Bond Yield Compression in the Countries Converging to the Euro

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Abstract:

This paper investigates the behavior of local currency government bond yields in Poland, Hungary and the Czech Republic, relative to changes in the eurozone bond market, for the purpose of evaluating their monetary convergence to the euro. Our testing of monthly series of macroeconomic fundamentals shows pronounced yield sensitivity of sovereign yields to changes in German yields. In addition, the TGARCH-M-GED tests of daily volatility dynamics of local yields as a function of German yields, conditional on changes in local term spreads, exchange rates and adjustments to central bank reference rates reinforce our point that German yields are significant drivers of local currency government bond yields. Based on the evidence of yield compression in the analyzed countries, we conclude that they are ready to adopt the euro without risking a disruptive shock to their financial stability.

JEL classification: E43, E44, F36

Keywords: bond yield compression, term spread, monetary convergence, new EU Member States, conditional volatility, GARCH

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I. Introduction

This paper investigates the behavior of local currency government bond yields in the three largest new Member States (NMS) of the European Union, i.e. Poland, Hungary and the Czech Republic in relation to changes in the euro area bond yields. Our aim is to ascertain whether bond yield compression is taking place in the countries aspiring to adopt the euro and, on this basis, to assess their monetary convergence. The alignment of long-term bond markets of the countries converging to the euro with that of the EU is a requirement placed among the five Maastricht convergence criteria. Specifically, the fourth criterion stipulates that the long-term interest rates of a converging country do not exceed by more than two percent the average rate of the three EU Member States experiencing the lowest inflation rates.[1]

Our goal is to focus specifically on the influence of the euro area bond yields on the local currency government bonds rather than to analyze the entire spectrum of bond yield determinants in NMS. Our contribution to the emerging literature on bond yields in NMS, which is overviewed in Section II, is that we develop a formal analytical model for the purpose of evaluating the monetary convergence from the standpoint of bond yield compression. In this respect, our paper advances beyond the studies addressing bond yields in NMS.

To determine whether and to what extent the euro area bond yields drive changes in local currency NMS bond yields, we analyze their functional relationship to German yields conditional on changes in key macroeconomic fundamentals, based on the monthly data series. In addition, we account for short-term shocks to volatility. Our analysis of conditional volatility dynamics is based on time-varying daily changes in local currency bond yields as a function of (1) convergence expectations built into local term spreads (2) the ten-year German bond yield (viewed as a representative benchmark for the euro area long-term interest rates) and (3) changes in local currency values of the euro. We employ the TGARCH-M-GED process, which is a combination of threshold GARCH (TGARCH)

[1] See ECB (2003a) for the prescribed specific measurement procedure of long-term interest rates based on the recommended 10-year maturity of government securities.

and the 'in-mean' extension (GARCH-M), estimated with GED residuals. In analyzing monthly data series, which are relatively short, we rely on the OLS estimation. Since the local currency long-term government bond markets did not exist in the three NMS prior to 1999, our data series begin as of early 2000, following their inception. [2]

The paper is organized as follows. Section II draws on related literature to provide theoretical underpinnings for our analytical model that is presented in Section III. The role of German bond yields as drivers of local currency yields in NMS is examined in Section IV on the basis of macroeconomic fundamentals. The conditional volatility dynamics analysis is presented in Section V. Section VI encapsulates the main results and includes policy implications.

II. Literature Overview

This section provides a review of selected literature as it relates to bond yield convergence within the framework of integrated financial markets. The sources of bond yield convergence can be traced to domestic, regional as well as global economic trends and policies. On the global scale, the widespread reduction of capital controls, financial innovations, advances in information technology, and resulting lower transaction costs are widely cited as factors contributing to interest rates convergence.[3] Regional integration efforts have triggered convergence of bond yields as well, particularly the formation and the anticipated enlargement of the European Monetary Union (EMU). For the euro candidates, expectations related to prospects of future accession to the euro and official programs of monetary convergence play a critical role in dampening long-term bond yields. The increased demand for emerging market debt is also a contributing factor. Yet,

[2] Ten-year government bond was introduced for the first time in Hungary on January 20, 1999, in Poland on May 21, 1999 and in the Czech Republic on May 22, 2000.

[3] For instance, Grimes (1994) finds that New Zealand's bond yields are significantly driven by foreign yields, in addition to domestic short-term interest rates and the ratio of foreign debt to GDP. Eckhold (1998) reaffirms robustness of Grimes' findings but, in the spirit of Uncovered Interest Rate Parity, adds currency expectations to the list of key drivers of local bond yields.

a disciplined domestic fiscal policy that reduces the government borrowing needs and thus the public debt expansion plays the most pivotal role in driving the yield compression.

A major factor contributing to yield compression stems from increased financial market integration brought on by the introduction of a single currency. The ECB (2003b) points to a significant convergence in the long-term government bond yields in the countries that subsequently adopted the euro in January 1999. This convergence was driven by expectations of the euro adoption and by the consequent elimination of the exchange rate risk.

Nevertheless, there seems to be a consensus in the literature pertaining to the EMU that the introduction of a single currency alone does not result in a full convergence of bond yields and that harmonization of disciplined national macroeconomic policies plays a significant role. As shown by Bernoth *et al*. (2004), the debt and deficit indicators, primarily the debt-service ratio explain the pronounced disparity in long-term interest rate risk premia among the EU Member States. In essence, the differences in the individual member countries' budgetary positions and the remaining high debt levels inhibit full convergence of interest rate risk premia. Moreover, the fiscal stance translates directly into the default risk premium as it is reflected in the government credit rating. This argument is confirmed by Gjersem (2003) who, besides recognizing the importance of eliminating exchange rate risk, attributes yield convergence to the existence of fiscal policy rules and their monitoring, which ultimately leads to the convergence of credit ratings to the highest level. In the euro are, the improved fiscal discipline resulted in the convergence of bond yields to historical lows in the period preceding the euro inception. He attributes the remaining spreads on treasury issues within the euro area to the differences in governments' credit ratings, liquidity as well as the issuance techniques among the independent issuing agents. Danthine *et al*. (2001) also point out to the prolonged segmentation of the government bond market across the euro area, which generates liquidity risk in the smaller markets and results in the difference in yields between similar government issues. Hartmann *et al*. (2003) concur that the euro-area bond market is still segmented, since the pricing of government bonds with identical credit rating has not fully converged. However, Codogno *et al*. (2003) downplay the role of liquidity and issuance uniformity in perseverance of yield differentials. They provide evidence that further fiscal convergence, specifically in debt-to-GDP ratios, is indispensable for reducing yield differentials in the euro area.[4] Pagano and von Thadden (2004) confirm that sovereign bonds are still not perfect substitutes although yields have converged significantly in the transition to EMU. The remaining small and variable yield differentials reflect small disparities in fundamental risk.

