreased, the rest of the Euro Area experienced opposite scenario. Economies of GIIPS countries suffered the most during the crisis period. We suggest that the reasonable risk of deflation and deflationary spiral reduced the role of inflation expectations for the nominal interest rates determination.

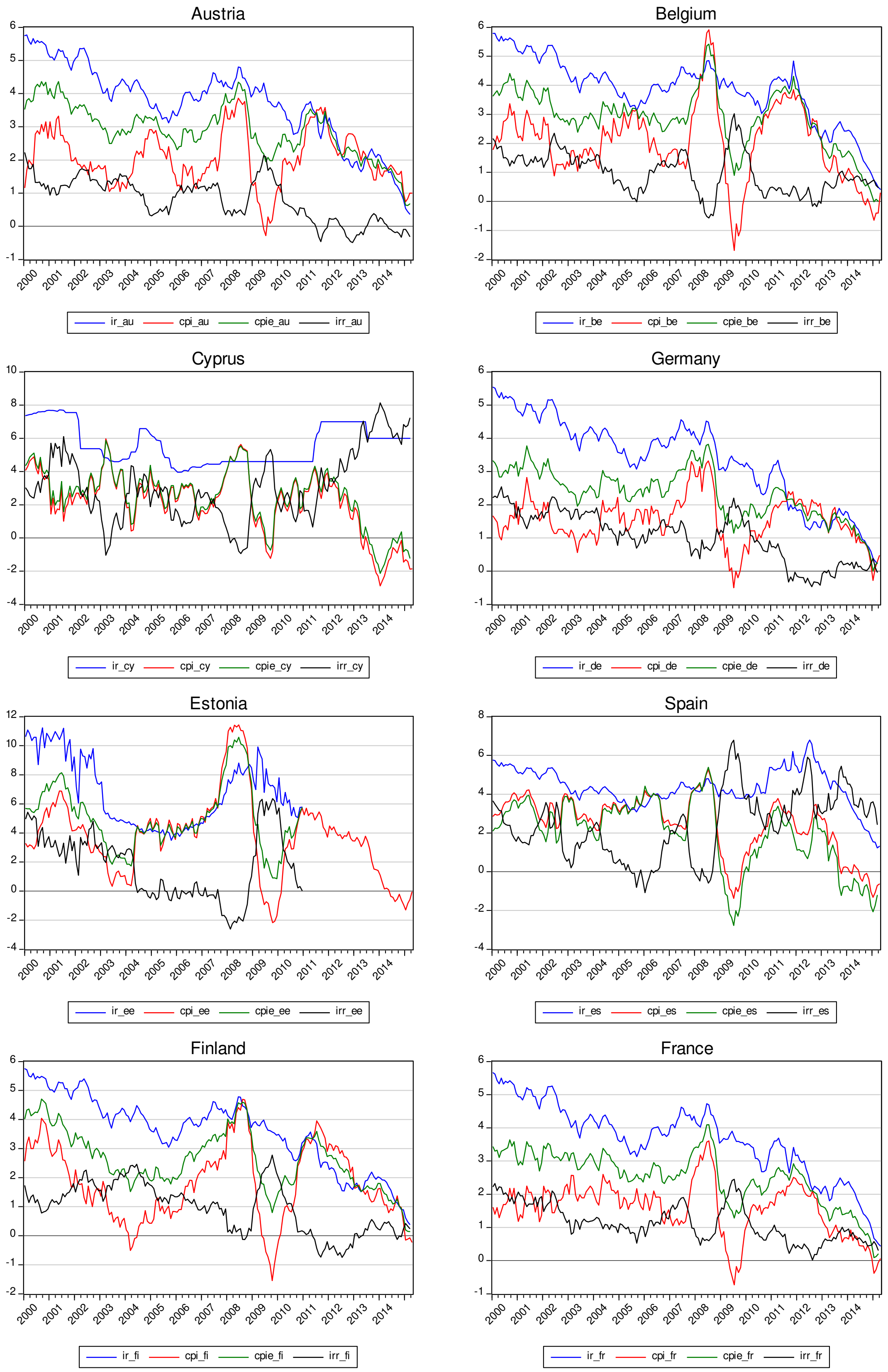
Examined differences in the responsiveness of the long-term interest rates to the inflation expectations shocks between periphery and core countries of the Euro Area reveals many opened questions associated with suitability of monetary policy conducted by ECB in the single currency area consisting of significantly heterogeneous countries. Implications of quantitative easing accompanied by near zero levels of the key interest rates aiming to boost the inflation may be biased due to existing differences in the inflation expectations between North and South of the Euro Area.

