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Testing the Expectations Hypothesis for the UK Term Structure

(First draft)

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Abstract

This paper tests the expectations hypothesis (EH) for the UK term structure of interest rates, employing regression analysis, volatility metrics and recently developed Lagrange Multiplier tests. The Lagrange Multiplier test of Bekaert and Hodrick (2001), whose asymptotic and small sample inferences are based on i.i.d. residuals of the VAR, is extended to allow for heteroskedasticity by using the wild bootstrap. Using simulations we assess the performance of both the Lagrange Multiplier and volatility tests. Our results show that although the EH does not hold for UK interest rates at the short end of the maturity spectrum, there is robust support for this theory at interim maturities.

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Section 1. Introduction

Interrelationship between interest rates of various maturities is a fundamental topic in economics and finance. One of the most tested theories of this relationship is the expectations hypothesis (EH) theory. According to the EH of the term structure, in equilibrium, investing in a succession of short-term bonds gives exactly the same expected return as investing in long-term bonds, when adjustment is made for the term premium.[1] Although various tests of this implication have yielded different results over various periods of time, less evidence against the EH has been found for the UK and other developed countries compared to US (see e.g. Hardoulelis 1994, Cuthbertson 1996, Cuthbertson, Hayes and Nitzsche 2000, and Engsted 2002). Campbell and Shiller (1991), Campbell (1995), Rudebusch (1995) and Roberds and Whiteman (1999) note the EH works better at the short and long ends of the maturity spectrum and less well in the intermediate maturity range for a given short rate, thus creating a "U" shaped pattern. However, Thornton (2004) illustrates that analysis should not be based on the slope coefficient of the test equation only, since even under the alternative hypothesis where the EH does not hold, one can have slopes that are numerically close to the theoretical ones.

Mankiw and Miron (1986) argues that the poor performance of the EH for the US over some periods is related to monetary policy pursued by the Fed, performing better in periods of monetary targeting than in periods of interest rate targeting (and even better before the foundation of the Fed).[2] Rudebusch (1995), Roberds, Runkle, and Whiteman (1996), and Balduzzi, Bertola and Foresi (1997) provide models that accommodate Fed behaviour and confirm Mankiw and Miron's finding.

The EH has not been subject to extensive testing for the UK, Taylor (1992), Cuthbertson (1996), MacDonald and Speight (1988), Cuthbertson, Hayes and Nitzsche (1996), and Cuthbertson and Nitzsche (2003) provide results for the UK using Treasury bill and bond rates, the Certificate Deposit rates, the London interbank offer rates, but all concentrate on only a portion of the maturity spectrum. While first two

[1] Another implication of the EH is that the forward interest rate must equal the expected spot rate. This implication is the subject of studies by Fama (1984), Fama and Bliss (1987), Backus, Foresi, Mozumdar and Wu (2001) and Christiansen (2003), among others, and will not be discussed in the present paper.
[2] Engsted (1996) reports similar results for Denmark.

studies provide rather mixed results, the next two clearly provide results favourable to the EH. Cuthbertson and Nitzsche (2003) do not reject the theory when the short rate is 1 month TB and the long rate is 10 years or shorter yield.

This paper extends the UK term structure literature by using a recently developed method by Bekaert and Hodrick (2001) to test the EH. The paper applies their testing methodology using multiple interest rate maturity pairs, as opposed to a single maturity pair they originally consider. Both asymptotic and small sample inferences rely on i.i.d. bootstrap of the VAR residuals in Bekaert and Hodrick (2001). However Goncalves and Kilian (2004) show that such resampling scheme is inaccurate in the presence of the conditional heteroskedasticity, which characterizes many financial time series. We therefore apply a wild bootstrap scheme to the Bekaert and Hodrick methodology. We also explore the claim of Sarno, Thornton and Valente (2005) that an informal analysis of the EH, as suggested in Campbell and Shiller (1987, 1991), is misleading in the UK when volatility clustering is allowed. Based on the US analysis that find monetary policy to be important, we examine this in the UK context by splitting our sample into the periods before and after the adoption of inflation targeting.

The paper is organised as follows. Section 2 examines the implications of the EH theory of the term structure of interest rates and outlines the methodologies adopted in our study. Section 3 discusses data and provides our empirical results. Section 4 concludes.