The importance of fiscal and monetary policy harmonization for containing interest rate risk premia in a country converging to a common currency system has found strong support in a number of studies analyzing government bond markets in the euro area. Among others, Côté and Graham (2004) find evidence that following the adoption of the Maastricht Treaty currency risk premia declined gradually and were essentially eliminated by the time the euro was launched in January 1999. Their empirical evidence demonstrates that prior to the inception of the euro national bond yields in the EMU countries had converged to yields of Germany, the EMU largest economy. They conclude that progress in macroeconomic policy harmonization was the prevalent contributing factor to convergence of long-term bond yields by driving the convergence of their long-run determinants. According to their study, the introduction of a common currency had a secondary effect. Thus they confirm the previous findings that convergence of national long-term yields results predominantly from the coordination of disciplined fiscal and monetary policies in the context of integrated financial markets.

In sum, on the basis of the single European currency experience we can agree that the interplay of two key factors can significantly advance bond yield convergence, namely (1) the formation of a common currency system or an anticipated entry to such a system and (2) the harmonization of national macroeconomic policies. Nevertheless, it is worthy noting that these two factors alone can not drive convergence to zero differentials for there are other aspects underlying the remaining yield spreads that need to converge as well, such as technical and regulatory ramifications of bond issuance across integrated financial markets.

[4] Their view contrasts with the common belief of markets and policymakers that traditional liquidity indicators, such as bid-ask spreads, trading volumes, and outstanding amounts, as well as the presence of liquid future contracts explain a substantial part of yield differentials since the EMU inception.

While the literature on the determinants of bond yields in the EMU countries is quite extensive, the investigation of yield convergence and the empirical evidence on yield compression in NMS have been seemingly scant. It is perhaps due to the relatively short historical record of long-term government debt markets in these countries. The preliminary findings on yield compression in NMS seem to be inconclusive. The International Monetary Fund (2003) has conducted tests based on data series ending as of mid-2003 that show that German yields were not significant drivers of local currency bond yields in the converging NMS countries[5]. The obtained results suggest that, as of that time, convergence was far from complete and that financial markets in NMS remained excessively vulnerable to domestic policy shocks. Similar results are reported by Holtemöller (2003) who shows that interest rate risk premia in the Czech Republic, Poland and Hungary over the corresponding euro area rates are still too excessive to conclude that convergence has been successful. He demonstrates that spreads of local over the euro area rates are non-stationary for Hungary and Poland, while stationary for the Czech Republic. In a similar vein, Kim *et al*. (2004) show weak and not advancing linkages between the Czech, Hungarian and Polish bond markets and the German market during the 1998-2003 period, in contrast to the strong linkages between the individual EU and the German markets. In a more optimistic view, Orbán and Szapáry (2004) show that yield compression in the three examined NMS already took place as of January 2004 (which means prior to these countries EU accession) since their spreads over the euro area yields were minimal. They were also considerably narrower than those of Spain, Portugal and Greece on the eve of their respective EU accessions. In addition, Holinka (2005) finds that the Czech long-term bond yields are significantly influenced by the European 10-year swap rates, in addition to the exchange rate, inflation risk premium, disposable income in relation to GDP, and the marginal return on capital.

The mixed econometric results on yields compression in NMS may stem from the ramifications of the policy mix applied during the early stage of long-term government

[5] The OLS regression estimations of the single-equation model conducted by the IMF are based on monthly data series on local bond yields for the Czech Republic, Hungary and Poland as a function of inflation, three-months-lagged retail sales and German yields (all in first differences). The regressions of one-, five- and ten-year local bond yields show that German yields were not significant determinants of the NMS yields.

bond market development. Specifically, lax fiscal policies and monetary strategies based on strict inflation targeting generated high local interest rate risk premia.[6] Those monetary strategies compelled central banks (CBs) to adopt very high interest rates in order to contain inflation. As the disproportionately high interest rates resulted in soaring risk premia, they impaired the linkage between the NMS and the euro area bond yields. However, they were indispensable for bringing inflation down closer to the EU levels (Orlowski, 2003). Moreover, inflation targeting strategies have been accompanied by greater exchange rate flexibility, although, to various degrees. Frankel *et al*. (2005) state that, under flexible exchange rates, the international transmission of bond yields is slower than under fixed exchange rates. Therefore it would not be surprising if local currency bond yields adjusted to the euro area levels only recently, following the adoption of inflation targeting and flexible exchange rates in NMS.

Overall, during the recent five-year period both nominal and real interest rates in NMS have fallen sharply outpacing the declining trend in the euro area. This decline precipitated from considerably strengthened financial stability in these countries that led to improved credit ratings, lower risks to investors and, consequently, declining bond yields. Therefore, in spite of the controversies related to the early evidence, one may expect that the integration of NMS government debt markets into the euro area bond markets has increased and that yield compression is taking place. From this standpoint, bond yield compression can be viewed as a proxy indicator for assessing the degree of financial integration, specifically a synchronization of the underlying macroeconomic fundamentals such as inflation expectations, real income and other factors affecting credit risk.

III. A Model of Bond Yields Co-Movement

We derive our model on the precepts of the Fisher theory and the Expectations Hypothesis (EH) of the term structure. The term structure of interest rates has gained reputation in the literature for its ability to provide useful information on the current stance of monetary and

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[6] Inflation targeting framework was officially adopted by the Czech Republic in January 1998, Poland in January 1999 and Hungary in May 2001. The evolution and stabilization effects of inflation targeting strategies in these countries are examined by Orlowski (2005a).

fiscal policy, as well as future economic activity, real interest rates and inflation (see for instance Mishkin, 1990; Bernanke and Blinder, 1992). Given this framework, the nominal interest rate R_t is determined by the real interest rate rr_t and the expected rate of inflation $E_t(\hat{\pi}_{t+m})$ from period *t* to period *(t+m)*.

$$R_t = rr_t + E_t(\hat{\pi}_{t+m}) \tag{1}$$

According to EH, long-term interest rates are determined by the market expectations for short-term interest rates augmented by a risk component that may vary with the corresponding maturity for a given rate. Thus, a long interest rate R_t^L is the expected short rate $E_t(R_{t+m}^S)$ plus the constant risk premium ($\phi_t^L = \bar{\phi}$). For simplification, we refrain from decomposing the risk premium and will refer to the risk component throughout our paper as "term premium".[7]

$$R_t^L = E_t(R_{t+m}^S) + \phi_t^L \tag{2}$$

Given the above, we can infer the difference between long and short-term interest rates, which defines the slope of the yield curve, also referred to as the term spread. Based on Fama (1990) who concludes that term spreads can forecast the expected term premia, we want to test whether they can also explain the yield convergence. Term spreads are widely credited in the literature for their usefulness for predicting future macroeconomic conditions.[8] This suggests that they can potentially be used as a convergence indicator for they can reasonably encapsulate information about real convergence and inflation

[7] From the empirical standpoint, the term premium for a converging economy would reflect the difference between the risk premium on national relative to foreign long-term debt and the relative risk premium on short-term debt. Thus by a precise definition, term premium is not simply the difference in spreads across maturities because in reality it involves a default risk component. Broner *et al*. (2004) make a similar point with respect to analysis of term structure in emerging economies.

