The Implementation of Monetary Policy in Euroarea, United Kingdom and USA: Evidence from Financial Crisis Period

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Abstract
This paper examines the monetary policy implementation before during and after the financial crisis for USA, UK and selected Eurozone countries. The empirical approach we follow is the Vector Error Correction model based on time series approach which examines analytically the monetary policy transmission mechanism. According to our results, the Euroarea monetary authorities are more inflation targeted comparing to USA and UK in the application of monetary policy strategy. Also, the analysis showed relatively high degree of European bond market integration before the crisis outbreak. We imply a structural break on our analysis for crisis period to examine the effect of the global market turbulence on monetary policy implementation. As we observed, the financial crisis distorted significantly the transmission channel and revealed different responses by central banks. However, the expansionary monetary strategy based on the implementation of unconventional measures prevented from an extended output contraction. Finally, we use some key macroeconomic variables to perform a comparison between the countries set and the Germany. Our results were significantly different from benchmark VEC framework indicating the existence of heterogeneity in the countries sample. So, the monetary authorities have to continue the use of unconventional measures to absorb the crisis repercussions, avoiding the fiscal expansion which deteriorated the market turmoil and results in increased debt level for the Eurozone countries.

Keywords: monetary policy, central banks, VEC, financial crisis

JEL classifications: E52, E58

Introduction

The aim of the paper is the analysis of the monetary policy and the evaluation of the monetary policy transmission mechanism before, during and after the financial crisis of 2007-2009. The objective is determined by the need to render the monetary policy more efficient concerning the financial markets and the real economy. The monetary authorities must have the sufficient information and influence in order to make optimal monetary policy choices and attained the desired effects on the macroeconomy. However, due to the structural differences, the effects of monetary policy decisions may vary across countries.

The monetary authorities traditionally use the determination of the level of short term interest rate to implement their policies, as their key conventional tool. The fundamental model of the monetary policy decision making is the Taylor rule (1993). According to Taylor, the monetary authorities focus both on the inflation and output gap to determine the level of short term interest rate. However, the information about the economy may be imperfect and becomes available

with a lag and this may distort the time consistency of monetary policy decisions.

The financial market turmoil of 2007-2009 has led to the most severe financial crisis since the Great Depression and had already great repercussions on the real economy. This crisis changed the monetary policy decisions making in EMU, UK, USA and globally and the macroeconomic imbalances and the adverse developments in financial sector had a negative impact on real economic activity. At the onset of the financial crisis, the main indicators for economic outlook worsened and the appearance of negative real interest rates was signaling that conventional monetary policy measures reached their limits.

So, as the conventional monetary policy tools proved insufficient, the monetary authorities turned to use unconventional instruments such as quantitative easing, credit easing and the influence of long term interest rates. The main goal of the unconventional tools was the liquidity injection and the stimulation of aggregate demand along with the influence of long term interest rates and money supply growth. However, the uncertainty which prevailed after the crisis, diminished the liquidity in financial markets leading in a global turmoil. Some, empirical estimates showed that the unconventional measures have generally helped to deal with the liquidity crisis, but not with the confidence crisis in the Euro Area's sovereign debt market (ECB 2012).

This paper attempts to investigate whether the monetary policy transmission channel has altered after the financial crisis, and the extent that the unconventional monetary policy measures affected the real economy and the financial markets. Furthermore, particular attention is given to the study of the impact of monetary policy decisions to country specific heterogeneity and the level of the global integration in response to monetary policy shocks. In more detail, the analysis of this paper is focused on the study of European Central Bank (ECB), the Bank of England and the Federal Reserve actions as monetary authorities. The countries that we analyze are USA (fed), UK (BoE), and Germany, France, and Italy (ECB).

Our selection for these countries is based on the fact that their monetary authorities give the signal for the global monetary policy decision making and their stance affects the global central banking. Concerning the European Monetary Union (EMU), we choose Germany, France and Italy, in order to examine the specific heterogeneity in EMU, and how the impact of monetary policy of ECB has affected the financial and macroeconomic indicators in each country. For euroarea, the financial crisis of 2007-2009 was followed by the sovereign debt crisis beginning at the end of 2009. Our goal in this paper is to analyze the impact of this crisis in countries, and how the each country specific economic indicators responded to the decisions of ECB, FED and BoE.

Our econometric strategy involves the analysis of a Vector Error Correction model on a time series specification framework that treat the selected variables as endogenous. The analysis is elaborated in three stages. The first stage includes the main empirical analysis comprised of the benchmark VEC model, the second stage is focused on the effects on the monetary policy mechanism after the imposition of the financial crisis structural break, and the third stage refers to the study of basic macroeconomic variables differentials between the USA, UK, France and Italy with Germany.

By performing the benchmark VEC analysis (1st stage) we observed a high level of integration in global markets along with increased convergence in Euroarea before the introduction of euro. The preliminary findings showed a high correlation between Germany and France bonds and significantly lower correlation with Italian bonds mainly due to the crisis period indicating a gap between the effectiveness of monetary policy in central Europe and in periphery. We found also, different behavior of monetary authorities concerning the output and inflation targeting.

