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The Extreme Risk Problem for Monetary Policies of the Euro-Candidates Countries

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Institut für Wirtschaftsforschung Halle
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The Extreme Risk Problem for Monetary Policies of the Euro-Candidates

Abstract

We argue that monetary policies in euro-candidate countries should also aim at mitigating excessive instability of the key target and instrument variables of monetary policy during turbulent market periods. Our empirical tests show a significant degree of leptokurtosis, thus prevalence of tail-risks, in the conditional volatility series of such variables in the euro-candidate countries. Their central banks will be well-advised to use both standard and unorthodox (discretionary) tools of monetary policy to mitigate such extreme risks while steering their economies out of the crisis and through the euro-convergence process. Such policies provide flexibility that is not embedded in the Taylor-type instrument rules, or in the Maastricht convergence criteria.

Keywords: monetary policy rules, tail-risks, convergence to the euro, global financial crisis, equity market risk, interest rate risk, exchange rate risk

JEL classification: E44, F31, G15, P34

Das Problem extremer Risiken für die Geldpolitik der Euro-Kandidatenländer

Zusammenfassung

Wir argumentieren, dass die Geldpolitik in den Euro-Kandidatenländern darauf abzielen sollte, die exzessive Instabilität in den zentralen Ziel- und Instrumentenvariablen der Geldpolitik zu mildern, insbesondere in Phasen turbulenter Finanzmärkte. Die empirischen Tests der Studie decken einen erheblichen Grad an Leptokurtosis auf, d. h. die Dominanz von so genannten *Tail-Risks* in den bedingten Volatilitätsserien der monetären Variablen in den Euro-Kandidatenländern. Ihre Zentralbanken wären daher gut beraten, neben den üblichen Instrumenten der Geldpolitik auch unorthodoxe Maßnahmen der Geldpolitik anzuwenden, wenn sie die Länder aus der Krise herausführen und danach auf die Übernahme des Euro vorbereiten. Damit erhielte die Geldpolitik jene Flexibilität, die ihr bei der Anwendung von Instrumentenregeln á la Taylor oder der Maastricht-Kriterien fehlt.

Schlagworte: Regeln der Geldpolitik, Tail-Risks, Euro-Konvergenz, weltweite Finanzkrise, Vermögensrisiko, Zinsrisiko, Wechselkursrisiko

JEL-Klassifikation: E44, F31, G15, P34

I Introduction

The global financial crisis of 2007-2009 has markedly altered monetary policy strategies and tactics of central banks around the world.[1] As a result of this crisis, monetary policy implementation cannot be based on parsimonious instrument rules à-la-Taylor that are derived from a historical relationship between the inflation gap and the output gap. At least two reasons underscore this intricacy. First, most of the central banks in the largest economies have been recently forced to enact quantitative easing strategies with zero-bound interest rates that fall below the rates implied by standard Taylor rules (Ahrend, 2008; Orlowski, 2010). Second, interest rates and other financial variables that serve as instrument or policy monitoring parameters for central banks have been very unstable, vulnerable to sudden volatility outbursts (Orlowski, 2010). The recent episodes of "tail risks", i.e. extreme shocks to volatility of these financial variables impair monetary policy implementation based on parsimonious rules that commonly assume normal distribution of its key variables thus routinely ignore their leptokurtic time-pattern. In essence, these extreme volatility shocks have inhibited monetary policy transmission mechanism and deteriorated efficiency of the standard interest-rate policy (Curdia and Woodford, 2010, Svensson, 2010).

Considering the recent prevalence of tail risks embedded in global financial market variables we aim to investigate the scale and proliferation of these extreme risks in the euro-candidate countries (ECCs). We further discuss repercussions of these extreme risks for monetary policies on the passage toward the euro adoption. Our empirical investigation is focused on detecting extreme volatility of the selected financial market variables, namely, equity market indexes, interbank rates and exchange rates, all of which are relevant for monetary policy-making in the converging economies. We analyze volatility patterns of these variables in the ECCs that are pursuing relatively independent monetary policies with flexible exchange rates, including the Czech Republic, Poland, Hungary and Romania. For comparative purposes, we also include Slovakia that has adopted the euro as of January 2009, while it embraced a flexible exchange rate regime during the euro-convergence period. We employ GARCH volatility tests augmented with the in-mean GARCH variance (as a proxy of a risk premium or discount). For the purpose of evaluating the degree of leptokurtosis, i.e. the prevalence of tail risks embedded in the conditional volatility patterns, we assume the generalized error distribution (GED) parameterization. Our working assumption is that the estimated GED parameters of the examined financial market variables are considerably lower than 2, indicating prevalence of severe tail risks.

1 A first version of this paper has been presented at the AEA convention in Atlanta, Januar 2010. We gratefully acknowledge the comments made by *Paul J. Van den Noord* (DG Ecfin, Brussels) and *Ali Kutan* (Southern Illinois University), and *Juliane Scharff* (IWH. Simone Lösel (IWH) provided excellent assistance. Of course, the usual disclaimer applies.

Section II of our paper overviews the pertinent literature addressing the sources of extreme risks and discussing their severity during the recent crisis. The setup of our analytical models is explained in Section III. The empirical results based on the GARCH-M-GED testing are presented and discussed in Section IV. The concluding Section V provides some suggestions for proper monetary policy responses to the incidence of extreme risks embedded in the examined financial market variables.

II Monetary Policy Rules: Accounting for Tail-Risks

A central point of interest in our analysis is whether monetary policy can be effective for containing risks, particularly the types of risks that have been precipitated by the ongoing global systemic crisis. There is no common answer to this conundrum in the literature. A standard prescription based on the actual policies following the Great Depression of the 1930s is that monetary policy cannot effectively contain the crisis because it is unable to lower the cost of credit in the presence of severe shocks to credit markets from the financial crisis. However, fiscal policy, in part in emerging markets, is even more constrained, since the injection of large spending amounts into the economy raises public debt, its cost, and has already raised the risks of sovereign default in some countries, including those in Europe. Reinhart and Rogoff (2009: chapter 12) have shed light on the limited capacity of emerging markets to engage in fiscal stimulus. Hence, we find Mishkin's (2009) and Jobst's (2009) argument plausible that there is a leading role for monetary policy to overcome the current crisis and to ensure a stable financial development in the future. Yet, the question remains whether the emerging markets, among them the Euro Candidate Countries (ECCs) possess sufficient monetary policy tools to respond effectively to financial crises.

With respect to the current crisis, there is a general consensus that substantial monetary policy easing has been indispensable (Curdia/Woodford, 2010). The recent vast, unprecedented liquidity injections by the Federal Reserve and other central banks have helped alleviate a severe economic recession. Without these liquidity injections the cost of credit would be very high, which would precipitate systemic risk and lead to high credit spreads. The recent expansionary monetary policies have helped reduce interest rates on risk-free securities and stifle credit spreads. These liquidity injections have reduced the credit spreads to a more normal level preceding the outbreak of the financial crisis in August 2009. In essence, central banks in the advanced economies have become 'lenders of first (rather than last) resort'. They have extensively engaged in providing liquidity to banks, which stopped trusting each other, particularly in the aftermath of the global credit squeeze stemming from the collapse of Lehman Brothers Inc., in early October 2008. However, there is no consensus about whether monetary policy should promptly return to 'the set of principles for setting interest rates that worked well during the Great Moderation' in the aftermath of the crisis, as suggested by Ahrend (2008) and Taylor (2009).

