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Ready for euro? Empirical study of the actual monetary policy independence in Poland

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Abstract

The aim of the article is to examine the actual degree of Polish monetary policy independence in the context of joining the Eurozone. It is frequently argued that the main cost of the participation in the EMU, or in any other common currency area, is the loss of monetary policy independence. In contrast, the paper raises the question of the actual possibility of such a policy in a small open economy operating within highly liberalized capital flows and highly integrated financial markets like Poland. Confirmation of the hypothesis concerning incomplete actual monetary independence is essential to the analysis of costs of the Polish accession to the EMU. The main hypothesis of the article is verified using a Vector Error-Correction Mechanism model and several parametric hypotheses concerning the speed and asymmetry of adjustment.

Keywords:
empirical analysis, Eurozone, monetary policy independence, monetary union

JEL:
E43, E52, E58, F41, F42, C32

Introduction

The assumption of full monetary policy independence in an open economy with floating exchange rates lies at the heart of most analyses concerning Polish economy. Numerous studies of the monetary policy independence that are based on the now classical concepts of "impossible trinity" and the theory of optimum currency areas show that the primary long-run cost of participation in a common currency area is the loss of independence of the monetary policy. Under capital mobility, a country that wants to pursue an independent monetary policy, oriented toward the domestic economy, must allow its exchange rate to float. If, on the other hand, the country fixes its exchange rate, it must follow the monetary policy of the anchor country. Because monetary policy is determined abroad, the country has in this case effectively lost monetary policy independence. In line with these concepts, it is argued that the adoption of the euro in Poland will result in loss of autonomy of the monetary policy (NBP 2009). This assumption is also central to most of the analyses of potential costs of joining the EMU by Poland. A negative answer to the validity of this assumption - if backed by empirical analyses - has important policy implications for joining the Eurozone by Central and Eastern European economies. This lack of monetary policy independence in small open economies with highly integrated financial markets would imply that these countries do not lose this independence during the accession to the EMU.

Monetary policy independence is understood as the ability of the central bank to set interest rates independently of international rates.[1] In this paper, we analyze if monetary policy in our focus economy, Poland, was 'determined' abroad - that is, was dominated by the policies of the larger monetary area. There could be many theoretical explanations for this phenomenon. Probably right now due to external conditions and increasing integration with the Eurozone Polish monetary policy is strongly correlated with the one of the ECB. The high degree of similarity between the domestic and foreign policies of the central bank can also be a reflection not so much of a lack of independence, but rather the symmetry of shocks affecting the domestic and the foreign economies. This could be also due to exchange rate considerations that could be in fact a manifestation of the fear-of-floating phenomenon in Poland (Goczek and Mycielska 2012). This distinction, however, has not much significance in this context, because when considering the cost of joining the euro area what seems to be especially important is whether the degree of policy coordination between the ECB and NBP is already so extensive that joining the zone does not significantly change the *de facto* independence. Possible confirmation of this hypothesis would challenge the widely accepted view that one of the costs associated with joining the EMU is the loss of independent monetary policy, especially in situations when the level of independence is in fact negligible.

Looking at simple correlations of these rates one could raise a question to what extent, given the high degree of international mobility of capital and the current system of floating exchange rates *de facto* dependent on European monetary conditions. This statement of the research problem allows putting forward the following main hypothesis of the paper: *Poland currently has no de facto independence in monetary policy, and changes in the Polish monetary policy are largely a consequence of the monetary policy changes led by the European Central Bank.* The main hypothesis of the paper is verified using cointegration testing of nominal interest rates in Poland and the EMU. Based on the results of cointegration testing a Vector Error Correction Mechanism (VECM) model is constructed. The model is then used to test several parametric hypotheses concerning the speed and asymmetry of adjustment between interest rates in Poland and EMU that allow determining the causality between monetary policies of both currency areas.

[1] See, among others, Frankel, Schmukler and Servén (2002), Fratzscher (2002), and Obstfeld, Shambaugh and Taylor (2002).

The first part of the article presents a literature review of monetary independence in small open economies. The second part describes the empirical strategy and parametric hypotheses that are verified using the VECM model. The third part presents the results concerning historical relationships between interest rates in Poland and the EMU. The article concludes with a discussion of policy implications of the results in the context of Poland's joining the Eurozone. The research shown in this paper is an attempt to complement the existing state of the art in the field of economic research on the benefits and costs of Poland's adoption of the euro. Therefore, the investigation of the *de facto* independence of monetary policy and exchange rate conditions has fundamental consequences for the assessment of the effects of introducing the euro as a legal tender in Poland.

1. Literature review

The studies on the Eurozone accession usually a priori assume that the main long-run cost of participation in a common currency area is the loss of independence (or autonomy) of monetary policy. According to these concepts, it is argued that the adoption of the euro will result in loss of autonomy of the monetary policy in accessing country. A similar perspective is adopted in a report summing the conclusions of previous research on the benefits and costs of adopting the euro by Poland (NBP, 2009). On page 152 the Authors state: "Adopting the euro is associated with the loss of ability to conduct an autonomous monetary policy. [...] Influence [of NBP] on the situation in Poland at the level of ECB interest rate will be incomparably smaller than the current situation in which the monetary policy is conducted independently by the Monetary Policy Council." The authors of the Report, however, did not indicate on what basis they assume that the Polish monetary policy at this stage of international financial integration is independent of the actions of the ECB. Moreover, it is symptomatic that the only estimate of the cost of losing monetary policy independence is a working paper accompanying the Report by Gradzewicz and Makarski (2009), which presents a simulation study based on the DSGE model assuming *a priori* independence of the Polish monetary policy.

However, the last two decades of research in macroeconomics resulted in a large body of empirical research examining the tendency of central banks to adopt policies which de facto differ from official statements and de jure policy objectives of these institutions. This literature posits a series of open economy considerations of these policies relevant to the Polish monetary policy, especially considering the ongoing debate on the costs and benefits of adopting euro as the legal tender in Poland. These considerations often stand in opposition to the current state of the art knowledge about monetary policy in the small open economy framework. In fact, the extent to which a country can obtain the autonomy of monetary policy depends on external factors in the domestic economy and the real and financial integration with the dominant large markets. In this context, it is questioned even if countries such as the UK and Sweden and before the adoption of the euro, Italy, the Netherlands, or France had any independence in their monetary policy from the interest rates set by the Bundesbank. di Giovanni and Shambaugh (2008) suggest that works through interest rates following monetary policy transmission in the countries that dominate the smaller markets. As a result, Frankel et al. (2004) show that countries with flexible exchange rates experience full transmission of world interest rates. Taylor (2010) goes as far as even to say that the EBC prior to the financial crisis was not carrying out an independent monetary policy stance, but was merely copying the decisions made by the FED.

As its theoretical motivation, this research builds on the literature of target zone models (Svensson, 1994). The fundamental argument of target zone models is that a target zone allows for a temporary deviation of domestic from foreign interest rates, if the target zone is credible. Interest rates may diverge persistently under a flexible exchange rate regime only if the domestic policies are credible and the monetary authority primarily targets domestic economic variables such as inflation and output. The size and the length of the deviation then can be used to measure the degree of monetary policy independence. By contrast, a monetary authority may not enjoy much monetary autonomy even under a more flexible exchange rate regime if it lacks credibility or if the economy is highly integrated financially with a larger monetary area such as the dollar or the euro area (Fratzscher, 2002).

Based on this literature four different reasons can be provided for which the policy de facto cannot be autonomous. Two of them relate to the phenomenon of fear of floating; two are endogenous to the economy. First the reasons for the lack of autonomy of the monetary policy associated with fear of floating are discussed. The actions of the central bank in a small open economy may be the outcome of its concerns about currency fluctuations – caused by international differences in interest rates, which themselves are consequences of central bank's actions. In this case, the high correlation between domestic and international interest rates may signal exchange rate stabilization policy of the bank, which officially runs a floating exchange rate policy. Therefore, such central bank behavior would indicate the occurrence of fear of floating phenomenon. In such cases, against the official standpoints and declarations of the central bank, the monetary policy measures are directed on limiting exchange rate volatility. Thereby the central bank, which changes its interest rates as a form of exchange intervention, also causes changes in monetary policy. It could be also, that the central bank makes changes in interest rates in response to changes in the monetary policy of a leading country - probably the country with the largest financial market in the region - in order to avoid differences in interest rates causing large capital flows and exchange rate volatility. At the same time, the behavior of interest rate may be a consequence of inflation targeting behavior. Still, the question remains whether the fear of floating phenomenon can be concealed, as an inflation targeting policy and are therefore anti-inflationary policy is an end in itself or a tool that is used to stabilize the exchange rate in a situation where the official position of authority precludes such intervention.