As a special case (2nd stage), we study the impact of the financial crisis period to our variables and as we showed, concerning the monetary policy stance, the transmission mechanism has changed after the financial turmoil. In addition, our results highlighted the European heterogeneity which stirred up the Eurozone debt crisis. Our analysis showed that the inflation rates affect positively the key monetary policy rates. In case of industrial production, the USA authorities give greater attention on minimizing the output gap, while the ECB give little significance on output growth. As we showed, the bank profit spread increased after the rise in key rates indicating that the monetary transmission worked. However, after the crisis outbreak, the effect on bank profit spread changed, as in Italy, the rise in key rate has negative impact on bank profit spread. The responses of industrial production and unemployment rate from variables used are similar for all countries. In addition, for USA, UK, Italy the response of inflation to increase in key rates are positive indicating existence of the so-called price puzzle.

In the third stage of our analysis, we set a comparison of the selected countries with Germany as the reference country. After the implementation of the VEC model, we observed that inflation differential affect negatively bank profit and yield spreads, contrary to our main estimation proposition. This fact, indicates that excessive inflation (above Germany levels) lead in spreads decline as the markets treat the effect as temporary. Also, the increase in key monetary rates lead to industrial production differentials decline as the monatery authorities contracts the money supply against economic overheating coming from overshoot in industrial activity.

Our paper differentiates from the main literature and includes the following innovations: First, we included a wide range of variables compared to the basic literature. Second, by applying our analysis we study the eurozone heterogeneity in main leading economic factors. Third, our sample covers an extended period (from 1990 to 2012) and this allows us to examine the monetary policy before during and after the financial crisis. Fourth, we impose a structural break in VEC analysis, in order to have a clear view of the structural change after financial crisis. Fifth, we develop a VEC model with main variables differentials in order to have a compared view of our results between the countries sample. Sixth, we confirm our basic results with some new robustness tests.

Literature Review

The prevalent literature examines the relationship with the key monetary policy measures with other market interest rates (mainly bond market rates), or macroeconomic factors (such as inflation). The methodological analysis in literature consists of: On one hand regression models, which defines the exogenous and endogenous variables and control the effect of exogenous variables to the endogenous ones. On the other hand, Vector autoregressive (VAR) models

which stress all the variables as endogenous and regress one with another simultaneously.

Hamilton, Kim (2000) measure the usefulness of modeling the yield curve in order to predict future GDP growth. They found that the contribution of the contribution of the spread can be decomposed into the effect of expected future changes in short rates and the effect of the term premium.

Abassi, Linzert (2011) introduce a regression model for Euribor rate evolution in order to examine the effectiveness of monetary policy in steering money market rates. As the Euribor rate, is affected by the EONIA rate, the authors tried to examine if the monetary policy transmission mechanism applied affectively during financial crisis.

Peersman, Smets (2001) use a benchmark VAR-model to analyze the effects of a monetary policy shock in the euro area by using a vector of endogenous euroarea variables, and a vector of exogenous (USA) variables. Their results show that a temporal rise in the nominal and real short term rates tend to be followed by real appreciation of the exchange rate and a temporary fall in output. As a result, a monetary tightening leads to the fall in investments and consumption, but in increase of net exports due to the reduction in internal demand.

Peersman (2011) estimated a Structural VAR model in order to examine the unconventional monetary policy actions in euroarea. The author used some innovations and showed that the increase in central bank balance sheet as a part of unconventional policy strategy, had a humped shape effect on economic activity and a permanent impact on consumer prices.

Mishkin (2010) elaborates a theoretical optimal monetary policy procedure which examines what the monetary authorities have learned after the financial crisis in a representative agent framework. As Mishkin indicates, the equation describing the dynamic behavior of economy is linear and the objective function specifying the goals of monetary policy is quadratic. Under this framework the monetary authorities perform the monetary policy strategies before the financial crisis.

Cecioni, Neri (2011) estimate a Bayesian VAR model over the periods before and after 1999 and suggests that the effects of a monetary policy shock on output and prices have not significantly changed over time. The estimation of a DSGE model with several real and nominal frictions over two subsamples shows that monetary policy has become more effective in stabilizing the economy as the result of a decrease in the degree of nominal rigidities and a shift in monetary policy towards inflation stabilization.

Christiano, Eichenbaum, Evans (1998) estimate a VAR model with the use of quarterly data from 1965 to 1995. The variables used consist of the log of real GDP, the log of the implicit GDP deflator, the smoothed change in an index of sensitive commodity prices, the federal funds rate, the log of total reserves, the log of nonborrowed reserves plus extended credit, and the log of either M1 or M2; respectively.

Data and Methodology

Our dataset is comprised of monthly monetary and macroeconomic variables for six countries. We separate the countries set with the criterion if they have independent monetary authorities. So, the one

set includes United Kingdom, United States and Euroarea which we called them "big" countries, and the other set involves Germany, France and Italy, which we called them "small" countries. The dataset covers the period from January 1990 to August 2012. The basic sources for data were FRED (Federal Reserve Economic Database), ECB Statistical Data Warehouse, Bank of England, Banka di Italia, Banque de France, ECB, Federal Reserve, and Datastream, Bloomberg as databases.

