Term Structure Linkages Among the New EU Countries and the EMU

Minoas Koukouritakis*
Department of Economics
University of Crete
Rethymno 74100, Greece

Leo Michelis†
Department of Economics
Ryerson University, Toronto
Ontario, M5B 2K3, Canada

Abstract

This paper uses cointegration and common trends techniques to investigate empirically the expectations hypothesis of the term structure of interest rates in the 10 new EU countries, and the 2 core EMU countries, France and Germany. By decomposing each term structure into its transitory and permanent components, we also analyze the possible short run and long run linkages among the term structures of these countries. The empirical results support the expectations theory of the term structure for all countries except Malta. Further, they point to both weak short run linkages and several strong long run linkages among the monetary policies of the 10 new EU and the core of the EMU. The group of the Central European countries and Latvia are prominent in the latter case.

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*Corresponding author: Department of Economics, University of Crete, University Campus, Rethymno 74100, Greece. Tel.: +30 2831077435, fax: +30 2831077406, e-mail: minoas@econ.soc.uoc.gr

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1 Introduction

The enlargement process of an economic union is an important issue in the theory and practice of economic integration. In the framework of the European Union (EU), enlargement has been a concern since the foundation of the European Economic Community by the Treaty of Rome in 1957. The Treaty states explicitly that one of its main objectives is the continuous and balanced expansion. Indeed the current EU is the result of various expansions since 1957.

After growing in size from the original six members to twelve members and then to fifteen member states, the EU has recently experienced its biggest expansion ever in terms of scope and diversity. On May 1, 2004 ten countries joined the Union. These countries are Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic and Slovenia. In order to successfully join the EU these countries had to satisfy certain economic and political criteria, which include being stable democracies, respect human rights and the rule of law as well as having a functioning market economy.

The Maastricht Treaty has laid down explicit nominal convergence criteria that must be satisfied before a candidate country can join the European Monetary Union (EMU) successfully. One criterion concerns the convergence of long term interest rates to the average interest rate of the three EMU countries with the lowest inflation rates. In the present paper we investigate interest rate linkages among the new EU countries using the expectations hypothesis of the term structure (EHTS) of interest rates. According to the EHTS, the interest rate on a long run government security is an average of the current short rate and the expected future rates on securities of shorter maturity. If future short rates are expected to be constant over time, then the yields curve will be a horizontal line at the level of the current short rate. If future short rates are expected to rise, then the yield curve will be upward slopping, while if future short rates are expected to fall, then the yield curve will be downward slopping. Thus, the EHTS provides a plausible link between short and long term interest rates over time.

Clearly the EHTS has important policy implications. The term structure is a channel through which government policies can affect the long term prospects of an economy. For example, if a government adopts policies that lower the expected future short rates, then the long term interest rate will be lower and consequently, investment and economic growth will be higher.

Even though most studies to date have been concerned with testing the EHTS for a specific country or group of countries[1], the decomposition of the term structure into its transitory (i.e. the $I(0)$ cointegration) and permanent (i.e. the $I(1)$ common trend) components can be equally useful and insightful. The cointegration relation, which captures the spread between the long and short rates, contains information about the effects of short run monetary policies, while the common trend contains information about long run macroeconomic conditions and expectations about the course of future government policies. The interdependence among the transitory or the permanent components for a group of countries can thus reveal information about the degree of policy convergence among the countries. This is useful information for applied economists and policy makers.

Hafer, Kutan and Zhou (1997) used the multivariate cointegration and common trends techniques of Gonzalo and Granger (1995) to study linkages in the term structures of interest rates in 4 EU countries: Belgium, France, Germany and the Netherlands. Using a sample of monthly observations from 1979:3 to 1995:6, they found that the EHTS holds for these countries. Also, by decomposing each term structure into its transitory and permanent components, these authors found that the long term interest rate is the source of the common trend in each country, and that the common trends are cointegrated across countries and thus move together over time, but no single country dominates the common trends. Holmes and Pentecost (1997) reported similar results for 6 EU countries (Belgium, France, Germany, Italy, the Netherlands and the UK), using a sample of monthly observations from 1974:1 to 1996:3.

[1] The empirical literature is large and, in general, supportive of the EHTS of interest rates. Among others, Hall, Anderson and Granger (1992) used monthly data from 1970:3 to 1988:12 to analyze the term structure of 12 yield series on US Treasury bills. Using multivariate cointegration methods and the vector error correction model approach (VECM), these authors found evidence supportive of the EHTS for the US. Hardouvelis (1994) used monthly data of different time spans to investigate empirically the EHTS for the G7 countries: Canada, France, Germany, Italy, Japan, the UK and the USA. Based on OLS regression and VAR techniques, he found that the EHTS holds for all countries except the USA. Gerlach and Smets (1997) studied the term srtuctures in a sample 17 countries with time spans between 10 and 30 years, and monthly data for 1-month, 3-month, 6-month and 12-month euro rates. Using cross-sectional regression analysis, they concluded that for most of the countries the EHTS is compatible with the data. Jondeau and Ricart (1999) adopted the VECM approach to test the EHTS on French, German, UK and US euro rates. Using monthly data for 1-month, 3-month, 6-month and 12-month euro rates from 1975:1 to 1997:12, they could not reject the EHTS for French and UK rates, but they rejected it for German and US rates.

In the present paper we contribute to the existing literature in several ways. First, we use the most recent data available from the early 1990s to the present and the VECM approach (e.g., see Johansen (1988, 1991, 1994, 1995)) to test the EHTS of interest rates for the 10 new EU countries and 2 EMU countries, France and Germany[2]. The evidence suggests that the EHTS holds for all countries of our sample, except for Malta.