E. Decomposition of Long-term Nominal Interest Rates

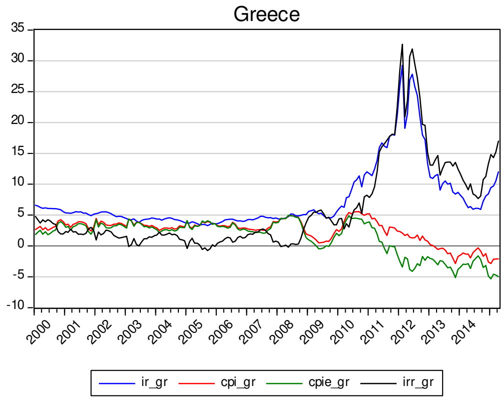
In this section we provide decomposition of long-term nominal interest rates into inflation expectations and expected real interest rates components. Stationary and permanent components of the long-term interest rates are calculated by the accumulation of the effect of both structural shocks. Estimation of expected real interest rates is calculated by adding the stationary components to the mean of difference between observed long-term interest rates and contemporaneous rate of inflation[2] (St-Amant, 1996). Estimation of inflation expectations is calculated by subtracting already calculated expected real interest rates from the nominal long-term interest rates.

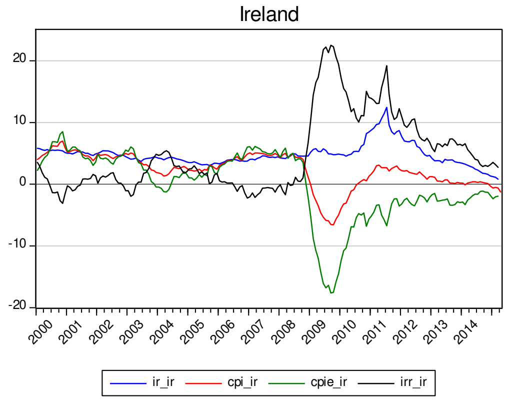
[2] Mean of difference between observed long-term interest rates and contemporaneous rate of inflation: AT (1.636%), BE (1.815%), CY (3.431%), DE (1.815%), EE (3.023%), ES (1.884%), FI (1.783%), FR (2.062%), GR (5.010%), IE (2.465%), IT (2.390%), LT (2.931%), LU (1.141%), LV (1.501%), MT (2.279%), NE (1.516%), PT (3.126%), SI (1.132%), SK (0.473%).

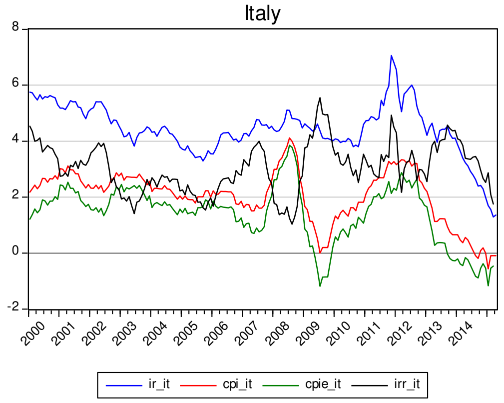
Figure 3 Decomposition of Long-term Interest Rates on Government Bonds[3]

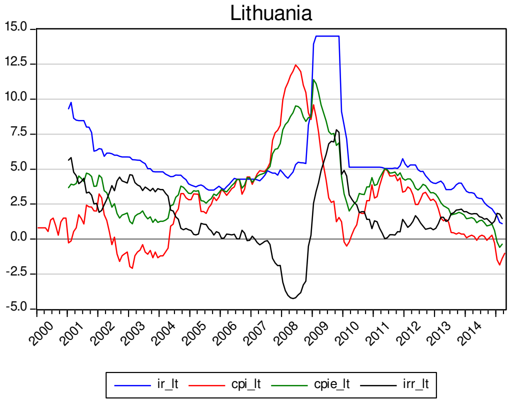


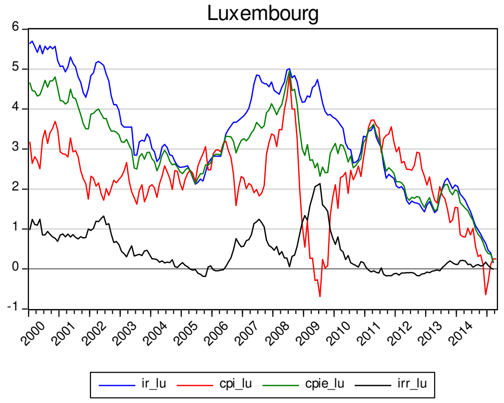
[3] Since 2011 there are no Estonian sovereign debt securities that comply with the definition of long-run interest rates for convergence purposes according to ECB. No suitable proxy indicator has been identified.