The variables we used as proxies for the key monetary policy rates are, the EONIA for Euroarea, the Sonia for UK and the Effective Fed funds rate for USA. We apply also the yield spread as the difference between the ten year bond rate and the three month treasury bill, as we wish to study the effect of key rates to the bond rates for "big" countries. For "small" countries we use the yield spread as a proxy monetary policy instrument as the short term three month Treasury bill rate is closely related to Eonia. Additionally, we use the bank profit spread (the difference between the bank lending and deposit rates) as main market rates in order to study the transmission mechanism of monetary policy. The yield spread and bank profit spread are applied for UK, USA, Germany, France and Italy.

We use also the unemployment rate for all the set of countries and the exchange rates of dollar to one euro, pound to one euro and dollar to one pound. The variables above are analyzed by their first differences. Furthermore, we include in our analysis the inflation rate and the industrial production in order to examine the impact of monetary policy to prices and output respectively.

Our econometric strategy is based on time series analysis by applying unrestricted Vector Autoregressive model. Vector Autoregressive models were popularized in econometrics by Sims (1980) and Litterman and Weiss (1984) as a combination of univariate time series model and simultaneous equations models and they are used as they capture the linear interdependencies among multiple time series. The VAR models are widely used due to some specific advantages they have. First, the researcher does not need to specify which variables are endogenous or exogenous, as they are all treated as endogenous. Second, the unrestricted VAR models examine the impact in variables from the innovations by other variables and study their behaviour. Third, the VAR model allows the value of a variable to depend on more than its own lags or combinations of the white noise term.

We apply the following VEC model:

$$\Delta Y_t = a + \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Pi_i \Delta Y_{t-i} + \varepsilon_t$$

where, a is a vector of constants, ΔY are the vectors of endogenous variables and ε is a vector of shocks or innovations of the model and Π's are p*p vectors of coefficients. Our analysis is based on Peersman, Smets (2001) work but it differentiates as our specification is based on VEC model as it better explains our results and takes accountthe cointegration in the sample variables. By applying the VEC analysis, we determine the order of the specific variables. Also, our framework includes additional variables such as unemployment rate and exchange rates in order to have a broader view of our results. Furthermore, our innovation in the analysis of VEC model is the financial crisis impact examination by applying dummy variables in the sample. Finally, as the ordering plays important role and may alter the results, we impose some different orderings in order to examine whether our results remains similar to our main analysis results.

Preliminary analysis

We start our analysis by the descriptive statistics investigation of key monetary policy rates. The main monetary policy rates began at high levels at the early 1990s. After the outbreak of economic crisis at 2007, the interest rates dropped sharply in order to stimulate aggregate demand against the recession. As the key interest rates approached the zero point the conventional tools of monetary policy implementation proved insufficient (especially as the real interest rates became negative). As the graph indicate, the EONIA and Fedfunds rate are significantly low at late 2012, but the SONIA rate is slightly higher as we remarked higher inflation rate for UK in this period.

The correlation analysis for the key central bank interest rates in the whole sample, indicates that there is strong positive correlation between the bank of England interest rate and the fed funds rate (0.88), but also a significant positive correlation between ECB interest rate (EONIA) and BoE interest rate (SONIA), 0.83. However, we observe a positive but weaker correlation between the ECB EONIA and Fed funds rate (0.77), indicating a different behavior of the monetary policy tools during this period.

Main analysis

In this section, we perform the benchmark VEC analysis in order to study the monetary policy implementation and the effect of the financial crisis by applying variance decomposition analysis and impulse responses functions. Our goal was to attain the exact evolution of the monetary policy transmission mechanism and the effect the financial crisis of 2007-2009 on the mechanism.

In our specification, we split the countries set into two different groups with the criterion if they have independent monetary authorities or belongs to a currency union. The first group includes the "big" countries which are USA, UK and the Euroarea as an entity. The second group contains the "small" countries, Germany, France and Italy, which belongs to the euro currency union. By applying this framework we are able to test the country specific heterogeneities after the implementation of monetary policy by ECB.

Variance decomposition analysis: Our main empirical analysis is based on the reported results from the variance decomposition analysis we performed. The variance decomposition analysis is used to aid in the interpretation of VAR and VEC models once they have been fitted, and indicates the amount of information each variable contributes to the other variables in the autoregression. In other words, it determines how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables.

Specifically, according to our VEC analysis, the variance decomposition of key monetary policy rates in "big" countries reveals that their forecast variance derives from their own evolutions. For Euroarea, a contribution to the variance decomposition of Eonia is given by the exchange rate dollar/euro.

For the inflation rate, a significant commitment to forecast the variance is offered by the key monetary policy rates (EONIA for Euroarea, Fed Funds rate for USA and Sonia for UK). In USA especially,

the fed funds rate affects by nearly 12 percent the variation of inflation rate. The corresponding percentage for the Euroarea is 3 percent. These results indicate that the monetary policy transmission mechanism performs better in USA than Eurozone. For the UK the Sonia rate affects nearly by 7 percent the inflation evolutions. For the "small" countries, the variance decomposition analysis tables showed that the main effects in inflation are derived from their past evolution, except from France, where significant role play the bank profit spread and the yield spread in the forecasted error of inflation.