The answer to this question lies in the real world behavior of key monetary policy and financial variables and, obviously, in the underlying behavior of agents in a monetary economy. We believe that a leptokurtic distribution of these variables is ubiquitous (Orlowski, 2008b, Miskin, 2009). If such distribution takes place, volatility of these variables is well-contained during normal market periods, but it tends to jump significantly at turbulent times. Hence, a leptokurtic distribution entails substantial tail-risks. Approximations of variable fluctuations based on the assumption of a normal (Gaussian) distribution tend to severely underestimate de-facto risks at turbulent (financial crisis) periods. The roots of these tail-risks are quite complex. Among the main causes are unanticipated corrections of asset prices and – as in the recent crisis - a bank credit freeze due to a rapid increase of liquidity risks (rapidly depreciating assets that cannot be easily liquidated). It has been pointed out in the literature that money supply is strongly and positively related to the price of assets (Minsky, 1982a and 1982b; Borio and Drehmann, 2008, 2009). If part of the money supply is endogenous, the balance sheet of financial institutions will expand along with the price of assets, creating its own credit and money. In this case one should consider that an approaching asset price bubble might induce market interest rates to rise due to the rising demand for investment goods to be produced and for their financing. If asset price inflation passes through to income inflation, the central bank's loss function would signal higher losses, and the bank would increase its policy rate – hence, acting pro-cyclical – it would signal that investing in assets would be even more profitable. A minor 'not-unusual' surprise (Minsky,1982a) or an exogenous shock like contagion would be a puncture to the asset bubble with a depreciation of debt and deflation and output decline following. This is the point when a tranquil period turns into a turbulent one, reflected in elevated volatility and risk of monetary and financial variables. The underlying leptokurtic distribution of the key monetary and financial variables seems to be in line with Minsky's financial fragility hypothesis (Minsky 1982a, 1982b), and Kindleberger's (2005) history of 'manias and crashes', and it is in line with the origin and course of the present financial crisis on the U.S. home market.

The leptokurtosis or tail-risks problem in a market economy raises severe challenges for central banks – mainly with respect to their loss function and their reaction function.[2] A first challenge is that both functions are based on judgments about the development of flow aggregates (commodity prices, output, interest rates), assuming that deviations from target or equilibrium positions are either caused by the business cycle or stochastic shocks. However, leptokurtosis results mainly from asset price movements, hence from judgments of agents about the long-term development of the price of the stocks of

2 We omit discussion of other important assumptions like the central bank's knowledge of a welfare function or a clear articulation of optimal policy rules (see *Polito and Wickens,* 2008).

financial or real assets. Indeed, there is evidence that central bank policies become ineffective during the periods of monetary tightening aimed at abating asset price inflation. For the U.S., Minsky observed the problem in the case of the credit crunch of 1966, the liquidity squeeze of 1969-1970, and the debacle of 1974-1975. Actually, the financial industry bypassed the restriction by producing financial innovations and extending credit. 'Monetary constraint in a situation in which ongoing investment activity leads to a rising demand for finance is effective only as it forces a sharp break in asset values', he concludes (Minsky 1982a: 77). The most recent example has been provided by the Federal Reserve attempt to reduce inflationary pressure by increasing the federal funds rate in 2004-2006; the whole financial innovation business became toxic when financial institutions circumvented these restrictions (Orlowski, 2008b).

The second problem lies with the central bank's reaction function. In the tranquil period preceding the recent global financial crisis (the 'Great Moderation'), economic theory recommended monetary authorities to adopt non-discretionary, instrument-rule-based policies with adjustments of the short-term interest rate as the predominant policy tool (Taylor, 1993). Most commonly, an inflation target, supplemented with output gap and/or exchange rate stability serve as key policy goals. The underlying assumption is a normal distribution of events in time. Svensson (2003) questions the effectiveness of rigid Taylor rules when the distribution of the variables is asymmetric, and proposed target rules with more discretion. The recent financial crisis has underscored the importance of active responses to 'tail-risk' or very large increases in volatility of the key monetary variables associated with their leptokurtic distribution (Orlowski, 2010). For this reason, non-discretionary policies based unconditionally on a simple Taylor rule are likely to be inadequate for containing tail-risks. In essence, the underlying risks associated with the episodes of elevated volatility of the policy variables can be managed more effectively with discretionary policies.

In the tranquil period preceding the recent crisis, adjustments of short-term interest rates have served as a predominant monetary policy instrument. Such parsimonious approach seems no longer relevant in light of the recent crisis, which has precipitated the need for massive liquidity injections to global financial institutions through central banks' purchases of risky assets. As a result, monetary policies of both highly developed and emerging market economies cannot simply focus on a single policy target. The policy target formulas have become more complex, incorporating not only price stability, but also economic growth, exchange rate stability and, perhaps most importantly, on containment of a broad spectrum of risks, including a broader viewed systemic risk, supplemented with a control or more specific risk categories such as the market-, liquidity-, credit-, default-, exchange rate-, counter-party- and other risks factors in the financial sector and the real economy.

A third challenge is rooted in the erosion of the central banks' independence. We do not have in mind the loss of independence due to a change in the position vis-á-vis governments, but due to liberalization and deregulation of capital flows and markets. With constraints to independence, a central bank has a limited ability to counteract financial crisis episodes, particularly in the case of emerging markets whose currencies are not used by central banks for international reserves. A theoretical explanation of this phenomenon can be found in Wolfson (2002) who states that the debt-deflation character of a crisis turns into a debt-devaluation interaction through which the volatility process in the key monetary and financial variables becomes strongly affected by international events. In the tranquil period, free capital flows and deregulated markets attract local agents to borrow in the reserve instead of the local currency as long as interest rates on the reserve currency credit are lower than the local currency credit rates. As a result, the local central bank de facto and gradually loses economic independence, and the steady inflow of foreign capital becomes increasingly difficult to sterilize. Higher domestic policy rates attract more foreign credit and induce a local currency appreciation. When asset-liability positions in the reserve currency country become entail greater risks, depreciation of non-reserve currencies poses a real threat to local debt positions denominated in foreign currency. Then, the ability of the central bank to act as a lender of last or 'first' resort is restrained and depends on the access to reserve currency.

A similar process of diminishing central bank independence has affected the ECCs – all with non-reserve currencies, particularly in the aftermath of a far-reaching liberalization of capital flows and financial sector deregulation as necessitated by their active preparation to satisfy the Maastricht convergence criteria (Gabrisch, 2009). With currencies which are rarely accepted for international credit, high interest differentials between domestic and foreign currency credits have strengthened incentives for local agents to take debt in foreign currency. A rising demand for foreign credit has bolstered capital inflows. Moreover, widening interest rate spreads have contributed to the appreciation of local currencies, which steady course has diminished the exchange rate risk.

The most severe reduction of central bank independence has been experienced in the four currency board countries (Bulgaria, Estonia, Latvia, and Lithuania), which have chosen the adoption of the euro as exit strategy. These countries are squeezed between the inability to adopt the euro officially and the inability to devalue. Any room for monetary policy maneuver depends on agreements with foreign monetary authorities to provide a reserve currency (as in the cases of Estonia through the swap agreement with the Swedish Riksbank in 2009 or Latvia through the IMF support).

In the next section, we aim to evaluate the magnitude and precipitation of leptokurtosis or tail-risks of the monetary variables in the EECs in order to suggest an appropriate course of their monetary policies during preparations of the euro adoption. Our empirical examination of tail-risks embedded in the key monetary policy variables in EECs is conducted for the Czech Republic, Poland, Hungary and Romania as the euro candidates that are following relatively flexible monetary regimes, and for a comparative analysis also for Slovakia that has adopted the euro since January 2009. A strong evidence of tail-risk would call for a more discretionary approach to monetary policy that is disentangled from its steady course implied by a Taylor rule. The countries in question have announced inflation targeting without a formal disclosure of a specific instrument rule (Orlowski, 2005 and 2008a). However, a recent examination of a possible adherence of the ECCs to open-economy instrument rules conducted by Orlowski (2010) suggests that the inflation gap is still a predominant driver of the Czech and the Polish central banks' reference rates. In contrast, adjustments in the Hungarian reference rates are associated mainly with changes in the exchange rate gap. Moreover, there is no evidence that the central bank reference rates respond to the task of lowering the output gap. In light of these findings, we prescribe to the Svensson (2003) argument that a targeting rule is less rigid than an instruments rule. However, we intend to examine whether the flexible inflation targeting policy enacted by ECCs has played any role in lowering extreme risks associated with the recent financial crisis.

A strong evidence of tail-risks in ECCs would call for a more discretionary approach to monetary policy that is disentangled from its steady course implied by a Taylor rule. We focus our analysis on three types of market risks that affect directly monetary policy decisions: equity market risk, interest rate risk, and exchange rate risk.