These hypotheses are testable empirically. The results obtained for countries which pursue the inflation targeting (the sample included Poland) by Ball and Reyes (2009) show that because of fear of floating the volatility of interest rates is higher than the changes in inflation and appears to be strongly associated with exchange rate volatility. These results are not sensitive to the existing exchange rate system, which confirms empirically the lack of autonomy of monetary policy in a country characterized by fear of floating.

In the case of Poland - changes in inflation translate into lower interest rate spreads in the case of a fixed exchange rate regime than for the benchmark managed floating exchange rate regime. The result is statistically significant. This would suggest the occurrence of the problem of fear of floating, since there is no clear difference in monetary policy between the behavior of real interest rates in inflation targeting regime and a managed exchange rate regime. This means that interest rates respond to changes in inflation similarly in the case of inflation targeting and floating exchange rates, and this contradicts the predictions of the classical concept of the „impossible trinity."

There has been no compelling evidence on the empirical side to support the assertion of a link between exchange rate flexibility and monetary autonomy. Hausman et al. (1999) find that interest rates in countries with floating exchange rate regimes are as dependent on and responsive to US monetary policy shocks as are those countries with fixed currency regimes. Frankel (1999) and Frankel et al. (2000) examine a broad sample of countries in the sample of 1970-2000 and also fail to detect a strong link between exchange rate flexibility and interest rate autonomy. The occurrence of fear of floating phenomenon is also confirmed by the results obtained by D'Adamo (2010) and van Dijk et al. (2006). European countries that have not adopted the euro, show a higher volatility (pursuing the inflation targeting policy), but it is not as high as in other non-European countries. It seems that a certain weight in monetary policy is given to the stability of the exchange rate against the euro. Moreover, van Dijk et al. (2006) show that correlation between the exchange rates of the main EU countries outside the euro area against the dollar and the euro rose after the introduction of the euro. Countries outside the area may wish to keep the exchange rates of their currencies stabilized to the euro, what result in a lower exchange rate volatility, without a definite need for a full abandonment of independent monetary policy. However, from a theoretical point of view and from the fear of floating de facto independence of monetary policy in a country characterized by this phenomenon will be limited.

On the other hand, the reasons for the lack of autonomy of monetary policy may be endogenous. For example, the Polish monetary policy is strongly correlated with the one of the ECB, probably due to external conditions and increasing integration with the Eurozone. The first explanation is growing business cycle correlation between the Polish and the euro area. In this sense, adoption of foreign interest rates can be assumed to be a result of increased economic integration through trade and financial markets, which resulted in the synchronization of business cycles, as suggested by the endogenous theory of optimum currency areas (see Frankel and Rose, 1998). This convergence increases with trade and capital links between these areas. Another possible cause may be an endogenous component of the global inflation – in such cases the central banks of both regions react in the same way to disturbances that are exogenous to their decisions. The high degree of similarity in policies between the domestic and foreign central bank can therefore be a reflection of not so much a lack of independence in an institutional sense, but rather of the symmetry of shocks affecting the domestic economy and foreign. However, for both of these endogenous causes of lack of autonomy of monetary policy lead to the same effect - in a positive sense, the monetary policy in the smaller country will not be autonomous.

Since this type of hypothesis is empirically difficult to be tested, much less attention to this issue is paid in the literature of the subject. D'Adamo (2010) argues that Poland belongs to a small group of direct inflation targeting countries that have shown exchange rate volatility over the last 10 years, comparable to the variability of the exchange rates of currencies of the similar countries from the sample. As it has already been argued, the finding of lower volatility of the exchange rate against the euro may be the result of the growing phase synchronization of business cycles, rather than exchange rate policy. However, tests for foreign reserves volatility have shown that after the introduction of the euro volatility of foreign exchange reserves increased significantly in all countries in the sample (the same goes for Poland). Estimated coefficient between the change in exchange rate and the change in reserves is positive and stable for the most countries of the region, and the importance attached to stability in relation to the euro is not clearly defined, but estimated to be somewhere between 0.4 and 0.5. This again suggests a lack of full autonomy in conducting monetary policy in the countries staying out of the EMU.

It stems from the discussion that regardless of the specified cause of the observed effect of monetary policy, a country with a small open economy and strong capital flows suffers from a reduction in the de facto monetary policy autonomy. This means that the adoption of floating exchange rate regimes does not allow countries such as Poland to obtain the autonomy of monetary policy. Therefore we argue that monetary authority may not enjoy monetary autonomy even under floating exchange rate regime if it exhibits fear of floating or if the economy is highly integrated with a large economy such as the euro area. The fears expressed by the fear of floating could be easily seen especially during the times of crisis in the financial markets and the Eurozone crisis, when NBP decided to intervene in the Forex markets despite its floating exchange rate declarations. These findings allow to argue that moving from a fixed to a floating exchange rate regime alone may not be sufficient to raise the degree of monetary autonomy. The reason is the rising degree of financial and real integration among economies in the EU, which has also led to an increased interdependence of interest rate movements. What this may indicate is that in an increasingly interdependent world we are moving from an "Impossible Trinity" to an "Impossible Duality" (Fratzscher, 2002). This means that even under floating exchange rate regimes it becomes ever more difficult for countries to exert independent and autonomous monetary policy.

Therefore proposed project is close in its hypothesis to the research carried out by Gabrisch and Buscher (2011) for Sweden, Denmark, and the UK. The study confirmed the presence of a high level of correlation between short-term Euribor rates and short-term interbank interest rates in these countries. The Authors confirmed the existence of this dependence not only in times of peace but also in times of disturbances, indicating that the ECB's policy has a significant impact on the domestic interest rates and, therefore, the monetary policy independence cannot be indicative of the benefits of staying outside the euro area. Similar conclusions were obtained by Reade and Volz (2010), who use the VAR method to show that the market interest rates in Sweden are correlated with the Euribor rates, and monetary policy in Sweden is largely a copy of the decisions made by the ECB. Similar studies on the Polish case are lacking, with the exception of few descriptive studies.

Goczek and Mycielska (2012) present the problem of the exchange rate conditions of pursuing an independent monetary policy in a small open economy, integrated financially with a larger monetary area that is in fact leading the monetary policy. Based on theoretical considerations presented in the article it could be argued that the freedom to conduct an independent monetary policy in the country characterized with the fear of floating of the exchange rate is limited, because the management of interest rates may be in fact reduced to an implicit exchange rate management tool. Empirical studies show that in the case of Poland can be thought of as an example of a fear of floating and that this situation resulted in a low degree of the monetary policy independence. From the perspective of the euro means that now Poland, due to the currency exchange conditions, cannot freely conduct its monetary policy. As the Authors note, significant fluctuations in exchange rate, due to the turmoil in the financial crisis and the crisis in the euro zone are not contrary to the main thesis of the article.

The codependence between the exchange rate regime and monetary policy independence was analyzed in Cuaresma and Wójcik (2006). The Authors investigate a DCC-MGARCH model of real interest rates in Germany and three Eastern European economies and conclude that these countries do not enjoy monetary policy independence. Moreover they have shown that in the case of Poland the increase of flexibility of the exchange rate regime went hand in hand with the correlation between interest rate in Poland and Germany, contrary to the Mundell-Fleming paradigm. It is necessary to point out, however, the limited and dated choice of the studied period. The investigation was carried out using data that span the period of 1994-2002. In contrast, the exchange rate of Polish Zloty was officially floated in mid-2000, so the period of most significant interest (from the viewpoint of the monetary independence analysis that can be carried out only against the backdrop of floating exchange rates) spanned over less than two years. What is more, the Authors themselves note, that they used real interest rates instead of nominal ones due to a high level of inflation in the beginning of this period. The Authors use a large number of dummy variables. This could potentially render some of the conclusions less strong. Therefore it seems that the analysis should be extended for the period of 2001-2013, when zloty had a floating exchange rate regime both in the de jure and the de facto sense.