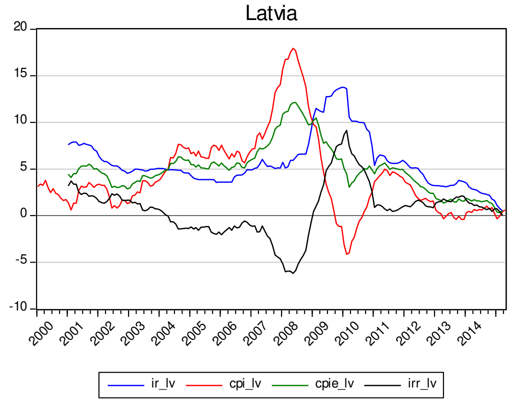

Greece
35
30
25
20
15
10
5
0
-5
-10
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
ir_gr cpi_gr cpie_gr irr_gr

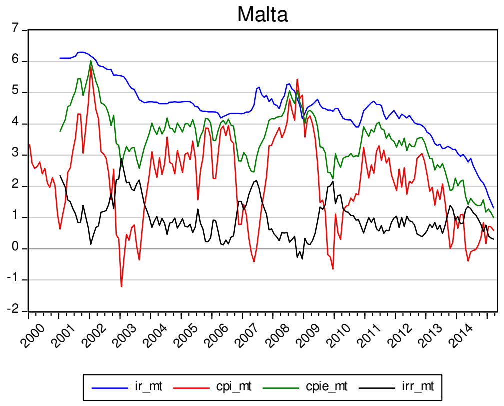

Ireland
20
10
0
-10
-20
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
ir_ir cpi_ir cpie_ir irr_ir

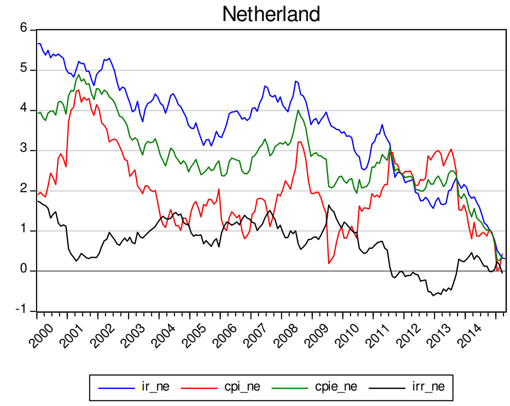

Italy
8
6
4
2
0
-2
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
ir_it cpi_it cpie_it irr_it

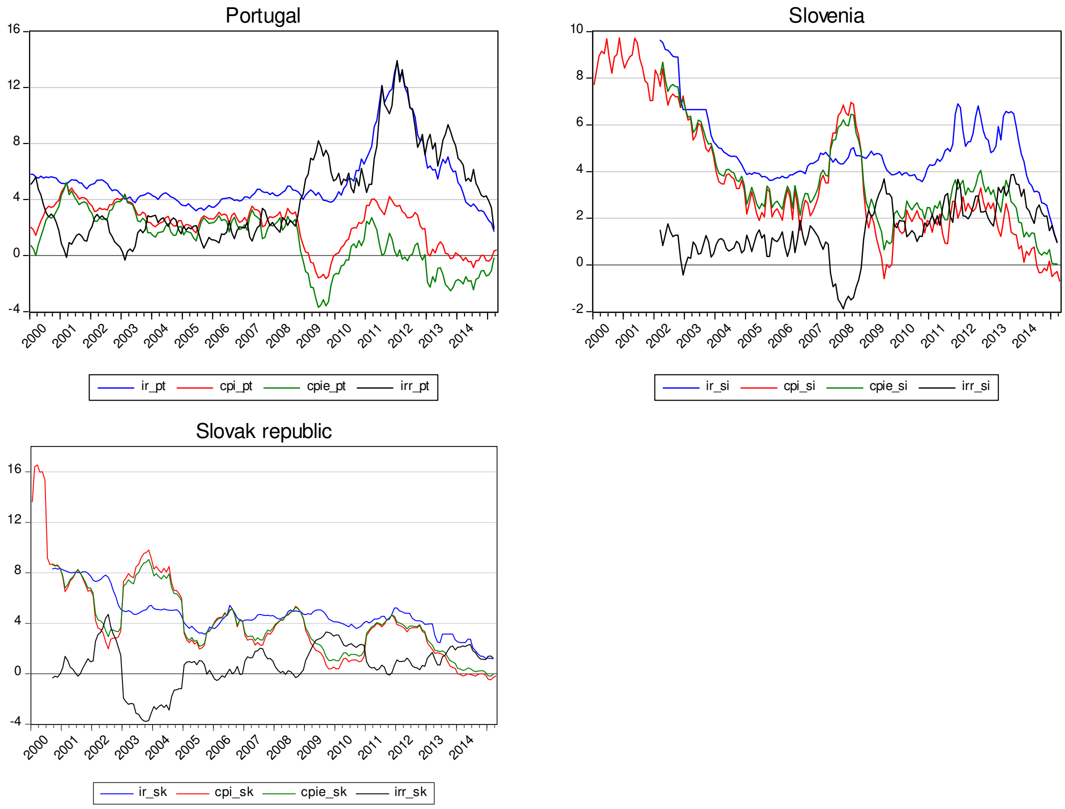

Lithuania
15.0
12.5
10.0
7.5
5.0
2.5
0.0
-2.5
-5.0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
ir_lt cpi_lt cpie_lt irr_lt