Second, we use the Gonzalo-Granger methodology to identify and estimate the common trends that drive the cointegrating relations between long and short rates in the given sample of countries. Hypothesis testing in this framework provides information as to which interest rate contains the common trend. This is useful information for the design of monetary policies of the 10 new EU countries and the 2 EMU countries.

Third, we analyze the possibility of short run interdependence among the monetary policies of these countries by conducting multivariate Granger causality tests based on the stationary components of the term structures. Our results indicate that the new EU countries and the 2 EMU countries set their monetary policies independently, in the short run.

Fourth, we investigate the possibility of long run interdependence of monetary policies by analyzing the long run co-movements of the estimated common trends among the term structure of interest rates. Hypothesis testing on the common trends provides information as to which countries contribute significantly to them. Our evidence indicates that, for most of the cases we examined, the common trends are determined by the permanent component of the EMU countries, thereby suggesting that the monetary policies of several of the new EU countries are determined by those of the 2 EMU countries in the long run. This is arguably the case for the group of the 4 Eastern European countries and Latvia. This finding, in turn, implies that these new EU countries may join the EMU successfully in the near future.

The rest of the paper is organized as follows. In Section 2 we briefly describe the EHTS of interest rates and outline the models for cointegration and common trends that we use in the paper. In Section 3 we describe the data and analyze the empirical results. In Section 4 we make some concluding remarks.

[2] France and Germany are chosen among the eurozone countries because they represent the core of the EMU.

2 Theoretical Framework

2.1 The EHTS of Interest Rates

The EHTS of interest rates states that the yield to maturity of an $n-$period bond $R_{n,t}$ will equal an average of the current and future rates on a set of $m-$period short yields $r_{m,t}$, with $m < n$, plus the term premium. The relationship can be expressed in the following form

$$(1 + R_{n,t})^n = \varphi^*_{n,t} \prod_{i=0}^{n-1} (1 + E_t r_{m,t+i}), \tag{1}$$

where $\varphi^*_{n,t}$ is a possible non-zero but stationary $n-$period term premium and E_t is the expectations operator conditional on information up to and including time t. The equality in equation (1) is established by the condition of no arbitrage opportunities to investors willing to hold both short term and long term bonds. Log-linearizing equation (1) we get

$$R_{n,t} = \varphi_{n,t} + (1/n) \sum_{i=0}^{n-1} E_t r_{m,t+i}. \tag{2}$$

where $\varphi_{n,t} = \log(\varphi^*_{n,t})$. Equation (2) indicates that the yield of the $n-$period bond and the $m-$period short yields are functionally related. For the subsequent analysis it is convenient to re-express equation (2) as

$$R_{n,t} - r_{m,t} = \varphi_{n,t} + (1/n) \sum_{i=1}^{n} E_t (r_{m,t+i-1} - r_{m,t}). \tag{3}$$

The left hand side of equation (3) represents the spread between the $n-$period (long term) yield and the $m-$period (short term) yield. Assuming that the yields are $I(1)$ and cointegrated the right hand side of equation (3) is stationary. It follows that the left hand side of equation (3) is stationary and that $(1, -1)'$ is a cointegration vector linking the long term and short term interest rates. In what follows, we analyze the time series and cointegration properties of the long term and short term interest rates, given the insights of equation (3).

2.2 The Cointegration and Common Trends Models

This section outlines the basic maximum likelihood theory of cointegration and the models that employed in the subsequent empirical analysis. The maximum likelihood theory of cointegration assumes that the stochastic variables are integrated of order one, or $I(1)$, and that the data generating process is a Gaussian[3] vector autoregressive model of finite order k, or $VAR(k)$ which may possibly include some deterministic components. Let Y_t be a $p-$dimensional column vector of $I(1)$ variables. Then the $VAR(k)$ can be written in a vector error-correction model (VECM) form as

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \mu_0 + \mu_1 t + \epsilon_t, \qquad t = 1...T \tag{4}$$

where Π and Γ_i are $p \times p$ matrices of coefficients, μ_0 and μ_1 are $p \times 1$ vectors of constant and trend coefficients, respectively and ϵ_t is a $p \times 1$ multivariate normal random error vector with mean vector zero and variance matrix Ω that is independent across time periods.

The hypothesis of cointegration can be stated in terms of the rank of the long run matrix Π in equation (4). Under the hypothesis of cointegration, this matrix can be written as

$$\Pi = \alpha\beta' \tag{5}$$

where α and β are $p \times r$ matrices of full rank. If $r = 0$, then $\Pi = 0$, which means that there is no linear combination of the elements of Y_t that is stationary. The other extreme case is when the rank of the Π matrix equals p. In this case Y_t is a stationary process. In the intermediate case, when $0 < r < p$ there are r stationary linear combinations of the elements of Y_t and $p - r$ non stationary common trends.

Under the hypothesis $\Pi = \alpha\beta'$, the relation between α and the deterministic term $\mu_t \equiv \mu_0 + \mu_1 t$ is crucial for the properties of the process Y_t. To see this, first decompose μ_0 and μ_1 in the directions of α and $\alpha_\perp$, where $\alpha_\perp$ is a $p \times (p - r)$ matrix that is the orthogonal complement to α:

[3] The Gaussian assumption is not necessary, but it is convenient for the derivation of asymptotic results.

$$\mu_i = \alpha\beta_i + \alpha_\perp\gamma_i, \qquad i = 0, 1 \tag{6}$$

where $\beta_i = (\alpha'\alpha)^{-1}\alpha'\mu_i$ and $\gamma_i = (\alpha'_\perp\alpha_\perp)^{-1}\alpha'_\perp\mu_i$. Next, following Johansen (1994), consider the following five submodels, which are ordered from the most to the least restrictive:

Model 0: $\mu_t = 0$

Model 1*: $\mu_t = \alpha\beta_0$

Model 1: $\mu_t = \alpha\beta_0 + \alpha_\perp\gamma_0$

Model 2*: $\mu_t = \alpha\beta_0 + \alpha_\perp\gamma_0 + \alpha\beta_1 t$

Model 2: $\mu_t = \alpha\beta_0 + \alpha_\perp\gamma_0 + (\alpha\beta_1 + \alpha_\perp\gamma_1)t$

The interpretation of these models becomes clear in the context of the solution of Y_t in equation (4). The solution is given by

$$Y_t = C\sum_{i=1}^{t}\epsilon_t + \frac{1}{2}\tau_2 t^2 + \tau_1 t + \tau_0 + W_t + A \tag{7}$$

where W_t is a stationary process, A is a vector such that $\beta' A = 0$, $C = \beta_\perp(\alpha'_\perp\Gamma\beta_\perp)^{-1}\alpha'_\perp$, $\Gamma = I_p - \sum_{i=1}^{k-1}\Gamma_i$, $\beta_\perp$ is a $p \times (p-r)$ matrix of full rank that is orthogonal to β and $\tau_2 = C\mu_1$.

Using equation (7), Johansen (1994) shows that the five submodels imply different behavior for the process Y_t and the cointegrating relations $\beta' Y_t$. Briefly, in Model 0, Y_t has no deterministic trend and all the stationary components have zero mean. In Model 1*, Y_t has neither quadratic or linear trend. However, both Y_t and the cointegrating relations $\beta' Y_t$ are allowed a constant term. In Model 1, Y_t has a linear trend, but the cointegrating relations $\beta' Y_t$ have no linear trend. In Model 2*, Y_t has no quadratic trend but Y_t has a linear trend that is present even in the cointegrating relations. In Model 2, Y_t has a quadratic trend but the cointegrating relations $\beta' Y_t$ have only a linear trend.

Because of the normality assumption, one can easily test for the reduced rank of the Π matrix using the maximum likelihood approach. This procedure gives at once the maximum likelihood estimators (MLE) of α and β and the eigenvalues needed in order to construct the likelihood ratio test. The MLE of α and β are obtained by regressing ΔY_t and Y_{t-1} on $\Delta Y_{t-1} ... \Delta Y_{t-k}$ and

μ_t (allowing for the restrictions imposed by each of the five models). These auxiliary regressions give residuals R_{0t} and R_{1t} respectively, and residual product matrices

$$S_{ij} = T^{-1} \sum_{t=1}^{T} R_{it} R'_{jt}, \qquad i,\ j = 0,\ 1 \tag{8}$$

Solving the eigenvalue problem

$$\left| \lambda S_{11} - S_{10} S_{00}^{-1} S_{01} \right| = 0 \tag{9}$$

for eigenvalues $1 > \widehat{\lambda}_1 > ... > \widehat{\lambda}_p > 0$ and eigenvectors $\widehat{V} = (\widehat{v}_1 ... \widehat{v}_p)$, normalized such that $\widehat{V}' S_{11} \widehat{V} = I$, one gets the MLE of α and β as $\widehat{\alpha} = S_{01}\ \widehat{\beta}$ and $\widehat{\beta} = (\widehat{v}_1 ... \widehat{v}_r)$, where $(\widehat{v}_1 ... \widehat{v}_r)$ are the eigenvectors associated with the r largest eigenvalues of equation (9).

In testing the null hypothesis that $rank(\Pi) \leq r$ against the alternative hypothesis that $rank(\Pi) = p$, the likelihood ratio statistic, called also the Trace statistic by Johansen and Juselius (1990), is given by

$$Trace = -T \sum_{i=r+1}^{p} \ln(1 - \widehat{\lambda}_i) \tag{10}$$

The testing is performed sequentially for $r = 0, ..., p-1$ and it terminates when the null hypothesis is not rejected for the first time.

It is also possible to test the null hypothesis that $rank(\Pi) = r$ against the alternative that $rank(\Pi) = r + 1$. In this case, the likelihood ratio statistic, which is called the $\lambda_{\max}$ statistic, is given by

$$\lambda_{\max} = -T \ln(1 - \widehat{\lambda}_{r+1}). \tag{11}$$

Of course, the $\lambda_{\max}$ statistic is equal to the Trace statistic when $p - r = 1$.

MacKinnon, Haug and Michelis (1999) have computed highly accurate critical values for the Trace statistic in equation (10) and the $\lambda_{\max}$ statistic in equation (11), using the response surface methodology. These critical values differ substantially from those existing in the literature, especially when the dimension of the VECM is large; e.g., compare to Osterwald-Lenum (1992).

Since we deal with large dimensional systems in this study, we use these new critical values for testing hypotheses[4].

In respect to the common trends, it is clear from equation (7) that the common trends in Y_t are contained in the first term of that expression. Given the definition of C, Johansen (1995, p. 41) defines the common trends by the cumulated disturbances $\alpha'_{\perp}\sum_{i=1}^{t}\epsilon_t$. Assuming that the common trends are a linear combination of Y_t, in the form $f_t = \alpha'_{\perp}Y_t$, Gonzalo and Granger (1995) derived the MLE of $\alpha_{\perp}$ as the eigenvectors corresponding to the $(p-r)$ smallest eigenvalues of the problem

$$\left|\lambda S_{00} - S_{01}S_{11}^{-1}S_{10}\right| = 0. \tag{12}$$

Solving equation (12) for eigenvalues $1 > \widehat{\lambda}_1 > ... > \widehat{\lambda}_p > 0$ and eigenvectors $\widehat{M} = (\widehat{m}_1 ... \widehat{m}_p)$, normalized such that $\widehat{M}'S_{00}\widehat{M} = I$, one gets the MLE of $\alpha_{\perp}$ as $\widehat{\alpha}_{\perp} = (\widehat{m}_{r+1} ... \widehat{m}_p)$.