On the other hand, Windberger, Cuaresma, and Walde (2012), while analyzing different methods of estimation of the volatility interest rates and exchange rates, come to the conclusion that Poland has had a significant degree of monetary independence in the last decade. In this research the data span period starting from 2002, but the Authors include structural breaks in their model to obtain more reliable estimates but the procedure of choosing the timing of those breaks is unclear. They also do not discuss the autocorrelation problems, what we found to be relevant for weekly frequency of interest rates in the case of Poland.

As it was already mentioned, the level of integration between the two monetary areas has a profound impact on the similarities in behavior of domestic and international interest rates. In this context it seems more reasonable to analyze the time of the increasing integration and cooperation between Poland and the EMU and thus the period after the year 2004 when Poland joined the EU. Moreover, the cooperation between NBP and EBC has a more profound character then the relationship between NBP and Bundesbank. This is important given the fact that the Bundesbank policy did not have to take into account the adjustment against all other EU countries. What is most important however is that the Eurozone is a much larger monetary area than the DM ever was. Hence the level of monetary integration is much stronger, since the gravity pull is much larger. Lastly, it is possible to point out that the method of analysis proposed in the article has not been applied previously to the analysis of Polish monetary policy independence.

2. Empirical methodology and specification

According to the target zone models the interest rates may diverge persistently under a flexible exchange rate regime only if the domestic policies are credible and the monetary authority primarily targets domestic economic variables such as inflation and output. Therefore the size and the length of the deviation then can be used to measure the degree of monetary policy independence. That may be interpreted as the degree to which the domestic interest rates follow international interest rates. If a steady state relationship exists between interest rates in the two monetary areas, and furthermore one country adjusts to this relationship, while the other does not, then this is evidence in favor of monetary dependence of the adjusting country on the non-adjusting one.

These assertions are testable empirically by cointegration testing between interest rates in both areas. This is allowed for by the fact that the time series for interest rates are I(1) since the 1970s. This is commonly accepted in the empirical literature on interest rates, even though it might not be plausible from the economic-theoretical viewpoint. However, the treatment of processes close to nonstationarity as non-stationary in the econometric approach is more appropriate and less harmful than acting upon a theoretical economic consistency.[2] The fact that

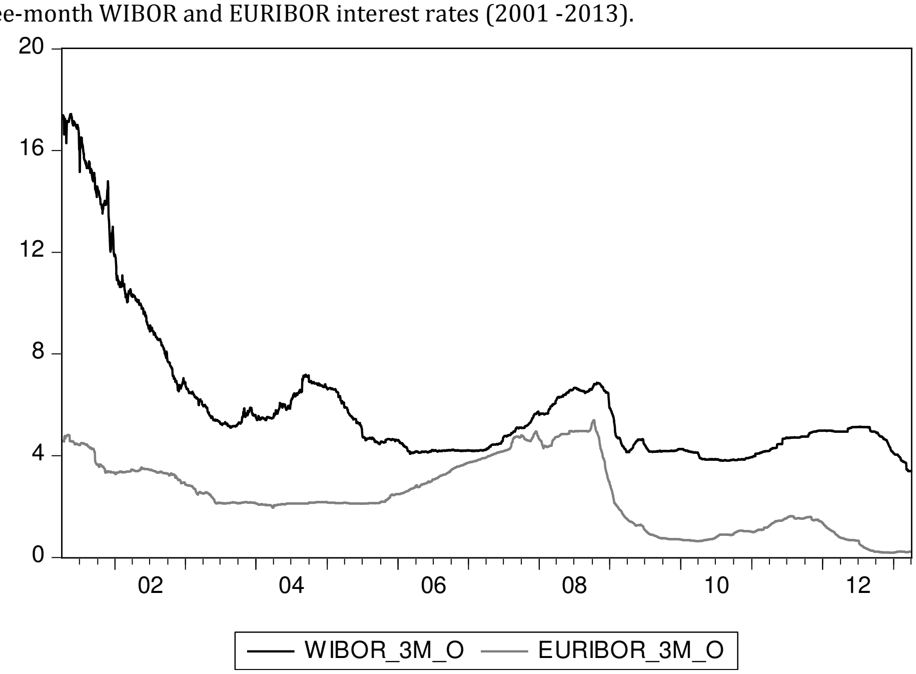
[2] See Pagan (1996), Moon i Perron (2007), Kliber et al. (2012).

the series of interest rates used in the article are I(1) was confirmed using KPSS unit root test. The results of these tests are shown in Table 3.

In the case of variables which are integrated of the same order it is possible to investigate the existence of a long-run relationship, which relates to the macroeconomic concept of a steady-state dynamic equilibrium. In econometric sense this would mean that there exists a cointegrating vector for the interest rates.

The most appropriate measure to proxy for monetary policy independence in two currency areas are interbank interest rates. If the domestic interbank interest rates react to the changes in the domestic monetary policy stance according to expectations then a given country enjoys a large degree of monetary policy independence. If, however, the interbank interest rates react mostly to foreign interest rate changes or if the two economies are intricately linked, as dictated by close movements of their three-month interbank interest rates, it is unlikely that domestic monetary policy exerts much independence. On the other hand, it could be argued that the more suitable measure of independence would be the correlation between reference rates of the relevant central banks. These variables, however, have a very low frequency of changes, low variance, and they do not take into account market expectations, but most importantly it could be that the central bank does not have any policy effectiveness, despite setting its reference interest rates far from the interest rate parity. Hence interbank interest rates provide an effective means for investigating monetary policy independence and based on the above listed reasons it could be argued that the measures of interest rates chosen for the empirical model estimated in the article are indeed appropriate. Based on this conclusion, in this empirical analysis 3-month WIBOR and EURIBOR interest rates are used during the period of 2001-2013 (after the floatation of PLN and joining the EU by Poland) with daily, weekly, and monthly frequency. Figure 1 plots the two variables.

Figure 1. Three-month WIBOR and EURIBOR interest rates (2001 -2013).



Source: own

According to the uncovered interest rate parity the analysis of the relationship between two interest rates in two countries should encapsulate changes in the nominal exchange rates. Nevertheless, almost all empirical analyses of monetary policy independence restrict themselves just to interest rates. As Juselius (2007) explains, the rank test of the cointegrating vector should indicate the steady state relation that should be preserved in any systems more general then the tested one (*sectoral-specific-to-general property*). Thus, the cointegrated vector-autoregressive model framework allows the modeling of partial systems as long as the rank test outcome is valid, so any cointegrating vectors found in that system should be found in any enlarged system (Ericsson et al., 1994, Juselius, 2007). Therefore it could be argued, that a cointegrated system involving solely interest rates, should be sufficient to model interest rate movements. In this way many facets of the monetary policy independence can be measured without any ex ante restrictions arbitrarily imposed by the authors.