Luxembourg
6
5
4
3
2
1
0
-1
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
ir_lu cpi_lu cpie_lu irr_lu


Latvia
20
15
10
5
0
-5
-10
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
ir_lv cpi_lv cpie_lv irr_lv


Malta
7
6
5
4
3
2
1
0
-1
-2
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
ir_mt cpi_mt cpie_mt irr_mt


Netherland
6
5
4
3
2
1
0
-1
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
ir_ne cpi_ne cpie_ne irr_ne



Note: Curves represent development of nominal interest rate on 10-year government bonds (IRR), inflation measured by CPI (CPI) and estimated components of long-term nominal interest rates represented by inflation expectations (CPIE) and expected real interest rates (IRR).
Source: Author's calculations.

Decomposition of long-term interest rates on 10-year government bonds in both the periphery and core member countries of the Euro Area revealed interesting differences in the (a) relative contributions of inflation expectations and expected real interest rates into nominal interest rates leading path since the establishment of the Euro Area as well as (b) relationship between inflation rates and inflation expectations in the above mentioned countries (Figure 3). Downward trend in long-term interest rates in the Euro Area member countries and related convergence in their development between North and South during the most of the pre-crisis period was associated with drop in inflation expectations while expected real interest rates remained relatively stable at 0-2 per cent corridor on average. However, expected real interest rates were generally higher in Ireland, Italy, Portugal and Spain or more volatile in Cyprus, Baltic countries and Slovakia. At the same time, inflation expectations experienced increasing trend during the last 2-3 years of a pre-crisis period when long-term interest rates tend to increase in most of the Euro Area member countries.

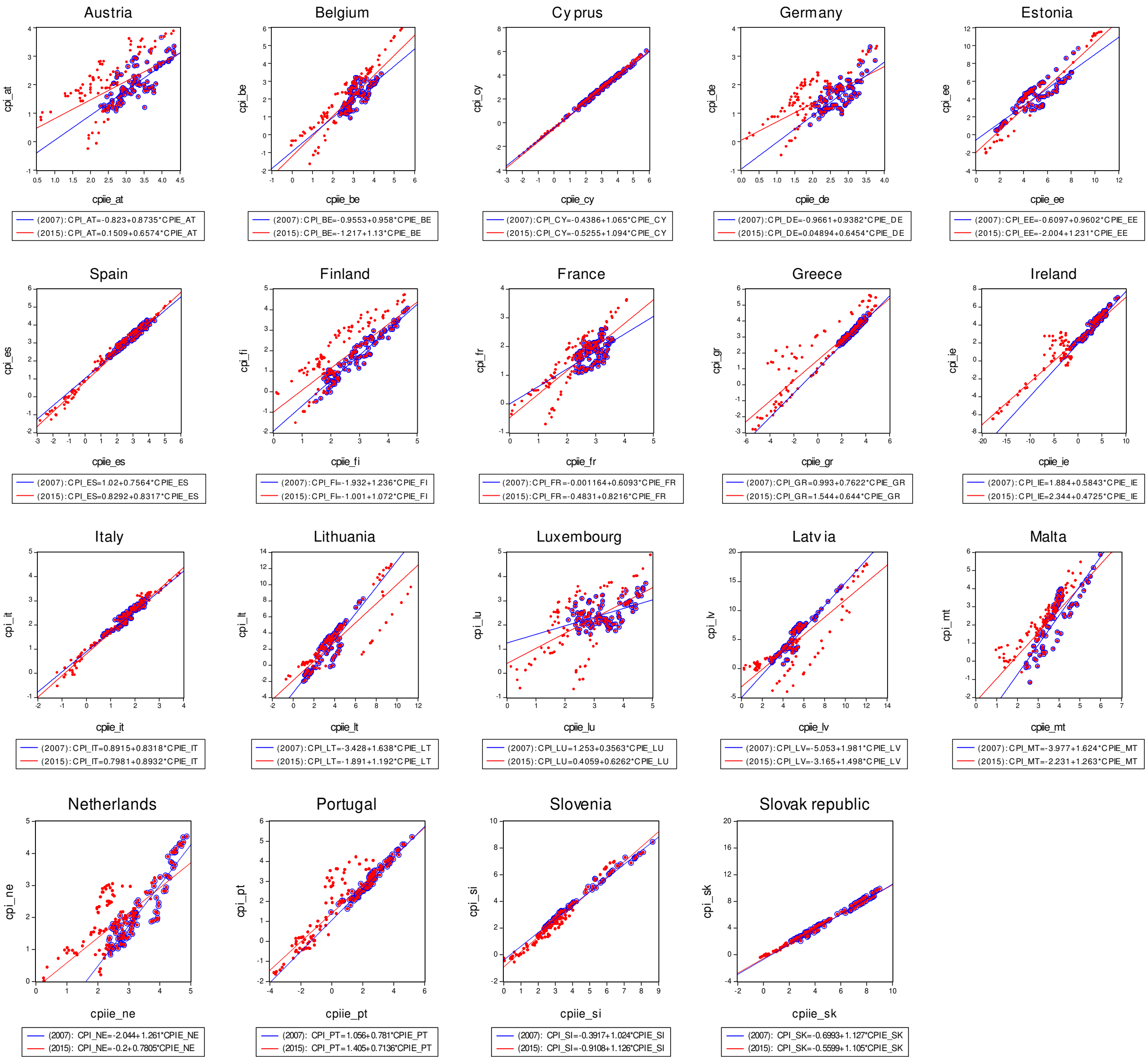
First crucial implication resulted from our estimations is represented by clear differences between inflation and inflation expectations derived from long-term interest rates between periphery economies and the core of the Euro Area. Inflation expectations in GIIPS countries tend to undershoot a trajectory of inflation path during the whole pre-crisis period. Moreover, this trend was even intensified during the crisis period. We suggest that increased uncertainty on the markets together with crisis related problems (recession, risk of default, fiscal unsustainability, etc.) clearly reduced inflation expectations below recent rates of inflation. As a result, risk of deflation during the periods of decreasing inflation expectations that even undershoot low inflation target generally increased. Moreover, low inflation expectations that undershot inflation in periphery countries of the Euro Area induced higher expected real interest rates in comparison with their true levels. Similarly to our results from impulse-response analysis we suggest that undershooting patterns in inflation expectations result from increased fear of deflation and slumping real economy in light of tightening financial conditions that shifted expected real interest rates upward.