[8] The usefulness of term spreads as indicators for monetary policy purposes is demonstrated, among others, by Estrella and Hordouvelis (1991) and Estrella and Mishkin (1997)

expectations that is potentially useful for guiding the convergence to a common currency. Their forecasting relevance is additionally signified by the fact that they are market-determined, thus not subject to revisions.

The nominal term spread for bonds across maturity spectrum is a function of expected changes in the real term spread and expected changes in inflation amplified by the time-varying term premium. If $E(rr_t^L - rr_t^S)$ reflects a direction of expected real term spread, $E_t(\hat{\pi}_t^L - \hat{\pi}_t^S)$ represent dynamic inflation expectations for the corresponding time period, and φ_t^L is a time-varying term premium, the nominal term spread can be expressed as

$$R_t^L - R_t^S = E_t(rr_t^L - rr_t^S) + E_t(\hat{\pi}_t^L - \hat{\pi}_t^S) + \phi_t^L \tag{3}$$

The real term spread can be specified as $rg_t = E_t(rr_t^L - rr_t^S)$. In order to ascertain the linkage between the local and the foreign term spreads, we bring in the Uncovered Interest Rate Parity (UIP) condition by including the expected exchange rate movement into our model. Consequently, in an open-economy setting, the differential between the domestic and the foreign nominal term spreads can be expressed as follows

$$(R_t^L - R_t^S) - (R_t^{L*} - R_t^{S*}) = rg_t - rg_t^* + E_t(\hat{\pi}_t^L - \hat{\pi}_t^S) - E_t(\hat{\pi}_t^{L*} - \hat{\pi}_t^{S*}) + \phi_t^L - \varphi_t^{L*} + E_t(s_t^{L-S})$$
(4)

The asterisk denotes foreign variables. This relationship is augmented by the expected depreciation of local currency for the L-S period represented by $E_t(s_t^{L-S})$. The impact of the expected currency movements would have merit particularly in the case of a smaller, open economy, whose CB actively conducts foreign exchange market interventions (Eckhold, 1998). Under such circumstances, transmission of currency movement into long-term interest rates becomes more pronounced.[9]

[9] Recent evidence on transmission of exchange rates into inflation and interest rates in transition economies can be found in Golinelli and Rovelli (2005) and Orlowski (2005a)

The difference between the national and the foreign term premia can be captured by

$$\psi_t = \varphi_t^L - \varphi_t^{L*} \tag{5}$$

It is further assumed that the nominal interest rate, which serves as a policy instrument or a reference rate for a local CB in a converging country will be adjusted in response to changes in the domestic nominal interest rate and changes in the foreign reference rate. This notion allows for identifying the foreign and the domestic monetary policy rules. Since the foreign CB follows a fully autonomous monetary policy, the foreign policy instrument rule is prescribed by

$$i_t^{CB*} = rg_t^* + E_t(\hat{\pi}_t^{L*} - \hat{\pi}_t^{S*}) + \varphi_t^{L*} \tag{6}$$

In contrast, the CB of a converging country cannot pursue a similar degree of monetary autonomy as it needs to consider the monetary convergence process. Thus the domestic policy rule is that the adjustment in the domestic policy instrument becomes a function of changes in the local nominal term spread and the expected exchange rate path. The local instrument rule is specified as

$$i_t^{CB} = rg_t + E_t(\hat{\pi}_t^L - \hat{\pi}_t^S) + \varphi_t^L + E_t(s_t^{L-S}) \tag{7}$$

In essence, such instrument rule seems plausible for an economy converging to a single currency when the CB monetary policy decisions are guided by forward-looking, flexible inflation targeting[10]. As oppose to strict inflation targeting that would require a monetary authority to gear policy decisions to the domestic inflation target only, the flexible inflation targeting framework allows combining the inflation target with a supplemental exchange rate stability objective.

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[10] The standard treatment of such instrument rule is that it is a function of observable variables (see Svensson, 2005). However, for a converging economy it seems plausible to assume that it can be based on forecast variables.

It can be further noted that the local CB may follow an alternative targeting rule that would be more suitable for an advanced stage of monetary convergence characterized by the term premium differential converging to zero ($\psi_t = 0$) and the exchange rate becoming fixed (for instance, upon the euro candidate's entry to the ERM2). Such a rule is derived on the basis of a notion that a successfully orchestrated monetary convergence means that domestic inflation is being brought in line with the foreign inflation forecast during the period leading to the anticipated adoption of a single currency, i.e. in a time horizon L (Orlowski, 2005b).[11] At such advanced stage, economic agents fully and reasonably anticipate convergence of inflation, thus $E_t(\hat{\pi}_t^L) = E_t(\hat{\pi}_t^{L*})$. Given the convergence of long term inflation expectations, the convergence of term premia and the fixed exchange rate, Eq. (6) and Eq. (7) can be combined into the following expression of the domestic policy instrument rule

$$i_t^{CB} = i_t^{CB*} + rg_t - rg_t^* - E_t(\hat{\pi}_t^S) + E_t(\hat{\pi}_t^{S*}) \tag{8}$$

As completion of the convergence process appears in sight, the local CB will attempt to coordinate the operating inflation target $\overline{\pi}_t^S$ with the foreign inflation forecast for S-period ahead, $E_t(\hat{\pi}_t^{S*})$. Thus CB will respond to the differential between the inflation target and the domestic inflation forecast for S-period by adjusting the policy instrument at the advanced stage of convergence in the following way

$$i_t^{CB} = i_t^{CB*} + rg_t - rg_t^* + \overline{\pi}_t^S - E_t(\hat{\pi}_t^S) \tag{9}$$

However, at the early stage of convergence, the domestic instrument rule prescribed by Eq. (7) seems to be more feasible and practical. By expressing the differential between the domestic and the foreign nominal term spreads in terms of the domestic and the foreign

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[11] In practical terms the euro area inflation forecast should be understood in terms of the Maastricht convergence criterion, which requires the domestic inflation not to exceed 1.5 percent above the average of the three lowest inflation rates among the EU Member States.

policy rules, i.e. by folding the Eqs. (6) and (7) into (4), the relative to abroad yield curve process becomes

$$(R_t^L - R_t^S) - (R_t^{L*} - R_t^{S*}) = rg_t + E_t(\hat{\pi}_t^L - \hat{\pi}_t^S) + \varphi_t^L + E_t(s_t^{L-S}) - i_t^{CB*} \tag{10}$$

Eq. (10) serves as a basis for testing responsiveness of local currency long-term bond yields to changes in foreign yields, conditional on changes in fundamental macroeconomic variables. This analysis is conducted in Section IV.

Eq. (10) can be rearranged to express the local currency long-term yield as a function of local term spread (as specified by Eq. (3)), foreign long-term yield, the differential between short domestic and foreign interest rate (specified as $\theta_t = R_t^S - R_t^{S*}$), the exchange rate and the foreign CB reference rate. The short-term interest rate differential can be attributed to the country specific risk conditions. Consequently, the local long-term bond yield process is given by

$$R_t^L = (R_t^L - R_t^S) + R_t^{L*} + \theta_t + E_t(s_t^{L-S}) - i_t^{CB*} \tag{11}$$

The relationship prescribed by Eq. (11) suggests that movements in long-term bond yields in a country converging to a single currency can be explained in terms of changes in: local term spreads, foreign bond yields, short term yield differentials, exchange rates and foreign CB reference rates. This functional identity is a basis for testing the bond yield volatility dynamics in Section V. From the standpoint of the main argument underlying our analysis, a significant positive relationship between local and foreign bond yields conditional on changes in the remaining variables implies the presence of yield convergence. Given a significant co-movement between local and foreign yields coupled with narrowing yield differentials, one could reasonably argue that relative risk premia are declining and, therefore, a successful convergence is under way.