Let us consider two time series for domestic and international interest rates that form a bivariate data vector X_t given by:

$$\mathbf{X}_t = \begin{pmatrix} r \\ r* \end{pmatrix}_t \tag{1}$$

The domestic interbank interest rate (WIBOR_3M) is denoted by r_t, the international interbank interest rate (EURIBOR_3M) is denoted by r_t*. The two variables are used to form a Vector Autoregressive (VAR) model described by the following equation:

$$\mathbf{X}_t = \Pi_0 + \Pi_1 t + \sum_{i=1}^{K} \Pi_i \mathbf{X}_{t-1} + \mathbf{u}_t \tag{2}$$

where the error term $\boldsymbol{u_t} \sim N(0, \sigma^2)$ is uncorrelated over t, the data vector $\mathbf{X}_t$ is $p \times T$ dimension, Π_i is the deterministic coefficient matrix (constant and trend) of a dimension $p \times p$. If the data are non-stationary in levels and stationary in first differences, then the equation (2) can be rearranged to form a vector error correction mechanism:

$$\Delta\mathbf{X}_t = \Pi^* \mathbf{X}^*_{t-1} + \sum_{i=1}^{K-1} \Gamma_i \Delta\mathbf{X}_{t-i} + \mathbf{u}_t \tag{3}$$

where:

$\mathbf{X}^*_{t-1} = (\mathbf{X}_{t-1}, 1, t)'$, $\Pi^* = (\Pi, \Pi_0, \Pi_1)$, $\Pi = \sum_{i=1}^{K} \Pi_i - I$ and $\Gamma_i = -\sum_{j=i+1}^{K} \Pi_j$. For the ease of exposition the coefficients for the lagged regressors and the deterministic terms were grouped together, which is similar to the taking of this problem in most econometric packages. Under the assumption that $\mathbf{X}_t \sim \mathrm{I}(1)$ and $\mathbf{u}_t \sim \mathrm{I}(0)$, the matrix Π is of reduced rank for the equation (3) to be balanced. If Π is of reduced rank, then there exists $p \times r$ matrices α and β such that $\Pi = \alpha\beta'$ and the equation (3) can be transformed to:

$$\Delta\mathbf{X}_t = \alpha\beta' \mathbf{X}^*_{t-1} + \sum_{i=1}^{K-1} \Gamma_i \Delta\mathbf{X}_{t-i} + \mathbf{u}_t . \tag{4}$$

The term $\beta' \mathbf{X}^*_{t-1}$ is the cointegrating vector showing the steady state relationship between the interest rates. In the context of interest rates those are linear combinations, which themselves are non-stationary, but the relationship between them is stationary with a steady state cointegrating vector forming uncovered interest rate parity.

If the matrix Π is of rank one, this means that a single cointegrating vector exists, and $\beta'$is $1\times p+2$ (constant and trend in the cointegrating relationship). Then the cointegrating vector can be rewritten to be:

$$\beta' \boldsymbol{X}_{t-1}^{*} = (\beta_0, \beta_1, \beta_2, \beta_3)\begin{pmatrix} 1 \\ t \\ r_t \\ r_t^{*} \end{pmatrix} = \beta_0 + \beta_1 t + \beta_2 r_t + \beta_4 r_t^{*} \qquad (5)$$

If it is found during the empirical analysis of the two interest rates, that the rank is indeed one, this means that there exists a single cointegration vector - a single steady state relationship. This is an indication of monetary policy dependence in the currency areas. However, it could be argued that this relationship does not have bilateral causality or feedback properties. From a theoretical viewpoint it is very probable that the Poland's target zone is not credible enough for domestic interest rate deviation from international rates to hold over prolonged periods, since the Polish economy is financially and economically integrated with the Eurozone. In contrast, an inverse relationship is quite unlikely to hold - it seems impossible that the Polish interest rates influence the interest rates of the currency area orders of enormity larger than the Polish economy.

The properties of these relationships can be verified using parametric test concerning coefficients from the matrix α. The statistical significance and the sign of the α coefficients indicate how a given interest rate reacts to disequilibrium from the cointegrating vector. This means that it is possible to indicate which of the interest rates adjusts to the other, at what speed and to what degree. In the analyzed case it is therefore expected that the WIBOR rate changes towards the steady state relation to the EURIBOR and not the other way around. This is testable through the hypothesis that the adjustment coefficient is insignificant in the EURORIBOR equation and significant in the WIBOR equation.

The specification of the cointegrating equation allows for the analysis of the steady state equilibrium holding between the interest rates in both currency areas. It is expected that the interbank market in the smaller currency area is going to exhibit a higher risk premium. This is modeled using the intercept in the cointegrating equation. A formal test concerning the sign and significance of this coefficient allows this hypothesis to be tested in the data. At the same time it could be argued that because of the expected Poland's entry into the EMU and the intensifying since the early 1990s financial integration of Poland into European capital markets this premium is expected to fall. This should be seen in the long run convergence of the two interest rates. This phenomenon can be measured using linear trend term coefficient in the cointegrating equation.

Summing up the discussion - the parametric hypotheses can be reduced to the following list:

1. H_0: Π is of rank one - *there exists a long run steady-state relationship between the interest rates in Poland and the Eurozone*.
2. H_0: $\beta_0 \leq 0$ - *test of the existence of a positive risk premium in Poland.*
3. H_0: $\beta_1 = 0$ - *no long-run convergence in risk premium between the two areas.*

4. H_0: $\alpha_1 \neq 0$ - *limited monetary independence in Poland, adjustment to the steady state relationship with the Eurozone*.

5. H_0: $\alpha_2 = 0$ - *no adjustment of Euribor to the interest rates in Poland, exogeneity of international interest rates.*

6. H_0: $\beta_1 = -1$ - *total homogeneity - the interest rates move jointly in a one by one fashion and if equilibrium is disturbed by a movement in a country's interest rate, then the smaller country's interest rate must move by the same amount to restore equilibrium.*

Moreover, given the steady state relationship between interest rates in the two monetary areas it is possible to check which of the interest rates is exogenous to the other. So if only one country adjusts to this relationship, while the other does not, then this is evidence in favor of monetary dependence of the adjusting country on the non-adjusting one. This could be further tested with Granger Block Exogeneity test, which is more powerful, then it's pairwise single equation alternative.

3. Empirical model results

Before continuing to the presentation of the empirical results, it should be pointed out that the presented model relates to the case of monthly frequency of the data, even though a similar investigation was estimated first on the daily data. The reasons for the choice have a twofold justification. The first justification is associated with the long-run characteristics of the investigated hypothesis. Daily frequency could potentially bring too much noise that can potentially bias the results. Second relates to a persistent autocorrelation seen in the daily frequency data and thus the possibility of overestimation of cointegration. However, analogous tests and models were run for daily, weekly, and monthly data obtaining very similar results.

Before continuing to the main investigation, Granger Causality testing was performed in order to determine the casual relations visible in the data. The results are shown in Table 2. There are no grounds to reject the hypothesis that WIBOR does not Granger case the EURIBOR. At the same time it was determined that the hypothesis that "EURIBOR does not Granger cause WIBOR" should be rejected. These results were independent of the number of lags used and they allow us to argue that the relationship between nominal interest rates in the two areas has a unidirectional rather than feedback property. While EURIBOR Granger causes WIBOR, the reverse relation is not confirmed in the data. This has determined the order of variables in the vector model's decompositions and cointegration testing.

As a second step, Unit Roots tests were run to check the stationarity of the time series in the bivariate data sample. Kwiatkowski et al. (1992) KPSS Unit Root test was used to determine the existence of unit roots in order to select the order of integration of the investigated time series. This test was used as a more robust alternative to the more common ADF test. It was determined that all of the investigated series are integrated of order one at 5 %.

The next step was to construct an unrestricted Vector Autoregressive (VAR) model. The Schwarz Information Criterion (SIC) has pointed to the two lags as the optimal number (the selection was based on this criterion to penalize large over indentified models as suggested in Juselius, 2007) as it was shown in Table 4. The results in the Table 5 show that all of the lags are significantly different from zero. Then, a Granger Block Exogeneity Test was run again. The results are shown in Table 6. Once more, the test determines that the hypothesized relationship has as a unidirectional property - WIBOR is endogenous, while EURIBOR is exogenous. The VAR has a borderline stability as the inspection of the AR Roots polynomial shows (Table 7). All roots lie at the inside of the unit root circle, though some are close to 1.

The next step was to perform Johansen Cointegration Tests in its all three versions (Johansen's "trace" statistic method, "maximum eigenvalue" statistic method. The third method chooses rank of the matrix Π to minimize an information criterion.) All three methods are based on Johansen's maximum likelihood (ML) estimator of the parameters of a cointegrating VECM, with different cointegrating equation assumptions and data trends specifications. At the same time the economic-theoretical meaning of each kind of assumption was taken into account. A positive constant in the cointegrating equation relates to a positive risk premium in the smaller country over the larger economy. The trend term relates to the expectations of Poland's participation in the EMU should manifest themselves in long-run interest rate convergence. This should be observable in the long-run fall of interest rate risk premium in Poland (Goczek and Mycielska, 2013).