Given this framework, it is easy to test whether or not certain linear combinations of Y_t can be common trends. Null hypotheses on $\alpha_{\perp}$ have the following form

$$H_0 : \alpha_{\perp} = G\theta \tag{13}$$

where G is a $p \times m$ known matrix of constants and θ is an $m \times (p-r)$ matrix of unknown coefficients such that $p - r \leq m \leq p$. To carry out the test, one solves the eigenvalue problem

$$\left|\lambda G'S_{00}G - G'S_{01}S_{11}^{-1}S_{10}G\right| = 0 \tag{14}$$

for eigenvalues $1 > \widehat{\lambda}_1^* > ... > \widehat{\lambda}_m^* > 0$, and eigenvectors $\widehat{M}^* = (\widehat{m}_1^* ... \widehat{m}_m^*)$, normalized such that $\widehat{M}^{*\prime}(G'S_{00}G)\widehat{M}^* = I$. Choose $\widehat{\theta}_{m\times(p-r)} = (\widehat{m}_{(m+1)-(p-r)} ... \widehat{m}_m)$ and $\widehat{\alpha}_{\perp} = G\widehat{\theta}$. The likelihood ratio test statistic for testing H_0 is given by

$$L = -T\sum_{i=r+1}^{p} \ln\left[(1-\widehat{\lambda}^*_{i+(m-p)})/(1-\widehat{\lambda}_i)\right]. \tag{15}$$

In the next section, we use the $L-$statistic in (15) to test the statistical significance of the

[4] The latest edition of EViews 5 has also adopted the MacKinnon et al.(1999) critical values.

$\alpha_\perp$ of the long term and the short term interest rate of the EU accession countries and the 2 EMU countries. A significant $\alpha_\perp$ implies that the respective interest rate is weakly exogenous and dominates the common trend in the cointegrating system.

3 Data and Empirical Results

3.1 Data

We collected data for the 10 new EU countries and for France and Germany. Due to lack of data availability we worked only on two interest rates for each country: either treasury bill yields (short term) and government bond yields (long term) or short term and long term commercial banks' lending rates. Our sample consists of monthly data of varying time spans for different countries determined by data availability. All interest rates are expressed in natural logarithms.

For Cyprus the time span is 1997:1 to 2004:12. Monthly average treasury bill rates were obtained from line 60c of the CD-ROM of the International Financial Statistics (IFS) of the IMF, 2004. Monthly average government bond yields were obtained from the Central Bank of Cyprus and refer to bonds with maturity greater than 5 years. For the Czech Republic the time span is 1993:8 to 2004:12. Treasury bill rates were taken from line 60c of the IFS. Long term government bond yields were obtained from line 61 of the IFS. This IFS data series begins at January 2000. For the period 1993:8-1999:12 we used long term government bond yields obtained from the Central Bank of the Czech Republic.

No data on treasury bill rates or government bond yields are available for Estonia, Latvia, Lithuania and Slovenia. For this reason, we used commercial banks' lending rates instead. For Estonia the time span is 1994:1 to 2004:12. Three-month lending rates were obtained from the Main Economic Indicators (MEI) of the OECD, 2004, and 10-year lending rates were taken from the Central Bank of Estonia. For Latvia short term and long term lending rates were obtained from the MEI and the time span is 1993:1 to 2004:12. For Lithuania 6 to12 months and over 5 years lending rates were taken from the Central Bank of Lithuania and the time span is 1997:1 to 2004:12. For Slovenia the time span is 1996:1 to 2004:12 and the short term and long term lending rates were obtained from the Central Bank of Slovenia.

For Hungary the time span is 1997:1 to 2004:12. The 3-month treasury bill rates and the 5-year government bond yields were obtained from the Central Bank of Hungary. For Malta the time span is 1993:1 to 2004:12. Monthly average treasury bill rates were obtained from line 60c of the IFS, while 5-year monthly average government bond yields were taken from the Central Bank of Malta.

For Poland the time span is 1994:2 to 2004:12. The 1-year treasury bill rates and the over 2 years government bond yields were obtained from the Polish Ministry of Finance. In the case of the Slovak Republic the time span is 1994:12 to 2004:12. The 1 to 6 months treasury bill rates were taken from the Central Bank of the Slovak Republic. For government bond yields the IFS data series (line 61) for the Slovak Republic begins at September 2000 and refers to 10-year government bond yields. For the period 1994:12-2000:8 we collected data from the Central Bank of the Slovak Republic.

For France the time span is 1988:1 to 2004:12. The 3-month treasury bill rates were obtained from the Central Bank of France and the long term government bond yields were taken from line 61 of the IFS. For Germany the time span is 1988:1 to 2004:12. The 12-month treasury bill rates were taken from line 60c of the IFS and the 5-year government bond yields were obtained from the Central Bank of Germany.

3.2 Testing for the EHTS

In this section we report and analyze the unit root and cointegration results between the short term and the long term interest rates for each country. Evidence of cointegration would validate empirically the EHTS of interest rates.

Before testing for cointegration, we tested each time series for unit roots using the Augmented Dickey-Fuller test at the 5 percent level of significance. The results are presented in Table 1. To select the appropriate lag length for the ADF test regression, we used the Akaike's information criterion. As shown in Table 1, we fail to reject the unit root hypothesis in the long and short rates for all countries, except Poland. In all the cases where the unit root hypothesis was not rejected , we also tested for a second unit root. As shown in Table 1, this hypothesis was rejected in all cases. Based on these results we proceeded with cointegration analysis using the VECM in equation (4) above, where $Y_t = (R_{n,t}, r_{m,t})'$.