IV. Macroeconomics Fundamentals and Yield Compression

In this section, we examine the yield compression in terms of changes in macroeconomic fundamentals as prescribed by the theoretical model developed in Section III. The question before us is whether yields in the euro area, as benchmarked by German bond yields, are significant drivers of national yields in the three examined NMS, which would imply that yield compression is taking place. [12] Accordingly, we test sensitivity of changes in yield spreads between NMS and Germany to changes in inflation differentials, exchange rates and domestic output growth rates. Separately, we test changes in local currency bond yields as a function of selected domestic and euro area variables. The tests are comparable to those performed by the IMF (2003), however, we use exclusively the ten-year yields in NMS and their spreads over the ten-year German yields, in consistency with the Maastricht criterion of long-term interest rates convergence.

In line with our model, we test the impact of the following specific variables on bond yields in NMS:

- German yields and the expected changes in the nominal exchange rate, as implied by the UIP condition
- the required long-term real rate and the expected inflation rate as they relate to the international Fisher effect
- the output gap as the real activity indicator, for ascertaining CB's reactions to business cycle developments.

The short history of the long-term bond markets in NMS and thus the relatively short sample of available observations pose a technical constraint to formulating dynamic forecasts of exchange and inflation rates. Consequently, we choose lagged or forwarded variables instead of forecast variables. In addition, the dynamic inflation and exchange rate forecasts would ideally be based on the final convergence parameters. However, neither the exact date of entry, nor the final conversion exchange rate and the future inflation path are known at the time of this writing. Moreover, the catch-up process is likely to entail

[12] We are taking the ten-year German MCBY as the reference yield for euro area long –term bonds. German yields have maintained the benchmark status since they have continued to display lower yields. For a detailed discussion on benchmark status see Dunne at al. (2002).

inflation rates exceeding the levels of Germany In such case, the NMS long-term debt would be priced on the basis of German long-term yields augmented with the inflation and the exchange rate risk premia (Orlowski, 2003). In the tests that are reported in this Section we assume that such risk premia are determined on the basis of observed changes in macroeconomic fundamentals, assuming that they predict future developments.

The selection of independent variables for our tests is based on four criteria. First, the current inflation rate becomes important when the expected and the observed values differ significantly, i.e. if the uncertainties pertaining to the inflation rate are quite high (the inflation risk premium is elevated). Second, the nominal exchange rate changes are priced in if they carry information about the EMU entry rate. However, they may also stem from adjustments in the policy instrument, i.e. the CB reference rate. Third, both the CBs of NMS and the ECB policy reference rates are taken into consideration. Although the CBs reference rates are usually not expected to influence directly the pricing of long-term assets, they are believed to have an impact through the term structure of interest rates, as they reflect the CB's inflation forecasts or expectations. Fourth, we include real activity indicators, namely, the output gap measure stated in terms of deviations from the Hodrick-Prescott filter of interpolated quarterly GDP series, and the straight (interpolated) series of quarterly year-on-year GDP growth rates. The former is assumed to indicate policy responses to the business cycle, while the latter mirrors real returns of the economy.

Because of the short number of available monthly observations for the ten-year bond yields, we employ the ordinary least square (OLS) procedure. The sample periods are January 2000 – March 2005 for Hungary and Poland, and June 2000 – March 2005 for the Czech Republic. The data are taken from the IMF-International Financial Statistics (consumer prices) and the NewCronos database (GDP, exchange rates, CBs rates, ten-year government bond yields). Due to non-stationarity of all tested variables at their levels, we perform the tests on their first differences. The CPI and GDP are entered as first-differences of their growth rates while the exchange rate is the one-month difference of the log of the nominal exchange rate to the euro.

….. insert Table 1 around here …..

The test results are shown in Table 1. The upper part of the table contains the estimation representations of the functional relationship of the spread between the NMS and German long-term yields as a function of selected independent variables. The lower part assumes local yields as dependent variables. The obtained results consistently prove prevalent co-movements between local and German yields. Thus in essence, local yields in all three countries are significantly driven by German yields. Our key finding is that the estimated sensitivity coefficient between both variables for Poland (reported in the lower part equation) is very close to unity implying that German yields have become almost perfect drivers of local yields. The same coefficient is marginally lower for the Czech Republic and somewhat lower for Hungary. In contrast, sensitivity of local yields to changes in the remaining independent variables is quite diverse in the examined countries.

In the Czech Republic, the CPI-based inflation differential over Germany and the two-months-lagged GDP growth rate appear to be statistically significant. Arguably, adjustments in the ECB reference rate affect significantly Czech yields, more than changes in the Czech CB reference rate do[13]. This discrepancy seems to suggest that the Czech bond market becomes increasingly influenced by the ECB monetary policy. Moreover, changes in the exchange rate do not affect Czech yields directly, which is understandable since the value of the euro in the Czech koruna has been quite stable during the past fifteen years with only minor nominal trend appreciation. Thus evidently, the financial markets seem to expect the current trend-rate to be already quite close to the euro entry rate, which makes long-term bond yields less susceptible to exchange rate shocks. The GDP growth rate, based on our proxy measure defined above, is a significant determinant of Czech yields. In general terms, the significance of the inflation rate and the current GDP growth rate variables suggests that the markets continuously rely, at least partially, on the country-specific information. Nevertheless, the importance of both German yields and the ECB reference rate in pricing Czech long-term bonds indicates that the Czech markets are already reasonably integrated with the euro area markets.

[13] A weak responsiveness of the Czech bond yields to changes in the Czech CB reference rate is reaffirmed by the early results obtained by Matoušek and Taci (2003). In a more recent study, Holinka (2005) shows that with lengthening of the maturity the influence of Czech CB on Czech yields decreases while the influence of the ECB rises.

In Hungary, fundamental variables have a seemingly different impact on long-term bond yields. German yields are a factor, as in the two remaining countries, but the adjustment process is only partial, since the coefficient for Hungary has a lower estimated value than for Poland or the Czech Republic. The local inflation rate plays an important role, as in the Czech case. The exchange rate drives Hungarian yields significantly, which is also the case in Poland but not the Czech Republic. Most notably, yields are highly sensitive to the local CB reference rate, which is unique for Hungary since the yields in the two remaining countries are rather sensitive to the ECB reference rate. Clearly, the disconnection of Hungarian yields from the ECB rates coupled with a somewhat weaker transmission of German into local yields implies that integration of the Hungarian with the euro area bond markets is less pronounced. Therefore, the Hungarian bond market might be more vulnerable to domestic rather than external shocks, which likely stems from rather ambiguous monetary policy and the resulting higher inflation rates in comparison to the remaining two countries. The Hungarian CB follows a dual-targeting strategy combining low inflation and exchange rate stability objectives, while the Polish and the Czech CBs prioritize stable, low inflation targets allowing the exchange rate to float almost freely. This may explain high sensitivity of Hungarian yields to inflation expectations and exchange rate developments.