Decomposition of interest rates on government bonds in the core of the Euro Area revealed different picture about the relative importance of inflation expectations and expected real interest rates in long-term interest rates determination. Inflation expectations tend to overshoot the long-term path of inflation in both countries during the whole period. This pattern is more significant during the pre-crisis period. Higher inflation expectations than recent inflation that did not induce excessive inflation pressures are good signal for central bank in good times though during periods of persisting deflationary pressures combined with recession it may decrease the chance to boost inflation up and possibly worsen the deflationary spiral. However, mismatch between inflation expectations and recent inflation decreased during the crisis period. On the other hand, lower expected real interest rates, as a component of nominal long-term interest rates, may improve liquidity of government bonds in the core of the Euro Area and soften the conditions on their sovereign debt markets.

F. Relationship between Inflation and Inflation Expectations

Figure 4 depicts mutual relationship (simple linear regression) between consumer price inflation and inflation expectations in the Euro Area member countries. The results are presented for both per-crisis and extended periods. In most countries inflation rates and inflation expectations are highly positively correlated. However, we have observed some differences when comparing the results for the North and South of the Euro Area during the pre-crises and extended period.

Figure 4 Correlation between Inflation and Inflation Expectations



Note: Inflation (CPI) and inflation expectations (CPIE) are expressed in percentage. Regression equation 2007 is calculated for the period 2000-2007 and regression equation 2015 for the period 2000-2015. Correlation coefficients between inflation and inflation expectations:
<u>2000-2007:</u> AT (0.755), BE (0.739), CY (0.994), DE (0.757), EE (0.865), ES (0.971), FI (0.956), FR (0.554), GR (0.964), IE (0.971), IT (0.931), LT (0.903), LU (0.506), LV (0.930), MT (0.868), NE (0.929), PT (0.975), SI (0.995), SK (0.993).
<u>2000-2015:</u> AT (0.630), BE (0.894), CY (0.998), DE (0.705), EE (0.942), ES (0.992), FI (0.834), FR (0.834), GR (0.924), IE (0.952), IT (0.987), LT (0.880), LU (0.629), LV (0.858), MT (0.858), NE (0.758), PT (0.927), SI (0.988), SK (0.996).

Source: Author's calculations.

Despite examined undershooting patterns in inflation expectations (Section E) in the periphery countries of the Euro Area the correlation between inflation and inflation expectations during the pre-crisis period was generally higher in GIIPS countries (together with Malta and Cyprus) than in the rest of the Euro Area. Similarly high correlation was observed in countries from Central and Eastern Europe that operated outside the Euro Area during the pre-crisis period. Crisis period affected mutual correlation between both variables. While the strength of the relationship between both variables did not significantly change in the periphery countries, the results for the remaining countries are mixed. While in the most countries in the North of the Euro Area the correlation between inflation and inflation expectations decreased, opposite scenario was examined in Belgium, France and Luxembourg.

Table 3 summarizes detailed information on correlation relationship between consumer price inflation and inflation expectations in the Euro Area member countries decomposed into three years long sub-periods.