Section 2. Expectations hypothesis theory of the term structure

2.1. Single Equation framework

According to the EH, a long term interest rate equals the sum of a constant term premium and an average of current and future short term interest rates over the life of the long term interest rate. That is, in a linearized version of the EH (see Shiller 1979)

$$R_{n,t} = \frac{1}{k}\sum_{i=0}^{k-1} E_t R_{m,t+mi} + \pi_{n,m} \ ; \qquad (1)$$

where $R_{n,t}$ and $R_{m,t}$ are long and short rates at time t respectively, $E_tR_{m,t+mi}$, $i=0,1,2,\ldots k-1$, is the expectation of the short rates at $t+mi$ formed at time t and $\pi_{n,m}$ is a term premium which can vary across maturities but not through time. Here $k=n/m$ is defined to be an integer, m is the maturity of a shorter rate and n is the maturity of a longer rate. Since the EH places no restriction on $\pi_{n,m}$, this term can be ignored by working with demeaned series.[3]

Equation (1) is rarely tested directly, probably due to the empirical results that conclude the series are integrated, in which case conventional statistical theory is not appropriate. Rather, another implication of (1) is usually tested, which is based on the ability of the spread between long and short rates to predict future short rate changes after imposing rationality on the expectations. Rationality requires

$$R_{m,t+mi} = E_tR_{m,t+mi} + v_{t+mi}, \tag{2}$$

where v_{t+mi} has zero mean and is orthogonal to the information available at time t. Subtracting $R_{m,t}$ from both sides of equation (1) and imposing rational expectations as in (2) yields probably the most commonly tested equation of the EH, which, after some rearrangement, can be written as

$$\sum_{i=1}^{k-1}(1-\frac{i}{k})\Delta^m R_{m,t+mi} = -\theta_{n,m} + \alpha S_{(n,m),t} + e_{(n,m),t}\,; \tag{3}$$

where $\Delta^m R_{m,t+m} = R_{m,t+m} - R_{m,t}$, $S_{(n,m),t} = R_{n,t} - R_{m,t}$ and $e_{(n,m),t}$ is a moving average process of order (n-m-1).

Equation (3) says that the current spread predicts a cumulative change in shorter term (m-period) interest rate over n periods, and under the null hypothesis of the EH, α should be unity.[4]

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[3] This assumption will simplify the derivation of restrictions on VAR parameters in what follows. See Melino (2001).

[4] Another implication of (1), that is less empirically supported, is that the yield spread predicts the m-period change in the longer- term yield, which is tested (see, for instance, Campbell and Shiller 1991) in $R_{n-m,t+m} - R_{n,t} = \gamma + \beta \frac{m}{n-m} S_{(n,m),t} + v_t$; under the null β is unity.

However, there are several econometric difficulties with the conventional regression approach applied to this equation. Firstly, we lose $(k-1)m$ observations at the end of the sample period. This can be quite serious in our case, as the data available for analysis are relatively small. For example, while our data spans January 1979 to May 2005, regression (3) involving 3 month and 5 year bonds can be estimated using data until only August, 1999, a substantial reduction in the sample size. Secondly, the error term $e_{(n,m),t}$, is a moving average of order $n-m-1$, so standard errors have to be corrected, for example using the method described in Newey and West (1987). But these adjustments do not work well when $n-m$ is not small relative to the sample size (see for example, Campbell and Shiller, 1991). Thirdly, as discussed in Campbell, Lo and MacKinlay (1997) the regressor is serially correlated and correlated with lags of the dependent variable, and this can cause finite sample problems as well.

2.2. VAR framework

The problems associated with the single equation methods can be avoided using a VAR framework. Following Campbell and Shiller (1991) we assume both short and long rates are nonstationary, specifically that they are *I(1)*, and the short rate change and the spread between short and long rates are *I(0)* processes. Then there exists a stationary vector stochastic process for $\mathbf{y_t}=[\Delta R_{m,t}; S_{(n,m),t}]'$. Assuming the process for $\mathbf{y_t}$ is represented by a demeaned VAR of order p, the resulting system can be written as a first order VAR in companion form:

$$\mathbf{z_t}=\mathbf{A}\mathbf{z_{t-1}}+\mathbf{u_t}; \qquad (4)$$

where the companion matrix $\mathbf{A}$ is of dimension $2p\times 2p$:

$$\mathbf{A}=\begin{bmatrix} a_1 & a_1 & \dots & a_{p-2} & a_{p-1} & a_p & c_1 & c_2 & \dots & c_{p-2} & c_{p-1} & c_p \\ b_1 & b_2 & \dots & b_{p-2} & b_{p-1} & b_p & d_1 & d_2 & \dots & d_{p-2} & d_{p-1} & d_p \\ 1 & 0 & \dots & 0 & 0 & 0 & 0 & 0 & \dots & 0 & 0 & 0 \\ 0 & 1 & \dots & 0 & 0 & 0 & 0 & 0 & \dots & 0 & 0 & 0 \\ \vdots & \vdots & \dots & \vdots & \vdots & \vdots & \vdots & \vdots & \dots & \vdots & \vdots & \vdots \\ 0 & 0 & \dots & 0 & 0 & 0 & 0 & 0 & \dots & 1 & 0 & 0 \end{bmatrix}$$

$\mathbf{z_t}$ has $2p$ elements, $\mathbf{z_t}$=[$\mathbf{y_t}$' $\mathbf{y_{t-1}}$' ... $\mathbf{y_{t-p+1}}$']', and $\mathbf{u_t}$ is again a $2p$ vector equal to [u_{1t} u_{2t} 0 0 $0...0$]', with u_{1t} and u_{2t} are uncorrelated over time. Thus the vector $\mathbf{z_t}$ is assumed to summarise the whole history of $\mathbf{y_t}$.