The variance decomposition analysis pointed out that for "big" countries, for industrial production, the forecast error volatility is offered mainly from the own variable fluctuations. In addition complementary role for the decomposition of the variance play the key monetary policy rates. More specifically, the largest portion belongs to UK where nearly 10 percent of the variance in industrial production growth comes from Sonia rate. For the Euroarea the corresponding percentage is 4 percent, but for USA the percentage is almost one, as in Eurozone, the industry section is more banking financed that in USA. The rise in key rates, lead to increase in bank lending rates through the monetary policy transmission mechanism, and as a result the cost of borrowing for industries increase. As the USA companies are less bank financed, the effect of changes in key monetary policy rates in industrial production is almost negligible. For the "small" countries, as we mentioned, the increase in bank lending rates, has negative impact on Eurozone industrial productivity. Confirming this, the variance decomposition analysis showed that the forecasted error volatility in industrial production derives from bank profit spread changes, mainly for Germany (14 percent).

The variance decomposition analysis, showed also, that the forecasted error volatility in unemployment rate both for "big" and for "small" countries comes from own variable changes. In addition, for Eurozone, special role also plays the Eonia rate (22 percent), as the increases in the key rate pushes up the unemployment rate. As for the exchange rates, the forecasted error variance is offered by the own lags movements. We present the variance decomposition table for USA.

Variance Decomposition of DFEDFUNDS:

Period	S.E.	DFEDFUNDS	DBANKPROFIT SPREAD	DYIELD SPREAD	DEXCHRATE DOLLPOUND	INPRODGR	INFL	DUNEMP
2	0.170665	94.80852	0.047194	0.526165	0.041662	4.193919	0.000165	0.382372
3	0.189603	94.14242	0.807095	0.562173	0.104221	3.610046	0.452719	0.321326
12	0.324308	94.37191	1.127348	0.607998	0.169940	3.255473	0.253374	0.213953
24	0.443845	94.57882	1.139614	0.627575	0.153933	3.142716	0.180777	0.176568
36	0.537425	94.65571	1.142955	0.634206	0.148274	3.102129	0.153945	0.162781

Variance Decomposition of DYIELDSPREAD:

Period	S.E.	DFEDFUNDS	DBANKPROFIT SPREAD	DYIELD SPREAD	DEXCHRATE DOLLPOUND	INPRODGR	INFL	DUNEMP
2	0.276107	4.095269	1.399133	93.41317	0.070516	0.001689	0.882158	0.138405

	0.29734			89.8994		0.24801	0.3092
3	3	5.903544	2.752931	4	0.118453	2	0.768403 17
	0.49989			91.7072		0.37561	0.1850
12	6	4.391621	2.487314	7	0.129280	6	0.723868 27
	0.67611			92.8210		0.27790	0.1080
24	4	4.110861	2.042856	3	0.071379	0	0.567917 51
	0.81504			93.2497		0.23954	0.0788
36	4	4.001485	1.875528	6	0.049360	8	0.505422 98

Variance Decomposition of DEXCHRATEDOLLPOUND:

Period	S.E.	DFEDFUNDS	DBANKPROFIT SPREAD	DYIELD SPREAD	DEXCHRATE DOLLPOUND	INPRODGR	INFL	DUNEMP
	0.04952			2.76399		1.64023		0.0166
2	8	0.071155	0.553055	0	92.934739		2.020136	96
	0.05330			2.91056		1.75725		0.0252
3	9	0.705513	0.500782	6	89.893095		4.207534	57
	0.09130			3.15571		1.20172		0.0254
12	8	0.704103	0.459156	5	90.898211		3.555684	06
	0.12448			3.24611		0.99739		0.0201
24	5	0.697310	0.425238	3	91.071170		3.542671	07
	0.15052			3.28041		0.92182		0.0181
36	4	0.695464	0.413247	7	91.138674		3.532216	62

Variance Decomposition of INPRODGR:

Period	S.E.	DFEDFUNDS	DBANKPROFIT SPREAD	DYIELD SPREAD	DEXCHRATE DOLLPOUND	INPRODGR	INFL	DUNEMP
	0.66290			0.81473		95.9257		0.0519
2	8	0.868671	1.880276	5	0.332749	7	0.125805	95
	0.72830			1.15952		93.2130		0.2085
3	9	0.742784	3.882646	5	0.354873	0	0.438653	18
	1.17027			0.98203		95.6320		0.1348
12	2	0.978946	1.832589	9	0.201026	5	0.238488	66
	1.56560			0.96554		96.4271		0.0800
24	2	1.014952	1.248781	5	0.128485	8	0.135059	01
	1.87933			0.95921		96.7363		0.0588
36	9	1.028038	1.022602	9	0.100037	5	0.094947	04

Variance Decomposition of INFL:

Period	S.E.	DFEDFUNDS	DBANKPROFIT SPREAD	DYIELD SPREAD	DEXCHRATE DOLLPOUND	INPRODGR	INFL	DUNEMP
	0.34317			0.05177		0.65487		0.0325
2	4	7.751660	12.58481	5	0.761087	5	78.16327	22
	0.37642			0.25878		1.70105		0.0807
3	2	10.74282	12.37573	3	0.730000	5	74.11082	97
	0.64347			0.15469		0.73548		0.0681
12	3	11.73993	9.840555	4	0.603572	1	76.85760	63
	0.88031			0.11962		0.49488		0.0491
24	2	12.22764	9.449431	1	0.575575	6	77.08372	30
	1.06581			0.10652		0.40684		0.0421
36	4	12.40118	9.303055	4	0.565596	0	77.17470	09

Variance Decomposition of DUNEMP:

Period	S.E.	DFEDFUNDS	DBANKPROFIT SPREAD	DYIELD SPREAD	DEXCHRATE DOLLPOUND	INPRODGR	INFL	DUNEMP
	0.15526			0.52484		1.37488		92.222
2	2	0.576152	3.236131	8	1.935189	8	0.130474	32
	0.17062			0.69365		1.13864		90.493
3	2	1.505175	3.183989	1	2.388120	4	0.597336	08
	0.27340			0.54433		0.88385		91.982
12	7	1.101904	3.607240	3	1.367045	5	0.513331	29

	0.36509		0.49728	0.81446		92.620
24	1	0.915496	3.8252673	0.8900052	0.436549	94
	0.43800		0.47967	0.78788		92.871
36	7	0.843412	3.9075386	0.7039221	0.406277	30

Impulse response functions: After the variance decomposition analysis we proceed to the analysis which is based on the implementation of impulse response functions. Impulse response functions (IRFs) are shocks to a VAR/VEC system. The IRFs identify the responsiveness of the dependent variables in the VAR/VEC when a shock is put to the error term. We apply a unit (one standard deviation) shock to each variable and examine its effects on the VEC system.

For "big" countries, we take the key monetary policy rates as the main monetary policy instruments and we examine the impact of interest rate innovations to other variables. For the "small" countries, as they have not independent monetary instruments, we treat the yield spread as the monetary instrument in order to examine the impact in variables to the specific shocks, as the correlation between the 3month treasury rates and 10year bond rates with the Eonia rate is high.

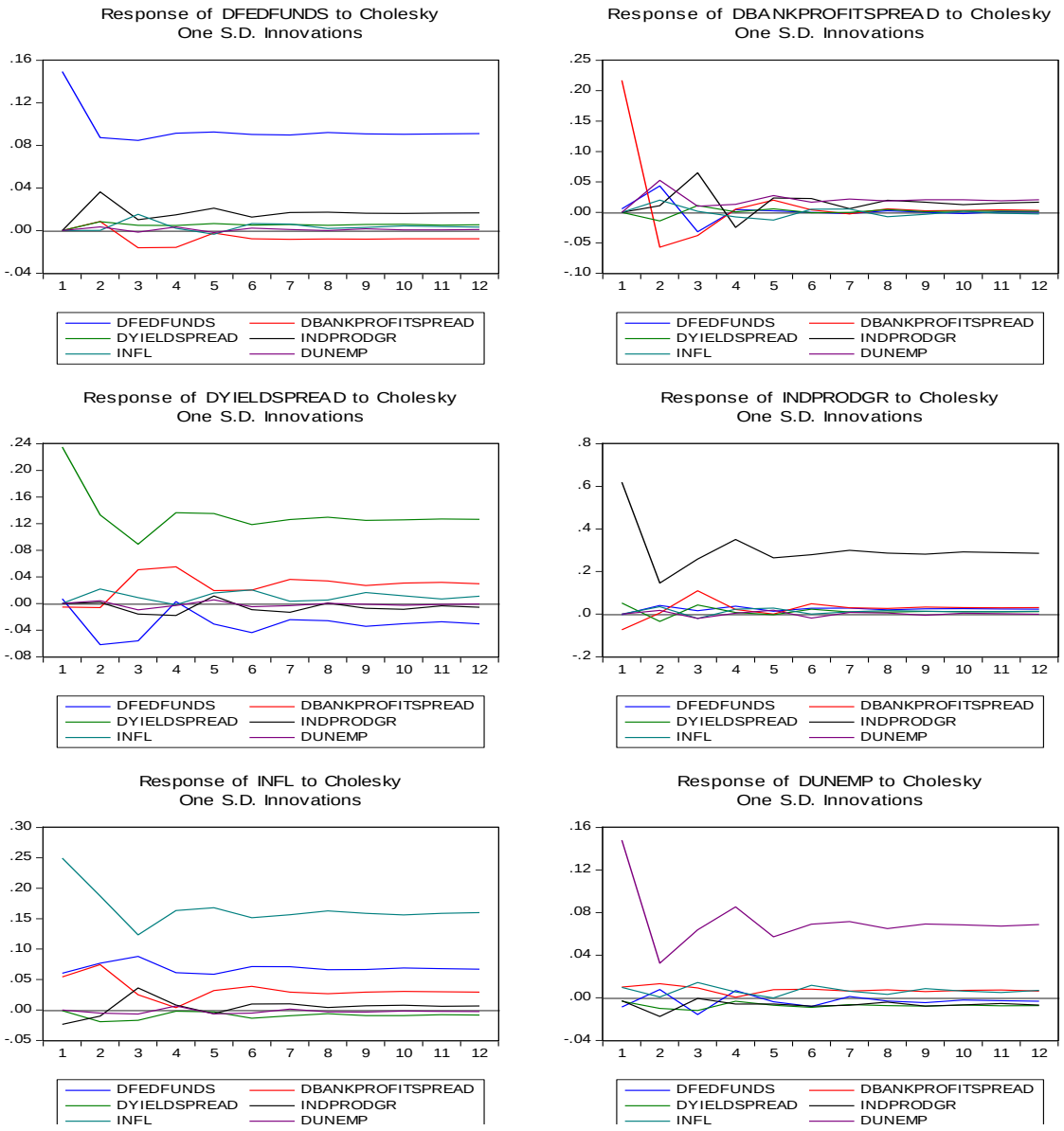
We begin our analysis with the responses of key monetary policy rates in shocks from the other variables. The impact of unit volatility shock by inflation rate affects positively the key monetary policy rates, as the implementation of monetary policy is based on the Taylor rule. So, for the three "big" countries, the key rates react positively from an increase in inflation rate. The effects of the other variables on key rates depend on the country. However, the impact of industrial production on key rates is relatively low for ECB, BoE, comparing to the inflation effect and we see that the monetary authorities strategy are more inflation targeted that output targeted. In case of FED the greater significance is dedicated to the output level target.