The results in various specifications were summarized in Table 8. In all analyzed cases, except quadratic trend in the data, the selected number of cointegrating equations was one. The case of quadratic trend should be rejected however, both under theoretical considerations and statistical results. It can be therefore concluded that there exists a single long-run cointegrating relationship. As in the lag-length selection problem, choosing the specification of the cointegration equation that minimizes either the Schwarz Information Criterion (SIC) or the Hannan and Quinn information criterion (HQIC) provides a consistent estimator of the steady-state equilibrium. Therefore it was determined that there exists a constant in the cointegrating equation without a trend term. Then the Johansen Test was performed again just for the selected specification achieving a very high statistical significance of the result. This is reported in Table 9. This evidence is overwhelmingly in favor of a steady state relationship between WIBOR and EURIBOR.[3] The obtained P-value is at 78%.[4] This test outcome is very conclusive, it is unlikely that any size distortions in the trace test could have a affected the test enough to bias this particular outcome.

Based on the above results a VECM model was constructed without an intercept in VAR and a constant in the cointegrating equation. The results are shown in Table 10. Then the AR Roots of the characteristic polynomial were shown in Table 11 in order to determine if the VECM model was stable. All roots except one lie inside of the circle, this is not of a concern since the error correction mechanism assumed in the VECM model imposes one Unit Root. More diagnostic tests followed. The results of LM autocorrelation of residuals test were shown in Table 12. The results show an AR(5) process. VECM models with the number of lags above 5 have not shown this property, however, since the Akaike Criterion at the outset preferred the lag length selected at 11, this number of lags was finally chosen. The results of this model are shown in the Table 13, the results of LM autocorrelation of residuals test were shown in Table 14. The Block Exogeneity test was re-run in the VECM model. Again these results shown in Table 15 confirm that the WIBOR is not a cause of EURIBOR while the opposite relationship holds in the Granger sense. Hence the hypothesized relationship is unidirectional.

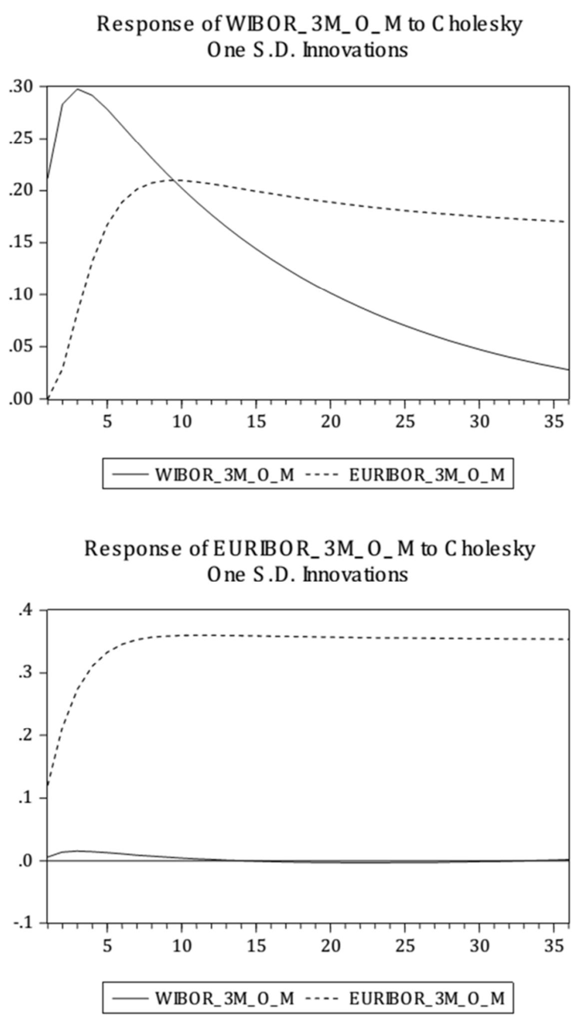
The constant term in the cointegrating equation was positive. These finding points toward positive risk premium associated with investing in Poland. A model with the trend term was also run to test the hypothesis of long-run convergence in interest rate and diminishing risk

[3] Rank test is robust to ARCH effects.
[4] For daily and weekly frequencies the results were 92% and 94%, respectively.

premium, even though this specification was not selected under the above specification selection procedure. Nevertheless this approach generally failed, since the trend term in the cointegrating equation proved to be insignificant. This allows to conclude that there are no grounds to reject the hypothesis that there is no long-run convergence in risk premium between the two areas.

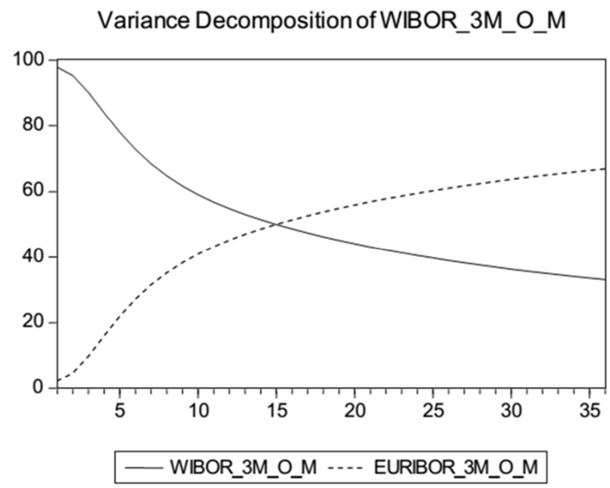
In order to interpret further the results the focus was put on the impulse response functions (IRF). IRFs describe how the innovations to one variable affect dynamically another variable over a given number of periods and allow answering how does an innovation to variable *k*, holding everything else constant, affect variable *j* after *i* periods? Cholesky decomposition was used to overcome contemporaneously correlated errors. The ordering imposed in the Cholesky decomposition was based on the Block Exogeneity Test reported earlier. The impulse response functions have been plotted in Figure 2. The shapes of the plotted functions point again toward the asymmetry of adjustment between the EMU and Poland.

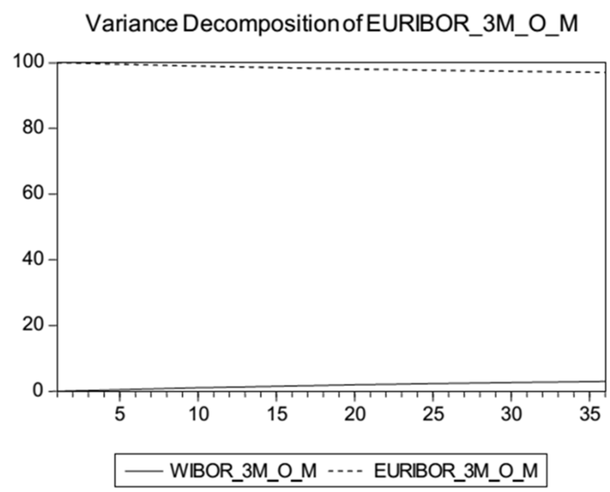
Figure 2. Impulse responses



Source: Own calculations.

Figure 3. Variance Decomposition





Source: Own calculations.

Variance Decomposition exercise gives another way to assess the hypothesized relationships with the use of cumulative variance changes of one variable caused by variance in a given variable. Figure 3 presents the cumulative effect of changes in both variables over 36 months. The Variance Decomposition plot given in Figure 3 allow for arguing that the analyzed system has only unidirectional relationship between the domestic and international rates. Based on this it could be argued that interest rates in the euro zone have a growing over time impact on the behavior of WIBOR rates. Again these results confirm the main hypothesis of the article.

Based on the above results it can be concluded that the empirical hypotheses investigation has brought the following results:

1. There exists a positive risk premium for investing a Poland.

2. There are no grounds to reject the hypothesis of no nominal interest rate convergence between Poland and the Eurozone. There exists a steady state in which the risk premium for investing in Poland does not diminish.