Now define vectors **e1** and **e2,** each of dimension $2p$, with unity in the first and second positions, respectively, and zeros everywhere else such that

$$\mathbf{e2'z_t}=S_{(n,m),t}\text{; and } \mathbf{e1'z_t}=\Delta R_{m,t\cdot}\ ;$$

Using these definitions and the EH implication embodied in (3), Campbell and Shiller (1991) obtain the theoretical spread[5]:

$$S^*_{(n,m),t} = \mathbf{e1'\,A[I} - m/n(\mathbf{I} - \mathbf{A}^n)(\mathbf{I} - \mathbf{A}^m)^{-1}](\mathbf{I} - \mathbf{A})^{-1}\mathbf{z_t}, \tag{5}$$

Which implies the restrictions on the **A** matrix given by

$$\mathbf{e2'} = \mathbf{e1'\,A[I} - m/n(\mathbf{I} - \mathbf{A}^n)(\mathbf{I} - \mathbf{A}^m)^{-1}](\mathbf{I} - \mathbf{A})^{-1}. \tag{6}$$

2.2.1 Bekaert and Hodrick test

These restrictions in (6) were predominantly tested by Wald tests, prior to Bekaert and Hodrick (2001), who suggest a Lagrange Multiplier test which employs restricted VAR parameters. Using Monte Carlo simulations they find the LM test has much better small sample properties than Wald and likelihood ratio based Distance Metric tests in terms of size and power. Since this methodology is relatively new, and is an important part of this study, it is summarised here.

Bekaert and Hodrick (2001) derive the Lagrange Multiplier test statistics based on Hansen's (1982) Generalized Method of Moments (GMM) estimator, which uses the orthogonality condition implied by (2).

If $\boldsymbol{\theta}$ is the matrix of the parameters to be estimated, the vector of orthogonality condition can be written

$$E[\mathbf{g}(\mathbf{x_t}, \boldsymbol{\theta})] = \mathbf{0},$$

[5] The Derivation is provided in Appendix A.

where $\mathbf{x_t} \equiv (\mathbf{y_t}', \mathbf{z_{t-1}}')'$.

Estimation uses the corresponding sample moment conditions for a sample of size T, namely

$$\mathbf{g_t}(\boldsymbol{\theta}) \equiv \frac{1}{T}\sum_{t=1}^{T}\mathbf{g}(\mathbf{x_t}, \boldsymbol{\theta});$$

It proceeds by selecting $\boldsymbol{\theta}$ to minimize the GMM criterion function

$$J_T(\boldsymbol{\theta}) \equiv \mathbf{g_t}(\boldsymbol{\theta})'\mathbf{W}\mathbf{g_t}(\boldsymbol{\theta}),$$

Where, assuming the VAR of (4) is correctly specified with $\mathbf{u_t}$ uncorrelated, weighting matrix, $\mathbf{W}$, is a consistent estimate of the inverse of

$$\boldsymbol{\Omega} \equiv E\left[\mathbf{g}(\mathbf{x_t}, \boldsymbol{\theta})\mathbf{g}(\mathbf{x_t}, \boldsymbol{\theta})'\right]. \tag{7}$$

Let the null hypothesis in (6) be expressed as:

$$H_o : \mathbf{a}(\boldsymbol{\theta_o}) = \mathbf{0} \tag{8}$$

and define a Lagrangian for the constrained GMM maximization problem as

$$L(\boldsymbol{\theta}, \boldsymbol{\gamma}) = -\frac{1}{2}\mathbf{g_t}(\boldsymbol{\theta})'\hat{\boldsymbol{\Omega}}_{\mathbf{T}}^{-1}\mathbf{g_t}(\boldsymbol{\theta}) - \mathbf{a_t}(\boldsymbol{\theta})'\boldsymbol{\gamma}; \tag{9}$$