As regards to the inflation rate, the impulse responses functions show, that for all the set of countries, a positive shock from industrial production leads to the increase in inflation rate. The fact that industries augment their production means that there is adequate demand by consumers which the industries aim to cover. This suggests inflationary pressures in the economy. The only exception is UK where the effect is negative. The responses of inflation to the impact of a unity volatility shock by the key monetary policy rates highlight the "price puzzle" (introduced by Sims 1992). These reactions of inflation are positive for USA, and UK which indicates the paradox of increased monetary rates and high inflation. Intuitively, the price puzzle occurs, as the central banks preemptively raise interest rates in anticipation of future inflation. For Euroarea, the responses are negative as we normally expected. In case of the "small" countries, the price puzzle exists only in Italy however, in Germany and France the proxy monetary instrument, yield spread indicates positive relationship between the spread and inflation rate.

In case of industrial production growth, the impulse responses functions show that the responses of industrial production to inflation rate innovations are positive. The increase in price level (money supply) rises total output and widens the profit spread for businesses and as a result they increase their productivity. Our results confirms the Keynesian view at least in the short run, as the

increase in money supply (M2) raises aggregate demand and has positive impact on output. As a result the neutrality of money (classical view) has negligible impact on our sample in the short run, as the prices fell to adjust immediately (sticky prices.

Despite the literature findings, the responses of industrial production to shocks from key monetary rates are positive for the three "big" countries. In addition for the "small" countries, the effect is similar, as the proxy monetary instrument, the yield spread has negative relation with output. We suppose, that firms suggest that a rise in interest rates gives signal for predicted economic overheating. The responses of unemployment rate to innovations from the industrial production are negative, as we expected. The increases in productivity lead to more job positions and the fall in unemployment rate. Furthermore, we have not find evidence of anytrade off existence between inflation and unemployment rate (Philipps curve) as these variables behavior differentiates depending on the specific country.



By applying the benchmark VEC model we observe some useful elements of monetary policy implementation. Both the variance decomposition

analysis and the impulse responses functions showed that inflation rate fluctuations are explained more by key monetary rates than the industrial production generally. In case of industrial production, the USA authorities and less the UK, give greater attention on minimizing the output gap, while the ECB and give little significance on output growth.

As we observed, the bank profit spread increased after the rise in key rates indicating that the monetary transmission worked. Additionally, the variance of the yield spread movements is explained strongly by key monetary policy rates as the VEC findings confirms. The responses of industrial production and unemployment rate from variables used are similar for all countries, and between them there exist a negative relationship.

The VEC analysis highlighted the existence of price puzzle in the sample, as the increase in key rates is followed by increase in inflation, as monetary authorities anticipated high inflation, but inflation eventually occurs. Especially, for USA, UK and Italy the responses of inflation to increase in key rates are positive confirming the price puzzle existence. Also, our benchmark analysis found non stable evidence for the Philips curve existence, as unemployment and inflation movements depends on the each country factors. Furthermore, an additional finding is the relative persistence in inflation rate even after the crisis period which indicates the relative stickiness of prices.

Finally, we observed also that the increase in inflation rate is followed by rise in industrial production level. The fact that inflation were relatively increased in crisis period indicated the increased money supply derived from unconventional measures by central banks. As the increase in inflation has positive effects on industrial production even after the crisis outbreak this confirms that expansionary monetary policy by the use of unconventional measures effectively worked.