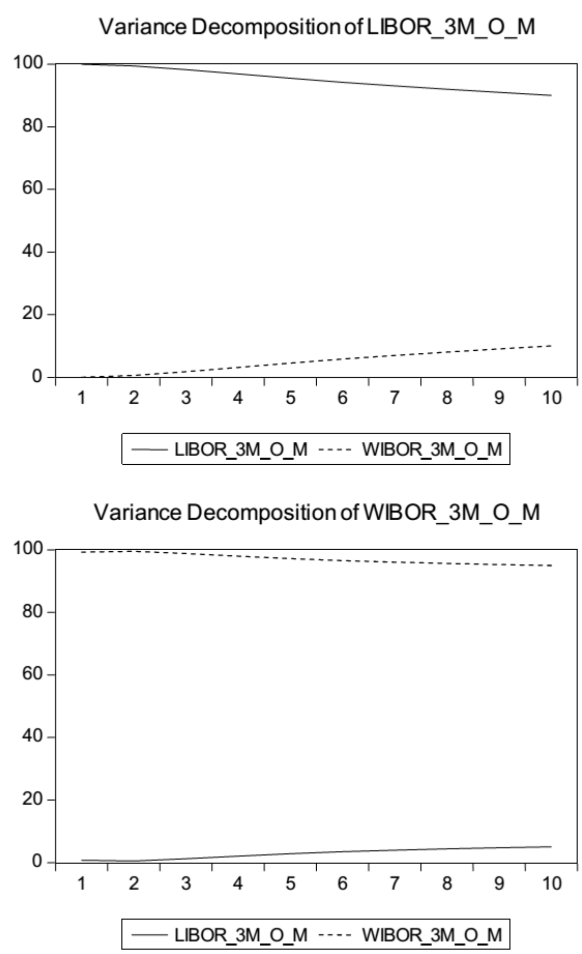
3. The results allow for arguing that the degree of monetary independence in Poland is low, but it does exist to a certain extent. At the same time Polish interest rates adjust to the changes in interest rates in the Eurozone for a given disequilibrium to the steady-state.

4. As expected, the international interest rates do not depend on the changes in monetary policy in Poland.

5. The hypothesis of a one-to-one relationship between interest rates between Poland and the Eurozone should be rejected.

It should be stressed that the model selection was based on econometric theory. During these selections a model with most conservative predictions was selected. Most of the rejected models have shown a much higher degree of Polish monetary policy dependence. It can be therefore concluded based on this assertion that the results are robust to the changes in frequency of the data, the number of selected lags, choice of the decomposition method, etc.

Figure 4. Variance Decomposition for the LIBOR - WIBOR Model.



Source: Own calculations.

4. Robustness

As a robustness check the same methodology was used to examine the relationship between WIBOR and LIBOR rate. At the outset it is expected that the dependence of Polish interest rates on the LIBOR is smaller than the dependence on EURIBOR. To this end a similar VECM model was run for WIBOR and LIBOR three month interbank interest rates. The model specification was selected using the same procedure as the model of WIBOR and EURIBOR. The lag length criteria and autocorrelation removal procedures have also selected 11 lags, similarly to the EURIBOR case. The results of this VECM modeling of WIBOR and LIBOR are shown in Table 16 and Figure 4. The LIBOR term is insignificant in the cointegrating equation. The variance decomposition exercise shows that there was no relationship between LIBOR and WIBOR, that would allow for calling it any kind of dependence in monetary stance between these monetary areas. This allows us to argue, that the methodology correctly permits to discriminate between dependence and independence in domestic monetary policy.

Conclusions

Based on the empirical results shown in the paper it could be argued, that small open economies like Poland, fully integrated financially with a monetary area, do not lose much monetary independence when they decide to enter a common currency area. This is due to the fact that it is impossible to enjoy this independence while being so dependent on financial flows from the major financial area and a country cannot lose something that it does not have in the first place. The confirmation of the hypothesis of a very low monetary independence in Poland in the empirical model shown in the paper allows arguing that the EMU joining could potentially have smaller costs than it was argued in the NBP (2009) report, in which it is assumed that Poland enjoys full monetary independence.

The explanations for these empirical results can be either exogenous or endogenous to the monetary policy conducted in Poland (Goczek and Mycielska, 2012). It seems that even now due to increasing integration with the Eurozone the Polish monetary policy is correlated with this of the ECB. The first reason for this correlation is an increasing level of correlation of business cycles in Poland and Germany. In this sense the direct transfer of European interest rates can be thought of as a general result of a continuing process of integration of the economies due to trade and financial flows, as the endogenous optimal currency areas theory posits (Frankel and Rose, 1998). This business cycle convergence is likely to grow with the increasing interdependence in trade and capital flows. Another explanation for the high level of correlation based on endogenous reasons is a similar adjustment, both on the ECB and NBP side, to a global component of inflation. The central banks of both areas simply react to common international shocks in prices. This allows arguing not for interdependence of these policies, but rather points toward the symmetry of shocks in both monetary areas. On the other hand these results can point toward fear of floating phenomenon in Polish monetary policy in which interest rate setting acts as a way to dampen exchange rate shocks. Thus, our approach could understate the actual degree of monetary independence offered by the floating exchange rate regime, because the monetary authorities opt for not making use of their monetary autonomy – be it due to fear of floating or because the cycle at home and abroad happen to require very similar monetary policy stances.

Nevertheless, whatever the explanation, in a positive sense the monetary policy in Poland seems to be dependent on the ECB policy and therefore the costs of joining EMU by Poland could be potentially smaller than it was argued in the NBP (2009) report on costs and benefits of joining the EMU while assuming *a priori* full monetary policy dependence. Of course, the exposition shown in the article is not meant to criticize either the report or even less so, the monetary policy conducted by NBP. The paper just points to the need to reassess the potential long-run costs of joining the EMU by Poland without a priori approach to the monetary policy independence.

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Appendix

Table 1. Descriptive statistics

	EURIBOR_3M_O	WIBOR_3M_O
Average	2.454340	6.209445
Median	2.147956	5.069072
Maximum	5.113087	18.96364
Minimum	0.185474	3.380000
Standard deviation	1.416518	3.322125
Sum	363.2423	918.9979
Sum of st. deviations	294.9589	1622.367
No of observations	3135	3070

Source: own calculations

Table 2. Pairwise Granger causality tests (Lags 2, no. of observations 148)

Null hypothesis:	F statistics	P-value
WIBOR_3M_O does not Granger cause EURIBOR_3M_O	0.42061	0.6575
EURIBOR_3M_O does not Granger cause WIBOR_3M_O	6.00449	0.0031

Source: own calculations

Table 3. KPSS unit root tests

		WIBOR_3M	EURIBOR_3M
KPSS test statistic for the series in levels		0.836311	0.595860
Asymptotic critical value:	1%	0.739000	0.739000
	5%	0.463000	0.463000
	10%	0.347000	0.347000
KPSS test statistic for the series in first differences		0.346657	0.092742
Asymptotic critical value:	1%	0.739000	0.739000
	5%	0.463000	0.463000
	10%	0.347000	0.347000
Integration order:		I(1)	I(1)

Source: own calculations

Table 4. Lag length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-623.6037	NA	16.09246	8.454104	8.494607	8.470561
1	62.20752	1343.819	0.001604	-0.759561	-0.638052	-0.710192
2	127.8132	126.7785	0.000698	-1.592070	-1.389555*	-1.509789*
3	128.9204	2.109816	0.000726	-1.552979	-1.269459	-1.437785
4	131.9234	5.640679	0.000736	-1.539505	-1.174979	-1.391399
5	135.6899	6.973191	0.000738	-1.536350	-1.090819	-1.355332
6	150.0763	26.24540	0.000642	-1.676707	-1.150169	-1.462776
7	153.3944	5.963665	0.000648	-1.667492	-1.059949	-1.420649
8	159.4482	10.71679	0.000631	-1.695246	-1.006697	-1.415490
9	162.6556	5.591354	0.000638	-1.684535	-0.914981	-1.371867
10	169.1542	11.15292	0.000617	-1.718300	-0.867739	-1.372719
11	174.4896	9.012530	0.000607*	-1.736346*	-0.804780	-1.357853
12	176.4508	3.259806	0.000625	-1.708794	-0.696223	-1.297389
13	181.4195	8.124526	0.000618	-1.721885	-0.628308	-1.277567
14	183.3339	3.078560	0.000637	-1.693701	-0.519118	-1.216471
15	187.9506	7.299439	0.000633	-1.702036	-0.446447	-1.191893
16	191.8553	6.068021	0.000635	-1.700747	-0.364152	-1.157692
17	194.5956	4.184587	0.000648	-1.683725	-0.266124	-1.107757
18	196.1767	2.371578	0.000672	-1.651036	-0.152430	-1.042156
19	199.5321	4.942436	0.000681	-1.642326	-0.062714	-1.000533
20	201.5705	2.947362	0.000702	-1.615817	0.044801	-0.941112
21	205.2300	5.192574	0.000708	-1.611216	0.130407	-0.903598
22	207.1500	2.672459	0.000732	-1.583108	0.239521	-0.842578
23	211.9459	6.545801	0.000729	-1.593864	0.309771	-0.820422
24	219.4034	9.976928	0.000700	-1.640587	0.344054	-0.834232
25	220.4778	1.408287	0.000733	-1.601051	0.464595	-0.761784
26	221.7620	1.648635	0.000766	-1.564351	0.582301	-0.692172
27	234.6981	16.25755*	0.000685	-1.685110	0.542548	-0.780017
28	235.9803	1.576792	0.000717	-1.648383	0.660281	-0.710378
29	238.1032	2.553204	0.000743	-1.623017	0.766653	-0.652099
30	239.9958	2.225088	0.000772	-1.594538	0.876137	-0.590709