To select the appropriate lag length, k, in equation (4), we set up a separate VECM for each country and used the likelihood ratio test. Under the hypothesis $\Gamma_k = 0$, the likelihood ratio test is asymptotically distributed as χ^2 with p^2 degrees of freedom (see Johansen 1995, p. 21). Further, to determine which submodel describes best each set of variables, we tested the submodels against each other using the likelihood ratio tests in Johansen (1995, Chapter 11, Corollary 11.2 and Theorem 11.3, pp. 161-162). These tests are also distributed as χ^2 with degrees of freedom determined by the pairs of models being tested as follows:

$$0 \underset{r}{\subset} 1^* \underset{p-r}{\subset} 1 \underset{r}{\subset} 2^* \underset{p-r}{\subset} 2 \ .$$

Table 2 reports the cointegration results between the long and short rates for each of the new EU countries, other than Poland, and the 2 EMU countries. Based on the Trace and the $\lambda_{\max}$ statistics at the 5 and the 10 percent level of significance, we find evidence of one cointegrating vector between the short term and the long term interest rates in all the countries, except Malta. Clearly, this is evidence in support of the EHTS of interest rates in all countries in this sample, except for Malta.

Table 3 reports the parameter estimates of the cointegration vectors, normalized on the long rate, for the countries for which there is evidence in the direction of the EHTS (i.e. Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, the Slovak Republic, Slovenia, France and Germany). Numbers in parentheses are likelihood ratio test statistics which are distributed as χ^2_1 asymptotically, under the null hypothesis that each component of the cointegration vector is insignificantly different from zero. As shown in Table 3, the parameters of the cointegrating vectors (β_i's) are statistically significant in all cases, which means that the short term and the long term interest rates enter significantly each cointegration vector. We also tested the hypothesis $H_0 : \beta_R + \beta_r = 0$, when $(\beta_R, \beta_r) = (1, -1)$. Equivalently, we tested whether or not the spread between the long term and short term interest rates belongs in the cointegration space of the term structure, as suggested by the EHTS. Using the likelihood ratio test statistic at the 5 percent level of significance, this hypothesis is rejected for Cyprus, the Czech Republic, Hungary, Latvia, Slovenia, France and Germany, but it cannot be rejected for Estonia, Lithuania and the Slovak Republic. Consequently, only the latter group of countries satisfy the EHTS exactly.

The parameter estimates of the adjustment coefficients α_R and α_r are also presented in Table 3. These are the coefficients of the error correction terms in the VECM and their subscripts denote the variable that adjusts to deviations from the long run equilibrium relation between the two rates. As shown in Table 3, α_R is statistically significant and α_r is statistically insignificant at the 5 percent level, for the three Baltic countries (i.e., Estonia, Latvia and Lithuania). This implies that, for this group of countries, the long term interest rate is an endogenous variable which adjusts to deviations from its long run equilibrium with the short rate. At the same time, the short rate is a weakly exogenous variable, changes of which have a permanent effect on both the long rate and the short rate. On the other hand, α_R is statistically insignificant and α_r is statistically significant for Cyprus, the Czech Republic, Hungary, the Slovak Republic, Slovenia, France and Germany. Hence for the latter group of countries, the evidence suggests that the short term interest rate adjusts to deviations from the long run equilibrium, while the long rate is weakly exogenous, affected primarily by fundamental factors such as the future state of the economy and expectations about the future path of government policies.

These empirical findings are reinforced by direct tests on the $\alpha_{\perp}$'s, the components of the common trend in each country. In order to test the statistical significance of each of the $\alpha_{\perp}$'s, we computed the $L-$statistic in equation (15) for specific choices of the G matrix. In particular, to test the null hypothesis that the long term interest rate has a permanent component in the common trend of a country, we set the G matrix to

$$G = \begin{bmatrix} 1 \\ 0 \end{bmatrix}.$$

Alternatively, to test the hypothesis that the short term interest rate has a permanent component in the common trend, we set the G matrix to

$$G = \begin{bmatrix} 0 \\ 1 \end{bmatrix}.$$

Table 3 reports the computed $L-$statistics. For the countries for which α_R is statistically significant (i.e., the three Baltic countries), the null hypothesis that the short term interest rate, r, has a permanent component in the common trend cannot be rejected at the 5 percent level of significance.

On the other hand, for the countries with a significant α_r (i.e. Cyprus, the Czech Republic, the Slovak Republic, Slovenia, France and Germany), the null hypothesis that the long term interest rate, R, has a permanent component in the common trend cannot be rejected at the 5 percent level of significance. For Hungary the null hypothesis cannot be rejected at the 10 percent level of significance. For these countries the short term interest rate adjusts to deviation from the long run equilibrium, while the long term interest rate is not affected by past disequilibria and thus "drives" the common trend.

3.3 Short Run Interdependence of Policies

In this section we analyze short run interdependence of monetary policies among the new EU countries and the 2 EMU countries, using Granger causality tests on the stationary components of the term structures. In order to include all the countries in our analysis, the time span is restricted to 1997:1- 2004:12. Poland is also included in this analysis as its interest rates and their spread are stationary variables.

Fluctuations in the transitory component (or the spread) of the term structure are often thought to be caused by changes in monetary policy. If these fluctuations are related across the new EU countries and the 2 EMU countries, then it is possible that, in addition to long run interdependence, their policy actions are interdependent in the short run. Since the transitory components of the term structures are stationary, we tested for such interdependence explicitly by conducting causality tests among the cointegrating relations, based on multivariate VAR models . The appropriate lag length for each VAR was selected using the likelihood ratio test, mentioned above.