III Model Set Up and Data

Monitoring *equity market risk* is an important task for monetary authorities, particularly at times of financial distress. Although volatility of equity market risk is not customarily entered in central bank loss functions or instrument rules, it has far-reaching reverberations in the credit markets, capital flows, financial and tangible investments, and exchange rate movements that all affect the conduct and direction of monetary policies. In fact, it has been documented in the literature that precipitation of equity market risk, proxied by increases in the VIX volatility index in the U.S., had strong spillover effects on credit and liquidity risks during the course of the 2007-2008 financial crisis (Mizen, 2008; Orlowski, 2008b). In essence, equity market volatility dynamics are a good reflection of the investors' confidence in the country's financial stability and resiliency against external financial contagion. For this reason, equity market risk dynamics should serve as an important monitoring devise for monetary policy-makers. The second category of market risk that is crucial for monetary policy decisions is the *interest rate risk*, because proliferation of interest rate risk inhibits effectiveness of monetary policy instrumentalization. In our opinion, a successful implementation of monetary policy during the course of convergence to the euro ought to take into consideration a relative interest rate risk captured by volatility dynamics of short-term interest rates in the candidate country vis-à-vis the volatility of the corresponding interest rate in the eurozone. This treatment allows us to assess a time path of an interest rate risk premium vis-à-vis the eurozone. From this standpoint, we investigate volatility of the euro-candidates' short term interest rates in relation to changes in the eurozone rate. *Exchange rate risk* is the third market risk category that we have chosen to scrutinize. This choice is related to instability of a possible exchange rate target and to unreliability of the exchange rate channel of monetary policy transmission. Needless to say, this channel serves as a focal venue of monetary policy implementation in the economies converging to a common currency. Elevated exchange rate risk at stressful market periods obfuscates asset valuation and the price of credit in the banking sector. It subsequently necessitates higher interest rates and tightened credit conditions. Monetary authorities must be assertive to jumps in the exchange rate volatility as these vicissitudes distort functioning of the exchange rate channel of policy transmission, which has been proven to be unstable in the ECCs (Golinelli/Rovelli, 2005; Orlowski, 2005 and 2008a; Kočenda/Valachy, 2006; Kočenda, et. al 2006). For the purpose of our empirical examination, we devise a simple model testing conditional volatility of exchange rate changes in the ECCs in response to the key determinants of exchange rates, i.e. the uncovered interest parity (UIP), and the purchasing power parity (PPP).

Following these notions, we investigate the developments of risks in the examined ECCs during the past decade, with a special attention to the propagating effects brought forth by the ongoing financial crisis. In order to capture risk dynamics, we examine changes in time-varying conditional volatility of major equity market indexes, relative short-term interest rates, and daily changes in the euro value of local currencies in these countries. We use a sample period beginning January 3, 2000 and ending August 7, 2009, with some adjustments stemming from different inception dates for secondary market trading of long-term government bonds. We employ GARCH(p,q)-M-GED tests (the generalized autoregressive conditional heteroscedasticity with the in-mean variance and generalized error distribution) in order to investigate the conditional volatility dynamics. In particular, we focus on the overall risk premium (or discount) reflected by the positive (or negative) value of the in-mean GARCH variance coefficient (the M-component). We further put emphasis on the degree of leptokurtosis (GED parameter < 2), and on the relative proportion of the shocks or 'news' to volatility reflected by the ARCH(p) coefficients, as well as the persistency in volatility implied by the GARCH(1) coefficient. The use of the GED parameter helps to smoothly transform a non-normal into a normal distribution and to apply the maximum likeloohod test. The time distribution of conditional standard deviations from the GARCH series allows us to examine the sub-periods of risk contraction and proliferation.

Equity market risk

We devise a model of changes in the (log of) local equity market indexes $E_{r|t}$ as a dependent variable in the conditional mean equation (the return process r_t) with changes in (the log of) the German DAX40 index E_t^{DAX40}, and the log of the GARCH variance σ_{t-1}^2 as regressors:

$$\Delta \log E_{t|rt} = \beta_0 + \beta_1 \Delta \log E_t^{DAX40} + \beta_2 \log \sigma_{t-1}^2 + \varepsilon_t \tag{1}$$

The corresponding GARCH(1,1) conditional variance specification is

$$\sigma_t^2 = h_0 + h_1 \varepsilon_{t-1}^2 + \gamma_1 \sigma_{t-1}^2 \tag{2}$$

with the ARCH(1) component denoted by ε_{t-1}^2 and the GARCH(1) by σ_{t-1}^2.

Interest rate risk

We analyze changes in domestic short-term interest rates (three-month interbank lending rates) i_t^{3M} in relation to changes in the three-month Euribor i_t^{*3M} and in the (log) exchange rate s_t. The inclusion of both independent variables allows for testing their possible impact on the key monetary policy variable of the central bank, and explains the room for an independent monetary policy pursuit. The conditional mean specification with the in-mean (log) GARCH variance is

$$\Delta i_{t|rt}^{3M} = \beta_0 + \beta_1 \Delta i_t^{*3M} + \beta_2 \Delta \log s_t + \beta_3 \log \sigma_{t-1}^2 + \varepsilon_t \tag{3}$$

The corresponding GARCH(p,1) conditional variance specification is

$$\sigma_t^2 = h_0 + h_1 \varepsilon_{t-1}^2 + \ldots h_p \varepsilon_{t-p}^2 + \gamma_1 \sigma_{t-1}^2 \tag{4}$$

We use high-order ARCH terms in this case as they were proven to be significant in preliminary testing.

Exchange rate risk

We employ the GARCH-M-GED process ascertaining daily changes in the euro values in local currency s_t as a function of the changes in the differential between short-term interest rates (three-month interbank offer rates) of the euro-candidate i_t^{3M} and the eurozone (Euribor) i_t^{3ME}, and changes in the term spread on ten-year less three-month sovereign bond yields $i_t^{10y} - i_t^{3M}$ as a proxy of inflation expectations. We also include changes in the local equity market index E_t as a regressor in the conditional mean equation, in order to reflect the impact of equity capital flows on exchange rates. The conditional mean equation is represented by

$$\Delta \log(s)_{t|rt} = \beta_0 + \beta_1 \Delta\left(i_t^{10Y} - i_t^{3M}\right) + \beta_2 \Delta\left(i_t^{3M} - i_t^{3ME}\right) + \beta_3 \Delta E_t + \log \sigma_{t-1}^2 + \varepsilon_t \quad (5)$$

The corresponding GARCH (p,q) conditional variance equation is

$$\sigma_t^2 = h_0 + h_1 \varepsilon_{t-1}^2 + h_2 \varepsilon_{t-2}^2 + \ldots + h_p \varepsilon_{t-p}^2 + \gamma_1 \sigma_{t-1}^2 + \gamma_2 \sigma_{t-2}^2 + \ldots + \gamma_q \sigma_{t-q}^2 \quad (6)$$

As in the previous cases, the ARCH(p) terms $h_p \varepsilon_{t-p}^2$ represent the impact of 'news' or shocks to volatility, and the GARCH(q) terms $\gamma_q \sigma_{t-q}^2$ reflect the role of persistency in volatility[3].

IV Estimation Results

Equity market risk developments

The results of the GARCH-M-GED estimation (Eqs. 1 and 2) of changes in ECCs equity market indexes relative to changes in the German DAX40 are shown in Table 1. Changes in the German stock market index drive up ECC market indexes in the same direction, but at a varied degree of significance. The most significant relationship for both indexes is detected for Hungarian and Slovak markets; the Polish and Czech markets show a less significant dependence on the German market movement, and the reaction of the Romanian market is insignificant. There is a negative risk premium on the Czech and Polish equity markets, as implied by the negative sign of log(GARCH) terms in the conditional mean equation. In contrast, the risk premium on the Romanian market is significantly positive. The risk premia results for Hungary and Slovakia are inconclusive.

As it is a common factor characterizing volatility of global equity markets, volatility of the Czech, Polish and Hungarian markets is highly persistent, as implied by GARCH coefficients in the conditional variance equations being close to unity. Correspondingly, the ARCH-type shocks to volatility in these three markets play a relatively minor role. The Romanian market conditional volatility series displays very different characteristics with a stronger role of ARCH terms and a lower degree of GARCH persistency. Arguably, the Romanian market is the most susceptible to unexpected shocks to volatility within the analyzed group of equity markets. More importantly from the standpoint of our analytical objectives, the estimated GED parameters in all five equity

3 In the preliminary testing, we have attempted to augment the conditional volatility series (Eqs. 2,4 and 6) with an EU accession dummy variable assuming the value of one for the period following the accession and zero before, in order to ascertain the impact of the EU membership on risk developments in the investigated series. This variable has proven to be insignificant in all examined cases suggesting that the EU accession has not decisively contributed to the financial stability in ECCs.

markets are significantly lower than 2, indicating considerable leptokurtosis, i.e. pronounced tail risks. Evidently, volatility in these markets tends to escalate considerably during turbulent market periods, while it remains subdued at times of normal market risk. Another interesting focal point is the sum of ARCH and GARCH coefficients. It is very close to unity in the cases of the Czech, Polish, Hungarian and Romanian markets, which suggests no visible gains in volatility convergence. The sum is significantly lower than the unity for the Slovak market, implying an overall reduction in volatility, thus a significant decline in market risk in this new member of the eurozone.