Table 3 Correlation between Inflation and Inflation Expectations

	2000-2002	2003-2005	2006-2008	2009-2011	2012-2014
Austria	0.8717	0.7094	0.9797	0.9234	0.8942
Belgium	0.9532	0.8319	0.9886	0.9834	0.9831
Cyprus	0.9961	0.9984	0.9999	0.9989	0.9999
Germany	0.9007	0.7761	0.9723	0.9042	0.9746
Estonia	0.9433	0.9808	0.9952	0.9682	
Spain	0.9932	0.9871	0.9974	0.9980	0.9911
Finland	0.9790	0.7596	0.9868	0.9731	0.9679
France	0.7511	0.8903	0.9652	0.9584	0.9700
Greece	0.9882	0.9933	0.9969	0.8795	0.5999
Ireland	0.9758	0.9747	0.9730	0.9648	-0.1646
Italy	0.9706	0.9724	0.9965	0.9900	0.9878
Lithuania	0.8757	0.9831	0.9843	0.7704	0.9878
Luxembourg	0.8851	-0.0369	0.7233	0.5098	0.8116
Latvia	0.8010	0.9735	0.9824	0.6838	0.9117
Malta	0.9865	0.9756	0.9658	0.9759	0.9269
Netherland	0.8892	0.6657	0.9410	0.6945	0.9463
Portugal	0.9965	0.9876	0.9855	0.9560	0.8750
Slovenia	0.9057	0.9976	0.9984	0.9618	0.9826
Slovakia	0.9988	0.9998	0.9973	0.9984	0.9986
average	**0.9295**	**0.8642**	**0.9700**	**0.8996**	**0.8691**

Note: Data represents coefficients of mutual correlations between inflation (CPI based) and inflation expectations.
Source: Author's calculation.

Early stage (2000-2002; bad times) followed by the establishment of the Euro Area indicates existence of strong positive correlation between inflation and inflation expectations in all countries. Recession in the European Union (2000-2001) and recovery from the end of 1990s recession in the prospective members of the Euro Area from Central and Eastern Europe was followed by a generally decreasing trend in both inflation and inflation expectations that caused a parallel and highly correlated movement in both variables. Increased dynamics in inflation during the second stage (2003-2005; intermediate times) induced a moderate reduction in the mutual relationship between inflation and inflation expectations in all countries as a whole (except for France). Early pre-crisis period (2006-2008; good times) brought a significant strengthening in the correlation between both variables in all countries. It seems that inflation expectations can adapt to changes in inflation smoothly provided that changes in economic environment are not sudden and associated adjustments in the economic outlook are undergoing over the longer time horizon. Early crisis sub-period (2009-2011) brought a reduction in the strength of correlation between inflation and inflation expectations thought mostly in smaller economies. While the mutual relationship between both variables slightly strengthened in most countries during the last sub-period (2012-2014), significant drop in the correlation coefficients in two countries (Greece and Ireland) caused a moderate drop in the correlation for the group of all countries as a whole.

Even decomposed results of the mutual relationship between inflation and inflation expectations into short sub-periods revealed existence of the significant positive correlation between both variables in GIIPS countries, Cyprus and Malta, and the new Euro Area member countries from Central and Eastern Europe. These results contribute to a growing evidence of a crucial role of inflation expectations in determining inflation especially in countries with imbalanced economic growth. Moreover, substantial role of inflation expectations in reducing the risk of deflationary pressures and associated stimulation of growth incentives even emphasizes the challenging task for ECB to provide a suitable monetary policy framework that would help to boost the performance of the countries in the South of the Euro Area while avoiding scenarios of imbalanced growth at the same time. However, as the recent literature suggest, it is not possible having single monetary policy framework for all Euro Area members countries. As a result, idea of a two-speed Europe may represent a convenient response of authorities to the competitiveness issues and intra-eurozone imbalances (Archick, 2015; Novotný, 2013; von Ondarza, 2013). Moreover, two-speed Europe could also accelerate real convergence not only in the "new" Euro Area members but also among "old" Euro Area member countries (ECB, 2015). However, putting this concept into practice requires further fiscal coordination or integration that is widely unpopular and therefore rather unrealistic.

5. Conclusion

Examination of the relative importance of inflation expectations and expected real interest rates in determining long-term nominal interest rates on 10-year government bonds in the periphery and core countries of the Euro Area revealed interesting implications of existing economic differences between both groups of countries. Increased contributions of expected real interest rates to the development of long-term nominal interest rates, undershooting patterns in inflation expectations according to the inflation rates together with strong positive correlation between inflation and inflation expectations in periphery countries of the Euro Area represent clear signal of markets to policy makers and possible scenarios of boosting inflation (ECB) and economic growth (national governments) in the Euro Area.

Higher expected real interest rates than actual real interest rates together with increased exposure of holding risky government bonds of periphery countries of the Euro area may force governments to undertake internal devaluation (with all risks associated with deflationary spiral) or to increase nominal interest rates on government bonds (with negative implications on costs of sovereign debt). We suggest that more dynamic convergence of periphery Euro Area member countries to the core countries together with strengthening of fiscal sustainability would help to reduce perceived risk of periphery countries followed by a reduction in expected real interest rates from government bonds.