Table 4 reports the causality results from the estimated VAR models. The tests results contain pairwise causality tests and joint causality tests that include all the countries in sample, except Malta. Malta was excluded from this analysis, since its interest rates do not cointegrate. It is clear from Table 4 that there is weak short run interdependence among the term structures of the countries in this group. Only 8 out of 110 possible pairwise test statistics (excluding the own effects) and 1 out of 11 joint test statistics are significant at the 5 percent level of significance.

Of the 8 significant pairwise tests, 2 pertain to France and Germany, correctly pointing to bidirectional causality between the spreads of the two countries. This is an expected result, since these two countries are members of the EMU and have had their monetary policies coordinated for a long time through the exchange rate mechanism of the European Monetary System. The remaining 6 significant pairwise tests are less plausible and harder to justify, as they relate to pairs of countries with apparently independent monetary policies. The single significant joint test pertains to all the countries in the sample affecting the German spread. This finding may be surprising but it points to the lack of German dominance within the EMU, that has been discussed in the literature; see e.g., Hafer, Kutan and Zhou (1997).

Overall, the majority of the above results point in the right direction by indicating weak short run linkages among the term structures, and thus independence of monetary policies among the new EU countries and the 2 EMU countries. This main finding is consistent with the absence, to date, of explicit coordination of monetary policies across the new EU countries and in relation to France and Germany.

3.4 Long Run Interdependence of Policies

In this section, we examine the possibility of long run linkages among the monetary policies of the new EU countries and the 2 EMU countries. To accomplish this objective we proceed sequentially using the results of Tables 2 and 3. First, we test for cointegration between the two estimated common trends of France and Germany. Second, having found that these two common trends cointegrate, we then tested for cointegration in the 3-dimensional VECMs, each consisting of the long and short rates for each country and the shared common trend of France and Germany[5]. In each case we also tested if the French/German common trend dominates the estimated common trend in each system. If it does, then we claim that the EMU determines the monetary policy of the country in the long run. The empirical evidence suggests that this is indeed the case for most of the new EU countries.

All the cointegration results were obtained using Johansen's likelihood ratio tests. In order to examine if the permanent component of the 2 EMU countries determines the common trend(s) in each VECM, we tested the statistical significance of the estimated $\alpha_{\perp}$'s, by computing the $L-$statistic in equation (15) for the following choice of the G matrix:

$$G = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix},$$

where the three rows correspond to the long and short interest rates for each country and the permanent component of France/Germany common trend, respectively.

The results are reported in Table 5. The first panel reports the results for the 2 EMU countries. As expected, the results indicate one cointegrating vector and one shared common trend, which is determined by the French common trend. The null hypothesis that Germany determines the common trend is rejected marginally, pointing, again, to the lack of German dominance within the EMU, from a long run perspective.

The second panel of Table 5 reports the results for each country in relation to the French/ German common trend. The cointegration results indicate that each country, except Malta, shares a single common trend with France and Germany, and that this trend is dominated by the French/German common trend, at the 5 percent level, except in the case of Estonia, Lithuania and Cyprus. Further as shown above, the EHTS does not hold for Malta, and this is reflected in the last row of the Table 5, that shows one cointegrating vector and two common trends.

[5] The appropriate lag length k for each VECM and the sub-model that describes best each set of variables were chosen following the same procedures as in Section 3.2 above.

Nonetheless, the French/German common factor and Malta's short rate enter significantly in the two common trends of this system. Consequently, the EMU still has a long run impact on Malta's term structure.

On the other hand, the EMU has decisive impact on the long run behavior of the term structures of the 4 Eastern European countries and Latvia. Evidently, these countries have adjusted their monetary policies in the direction of the EMU countries. No major monetary adjustments will be required if and when these countries decide to join the EMU in the future. At the same time, the evidence for Cyprus, Estonia and Lithuania suggests that the monetary policies of these countries are not influenced by those of the EMU countries in the long run. Thus, they may need to adjust their policies towards the EMU countries in order to be ready to join the EMU[6]. Currently, these countries face similar macroeconomic conditions. For example, the increasing debt rate of Estonia and Lithuania has lead them to adopt low interest rates in order to attract foreign investment and service their debt. Cyprus, also, faces an increasing debt rate and only recently has allowed its interest rates to be determined completely by the free market. These facts may explain our evidence. Currently though these countries, along with most of the new EU countries, are preparing to join the Exchange Rate Mechanism II, an action that will allow them to adjust their policies in the direction of the EMU countries.

Overall, the above findings indicate that for the most of the new EU countries, their monetary policies are determined by the monetary policy of the EMU, in the long run. These results strengthen the case that the new EU member states will successfully join the EMU in the future.

[6] These results are consistent with the results of a separate exercise where we examined the cointegration properties of the common trends for subgroups of countries. For the system that included the common trends of the four Central European countries and the French/German common trend, our results indicated four cointegrating vectors and a single common trend. The system consisting of the three common trends of the Baltic countries and the French/German common trend, had two cointegrating relations and two common trends. For the system that included all the new EU countries (except Malta and Poland) and French/German common trend, our results indicated seven cointegrating vectors and two common trends.

4 Concluding Remarks

In this paper we investigated empirically the term structure of interest rates among the 10 new EU countries and the 2 core EMU countries, France and Germany. Since the interest rates follow random walks, we evaluated the expectations hypothesis of the term structure using cointegration analysis and common trends techniques. Further, we analyzed short run and long run interdependence among the monetary policies of the new EU countries and the 2 EMU countries.

Our empirical findings indicate that the EHTS holds for all the new EU countries, except for Malta. For Cyprus, the Czech Republic, Hungary, the Slovak Republic, Slovenia, France and Germany, the long term interest rate is weakly exogenous and drives the common trend in each term structure. On the other hand, for the three Baltic countries, the short term interest rate is weakly exogenous and has a permanent component in the common trend.