Structural break: The financial crisis period

After applying the benchmark VEC model, we performed the structural stability tests in order to examine any instability issues in the estimation sample. According to the obtained results, we observed structural breaks at a setted benchmark year 2008, for all countries except France. Our procedure, was to re-estimate the model in order to study the impact of financial crisis on our framework. We apply VEC model for this specification as the Johansen tests showed that the variables were cointegrated. The econometric strategy includes the analysis of VEC model and impulse responses functions with the addition of a dummy variable in vector of X’s of the endogenous variables of the benchmark model, which indicate the crisis period. The benchmark date is January 2008, so the dummy variable is zero before this date and one for this date and beyond.

The analysis we elaborate, demonstrated that the monetary policy transmission channel has changed during the crisis and the results are relatively persistent in after crisis period. By adopting that the monetary policy authorities are focused on the Taylor rule in monetary policy decision making, we assert that the information from output level and inflation has different outcome for central banks rate after the benchmark year 2008, and the effects of key monetary rates on the macroeconomic variables have significantly changed.

As our analysis showed, the responses of Eonia and Sonia rate to crisis dummy shocks are negative, as the central banks decreased interest rates against financial turmoil. However, for USA the responses of fed funds rate are positive to a crisis shock. For the small countries, the proxy for policy instrument the yield spread has positive response to innovations from crisis shock as after 2008, the long term rates raised due to the increased credit risk. The responses of inflation rate to crisis shock are slightly positive for Euroarea, USA and France. The responses of inflation to UK, Germany and Italy are negligible.

As the impulse responses functions show, the responses of industrial production growth to crisis shocks are negative for all the countries, as after the financial crash the industrial production fell significantly. The responses of unemployment rate to innovations from crisis dummy are positive, as the financial crisis lead to increased unemployment rate.

The results indicate that the monetary policy transmission mechanism changed after the financial crisis outbreak. For Euroarea, the responses of inflation rate, industrial production and exchange rate dollar/euro to innovations from Eonia in pre-crisis period are negative, but they are positive after crisis. The reactions of unemployment rate to shocks from Eonia rate are positive in pre-crisis period but become negative after the benchmark year 2008.

For USA, the results are similar to the Eurozone ones. The responses of fed funds rate to inflation innovations are positive in pre-crisis period but become negative in the period after 2008. The responses of industrial production, to fed funds rate shocks are positive in pre-crisis and become negative in post crisis period. The responses of inflation rate to industrial production innovations are negative firstly but after crisis become positive. The responses of unemployment rate to fed funds rate shocks in pre-crisis period are negative but after the financial crisis become positive.

In case of UK, the responses of Sonia rate to inflation rate before crisis period are positive, but after the breakpoint date become negative. Also, the responses of Sonia rate after crisis are negative contrary to the pro crisis period. The responses of industrial production to inflation innovations are negative before crisis outbreak and then become negative. The responses of unemployment rate to Sonia rate are positive before crisis and then become negative. Our results confirm the monetary policy transmission mechanism distortion.

For Germany, the impulse responses functions show that adding the crisis dummy variable, we observe that the response of yield spread to inflation rate are positive before crisis but after the crisis become negative. The responses of yield spread to innovations from industrial production are negative and after crisis become positive. As the industrial production increased before crisis, the short term rates also rise. However, after the financial crisis, the increase in industrial production leads in long term rate increase. The responses of unemployment rate to inflation shocks are positive in pre-crisis period, but after the financial crisis become negative. The responses of unemployment rate to industrial production and yield spread innovations are negative before 2008, but then become positive.

For France, the responses of yield spread to innovations from industrial production and inflation rate are positive before the crisis period, and afterwards become negative. The responses of

industrial production to inflation rate shocks are negative before crisis and then become positive. Furthermore, the responses of inflation rate to industrial production innovations are negative before crisis and after 2008 become positive. The responses of unemployment rate to yield spread shocks in pre-crisis period are negative and then become positive. In case of Italy, the responses of industrial production shocks to yield spread innovations are positive before benchmark crisis date but then become negative.

Comparison between countries factors and Germany

We perform as a special case a comparison between USA, UK, France, Italy and Germany as the reference country by applying an alternative VEC model and we study the behaviour of inflation, industrial production and unemployment of each country with Germany. Our specification, show us the effect of the spreads to other variables and how an unexpected rise of one variable beyond normal level(Germany) affects the others.

The alternative specification that we imposed showed some important findings which refers to all the set of countries. Firstly, inflation rate differential movements affects negatively both the bank profit spread (lending-deposit rate) and the yield spread (10year bond rate-3month treasury rate) despite of the positive effect we found for both of them on the main analysis section. This result show that the overshoot in domestic inflation rate leads to decline in the above spreads as the market participants think that the effect will be absorbed and it will return to normal levels.

In addition, the results showed that for USA, UK an increase in key policy rates, fed funds rate and Sonia respectively will lead to industrial production spread decline. The excessive industrial production entails the risk of high future inflation, and as a result the monetary authorities follow contractionary policy. As our framework reveals, the positive industrial production shocks will be followed by higher inflation rate differential contrary the negative behaviour of the main findings section. This result confirms, the negative relationship of key rates with industrial production differential we mentioned above.