In Poland, German yields are important drivers of bond yields, as indicated above. In addition, Polish yields are significantly affected by changes in the exchange rate, the GDP growth rate and the ECB reference interest rate. As in the Czech case, the GDP growth rate and the ECB reference rate seem to encapsulate real returns to investors, thus they serve as benchmarks for pricing long-term assets. The lack of yield sensitivity to the domestic inflation rate coupled with the pronounced exchange rate effect might imply that the Polish market expects a prolonged inflation convergence, due to some inflationary pressures stemming from the accelerated real GDP growth. Furthermore, the high volatility of the Polish zloty in terms of the euro under the purely floating exchange rate (since April 2000) has made it very difficult to ascertain the future euro conversion rate, as well as the ERM2 reference rate. This exacerbates the risk premium on long-term local currency government bonds. The negligible importance of the Polish CB reference rate during the analyzed sample period seems to suggest that its policy instrument has been adjusted in response to the short- to medium-term inflation forecasts but not to the long-term inflation projection. In hindsight, Polish bond yields are significantly driven by German yields, the ECB rate and the exchange rate, all of which imply a high degree of integration with the euro zone financial markets.

In sum, German yields play an important role in the determination of long-term bond yields in all three NMS. Moreover, our tests also reveal that the adjustments in the ECB reference rate significantly affect bond yields in Poland and, to a lesser degree in the Czech Republic, but not in Hungary. The influence of the euro area variables, although uneven across the three NMS, indicates a discernible degree of their financial market integration, which underpins the ongoing monetary convergence to the euro. The impact of changes in domestic variables on bond yield dynamics in these NMS also varies. The observed diverse reactions stem very likely from the prevalent differences in their monetary policies and exchange rate regimes.

Our findings that German yields are significant drivers of local yields in the multivariate framework of macroeconomic fundamentals are quite different from the early results obtained by the IMF (2003), Holtemöller (2003) as well as Kim *et al*. (2004). In the next section we examine whether these findings hold under the conditional volatility dynamics of relative bond yields based on the daily data series.

V. Yield Compression: Volatility Dynamics Analysis

Our sample covers 1431 daily observations for the period January 3, 2000 - June 27, 2005 for Hungary, Poland and Germany. For the Czech Republic, the sample begins on May 22, 2000 (1331 observations), due to the delayed inception of its long-term bond market. The data are taken from the Bloomberg database (supplemented with Reuters data on ten-year Polish bond yields for January 3 - February 3, 2000 and December 7, 2001 – November 25, 2002, due to unavailability of Bloomberg Generic Network prices for these periods) and from Eurostat (for German MCBY-Maastricht Conditions Bond Yields).

Before testing of our model developed in Section III, we present graphically national over German MCBY yields spreads during the sample period (Figure 1). The spread between the Polish over German ten-year yields was initially extremely high, reaching 9 percentage points in the last quarter of the year 2000. Since then, it has narrowed considerably to less than 2 percentage points in mid-2005. The narrowing of spreads stems from a significant decline in inflation expectations that can be attributed to credible inflation targeting strategy coupled with gradually improving fiscal discipline. Hungary started from a significantly narrower spread than Poland, but has not been able to reduce it further since mid-2002. Its ten-year spread over German yields is now the highest among the three examined NMS due the continuously elevated inflation expectations and the struggle to maintain fiscal discipline. In contrast, Czech yields descended to the levels of German yields already in mid-2002, then experienced a brief period of gradual rising, and now seem to be aligned again.

.... insert Figure 1 around here …..

We now determine the respective unconditional correlations between national and German bond yields in order to ascertain their co-movement. We also examine coefficients of elasticity of changes in the ten-year national yields to changes in German yields. The results of both tests are shown in Table 2.

….. insert Table 2 around here …..

For the entire sample period of daily observations, there is a moderate unconditional correlation between Czech and German yields. In contrast, pairwise correlations of Hungarian and Polish yields with German yields are significantly lower. Thus Czech yields are more integrated with those of the euro area than yields of two remaining NMS. These findings, to some extent, reaffirm the IMF (2003) and Holtemöller (2003) conclusions that, from the government debt market perspective, NMS are still not ready to join the euro. A more encouraging message stems from the pairwise yield elasticity coefficients. Their positive, close to unity values imply that the daily percentage changes between national and German yields are almost perfectly synchronized.

Nevertheless, the unconditional correlations and elasticity coefficients for the entire sample period are overly simplistic measures for assessing yield compression. More meaningful inference can be drawn when the sample period is divided into two parts: (1) the pre-EU accession (i.e. prior to May 1, 2004) and (2) the post-EU accession period. As shown in Table 3, during the latter period the average bond yields as well as the daily volatility have fallen considerably in the Czech Republic and Poland but somewhat less in Hungary. The unconditional correlations of both Polish and Hungarian with German yields have become stronger after the EU entry. At the same time, correlation between Czech and German yields has weakened, which is somewhat puzzling. This result might be possibly explained by the fact that the Czech CB allowed for greater exchange rate flexibility by suspending foreign exchange market interventions already about a year prior to the EU accession.

….. insert Table 3 around here …..

We now proceed with the empirical testing of the time-varying conditional co-movements between NMS and German yields on the basis of our model prescribed by Eq. (11). We estimate the time-varying volatility of national yields as a function of German yields and a set of exogenous variables in order to ascertain yield compression more precisely. We employ threshold generalized autoregressive conditional heteroscedasticity (TGARCH) model with the conditional variance in the mean equation (M) combined with the generalized error distribution (GED), which allows for variable kurtosis in the data. [14] The "in mean" extension of the model (GARCH-M) ads the heteroscedastic variance term directly into the regression equation allowing time-varying volatility to be related to expected yields since they are influenced by term premia. Departing from the normal distribution assumption, specifically, allowing the series to be leptokurtic (GED parameter<2) routinely holds for daily frequency series of financial assets. We further

[14] For a comprehensive overview of the ARCH-class models see (Engle, 2004). Their usefulness and applicability for testing volatility dynamics of financial assets is examined by Poon and Granger (2003). ARCH-class models have been also used for the purpose of testing co-movements between emerging and developed financial markets. Among others, Batten *et al*. (2006) employ GARCH to demonstrate strong susceptibility of Asia-Pacific emerging bond market issuers to changes in benchmark U.S. Treasury bonds.

incorporate German yields and local CB reference interest rates as regressors in the conditional variance equation.