Our results also indicate that most of the new EU countries set their monetary policies independent, in the short run, and changes in their policies are not influenced by changes in the monetary policies of France or Germany. However, in the long run, the monetary policies of the new EU member states, other than those of Cyprus, Estonia and Lithuania, are determined by the monetary policies of the 2 EMU countries.

By focusing on common trends analysis, our study provides new and useful insights about the degree of monetary convergence of the new EU member states with the core of the eurozone. There is clear evidence of long run convergence of the monetary policies of the four Eastern European countries and Latvia with the monetary policies of the EMU. Thus these new EU countries may be ready to join the EMU successfully in the near future. The rest of the new EMU countries do not seem to be completely ready yet, and may require further adjustments in their monetary policies in the direction of the EMU policies.

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Table 1
Augmented Dickey - Fuller tests for a unit root[a]

Country	Short term interest rate Level	First difference	Long term interest rate Level	First difference
Cyprus	-1.42	-9.29*	-1.50	-4.86*
Czech Republic	-1.60	-6.66*	-1.88	-9.37*
Estonia	-2.46	-9.61*	-2.05	-8.44*
Hungary	-1.64	-6.10*	-1.47	-7.40*
Latvia	-1.87	-4.24*	-0.50	-5.99*
Lithuania	-2.00	-13.40*	-1.85	-7.21*
Malta	-0.78	-6.44*	-1.91	-4.58*
Poland	-3.99*		-4.50*	
Slovak Republic	-1.56	-11.66*	-1.75	-10.42*
Slovenia	-1.45	-10.36*	-0.55	-9.92*
France	-2.46	-8.30*	-0.57*	-6.41*
Germany	-0.51	-8.86*	-1.51	-3.96*

[a] The entry in each cell is the ADF test statistic. * denotes rejection of the unit root hypothesis at the 5% level of significance. For the countries of the table, the sample sizes are 96 for Cyprus, 137 for the Czech Republic, 132 for Estonia, 96 for Hungary, 144 for Latvia, 96 for Lithuania, 144 for Malta, 131 for Poland, 121 for the Slovak Republic, 108 for Slovenia, 204 for France and 204 for Germany.

Table 2
Trace and $\lambda_{\max}$ statistics

	Cyprus		Czech Republic		Estonia		Hungary	
$(p-r)$	Trace	$\lambda_{\max}$	Trace	$\lambda_{\max}$	Trace	$\lambda_{\max}$	Trace	$\lambda_{\max}$
2	38.23**	38.11**	20.88**	19.67**	17.23**	15.20**	15.09**	13.29**
1	0.13	0.13	1.21	1.21	2.04	2.04	1.80	1.80
k^{a}	2		3		3		2	
Model	0		1*		0		0	
	Latvia		**Lithuania**		**Malta**		**Slovak Republic**	
$(p-r)$	Trace	$\lambda_{\max}$	Trace	$\lambda_{\max}$	Trace	$\lambda_{\max}$	Trace	$\lambda_{\max}$
2	28.76**	23.30**	21.44**	16.03**	2.86	1.75	24.99**	24.65**
1	5.46	5.46	5.41	5.41	1.11	1.11	0.34	0.34
k	6		5		3		3	
Model	1*		1*		0		0	
	Slovenia		**France**		**Germany**			
$(p-r)$	Trace	$\lambda_{\max}$	Trace	$\lambda_{\max}$	Trace	$\lambda_{\max}$		
2	14.12**	11.75**	18.71*	15.22*	19.89*	18.33**		
1	2.37	2.37	3.49	3.49	1.56	1.56		
k	4		2		1			
Model	0		1*		1*			
	5% critical values for Model 0		**5% critical values for Model 1***		**10% critical values for Model 1***			
$(p-r)$	Trace	$\lambda_{\max}$	Trace	$\lambda_{\max}$	Trace	$\lambda_{\max}$		
2	12.32	11.23	20.25	15.88	17.98	13.91		
1	4.13	4.13	9.17	9.17	7.56	7.56		

The value reported at the top of each column is for $r = 0$, so that $p - r = p$, where $p = 2$ (i.e. the number of interest rates included). ** (*) denotes rejection of the null hypothesis of at most r cointegrating relations at the 5% (10%) level of significance.
[a] k indicates the lag length.

Table 3
Testing for the term structure of interest rates

	Cyprus	Czech Republic	Estonia	Hungary
β_R	1.00** (37.78)	1.00** (18.33)	1.00** 12.54)	1.00** (11.43)
β_r	-1.16** (37.89)	-0.72** (17.28)	-1.00** (13.13)	-0.93** (11.47)
$H_0 : \beta_R + \beta_r = 0$	37.51**	14.54**	0.01	9.52**
α_R	0.03 (0.18)	-0.06 (1.16)	-0.09** (9.66)	-0.10 (0.78)
α_r	0.49** (37.41)	0.12** (16.75)	0.09 (2.67)	0.23* (3.31)
$\alpha_\perp^R$	-27.58	-14.67	-3.63**	-11.17
$L-$statistic	0.18	1.16	9.66	0.78
$\alpha_\perp^r$	1.80**	-7.09**	-3.75	-4.72*
$L-$statistic	37.38	16.77	2.67	3.31
	Latvia	**Lithuania**	**Slovak Republic**	**Slovenia**
β_R	1.00** (17.67)	1.00** (9.42)	1.00** (23.81)	1.00* (3.41)
β_r	-0.68** (17.77)	-0.84** (10.37)	-1.00** (22.70)	-1.09* (3.83)
$H_0 : \beta_R + \beta_r = 0$	14.24**	0.45	0.02	9.11**
α_R	-0.47** (14.35)	-0.23** (10.58)	-0.07 (2.48)	0.04 (2.10)
α_r	0.13 (1.97)	0.01 (0.11)	0.14** (7.79)	0.08** (7.96)
$\alpha_\perp^R$	2.41**	0.78**	-4.81	-29.16
$L-$statistic	14.34	10.57	2.48	2.09
$\alpha_\perp^r$	9.05	13.30	-2.66**	13.76**
$L-$statistic	1.97	0.11	7.79	7.97
	France	**Germany**		
β_R	1.00** (11.32)	1.00** (16.34)		
β_r	-0.52** (11.39)	-0.66** (13.81)		
$H_0 : \beta_R + \beta_r = 0$	10.47**	14.52**		
α_R	0.01 (0.09)	-0.01 (0.12)		
α_r	0.14** (11.17)	0.14** (8.54)		
$\alpha_\perp^R$	-33.64	-19.85		
$L-$statistic	0.10	0.12		
$\alpha_\perp^r$	1.72**	-1.92**		
$L-$statistic	11.16	8.52		