Finally, by elaborating the alternative VEC model, we found that the responses of unemployment rate differential in USA and France from industrial production differential movements are positive, against our basic specification. The intuition behind this result is that the abnormal increase in industrial activity signals economic overheating and the economy may quickly insert to recession.

Robustness tests

We apply the robustness analysis for our VEC model in order to verify and assess our results, by performing four robustness tests. We set up with the control for any endogeneity bias in our benchmark specification. As the VAR/VEC analyses are endogenous models, they often face variables ordering problems which rise endogeneity issues. We address the endogeneity bias issue by testing the behavior of the variables if we change their order and run again the VEC model. Firstly, we set the first variable, as last and the last variable as first, and so on. Secondly, we chose randomly the order of the variables. As we observed, all the results remained the same after the

ordering changes we performed, thus confirming our benchmark analysis and rejecting any enodogeneity issue.

Afterwards, we consider alternative identification of the main monetary policy instrument and we apply variance decomposition analysis and impulse response functions (money supply and interest rates). Then, we add to VEC analysis of the "big" countries the key monetary instruments of the others and consider them as endogenous analyzing their impact. Finally, we apply VAR model instead of the VEC model we used in main analysis.

Firstly, we change the monetary policy instrument and we equate each monetary policy rates with money supply growth as an alternative monetary measure (as in Christiano, Eichenbaum, Evans 1999). For the "big" countries we use M2 growth instead of EONIA, SONIA, FED funds rate. For the "small" countries, we exclude the yield spread and we replace it with M2 growth of Euroarea. Our results indicate that for Euroarea, USA and UK the money supply shock leads in the reverse results of the EONIA, SONIA, FED funds rate shocks respectively, reflecting the robustness of our results. Furthermore, the results confirm the so called "price puzzle" we find in the benchmark analysis. For the "small" countries, the money supply shock leads in the straight results of the yield spread shock for each country, and our results remain robust.

Secondly, we perform the VECM analysis and instead of the key monetary policy rates we use three month Euribor for Euroarea, three month Libor rate for UK and three month Eurodollar rate for USA. These rates are highly positive correlated with the key rates. We apply the impulse response function analysis and as we show, the behavior of the variables to innovations from the above rates are identical to the shocks from the main policy rates (appendix 3). Thus, our results are verified and remain robust.

As a third robustness test we change the variables in VEC analysis of the "big" countries and we add the monetary policy tools of others in order to examine their impact in domestic variables and in the monetary policy instruments. We found that the results remain the same, as the EONIA effect is stable with the insertion of fed funds rate and SONIA rate to the Eurozone VEC. The results of the UK VEC and USA VEC are analogous to the Eurozone case.

Fourth, we change our econometric methodology by performing VAR analysis instead of the benchmark VEC we elaborated. As our variables are marginal cointegrated the VAR analysis have to reveals us similar results. We elaborated the impulse response functions for each country and the variance decomposition analysis. As we observed, the VAR analysis showed that our results remain exactly the same with the VEC analysis (appendix 3) and this gives the robustness of our sample results.

Conclusion

We have specified and estimated the monetary policy transmission mechanism before and after the financial crisis of 2007-2009, based on a VEC model with macroeconomic and financial variables.
Firstly, in preliminary analysis, we split the sample before and after the introduction of euro. Our preliminary results, showed that before the introduction of euro, the bond market reveled signs of convergence of the European government notes. In addition, the period before euro the yields of UK and USA with the European ones are negatively

correlated as these bonds deemed as substitutes in global markets. After the introduction of euro the bond rates are positive both European and non-European indicating the global bond market integration. We include in our country framework Italy in order to highlight the European heterogeneity between the countries in the center of Europe (Germany, France) and the countries outside it (Italy). We observed that the bond rates of the Germany and France are highly correlated; however, the correlations of the Italy bond rates with Germany and France are relatively weak.

Secondly, we perform three stages VEC analysis, where initially we used the benchmark VEC model in order to specify the conduction of monetary policy by central banks. Secondly, we introduce the financial crisis effect on our model to examine the behavior of the central banks, and thirdly we elaborate an alternative VEC by adding variables differentials. By applying these strategies, we showed that the monetary policy transmission mechanism has changed and remains dysfunctional for the period after the financial crisis. As a result, the conventional monetary policy instruments become ineffective. For example, a monetary expansion with the decrease in key nominal interest rate, has limited effect especially for countries in periphery (Italy), as the results show that bank and bond rates have relatively low correlation with Eonia.

So, the central bank authorities have to preserve the unconventional monetary policy tools or expand them with increased money supply to boost the anemic economic growth. By analyzing the impulse responses, we also confirmed the assumption that ECB strategy is mainly inflation targeted rather than output targeted. Contrary, the FED aims more to output growth and less to inflation. The bank of England has moderate impact both for inflation and output, with somewhat slightly higher reflexes on inflation innovations.

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