Our TGARCH-M-GED procedure consists of the conditional mean and the conditional variance equations (Eqs. 12 and 13 respectively). The conditional mean equation is in essence derived from Eq. (11), however, with several modifications. It examines the local ten-year bond yield R_t^{10Y} as a function of the polynomial (quadratic) spread between five-year R_t^{5Y} and three-month R_t^{3M} local yields, German yields R_t^{10Y*}, the euro value expressed in domestic currency terms as $\log S_t$ and the GARCH conditional variance σ_t^2 (the GARCH in-mean component), which is a proxy for the directional change in the local term premium.[15] It is further assumed that the foreign CB reference interest rate follows a steady, exogenously determined course, thus its autoregressive movement is zero. The resulting mean equation is as follows

$$R_t^{10Y} = \alpha_0 + \alpha_1 (R_t^{5Y} - R_t^{3M}) + \alpha_2 (R_t^{5Y} - R_t^{3M})^2 + \alpha_3 R_t^{10Y*} + \alpha_4 \log S_t + \alpha_5 \sigma_t^2 + \xi_t \tag{12}$$

All underlying variables are entered in first differenced terms since they are non-stationary at their levels in all examined cases. The quadratic effect of the five-year to three-month spread allows us to capture its marginal effect on local long-term yield. Unlike in Eq.(11), the domestic policy instrument variable, namely, the CB reference interest rate i_t^{CB}, is now placed as a regressor in the conditional variance equation in order to emphasize its possible dampening effect on bond yield volatility. Finally, the exchange rate variable is entered as the first difference of the log of the spot value of the euro in local currency terms.

[15] In testing the predictive power of the term spread, it is important to choose the yields of debt securities which are actively traded and which reflect market expectations. Therefore we examine the spread between the five-year government bond yield and the three-month money market rate, which is the available proxy for the three-month yield. This puts us in agreement with Domain and Reichenstein (1998), who argue that the spread between the intermediate- and short-term and not between the long- to short-term yields trails the embedded risk premia.

The conditional variance equation is formulated as the TGARCH(p,q,r) process and specified as

$$\sigma_t^2 = \beta_0 + \sum_{l=1}^{p} \beta_{1l}\xi_{t-l}^2 + \sum_{k=1}^{r} \beta_{2k}\xi_{t-k}^2\Gamma_{t-k} + \sum_{j=1}^{q} \beta_{3j}\sigma_{t-j}^2 + \beta_4 R_t^{10Y*} + \beta_5 i_t^{CB} \qquad (13)$$

The p-order ARCH terms represented by $\sum_{l=1}^{p} \beta_{1l}\xi_{t-l}^2$ reflect the impact of 'news' or shocks to the current volatility of the bond yield process prescribed by Eq. (12), induced l-periods before. The q-order GARCH terms $\sum_{j=1}^{q} \beta_{3j}\sigma_{t-j}^2$ show the degree of persistency in volatility. The leverage threshold effects or r-order TARCH terms $\sum_{k=1}^{r} \beta_{2k}\xi_{t-k}^2\Gamma_{t-k}$ reveal the degree of asymmetry of shocks to volatility, in which Γ_{t-k} are k-period dummy variables assuming the value of one for all the observed negative shocks $\left(\xi_{t-k}\langle 0\right)$ and zero for the positive ones. Two additional regressors are built into the conditional variance equation in order to capture their perceived impact on volatility of local currency bond yields: (1) German yields, and (2) the CB reference rates. Due to non-stationarity at their levels, both of these regressors are entered in first differenced terms.

Inevitably, some of the key fundamental variables that are likely to drive local bond yields, such as inflation, output gap, etc., are not incorporated since these estimations are based on daily data frequency. In all tested cases, empirical estimations with the log-likelihood maximizing GED residuals allows for alleviating the danger of a serious overestimation of volatility, which would be the case if the normal (Gaussian) distribution assumption were imposed (GED=2).

The results of selected empirical estimations of Eqs. (12) and (13) are shown in Table 4. We report only the most robust estimation representations on the basis of maximizing the likelihood ratio and minimizing the Akaike and Schwartz information criteria. The obtained evidence implies that daily changes in German yields significantly affect changes in national yields in all three examined NMS, as indicated by the high statistical significance of their estimated α_3 coefficients in the conditional mean equation. These coefficients have all correct, positive signs, which suggest that both German and national yields tend to move in the same direction. The impact of conditional changes in German yields on national yields is the most pronounced for the Czech Republic, while it is somewhat weaker for Poland and considerably less significant for Hungary. In the conditional variance equation, changes in German yields inversely affect volatility of national yields, but this effect is significant only in the case of Poland. This suggests that a possible increase in German yields is likely to mitigate the conditional volatility of Polish yields. Adversely, the decline might exacerbate volatility of national yields. The obtained results carry an important message for policy-makers in NMS as they are all seemingly concerned about sustaining financial markets stability and lowering risk premia to investors.

….. insert Table 4 around here …..

The term spread and its marginal effect contain useful information on local bond yields as well. The term spread coefficients are all positive and very significant implying that long-term bond yields tend to fall with the declining spreads, which underpins the occurrence of the NMS yield compression. There is also a strong negative marginal (quadratic) effect in all three countries, which reflects the marginal impact of a change in term spread on long-term bond yields. In the Czech case, a higher ten-year yield is associated with a steeper yield curve as implied by the low value of estimated α_2 coefficient. This effect is weaker in the other two NMS. Apparently, transmission of possible inflation expectations along the yield curve is more pronounced in the Czech Republic than in Poland or Hungary. However, the Hungarian yield curve tends to be most elevated, primarily due to the strong positive effect of the currency depreciation on long-term yields (reflected by the high estimated value of α_4).

The impact of currency depreciation on local currency bond yields varies across these countries. The estimated α_4 coefficients imply that currency depreciation almost instantly raises yields in Hungary and Poland, while its effect in the Czech Republic is less pronounced. On the basis of higher value of the α_4 coefficient for Hungary relative to

Poland it can be argued that there is a stronger transmission of the exchange rate risk into the interest rate in Hungary. Thus the high value of this coefficient seems to validate the Hungarian CB commitment to exchange rate stability within the flexible inflation targeting framework.

The GARCH conditional variance in the mean equation has a negative sign and is significant only for Hungary and Poland, which implies that the conditional risk premia in these two countries have been steadily declining. In contrast, the GARCH conditional variance does not affect changes in Czech yields, simply because the conditional risk premium might have evaporated there by now.

The estimated conditional variance equations show a strong impact of the previous-period news about volatility on current volatility dynamics of bond yields, as implied by high and significant ARCH(1) coefficients. Higher-order ARCH effects quickly dissipate in the Czech Republic and Hungary. By contrast, there are significant higher-order ARCH effects detected for Poland suggesting that its yield volatility is subject to seemingly diverse external shocks of unspecified duration. This result is not surprising as Poland has been recently struggling to control political risk and maintain fiscal discipline (both factors might have infused some instability to the country's bond market).

There is a significant asymmetric first-order leverage effect in the case of Hungary only[16]. The TARCH(1) estimated coefficient has a negative sign suggesting that the shocks suppressing volatility in the preceding period $\left(\xi_{t-1} \langle 0\right)$ further reduce the actual volatility of bond yields and this impact is much stronger than a possible propagation of volatility induced by positive shocks $\left(\xi_{t-1} \rangle 0\right)$.