R and r denote the long term and short term interest rate respectively. The β's are the parameters of the cointegrating vectors, normalized on the long term interest rates. The α's are the adjustment coefficients and $\alpha_\perp$s are their orthogonal complements. Numbers in parentheses are likelihood ratio statistics for $H_0 : \beta_i = 0$ or $H_0 : \alpha_i = 0$. Numbers in the row of $H_0 : \beta_R + \beta_r = 0$ are likelihood ratio test statistics. $L-$statistics are for the null hypothesis that the respective interest rate (either R or r) determines the common trend. ** (*) denotes rejection of the null hypothesis at the 5% (10%) level of significance.

Table 4
Short run interdependence among the new EU countries and the EMU countries: Multivariate Granger Causality tests[a]

Dependent variable	Explanatory variables (lag length = 3) CY	CZ	EE	HU	LV	LT	PL	SK
CY	21.31*	4.58	2.48	8.82*	2.90	1.10	1.60	0.29
CZ	3.98	53.14*	4.91	1.92	1.88	3.12	1.10	4.13
EE	3.69	9.56*	14.64*	1.81	0.60	1.57	9.84*	2.18
HU	2.59	4.61	5.64	56.27*	1.54	1.72	1.93	2.59
LV	2.51	2.60	3.34	1.31	16.38*	1.58	5.16	2.07
LT	0.41	1.49	2.05	1.25	2.06	63.99*	3.98	0.31
PL	1.28	0.07	4.18	1.74	1.69	1.00	210.44*	1.68
SK	0.61	2.14	12.10*	0.26	3.36	3.10	0.94	8.51*
SV	0.88	1.09	4.64	1.53	1.86	3.60	2.09	10.89*
FR	1.10	4.18	1.87	4.83	0.23	3.16	3.25	1.94
GE	3.04	7.60	2.78	0.94	6.77	4.01	2.04	3.10
df [b]	3	3	3	3	3	3	3	3

	SV	FR	GE	Joint
CY	3.50	2.02	0.34	28.51
CZ	2.12	3.49	1.11	24.92
EE	1.42	4.22	2.45	39.83
HU	1.33	0.85	2.71	21.69
LV	1.25	3.46	1.98	28.34
LT	1.42	1.20	1.47	19.03
PL	1.38	3.32	2.92	19.04
SK	2.77	3.82	3.42	32.38
SV	314.79*	2.52	3.97	42.77
FR	9.48*	144.04*	8.14*	40.62
GE	6.29	37.39*	17.63*	72.18*
df	3	3	3	30

[a] The number in each cell is the Wald test statistic, which, under the null, is asymptotically distributed as χ^2. [b] df stands for the degrees of freedom.
* denotes rejection of the null hypothesis $\Gamma_k = 0$ at the 5% level of significance.
The country symbols are: CY for Cyprus, CZ for the Czech Republic, EE for Estonia, HU for Hungary, LV for Latvia, LT for Lithuania, PL for Poland, SK for the Slovak Republic, SV for Slovenia, FR for France and GE for Germany.

Table 5
Common trend linkages among the new EU countries and the EMU countries

Group	CEs [a]	CTs [b]	H_0 [c]	$L-statistic$	df [d]	$\chi^2_{(0.05)}$
EMU-2	1	1	French CT	0.01	1	3.84
			German CT	3.99*	1	3.84

Country	CEs	CTs	H_0	$L-statistic$	df	$\chi^2_{(0.05)}$
Czech Republic	2	1	$F\&G$	3.37	2	5.99
Hungary	2	1	$F\&G$	5.67	2	5.99
Slovak Republic	2	1	$F\&G$	5.13	2	5.99
Slovenia	2	1	$F\&G$	1.31	2	5.99
Estonia	2	1	$F\&G$	18.90*	2	5.99
Latvia	2	1	$F\&G$	1.76	2	5.99
Lithuania	2	1	$F\&G$	7.20*	2	5.99
Cyprus	2	1	$F\&G$	12.25*	2	5.99
Malta	1	2	$F\&G$ and R	17.26*	2	5.99
			$F\&G$ and r	0.63	2	5.99

[a] CEs stands for the number of cointegrating relations, which is indicated by the Trace and $\lambda_{\max}$ statistics at the 5% level of significance. [b] CTs denotes the number of common trends. [c] H_0 tests whether France or Germany determines the shared common between them trend. [d] df $= (p-r) \times (p-m)$ stands for the degrees of freedom of the $L-statistic$. $F\&G$ stands for the permanent component of the French and the German common trend. * denotes rejection of the null hypothesis at the 5% level of significance.