Table 1:
Changes in (the log of) equity market indexes vis-à-vis the changes in (the log of) the German DAX40 index
GARCH-M-GED estimation – Eqs.(1) and (2). Daily series; sample period Jan 3, 2000 – Aug 7, 2009.

Variables⇓	**Czech Republic**	**Poland**	**Hungary**	**Romania**	**Slovakia**
Conditional mean equation (coefficient x 100)					
Constant term	-6.633*	-1.092**	1.972	6.263**	0.052***
German DAX40 index	9.306*	1.493*	17.998***	8.407	3.541***
Log(GARCH)	-0.084**	-1.304***	0.018	0.065**	0.005
Conditional variance equation					
Constant	0.001***	0.001**	0.001***	0.001***	0.001***
ARCH(1)	0.118***	0.052***	0.089 ***	0.334***	0.094***
GARCH(1)	0.868***	0.942***	0.887***	0.655***	0.654***
GED parameter	1.387***	1.356***	1.418***	1.045***	0.568***
Diagnostic statistics					
Log Likelihood	7,432.9	6905.5	7,114.0	7,094.3	8,595.1
AIC	-5.936	-5.514	-5.681	-5.665	-6.859
SIC	-5.919	-5.498	-5.665	-5.650	-6.843
Durbin-Watson stat.	1.86	1.93	1.89	1.70	1.99

Notes: all variables are in first differences; t-statistics are in parentheses; AIC = Akaike information criterion; SIC = Schwartz information criterion; stock market indexes are Prague SE PX, Warsaw WIG20, Budapest BUX, Bucharest BET(L), Bratislava SXSAX16; *** denotes significance at 1%, ** at 5% and * at 10%.

Source: authors' own estimation based on Datastream.

The time-path of conditional volatilities for the Czech, Polish, Hungarian, Slovak and Romanian stock market indexes is shown in Figures 1a-e (see Appendix). In all five cases, the market risk surged during the peak of the global financial crisis. The largest volatility upswings in the GARCH series took place during the period between October 10 and mid-November of 2008 (observations range 2298-2330). All five stock markets took an unprecedented hit on October 10, in the aftermath of the Lehman collapse, which triggered the subsequent systemic risk epitomized by the standstill in international credit markets, coupled with the risk aversion of international investors that contributed to a withdrawal of capital from emerging markets. The October 10th market plunge was followed by a series of up-and-down swings of the ECCs' equity markets, and the elevated volatility did not recede to its pre-crisis pattern until July/August of 2009. The analysis of volatility dynamics with respect to the pre- and the post-EU accession periods is also revealing. The GARCH residuals seem to gradually receding during the pre-accession periods in all five markets, but there is no discernible containment of volatility since the respective EU accessions. It can be therefore argued that the EU membership has not engendered stability in equity markets of the ECCs. Moreover, the stock market volatility in Slovakia has increased considerably even after its euro adoption in January 2009. The Slovak case seems to suggest that entering the common currency system does not insulate a local stock market from large external shocks, at least at times of global market vicissitudes. These developments related to the EU accession and the euro adoption should be of concern for monetary authorities, since these moves do not automatically entail gains in financial stability.

It can be generally concluded that equity markets in the ECCs remain highly vulnerable to exogenous systemic shocks, due to significant leptokurtosis, or tail-risks embedded in their volatility dynamics series. The likelihood of disruptive spillover effects of the elevated equity market risk at times of financial distress into domestic credit, investment and economic growth remains very high.

Interest Rate Risk

The results of the empirical estimation of Eqs. (3) and (4) are shown in Table 2. From the perspective of our analytical objectives, the most striking outcome is the extreme leptokurtosis of the interbank rates volatility series in all five cases in comparison with the equity market series. The estimated GED parameters for the ECC interbank markets are all very low indicating prevalence of strong tail risks. This finding highlights our claim that short-term interest rates of the euro-candidates are likely to jump significantly at times of financial distress, underscoring exceptional vulnerability of their banking sectors during such periods. In addition, there is a significant risk discount in the cases of the Romanian and Slovak rates as implied by the negative log(GARCH) coefficients in the conditional mean equations. These reactions are likely related to changes in inter-bank borrowings from local versus eurozone banks. This negative path is likely related to the very high initial risk premiums in these two countries. At the same time, there is a tiny interest rate risk discount detected in the cases of the Czech, Polish and Hungarian interbank rate series. The conditional volatility series of interbank rates is highly persistent in the cases of Polish and Hungarian interbank markets, as signified by high values of GARCH coefficients. Interbank rates remain vulnerable to the ARCH-type shocks with non-uniform diffusion in the cases of the Czech, Polish and Hungarian rates.

Table 2:
Changes in three-months market interest rates vis-à-vis the changes in Euribor-3-months rates and the log of the exchange rate against the euro
GARCH-M-GED estimation – Eqs.(3) and (4). Daily series; sample period Jan 3, 2000 – Aug 7, 2009.

Variables⇓	**Czech Republic**	**Poland**	**Hungary**	**Romania**	**Slovakia**
Conditional mean equation (coefficient x 100)					
Constant term	-0.124***	-0.000***	0.000***	-38.801***	-28.041***
EURIBOR3M	0.000	0.000	0.000***	0.000***	-0.000
Log(Exchange rate)	0.000	0.000	-0.000	0.017***	0.000
Log(GARCH)	-0.000***	-0.000***	-0.000***	-11.468***	-3.972***
Conditional variance equation					
Constant	0.000***	0.006***	0.000***	0.002***	0.000***
ARCH(1)	0.537***	2.314***	0.780***	0.006***	0.012***
ARCH(2)	-0.280***	-1.309**	-0.480***	-0.002***	-0.008***
ARCH(3)	---	---	-0.179***	---	0.000***
GARCH(1)	0.520	0.789***	0.876***	0.412***	0.652***
GED parameter	0.266***	0.234***	0.155***	0.174***	0.380***
Diagnostic statistics					
Log Likelihood	10634.12	4301.81	7779.824	5502.916	5832.546
AIC	-8.490	-3.430	-6.208	-4.390	-4.962
SIC	-8.469	-3.409	-6.185	-4.369	-4.937
Durbin-Watson stat.	2.020	2.314	1.852	1.107	1.670

Notes: all variables are in first differences; t-statistics are in parentheses; AIC = Akaike information criterion; SIC = Schwartz information criterion; *** denotes significance at 1%, ** at 5% and * at 10%.

Source: authors' own estimation based on Datastream.

The graphical displays (Figures 2a-e in the Appendix) of the GARCH conditional standard deviation series show huge jumps in interest rate volatility coinciding in the cases of the Czech Republic, Hungary and Romania with the October 10, 2008 turbulence in global financial markets, with the notable exception of Poland.

In all, relative interest rate volatility or interest rate risk premiums in the examined ECCs remain very high. It also remains to be elevated in Slovakia, in spite of its new membership of the eurozone. This makes ECCs financial systems susceptible to large interest rate shocks and contagion effects at time of financial distress. Under such circumstances, a strict adherence of monetary policy implementation to interest rate rules seems both implausible and counter-productive for creating a foundation financial stability.

Exchange rate risks

The estimation results of the exchange rate volatility series specified by Eqs. (5) and (6) are shown in Table 3. The estimated model is multivariate and more elaborate than the equity market and the interbank rate series due to the overall statistical significance of the regressors included in the conditional mean equation.