As expected, the GARCH(1) effect is quite pronounced in all three examined cases. Its estimated coefficient is the highest for Hungary indicating high persistency in yield volatility. The GARCH(1) effect is weaker for Poland and even less pronounced for the Czech Republic. Furthermore, the sum of ARCH and GARCH terms is considerably lower in the Czech case relative to the two remaining countries, indicating a strong, ongoing convergence of volatility of Czech yields to the steady-state. The convergence effect is

[16] Higher-order TARCH and GARCH effects have been tested in all three cases and proven to be entirely insignificant.

less pronounced in the case of Poland, as the sum of both terms is closer to unity. In contrast, there seems to be a divergence in volatility from the steady-state in the case of Hungary since the sum of ARCH and GARCH terms exceeds unity.

In concurrence with our initial assumptions, GED parameters are consistently lower than 2.0 implying a leptokurtic data distribution with thick tails and thin waist in all three cases. In practical terms it means that the yield volatility tends to be contained during tranquil market periods while it is exacerbated at turbulent times. This is a common feature of developing financial markets that remain vulnerable to exogenous shocks (Engle, 2004). Such vulnerability of NMS bond markets as revealed by the obtained GED parameters underscores legitimacy of a rather cautious approach to adopting the euro, as a premature accession would likely entail large, potentially destabilizing shocks to the candidates' financial markets.

In sum, the empirical tests are most robust for Czech bond yields indicating a strong evidence of volatility convergence to the steady state and their relatively strong co-movement with German yields. The tests are a bit less robust for the remaining two countries. In the case of Poland, the ambiguous ARCH effects seem to obfuscate the argument about volatility convergence. However, the two regressors augmenting the conditional variance equations are significant there. Evidently, declining German yields as well as reductions in the CB reference rate tend to exacerbate bond yield volatility in Poland.

VI. A Synthesis and Policy Suggestions

Our analysis shows that integration of Polish, Hungarian and Czech financial markets with the euro area markets is progressing. The empirical evidence suggests that German bond yields have become significant drivers of local currency bond yields in these countries. Their local yields display sensitivity, although to various degrees, to monthly changes in fundamental variables, including inflation differentials, exchange rates, GDP growth rates, as well as the local CBs and the ECB reference interest rates. The co-movements between the NMS and German bond yields is also detected by the TGARCH-M-GED process that accounts for daily volatility dynamics of local currency bond yields as a function of German yields, local term spreads and the exchange rates.

In sum, we provide statistical evidence that monetary convergence of the euro candidate countries is taking place, which in turn implies that the examined NMS might be ripe for adopting the euro without risking potentially destabilizing shocks to their financial markets. As their bond markets become increasingly integrated with the euro area bond markets, their vulnerability to such shocks is less pronounced.

It is worthy noting that the actual path of bond yield compression has been periodically assessed by the ECB in its 'Convergence Reports'. The most recent 2004 Report shows that the average ten-year bond yield in the Czech Republic during the reference period September 2003 – August 2004 was 4.7 percent, well-below the Maastricht reference value of 6.4 percent (ECB, 2004). However, Poland and Hungary did not reach the required benchmark; their average ten-year yields were 6.9 and 8.1 percent respectively. Nevertheless, in the near future the bond yields in NMS are expected to fall below the Maastricht benchmark, as they have been gradually declining, and at the end of June 2005 reaching 6.4 percent in Hungary, 4.9 percent in Poland, and 3.2 in the Czech Republic.

In spite of the encouraging evidence on bond yield compression, serious challenges to financial stability in NMS are not out of sight. As proven in our analysis of the yield volatility dynamics, rising market interest rates are likely to exacerbate fluctuations of local currency bond yields, thus they may reverse the course of yield convergence. Without doubt, there are continuous pressures on NMS nominal interest rates attributable to renewed inflation expectations, which stem from aggregate supply shocks (including the recently sharp increase in energy prices), as well as aggregate demand shocks. Therefore, it is imperative that the converging countries continue pursuing monetary policies aimed at containing inflation. But these efforts to reduce risk premia need to be supplemented with disciplined fiscal policies in order to succeed.

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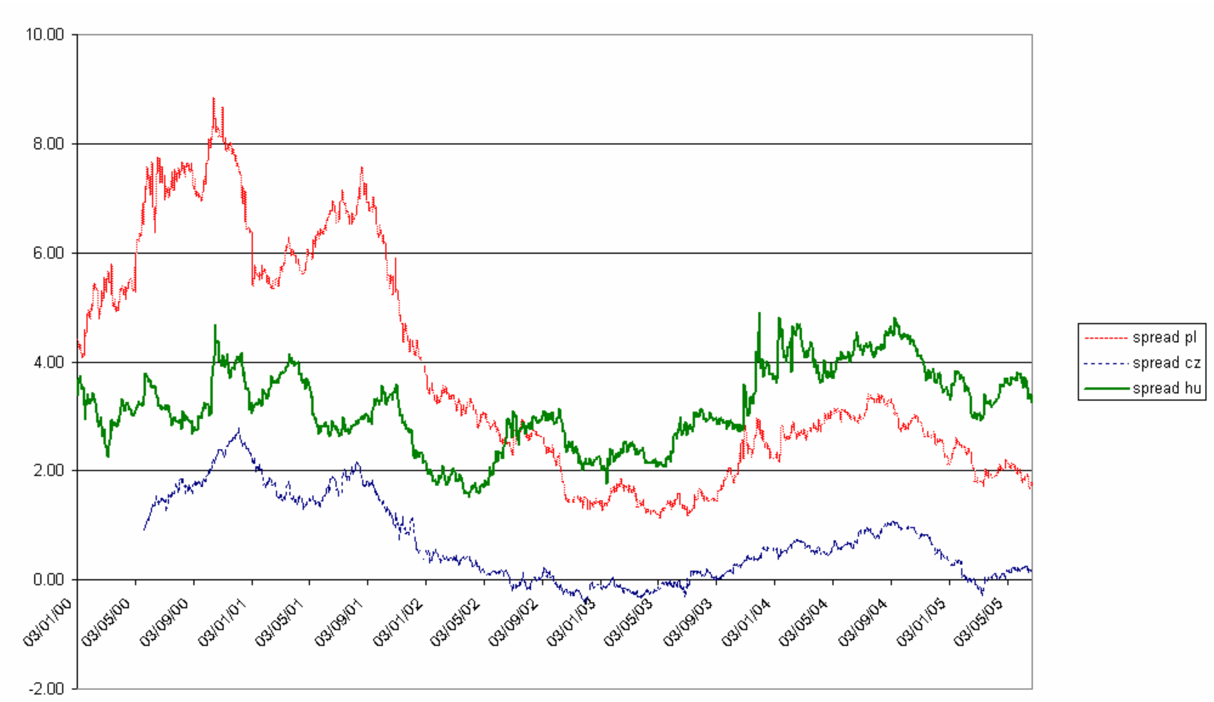
Figure 1. Spreads between 10Y government bond of the Czech Republic / Hungary / Poland and Germany



Data Source: Bloomberg (supplemented with Reuters data on Polish ten-year yields for Jan 3 - Feb 3, 2000 and Dec 7, 2001 – Nov 25, 2002 due to unavailability of Bloomberg Generic Network prices for these periods) and Eurostat for German MCBY (Maastricht Conditions Bond Yields).