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References

ACHARYA, V.V., STEFFEN, S. (2015) The "Greatest" Carry Trade Ever? Understanding Eurozone Bank Risks, *Journal of Financial Economics*, 115(2): 215-236

ARCHICK K. (2015) The European Union: Current Challenges and Future Prospects in Brief, [Congressional Research Service Report] Washington, Congressional Research Service, 13 p.

AROUBA, S.B. (2014) Term Structures of Inflation Expectations and Real Interest Rates: The Effects of Unconventional Monetary Policy, [Federal Reserve Bank of Minneapolis, Staff Report No.502/2014], Minneapolis, Federal Reserve Bank of Minneapolis, 51 p.

BINDSEIL, U., WINKLER, A. (2012) Dual Liquidity Crises under Alternative Monetary Frameworks: A Financial Accounts Perspective, [ECB Working Paper, no. 1478], Frankfurt am Main, European Central Bank, 61 p.

BLANCHARD, O.J., QUAH, D. (1988) The Dynamic Effects of Aggregate Demand and Aggregate Supply Disturbances, [National Bureau of Economic Research Working Paper No. 4637] New York, National Bureau of Economic Research, 39 p.

BOOTH, G.G., CINER, C. (2000) The Relationship between Nominal Interest Rates and Inflation: International Evidence, *Journal of Multinational Financial Management*, 11(3): 269-280

BORIO, C., DISYATAT, P. (2009) Unconventional Monetary Policies: An Appraisal, [BIS Working Paper, no. 292], Basel, Bank for International Settlements, 29 p.

CAMPBELL, J.Y., SHILLER, R.J. (1991) Yield Spreads and Interest Rate Movements: A Bird's Eye View, *Review of Economic Studies*, 58(3): 495-514

CHERNOV, M., MUELLER, P. (2012) The Term Structure of Inflation Expectations, *Journal of Financial Economics*, 106(2): 367-394

CHRISTENSEN, J.H.E., LOPEZ, J.A., RUDEBUSCH, G.D. (2008) Inflation Expectations and Risk Premiums in an Arbitrage-Free Model of Nominal and Real Bond Yields, [Federal Reserve Bank of San Francisco, Working Paper No.34/2008], San Francisco, Federal Reserve Bank of San Francisco, 39 p.

CHRISTENSEN, J.H.E., LOPEZ, J.A., RUDEBUSCH, G.D. (2012) Extracting Deflation Probability Forecasts from Treasury Yields, *International Journal of Central Banking*, 8(4): 21-60

COCHRANE, J.H., PIAZZESI, M. (2005) Bond Risk Premia, *American Economic Review*, 95(1): 138-160

CROWDER, W.J., HOFFMAN, D.L. (1996) The Long-Run Relationship between Nominal Interest Rates and Inflation: The Fisher Equation Revisited, *Journal of Money, Credit and Banking*, 28(1): 102-118

DE GRAUWE, P. (2013) Design Failures in the Eurozone: Can they be fixed?, [LSE "Europe in Question" Discussion Paper, no. 57], London, London School of Economics, 61 p.

DEACON, M., DERRY, A. (1994) Estimating Market Interest Rate and Inflation Expectations from the Prices of UK Government Bonds, *Bank of England Quarterly Bulletin*, 34: 232-240

DEN HAAN, W.J. (1995) The Term Structure of Interest Rates in Real and Monetary Economics, *Journal of Economic Dynamics and Control*, 19(5-7): 909-940

EIJFFINGER, S., SCHALING, E., VERHAGEN, W. (2000) The Term Structure of Interest Rates and Inflation Forecast Targeting, [CEPR, Discussion Paper 2375], London, Centre for Economic Policy Research, 23 p.

EMIRIS, M. (2006) The Term Structure of Interest Rates in a DSGE Model, [National Bank of Belgium, Working Paper Research No. 88] Brussels, National Bank of Belgium, 55 p.

ENGSTED, T. (1995) Does the Long-Term Interest Rate Predict Future Inflation? A Multi-Country Analysis, *The Review of Economics and Statistics*, 77(1): 42-54

European Central Bank (2015) Real Convergence in the Euro Area: Evidence, Theory and Policy Implications, *ECB Economic Bulletin*, 5: 30-35

EVANS, M.D.D. (1998) Real Rates, Expected Inflation, and Inflation Risk Premia, *Journal of Finance*, 53(1): 187-218

FENDEL, R. (2009) Note on Taylor Rules and the Term Structure, *Applied Economics*

Letters, 16(11): 1097-1101

GARCIA, R., PERRON, P. (1996) An Analysis of the Real Interest Rate under Regime Shifts, *Review of Economics and Statistics*, 78(1): 111-125

GERLACH-KRISTEN, P., RUDOLF, B. (2010) Macroeconomic and Interest Rate Volatility under Alternative Monetary Operating Procedures, [Swiss National Bank, Working Paper No. 2010-12] Zurich, Swiss National Bank, 40 p.