We find that changes in the euro values in the ECCs' local currencies are highly sensitive to changes in local stock market indexes, with the notable exception of Slovakia, as implied by the negative signs of the equity market index coefficients suggesting that capital inflows to domestic equity markets correspond with the local currency appreciation (euro depreciation). This result highlights a strong role of foreign capital inflows in local market gyrations. A wider term spread on sovereign bond yields (10Y less 3M bond yields) corresponds with the depreciation of the Polish Zloty (PLN), the Czech Koruna (CZK), the Hungarian Forint (HUF) the Slovak Koruna (SKK), but not the Romanian Lei (RON). In the first four cases, the wider term spread translates into currency depreciation thus satisfying PPP conditions, as it very likely reflects rising long-term inflation expectations. The interest rate differential captured by the widening spread between local inter-bank offer rates and Euribor is associated with the depreciation of CZK, PLN and HUF, contrary to the UIP assumptions, since local banks are likely to increase borrowings in the local currency when it is expected to depreciate. Romania is again a notable exception. We do not detect a risk premium or discount on local currencies in any of the examined cases, as it is implied by insignificant log(GARCH) in the mean equations [4].

4 See *Kočenda/Poghosyan* (2009) for a more detailed examination of macroeconomic determinants of the exchange rate risk in the new EU Member States. Using the stochastic discount factor and GARCH-M modeling, they provide evidence that both nominal and real economic variables play important role in the determination of exchange rate risk in these countries.

Table 3:
Changes in (the log) exchange rates vis-à-vis the euro as a function of changes in: the term spread on sovereign bond yields, the 3M interest rate differential and the stock market index.
GARCH-M-GED estimation – Eqs.(5) and (6). Daily series; sample period Jan 3, 2000 – Aug 7, 2009 (Apr 1, 2005 – Aug 7, 2009 for Romania; Jan 3, 2003 – Dec 31, 2008 for Slovakia).

Variables⇓	**Czech Republic**	**Poland**	**Hungary**	**Romania**	**Slovakia**
Conditional mean equation (coefficient x 100)					
Constant term	-0.002	0.346*	-0.164*	0.191*	-0.000
Term spread	0.317**	1.232***	1.990***	-0.056**	0.044
Interest rate differential	0.293	1.218***	2.124***	-0.290***	0.037
	-1.483***	-5.277***	-2.592***	-4.055***	0.031
Stock market index	-0.002	0.034*	0.014*	0.018*	-0.000
Log(GARCH)					
Conditional variance equation					
Constant	0.000**	0.000**	0.000***	0.000**	0.000**
ARCH(1)	0.204***	0.154***	0.286***	0.339***	0.167***
ARCH(2)	-0.177***	-0.102***	-0.078	-0.263***	---
ARCH(3)	---	---	-0.097**	---	---
GARCH(1)	0.969***	0.941***	0.891***	0.924***	0.861***
GED parameter	1.050***	1.280***	0.995***	0.939***	0.842***
Diagnostic statistics					
Log Likelihood	9,442.985	8,381.908	9,106.733	4,590.746	9,574.790
AIC	-8.487	-7.539	-8.191	-8.261	-9.189
SIC	-8.461	-7.513	-8.162	-8.216	-9.165
Durbin-Watson stat.	2.125	2.256	2.232	1.913	1.990

Notes: all variables are in first differences; AIC = Akaike information criterion; SIC = Schwartz information criterion; a minus one-day lag is applied to the Czech 3M Pribor vis-à-vis 3M Euribor; term spread reflects 10Y less 3M sovereign bond yields; short-term interest rates are: 3M Pribor, 3M Wibor, 3M Bubor, RMIBK3M, 3M Skibor, 3M Euribor; stock market indexes are Prague SE PX, Warsaw WIG20, Budapest BUX, Bucharest BET(L), Bratislava SXSAX16; *** denotes significance at 1%, ** at 5% and * at 10%.

Source: authors' own estimation based on Datastream and Eurostat data.

The conditional volatility of the analyzed series is highly persistent in all five ECCs, as implied by GARCH(1) coefficients all being close to unity. The most significant ARCH shocks to volatility are detected in the case of RON, followed by the HUF, CZK and

PLN series. Certainly the most crucial finding of the conducted tests is the very high degree of leptokurtosis in the exchange rate series in all five cases, as implied by the estimated GED parameters significantly lower than 2. However, the extreme risk in the case of the exchange rate volatility series is considerably less pronounced than the one detected for the interbank rates series.

Further insights to the time-varying path of exchange rate volatility are provided by GARCH standard deviations shown in Figures 3a-e (Appendix). During the post-EU accession periods, the conditional exchange rate volatility has remained subdued in the cases of the Czech Republic, Poland and Hungary, but clearly not in Romania. It is worth noting that there have been several pronounced volatility jumps in Slovakia during this period. However, the country's euro adoption in January 2009 has evidently helped mitigate exchange rate risk in the preceding turbulent months, which has not been the case in the remaining four countries. The exchange rate risk of the euro-candidates has remained elevated considerably in the aftermath of the October 10, 2008 peak of the global financial crisis, with some signs of returning to more normal pre-crisis conditions taking place only in mid-2009.

In essence, the 2007-2009 global financial crisis has impaired the process of gaining exchange rate stability in the analyzed ECCs, with the notable exception of Slovakia, whose actual euro adoption has helped cushion the transmission of global financial shocks. One may thus argue that the real prospects of adopting the euro, including the actual entry to the ERM2, may reduce exchange rate risk in these countries, thus also lead to a more effective absorption of external shocks.

V Conclusion: Monetary Policy Reconsidered

The main argument of our study is that monetary policies in the ECCs need to take into consideration a task of mitigating market risks and, in particular, tail-risks embedded in the key monetary policy target and instrument variables. But in order to fulfill this task, ECCs monetary policies ought to be rather unorthodox and seemingly more complex than those based on simple Taylor rules.

In principle, we prescribe to the perceived dichotomy between monetary policy and financial-stability policy identified among others by Borio and White (2003) and Svensson (2010), however, with some reservations. If there was an absolute dichotomy between both policies, monetary policy could follow a pre-determined rule at all times and financial-stability policy based on macroprudential regulation would be aimed at countering asset-price bubbles and unexpected volatility episodes in the time-series of financial variables. However, we believe that monetary policy should counteract the shocks that are not transitory and can permanently imperil financial stability (aggravate systemic risk) by levying high risk premium on interest rates.

Along this line of reasoning, we do not advocate policies based on "leaning against the wind" prescribed among others by Borio and White (2003) that call for levying some premium on interest rates aimed at countering proliferation of asset bubbles. In our opinion, such premium would entail undesired welfare costs and induce a signal effect of expected bubbles that would ultimately trigger speculative currency attacks.

Prudent monetary policies responding to possible occurrence of extreme risks ought to be counter-cyclical and relatively flexible. Extreme risks can be at least partially mitigated by forward-looking policies based on smoothed forecasts. As suggested by our empirical findings, the episodes of extreme risks - particularly prevalent in the interbank credit markets - have seriously distorted forecasts of key monetary policy variables. The recent financial crisis has made these forecasts increasingly unreliable and inaccurate. Our paper suggests that this distortion stems for the failure to account for leptokurtosis in the forecasting models. We have attempted to fix this problem by augmenting our GARCH volatility tests with GED parameterization.

Our empirical investigation of the equity market-, interest rate-, and exchange rate risks implies that tail risks are significant in the five examined ECCs and their conditional volatility series distribution is leptokurtic (thick-tailed). It can be thus argued that volatility of these variables is likely to be subdued at normal periods, but it tends to explode during turbulent times. It was certainly the case during the period following the October 2008 peak of the current global financial crisis. This result puts severe challenges to the loss and reaction functions of the central banks in ECCs. Forecasting becomes increasingly inaccurate, which leads to a discretionary rather than a rule-based monetary policy. Disturbances are likely to take place in the future if the ECCs monetary authorities do not address adequately tail risks through a broad range of macro-prudential policies and emergency measures, such as sterilized interventions, emergency liquidity injections, currency swap lines, special lending facilities for banks, etc. Possible episodes of risk explosions could be destabilizing to the financial systems and disruptive to the process of effective convergence to the euro.

On a final note, we agree with the "Geneva Report" (Brunnermeier, et. al, 2009) suggestion that macroprudential policies should be counter-cyclical and leaning against the bubbles whose potential implosion could impair financial system stability. However, in the case of ECCs, the extreme risks of financial variables arise from asset-price bubbles generated not only by domestic factors, but were also transmitted through external contagion effects. Due to the absorption of external shocks, international coordination of these policies is crucial, particularly for the ECCs as a group of economies pursuing the joint task of adopting the euro in the not-so-distant future.