Source: own calculations

Table 5. Significance tests for lags

	WIBOR_3M	EURIBOR_3M	Total
Lag 1	401.5046	808.5120	1165.694
	[0.000000]	[0.000000]	[0.000000]
Lag 2	47.74244	138.0054	174.9821
	[4.29e-11]	[0.000000]	[0.000000]
df	2	2	4

Note: χ^2 statistics, p-values in parentheses.
Source: own calculations

Table 6. VAR block exogeneity tests

Dependent variable: EURIBOR_3M_O

Excluded variable:	Chi-sq	df	Prob.
WIBOR_3M_O	10.56449	2	0.0051

Dependent variable: WIBOR_3M_O

Excluded variable:	Chi-sq	df	Prob.
EURIBOR_3M_O	0.433045	2	0.8053

Source: own calculations

Table 7. Unit roots of VAR characteristic polynomial

Root	Modulus
0.957246	0.957246
0.938995	0.938995
0.718391	0.718391
0.417307	0.417307

Source: own calculations

Table 8. Information criteria in Johansen cointegration tests

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	1	1	2
Max-Eig	1	1	1	1	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	110.9242	110.9242	112.5400	112.5400	117.8209
1	122.5554	127.9389	128.0410	128.3409	128.6619
2	123.4288	128.9204	128.9204	130.8890	130.8890
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	-1.390868	-1.390868	-1.385675	-1.385675	-1.430012
1	-1.493991	-1.553229*	-1.541094	-1.531634	-1.522459
2	-1.451741	-1.498925	-1.498925	-1.498500	-1.498500
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	-1.228856	-1.228856	-1.183161	-1.183161	-1.186995
1	-1.250974	-1.289960*	-1.257574	-1.227862	-1.198436
2	-1.127718	-1.134399	-1.134399	-1.093471	-1.093471

Source: own calculations

Table 9. Johansen test – cointegration with no trend

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.205410	35.99243	20.26184	0.0002
At most 1	0.013176	1.962970	9.164546	0.7850

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.205410	34.02946	15.89210	0.0000
At most 1	0.013176	1.962970	9.164546	0.7850

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

WIBOR_3M_O_M	EURIBOR_3M_O_M	C
-0.357630	0.161958	1.272814
-0.185401	0.831495	-0.643878

Unrestricted Adjustment Coefficients (alpha):

D(WIBOR_3M_O_M)	0.105502	0.002244
D(EURIBOR_3M_O_M)	0.014576	-0.013335

1 Cointegrating Equation(s):	Log likelihood	127.9389

Normalized cointegrating coefficients (standard error in parentheses)

WIBOR_3M_O_M	EURIBOR_3M_O_M	C
1.000000	-0.452865	-3.559023
	(0.33575)	(0.95149)

Adjustment coefficients (standard error in parentheses)

D(WIBOR_3M_O_M)	-0.037731
	(0.00623)
D(EURIBOR_3M_O_M)	-0.005213
	(0.00358)

Source: own calculations

Table 10. VEC model with 2 lags

Cointegrating Eq:	CointEq1	
WIBOR_3M_O_M(-1)	1.000000	
EURIBOR_3M_O_M(-1)	-0.854813	
	(0.33246)	
	[-2.57115]	
C	-2.810981	
	(0.92885)	
	[-3.02629]	
Error Correction:	D(WIBOR_3M_O_M)	D(EURIBOR_3M_O_M)
CointEq1	-0.036622	-0.004953
	(0.00623)	(0.00403)
	[-5.88060]	[-1.22860]
D(WIBOR_3M_O_M(-1))	0.274499	-0.036171
	(0.07557)	(0.04892)
	[3.63239]	[-0.73932]
D(WIBOR_3M_O_M(-2))	-0.095083	-0.005167
	(0.07874)	(0.05098)
	[-1.20749]	[-0.10135]
D(WIBOR_3M_O_M(-3))	0.164118	0.006472
	(0.07792)	(0.05044)
	[2.10628]	[0.12830]
D(WIBOR_3M_O_M(-4))	-0.094518	-0.019441
	(0.07799)	(0.05049)
	[-1.21197]	[-0.38506]
D(WIBOR_3M_O_M(-5))	0.307960	0.033192
	(0.06710)	(0.04344)
	[4.58958]	[0.76408]
D(EURIBOR_3M_O_M(-1))	0.293185	0.792421
	(0.13327)	(0.08628)
	[2.19993]	[9.18430]
D(EURIBOR_3M_O_M(-2))	0.186236	-0.184764
	(0.16921)	(0.10955)
	[1.10061]	[-1.68659]
D(EURIBOR_3M_O_M(-3))	0.170888	0.163773
	(0.16871)	(0.10923)
	[1.01289]	[1.49940]
D(EURIBOR_3M_O_M(-4))	-0.046428	-0.019361
	(0.16817)	(0.10887)
	[-0.27609]	[-0.17784]
D(EURIBOR_3M_O_M(-5))	-0.543664	-0.058155
	(0.14023)	(0.09079)
	[-3.87693]	[-0.64057]
R-squared	0.643504	0.520513
Adj. R-squared	0.617483	0.485514
Sum sq. resids	4.954280	2.076508
S.E. equation	0.190165	0.123114
F-statistic	24.72963	14.87220
Log likelihood	41.37216	105.7199
Akaike AIC	-0.410435	-1.279999
Schwarz SC	-0.187669	-1.057233
Mean dependent	-0.110249	-0.031954
S.D. dependent	0.307471	0.171640
Determinant resid covariance (dof adj.)		0.000538
Determinant resid covariance		0.000461
Log likelihood		148.4515
Akaike information criterion		-1.668263
Schwarz criterion		-1.161977

Source: own calculations

Table 11. Unit roots of VEC characteristic polynomial

Root	Modulus
1.000000	1.000000
0.939520	0.939520
0.567900	0.567900
0.417699	0.417699
0.079489 - 0.040246i	0.089097
0.079489 + 0.040246i	0.089097

Source: own calculations

Table 12. LM test for autocorrelation of VEC residuals with two lags

Lags	LM-Stat	Prob
1	3.814610	0.4317
2	3.496127	0.4785
3	7.955864	0.0932
4	1.740527	0.7833
5	16.70685	0.0022
6	11.93612	0.0178
7	7.963948	0.0929
8	2.549828	0.6357
9	8.529798	0.0740
10	9.468010	0.0504
11	2.624108	0.6226
12	5.508509	0.2390
13	1.724077	0.7863
14	3.052237	0.5491
15	2.684966	0.6118
16	2.819908	0.5884
17	2.814719	0.5893
18	2.360087	0.6699
19	2.443234	0.6548
20	2.818200	0.5887
21	1.220637	0.8747
22	3.905864	0.4189
23	5.863583	0.2096
24	1.044327	0.9030