GÜRKAYNAK, R.S., SACK, B., WRIGHT, J.H. (2007) The U.S. Treasury Yield Curve: 1961 to the Present. *Journal of Monetary Economics*, 54(8): 2291-2304

HAUBRICH, J.G., PENNACCHI, G., RITCHKEN, P. (2012) Inflation Expectations, Real Rates, and Risk Premia: Evidence from Inflation Swaps, *Review of Financial Studies*, 25(5): 1588-1629

KIM, D.H., ORPHANIDES, A., (2012) Term Structure Estimation with Survey Data on Interest Rate Forecasts, *Journal of Financial and Quantitative Analysis*, 47(1): 241-271

KRISHNAMURTHY, A., VISSING-JORGENSEN, A. (2011) The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy, [National Bureau of Economic Research Working Paper No. 17555] New York, National Bureau of Economic Research, 53 p.

KULISH, M. (2007) Should Monetary Policy Use Long-term Rates? *B.E. Journal of Macroeconomics*, 7(1): 1-26

LABADIE, P. (1994) The Term Structure of Interest Rates over the Business Cycle. *Journal of Economic Dynamics and Control*, 18(3-4): 671-697

LAI, K.S. (2004) On Structural Shifts and Stationarity of the Ex Ante Real Interest Rate, *International Review of Economics and Finance*, 13(2): 217-228

LANNE, M. (2001) Near Unit Root and the Relationship between Inflation and Interest rates: A Reexamination of the Fisher Effect, *Empirical Economics*, 26(2): 357-366

MCGOUGH, B., RUDEBUSCH, G., WILLIAMS, J.C. (2005) Using a Long-term Interest Rates as the Monetary Policy Instrument, *Journal of Monetary Economics* 52(5): 855-879

MICHAUD, F.-L., UPPER, CH. (2008) What Drives Interbank Rates? Evidence from the Libor Panel, [BIS Quarterly Review, March 2008], Basel, Bank for International Settlements, p. 47-58

NEELY, CH.J., RAPACH, D.E. (2008) Real Interest Rates Persistence: Evidence and Implications, [Federal Reserve Bank of St. Louis, Review No. 6/2008] St. Louis, Federal Reserve Bank of St. Louis, 90(6): 609-641

NOVOTNÝ, V. (ed.) (2013). *From Reform to Growth: Managing the Economic Crisis in Europe*. Brussels, Centre for Economic Studies, 543 p.

PEERSMAN, G. (2011) Macroeconomic Effects of Unconventional Monetary Policy in the Euro Area, [ECB Working Paper, no. 1397], Frankfurt am Main, European Central Bank, 33 p.

RAGAN, C. (1995) Deriving Agents' Inflation Forecasts from the Term Structure of Interest Rates. [Bank of Canada, Working Paper, No. 1/1995] Ottawa, Bank of Canada, 41 p.

RUDEBUSCH, G.D. (2002) Term Structure Evidence on Interest Rate Smoothing and Monetary Policy Inertia, *Journal of Monetary Economics*, 49(6): 1161-1187

RUDEBUSCH, G.D., SACK, B.P., SWANSON, E.T. (2006) Macroeconomic Implications of Changes in the Term Premium, [Federal Reserve Bank of San Francisco, Working Paper No.46/2006], San Francisco, Federal Reserve Bank of San Francisco, 48 p.

RUDEBUSCH, G., SWANSON, E. (2012) The Bond Premium in a DSGE Model with Long-run Real and Nominal Risks, *American Economic Journal: Macroeconomics*, 4(1): 105-143

ST-AMANT, P. (1996) Decomposing U.S. Nominal Interest Rates into Expected Inflation and Ex Ante Real Interest Rates Using Structural VAR Methodology, [Bank of Canada, Working Paper No. 2/1996] Ottawa, Bank of Canada, 28 p.

TAYLOR, H. (1982) Interest Rates: How Much Does Expected Inflation Matter, *Business Review*, 65(4): 3-12

TOBIAS, A., WU, H (2010) The Term Structures of Inflation Expectations, [Federal Reserve Bank of New York, Staff Report No.362/2010], New York, Federal Reserve Bank of New York, 32 p.

VAYANOS D., VILA, J.L. (2009) A Preferred-Habitat Model of the Term Structure of Interest Rates, [National Bureau of Economic Research Working Paper No. 15487] New York, National Bureau of Economic Research, 57 p.

VON ONDARZA N. (2013) Strengthening the Core or Splitting Europe, [SWP Research Paper No. 2] Berlin, Stiftung Wissenschaft und Politik, 34 p.

WOOD, J.H. (1983) Do Yield Curves Normally Slope Up? The Term Structure of Interest Rates, 1862-1982, *Economic Perspectives*, 7(4): 17-23

WRIGHT, J. (2011) Term Premia and Inflation Uncertainty: Empirical Evidence from an International Panel Data Set, *American Economic Review*, 101(4): 1514-1534