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Appendix: Figures

Figures 1a-e: GARCH Conditional Standard Deviation for Equity Market Index Series vis-à-vis German DAX40

Figure 1a: The Czech Republic: Prague SE PX Index

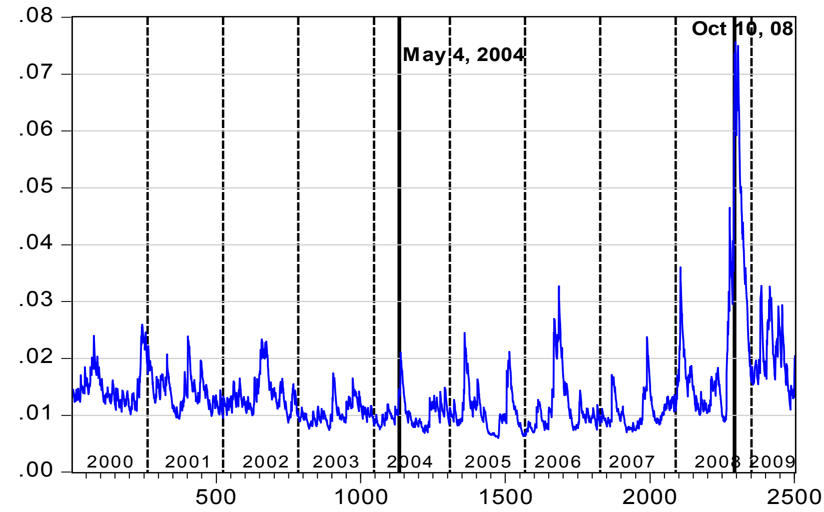


Figure 1b: Poland: Warsaw WIG20 Index

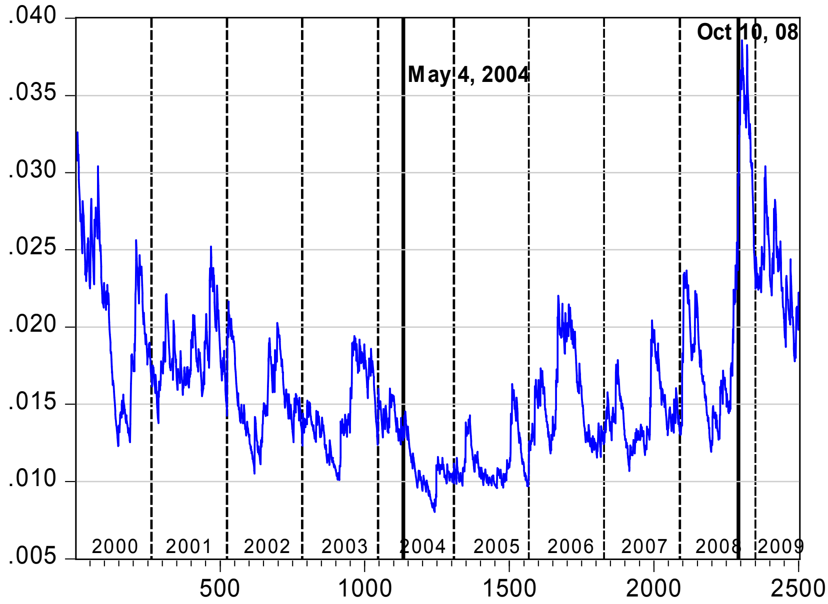


Figure 1c: Hungary: Budapest BUX Index.

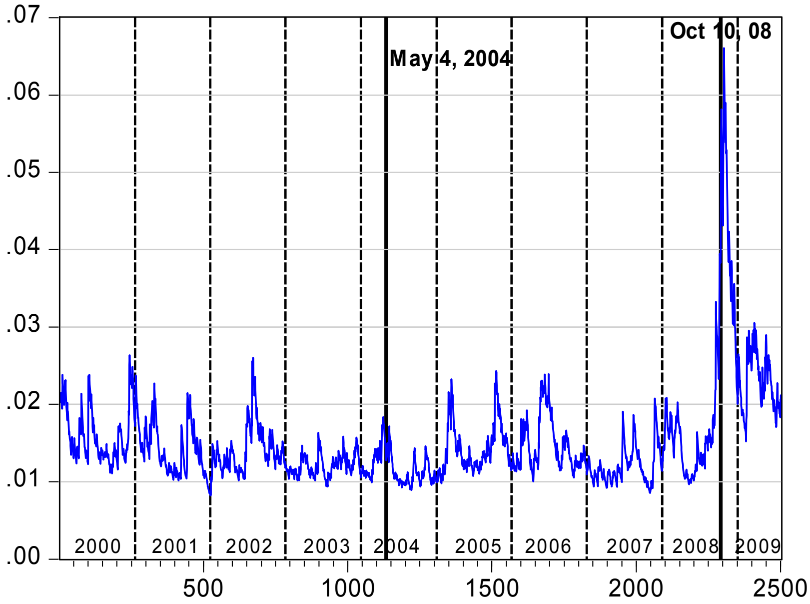


Figure 1d: Romania: Bucharest BET(L) Index.

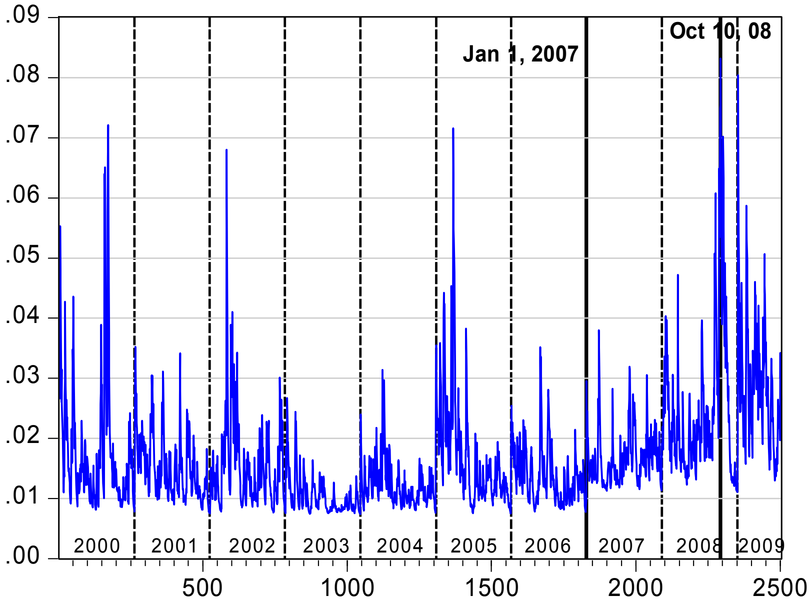
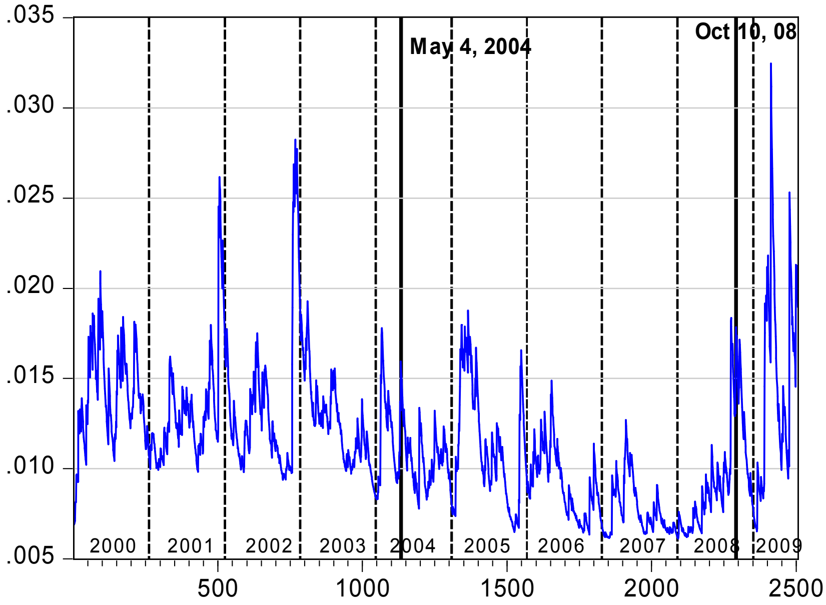


Figure 1e: Slovakia: Bratislava SXSAX16 Index



Source: Own estimations based on Datastream data.

Figures 2a-e: GARCH(p,q)-M-GED conditional standard deviations of daily changes in local 3M interbank rates in relation to changes in 3M euribor and the exchange rate, Eqs. (3) and (4).
January 3, 2000 – August 7, 2009 daily series.