Source: own calculations

Table 13. VEC model with 11 lags

Cointegrating Eq:	CointEq1
WIBOR_3M_O_M(-1)	1.000000
EURIBOR_3M_O_M(-1)	-0.632655
	(0.43275)
	[-1.46195]
C	-3.377720
	(1.18828)
	[-2.84254]

Error Correction:	D(WIBOR_3M_O_M)	D(EURIBOR_3M_O_M)
CointEq1	-0.030250	-0.005471
	(0.00607)	(0.00420)
	[-4.98255]	[-1.30328]
D(WIBOR_3M_O_M(-1))	0.312340	-0.017160
	(0.08736)	(0.06041)
	[3.57527]	[-0.28407]
D(WIBOR_3M_O_M(-2))	0.119094	-0.009048
	(0.09194)	(0.06358)
	[1.29529]	[-0.14232]
D(WIBOR_3M_O_M(-3))	0.021359	-0.034608
	(0.08759)	(0.06057)
	[0.24385]	[-0.57141]
D(WIBOR_3M_O_M(-4))	-0.162064	-0.001938
	(0.08593)	(0.05942)
	[-1.88590]	[-0.03262]
D(WIBOR_3M_O_M(-5))	0.235070	0.079968
	(0.08182)	(0.05658)
	[2.87291]	[1.41345]
D(WIBOR_3M_O_M(-6))	0.212582	-0.005366
	(0.08248)	(0.05703)
	[2.57747]	[-0.09408]
D(WIBOR_3M_O_M(-7))	-0.228184	0.013892
	(0.07750)	(0.05359)
	[-2.94433]	[0.25925]
D(WIBOR_3M_O_M(-8))	-0.012597	-0.039885
	(0.07939)	(0.05489)
	[-0.15869]	[-0.72660]
D(WIBOR_3M_O_M(-9))	0.237729	-0.018309
	(0.07846)	(0.05425)
	[3.03008]	[-0.33750]
D(WIBOR_3M_O_M(-10))	-0.048621	-0.035150
	(0.08080)	(0.05587)
	[-0.60175]	[-0.62916]
D(WIBOR_3M_O_M(-11))	-0.080501	0.024501
	(0.07259)	(0.05019)
	[-1.10899]	[0.48813]
D(EURIBOR_3M_O_M(-1))	0.232259	0.809376
	(0.13030)	(0.09009)
	[1.78256]	[8.98377]
D(EURIBOR_3M_O_M(-2))	0.208991	-0.185105
	(0.16219)	(0.11215)
	[1.28852]	[-1.65052]
D(EURIBOR_3M_O_M(-3))	0.100515	0.160221
	(0.16338)	(0.11297)
	[0.61522]	[1.41826]
D(EURIBOR_3M_O_M(-4))	-0.082210	-0.030604
	(0.16276)	(0.11254)
	[-0.50509]	[-0.27193]
D(EURIBOR_3M_O_M(-5))	-0.531380	-0.106888
	(0.16238)	(0.11228)
	[-3.27236]	[-0.95196]
D(EURIBOR_3M_O_M(-6))	0.019391	0.145008
	(0.16736)	(0.11572)
	[0.11586]	[1.25308]
D(EURIBOR_3M_O_M(-7))	0.463989	-0.123778
	(0.16798)	(0.11615)
	[2.76216]	[-1.06567]
D(EURIBOR_3M_O_M(-8))	-0.241682	-0.016938
	(0.16988)	(0.11746)
	[-1.42266]	[-0.14420]
D(EURIBOR_3M_O_M(-9))	-0.156624	-0.088338
	(0.17019)	(0.11768)
	[-0.92027]	[-0.75066]
D(EURIBOR_3M_O_M(-10))	-0.026511	0.327939
	(0.16947)	(0.11718)
	[-0.15644]	[2.79861]
D(EURIBOR_3M_O_M(-11))	0.179020	-0.146537
	(0.14350)	(0.09923)
	[1.24750]	[-1.47680]
R-squared	0.716571	0.565150
Adj. R-squared	0.666687	0.488617
Sum sq. resids	3.938863	1.883198
S.E. equation	0.177513	0.122742
F-statistic	14.36487	7.384345
Log likelihood	58.34479	112.9509
Akaike AIC	-0.477632	-1.215553
Schwarz SC	-0.011849	-0.749770
Mean dependent	-0.110249	-0.031954
S.D. dependent	0.307471	0.171640

Determinant resid covariance (dof adj.)	0.000458
Determinant resid covariance	0.000327
Log likelihood	173.8749
Akaike information criterion	-1.687499
Schwarz criterion	-0.695179

Source: own calculations

Table 14. LM test of autocorrelation VEC residuals with 11 lags

Lags	LM-Stat	Prob
1	6.859570	0.1435
2	10.12680	0.0383
3	2.476679	0.6488
4	4.736165	0.3155
5	6.963136	0.1378
6	0.281399	0.9910
7	2.996717	0.5584
8	1.419261	0.8408
9	4.848749	0.3032
10	2.550462	0.6356
11	5.231452	0.2644
12	7.402989	0.1161
13	3.060770	0.5477
14	4.231529	0.3756
15	2.969525	0.5629
16	1.403219	0.8436
17	0.983502	0.9123
18	2.711913	0.6071
19	1.442442	0.8368
20	4.231890	0.3755
21	2.215757	0.6961
22	1.355782	0.8518
23	6.229141	0.1827
24	0.722847	0.9485

Probs from chi-square with 4 df.

Source: own calculations

Table 15. VEC block exogeneity tests

Dependent variable: D(WIBOR_3M_O_M)

Excluded	Chi-sq	Df	Prob.
D(EURIBOR_3M_O_M)	50.03555	11	0.0000
All	50.03555	11	0.0000

Dependent variable: D(EURIBOR_3M_O_M)

Excluded	Chi-sq	Df	Prob.
D(WIBOR_3M_O_M)	4.920363	11	0.9350
All	4.920363	11	0.9350

Source: own calculations

Table 16. Robustness test - VEC model for LIBOR_3M

Vector Error Correction Estimates
Date: 18/05/13 Time: 14:37
Sample (adjusted): 2001M01 2013M03
Included observations: 147 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
WIBOR_3M_O_M(-1)	1.000000	
LIBOR_3M_O_M(-1)	-0.073100	
	(0.25870)	
	[-0.28257]	
C	-4.334253	
	(0.77784)	
	[-5.57218]	
Error Correction:	**D(WIBOR_3M_O_M)**	**D(LIBOR_3M_O_M)**
CointEq1	-0.031355	-0.025893
	(0.00626)	(0.00679)
	[-5.00844]	[-3.81570]
D(WIBOR_3M_O_M(-1))	0.436088	-0.101807
	(0.08091)	(0.08770)
	[5.38984]	[-1.16087]
D(WIBOR_3M_O_M(-2))	-0.009079	-0.036804
	(0.07782)	(0.08435)
	[-0.11666]	[-0.43631]
D(LIBOR_3M_O_M(-1))	-0.033076	0.200472
	(0.07745)	(0.08395)
	[-0.42703]	[2.38788]
D(LIBOR_3M_O_M(-2))	0.134155	0.090217
	(0.07636)	(0.08277)
	[1.75692]	[1.09003]
R-squared	0.506734	0.200559
Adj. R-squared	0.492840	0.178040
Sum sq. resids	6.854880	8.053602
S.E. equation	0.219713	0.238150
F-statistic	36.46935	8.906044
Log likelihood	16.72821	4.883052
Akaike AIC	-0.159568	0.001591
Schwarz SC	-0.057852	0.103307
Mean dependent	-0.110351	-0.042607
S.D. dependent	0.308520	0.262679
Determinant resid covariance (dof adj.)		0.002718
Determinant resid covariance		0.002536
Log likelihood		22.14947
Akaike information criterion		-0.124483
Schwarz criterion		0.139977

Source: own calculations

Table 17. VEC model for LIBOR_3M Block Exogeneity tests

Dependent variable: D(LIBOR_3M_O_M)

Excluded	Chi-sq	df	Prob.
D(WIBOR_3M_O_M)	8.850267	11	0.6357
All	8.850267	11	0.6357

Source: own calculations

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