Table 1. Bond yield compression in relation to macroeconomic fundamentals

	Czech Republic	Hungary	Poland
Dependent variable: Spread between 10yr GB of NMS and Germany Independent variables↓			
constant term	-0.0023 (-0.11)	0.0274 (0.62)	-0.0310 (-0.68)
CPI inflation differential	lag 1 0.091 (2.03)	lag 0 0.1816 (1.92)	Na
log of nominal exchange rate	na	lag 0 7.057 (2.41)	lag 0 4.034 (2.13)
reference rate spread - local versus ECB	na	lag 0 0.1579 (2.33)	Na
ECB reference rate	lag 0 0.3024 (2.61)	na	lag 0 0.6763 (2.63)
GDP growth rate	lag 2 0.2511 (1.85)	na	lag 6 0.3384 (2.51)
autoregressive correction	AR1 0.3389 (2.96)	AR2 -0.2059 (-1.96)	AR1 0.2460 (2.27)
adjusted R^2 Durbin-Watson stat. log likelihood Schwartz info. Criterion	0.362 1.750 28.996 -0.650	0.316 2.266 -19.012 0.932	0.332 1.977 -21.505 1.012
Dependent variable: 10y GB of NMS Independent variables↓			
constant term	-0.0003 (-0.01)	-0.0240 (-0.52)	-0.0005 (-0.01)
German 10y GB	lag 0 0.8477 (6.98)	lag 0 0.6400 (2.22)	lag 0 0.9890 (3.42)
CPI inflation rate	lag 1 0.1651 (3.86)	na	Na
log of nominal exchange rate	na	lag 0 6.7660 (2.26)	lag 0 4.2304 (2.24)
CB reference rate	na	lag 0 0.2241 (2.32)	Na
ECB reference rate	lag 0 0.2155 (2.08)	na	Lag 0 0.6054 (2.33)
GDP growth rate	lag 2 0.2401 (2.05)	na	lag 6 0.3030 (2.19)
autoregressive correction	AR1 0.2968 (3.69)	AR2 -0.1746 (-1.60)	AR1 0.2694 (2.58)
adjusted R^2 Durbin-Watson stat. log likelihood Schwartz info. Criterion	0.689 1.715 36.924 -0.853	0.303 2.292 -20.714 0.986	0.423 1.994 -20.694 1.052

Notes: all variables are in first-differenced terms; nominal exchange rates are local currency values of one euro; t-statistics are in parenthesis; the sample periods are: January 2000 March 2005 for Hungary and Poland, and June 2000 – March 2005 for the Czech Republic.

Data Source: IMF- International Financial Statistics and NewCronos Database.

Table 2: Unconditional correlation and elasticity coefficients of daily changes in 10Y NMS and German government bond yields

10Y government bond yields of:	Unconditional Correlation Coefficient with 10Y German Yield	German Yield Elasticity Coefficients of Local Yields (double-log of 1st differences)
Czech Republic	0.318	+1.055
Hungary	0.133	+0.897
Poland	0.132	+0.899

Notes: Calculations are based on first differences of daily bond yield indexes for the periods January 3, 2000-June 27,2005 for Germany, Hungary and Poland, and May 22, 2000-June 27, 2005 for the Czech Republic.

Data source: as in Figure 1.

Table 3. Daily volatility and correlation of 10Y NMS and German bond yields during pre- and post-EU accession

	Average yield[1)]	**Standard deviation**[1)]	**Coefficient of variation**[1)]	**Unconditional correlation with 10YGerman yields** [2)]
Czech 10Y bond:				
5/22/2000-4/30/2004	*5.305*	*1.125*	*0.212*	*0.383*
5/1/2004-6/27/2005	4.461	0.675	0.151	0.124
Hungary's 10Y bond:				
1/3/2000-4/30/2004	*7.647*	*0.830*	*0.109*	*0.124*
5/1/2004-6/27/2005	7.637	0.742	0.097	0.198
Poland's 10Y bond:				
1/3/2000-4/30/2004	*8.794*	*2.593*	*0.295*	*0.126*
5/1/2004-6/27/2005	6.365	0.831	0.131	0.233

Notes: computed on the basis of: [1)] levels, [2)] first differences.

Data Source: as in Figure 1.

Table 4. Volatility dynamics of yield compression - estimation representations of Eqs.(12) and (13)

	Czech Republic	Hungary	Poland
Conditional mean Eq. (12)			
α_0 constant term	-0.016 (-1.06)	0.001 (1.27)	-0.042 (-4.57)***
α_1 (5Y-3M yield)	0.301 (22.41)***	0.469 (53.94)***	0.300 (28.06)***
α_2 (5Y-3M yield)^2	-0.283 (-3.49)***	-0.061 (-2.04)**	-0.098 (-4.08)***
α_3 (German 10Y yield)	0.204 (11.40)***	0.075 (6.15)***	0.174 (6.79)***
α_4 (EUR exchange rate)$^{1)}$	0.365 (1.81)*	3.335 (16.13)***	0.979 (5.79)***
α_5 (GARCH)$^{2)}$	0.319 (0.11)	-0.315 (-4.45)***	-0.007 (-4.19)***
Cond. variance Eq. (13)			
β_0 constant term	0.001 (16.34)***	0.001 (4.88)***	0.001 (5.31)***
β_{11} ARCH(1)	0.261 (5.98)***	0.591 (4.79)***	0.393 (5.10)***
β_{12} ARCH(2)	0.045 (1.51)	-0.021 (-0.31)	-0.032 (-0.54)
β_{13} ARCH(3)	na	na	0.078 (1.60)*
β_{14} ARCH(4)	na	na	0.213 (3.40)***
β_2 TARCH(1)	na	-0.433 (-3.28)***	na
β_3 GARCH(1)	0.255 (46.47)***	0.527 (6.87)***	0.356 (4.62)***
β_4 (German 10Y yield)	0.001 (0.33)	0.001 (0.18)	-0.009 (-5.15)***
β_5 (c. bank reference rate)	-0.002 (-1.44)	-0.002 (-1.75)*	-0.005 (-10.89)***
GED parameter	1.303 (83.64)***	0.732 (26.52)***	0.899 (24.18)***
adjusted R-squared	0.150	0.041	0.068
Log likelihood	2628.18	2215.56	1789.41
Akaike Info. Criterion	-3.936	-3.081	-2.483
Schwartz Info. Criterion	-3.885	-3.030	-2.428
Durbin Watson stat.	2.09	1.80	2.45

Notes: 1) Δlog of domestic currency value of one EUR, 2) log(GARCH) for Czech Republic and Poland and GARCH for Hungary. Significance at 1 percent ***, 5 percent **, and 10 percent *.

Data Source: as in Figure 1; for central bank reference rates: Czech National Bank, National Bank of Hungary, National Bank of Poland.