Figure 2a: Czech interbank rates, GARCH(2,1)-M-GED specification

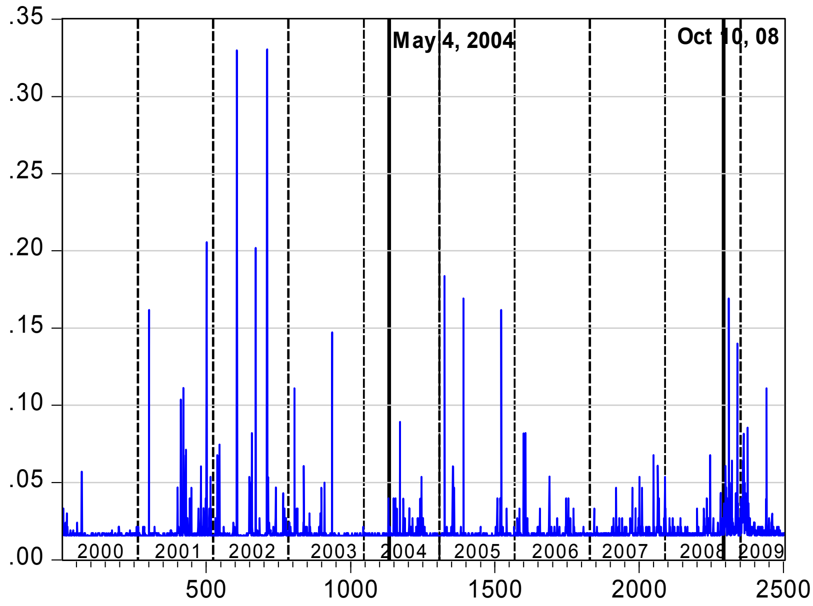
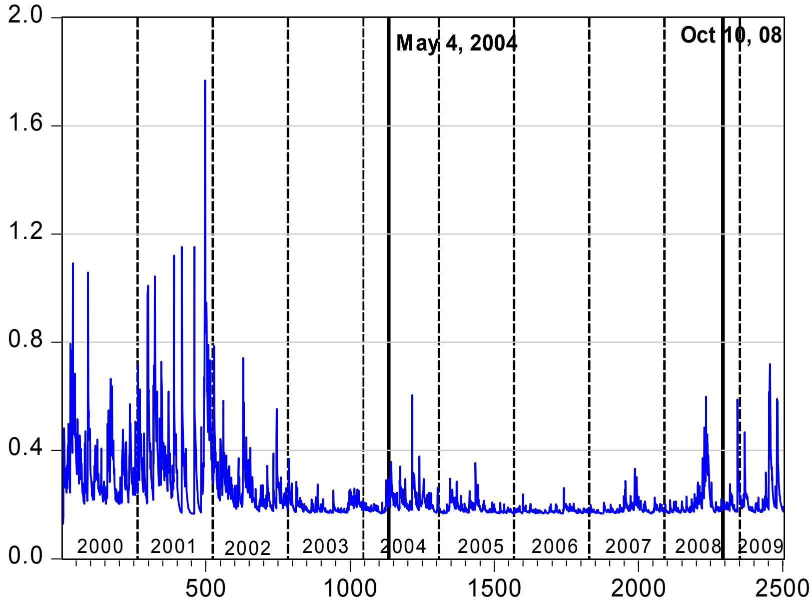


Figure 2b: Poland's interbank rates GARCH(2,1)-M-GED specification



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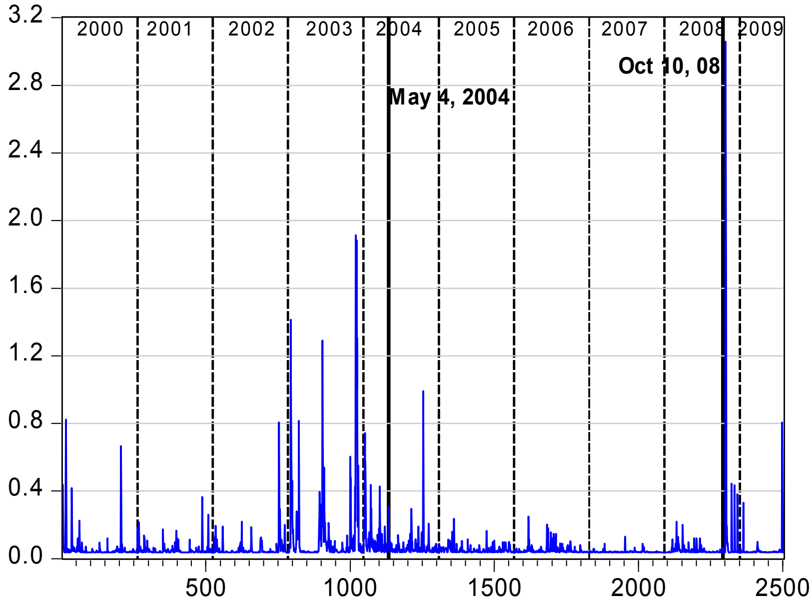


Figure 2d: Romania's interbank rates GARCH(2,1)-M-GED specification

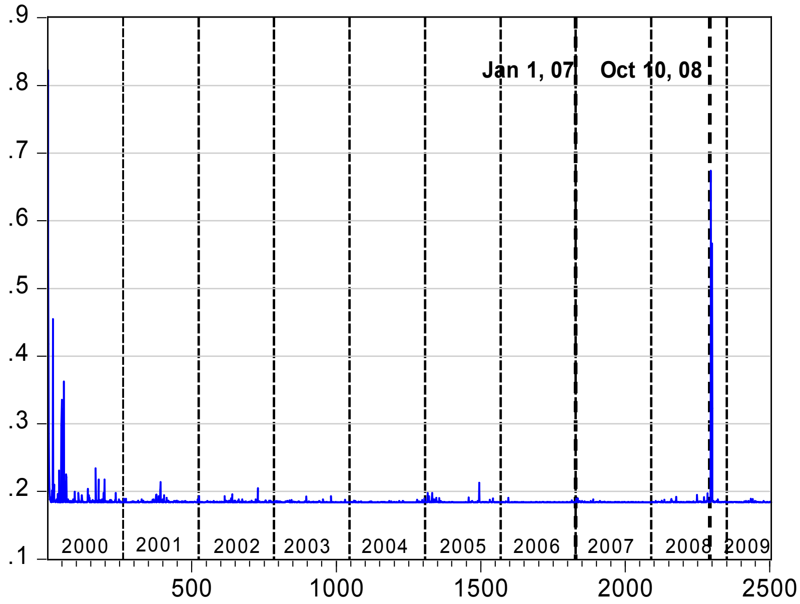
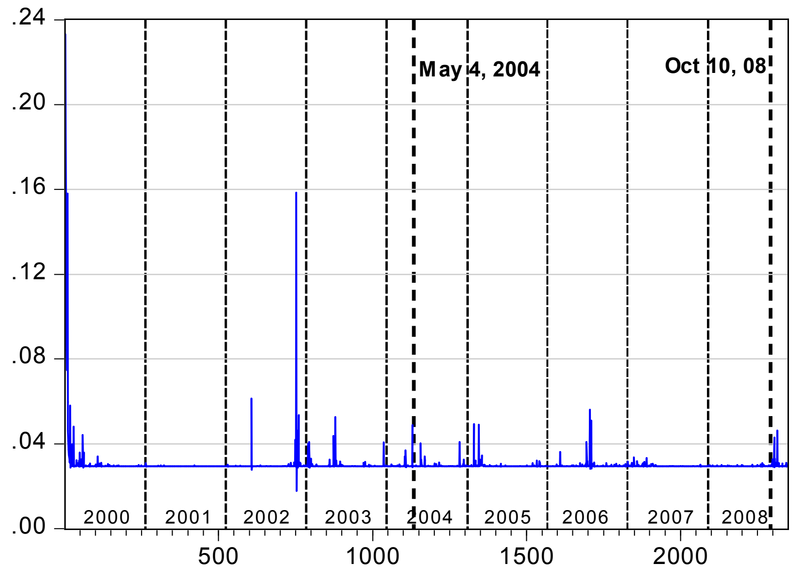


Figure 2e: Slovakia's interbank rates GARCH(3,1)-M-GED specification



Source: authors' own estimation based on Datastream data.

Figures 3a-e: GARCH conditional standard deviations generated from estimations of Eqs.(5) and (6) reported in Table 3. January 3, 2000 – August 7, 2009 daily series.
Figure 3a: The Czech Republic

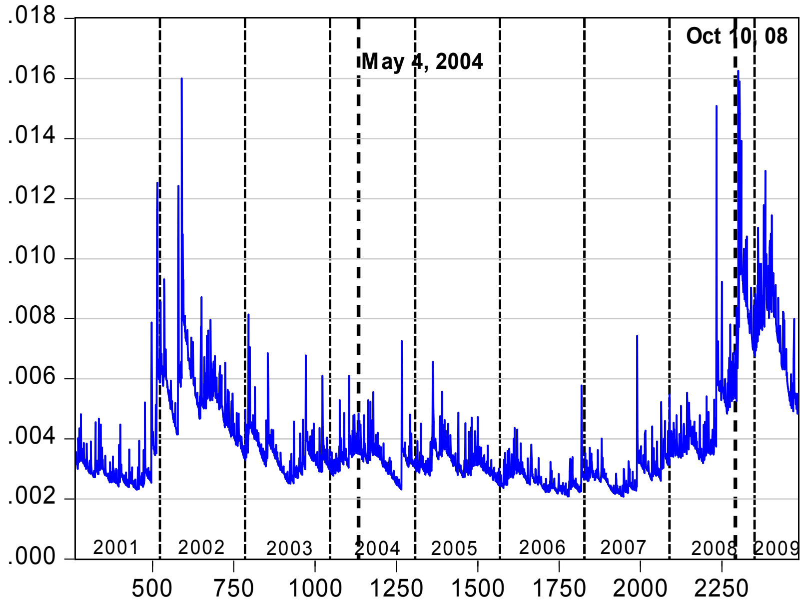


Figure 3b: Poland

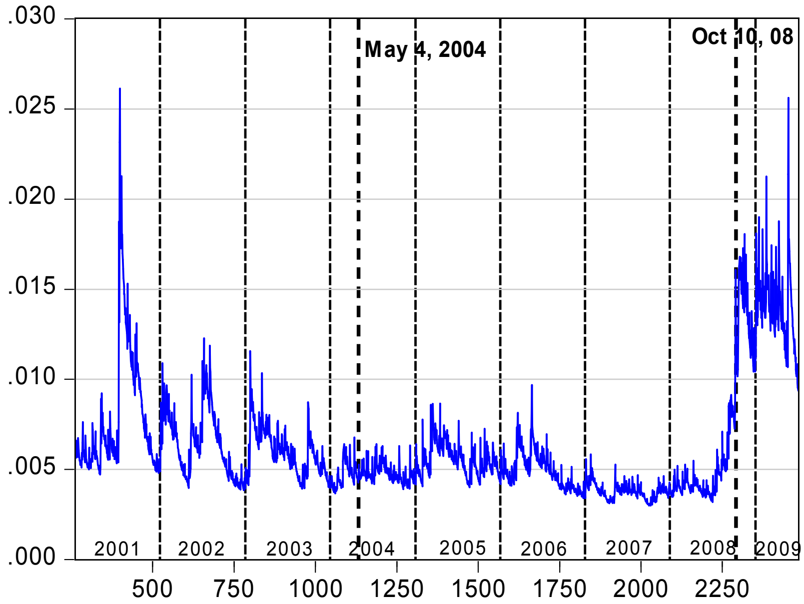


Figure 3c: Hungary

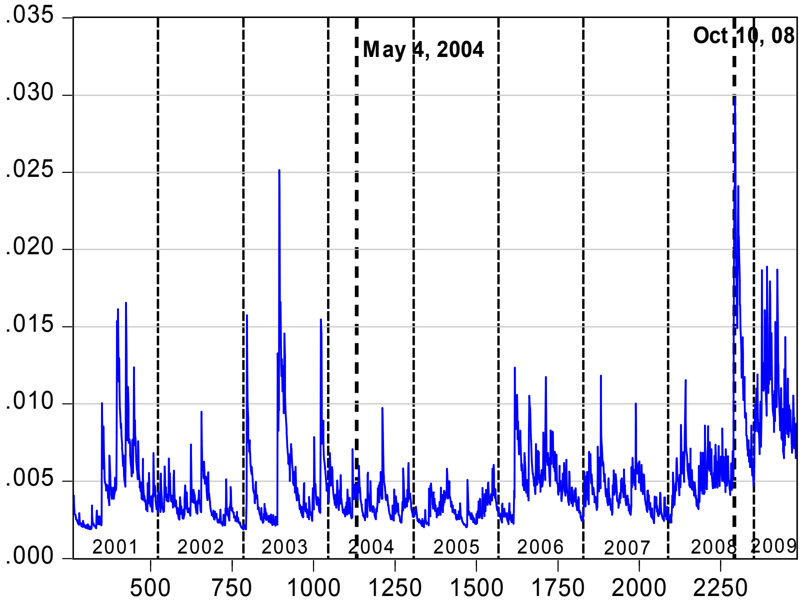


Figure 3d: Romania (April 1, 2005 - August 7, 2009 daily series).

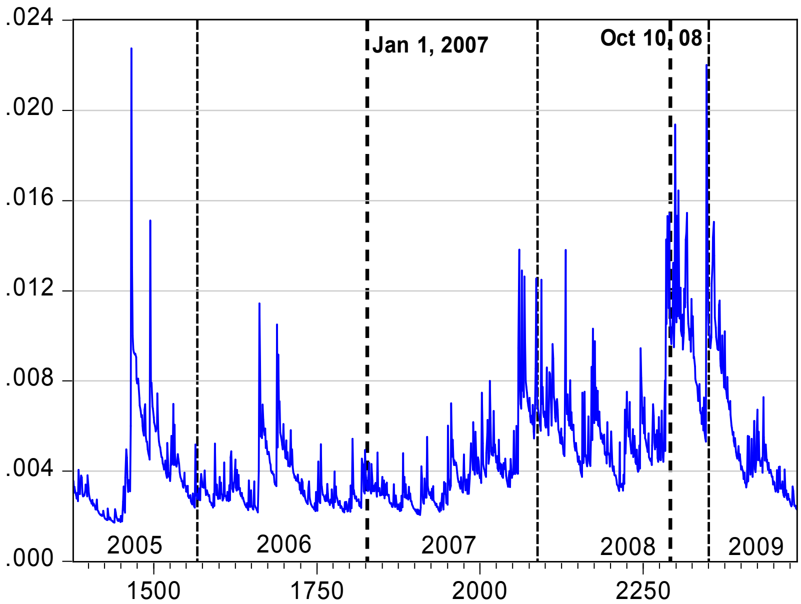
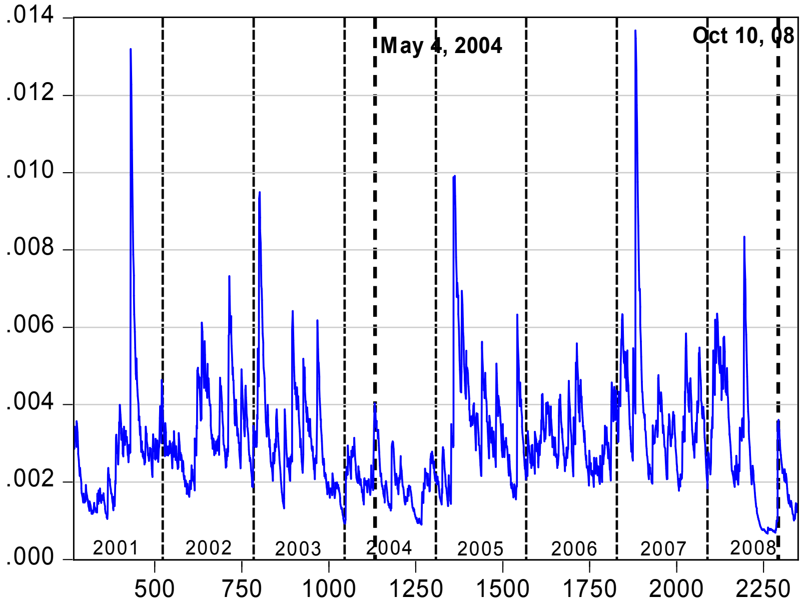


Figure 3e: Slovakia (January 3, 2003 – December 31, 2008 series)



Source: authors' own estimation based on Datastream and Eurostat data.