where $\boldsymbol{\gamma}$ is a vector of Lagrange multipliers and $\hat{\boldsymbol{\Omega}}_{\mathbf{T}}$ is a consistent estimate of $\boldsymbol{\Omega}$ obtained from (7) using the sample mean in place of the expectation. Since direct maximization of (9) is difficult, Bekaert and Hodrick (2001) suggest extending an approach put forward by Newey and McFadden (1994) who demonstrate how to derive a constrained consistent estimator starting from an initial unconstrained consistent one. Using a Taylor's Series expansion to the non-linear first order conditions for (9) yields

$$\sqrt{T}\mathbf{g_T}(\bar{\boldsymbol{\theta}}) \approx \sqrt{T}\mathbf{g_T}(\boldsymbol{\theta_0}) + \mathbf{G_T}\sqrt{T}(\bar{\boldsymbol{\theta}} - \boldsymbol{\theta_0}); \tag{10}$$

$$\sqrt{T}\mathbf{a_T}(\bar{\boldsymbol{\theta}}) \approx \sqrt{T}\mathbf{a_T}(\boldsymbol{\theta_0}) + \mathbf{A_T}\sqrt{T}(\bar{\boldsymbol{\theta}} - \boldsymbol{\theta_0}) \tag{11}$$

where $\mathbf{G_T}$ and $\mathbf{A_T}$ are gradients, with respect to $\boldsymbol{\theta}$, of the sample orthogonality conditions and the vector of constraints, respectively, and under the null hypothesis, $\mathbf{a_T(\theta_0) = 0}$. Substituting these into the first-order conditions,

$$\bar{\boldsymbol{\theta}} \approx \boldsymbol{\theta}_0 - \mathbf{B}_T^{-1/2}\mathbf{M}_T\mathbf{B}_T^{-1/2}\mathbf{G}'_T\hat{\boldsymbol{\Omega}}_T^{-1}\mathbf{g}_T(\boldsymbol{\theta}_0) - \mathbf{B}_T^{-1}\mathbf{A}'_T(\mathbf{A}_T\mathbf{B}_T^{-1}\mathbf{A}'_T)^{-1}\mathbf{a}_T(\boldsymbol{\theta}_0) \quad (12)$$

$$\bar{\boldsymbol{\gamma}} \approx -(\mathbf{A}_T\mathbf{B}_T^{-1}\mathbf{A}'_T)^{-1}\mathbf{A}_T\mathbf{B}_T^{-1}\mathbf{G}'_T\hat{\boldsymbol{\Omega}}_T^{-1}\mathbf{g}_T(\boldsymbol{\theta}_0) + (\mathbf{A}_T\mathbf{B}_T^{-1}\mathbf{A}'_T)^{-1}\mathbf{a}_T(\boldsymbol{\theta}_0) \quad (13)$$

where $\mathbf{B}_T \equiv \mathbf{G}'_T\hat{\boldsymbol{\Omega}}_T^{-1}\mathbf{G}_T$ and $\mathbf{M}_T \equiv \mathbf{I} - \mathbf{B}_T^{-1/2}\mathbf{A}'_T(\mathbf{A}_T\mathbf{B}_T^{-1}\mathbf{A}'_T)^{-1}\mathbf{A}_T\mathbf{B}_T^{-1/2}$.

Let $\tilde{\boldsymbol{\theta}}$ represent an initial consistent unconstrained estimate. Then constrained estimates, $\bar{\boldsymbol{\theta}}$ and $\bar{\boldsymbol{\gamma}}$, are obtained by iterating on equations (12) and (13), substituting $\tilde{\boldsymbol{\theta}}$ for $\boldsymbol{\theta}_0$ to derive a second constrained estimate, and so forth until the constraint is satisfied, i.e. $\mathbf{a_T(\theta) = 0}$.[6]

This yields the constrained estimates, together with the Lagrange Multipliers, which under the EH null hypothesis and assuming i.i.d. disturbances has asymptotic distribution

$$\sqrt{T}\bar{\boldsymbol{\gamma}} \rightarrow \mathbf{N}\left[\mathbf{0}, (\mathbf{A}_T\mathbf{B}_T^{-1}\mathbf{A'}_T)^{-1}\right]. \quad (14)$$

The values of the Lagrange multipliers are not zero when imposition of the constraints significantly affects the value of the objective function. From (14), the LM test is

$$T\bar{\boldsymbol{\gamma}}'(\mathbf{A}_T\mathbf{B}_T^{-1}\mathbf{A}'_T)\bar{\boldsymbol{\gamma}} \rightarrow \chi^2(2p); \quad (15)$$

where p is the number of lags in the VAR.

Bekaert, Hodrick and Marshall (1997) show that the estimated unconstrained VAR parameters, although consistent, are biased in small samples, we therefore follow Bekaert and Hodrick (2001) to bias-correct them. The estimated unconstrained VAR parameters and an i.i.d. bootstrap of the vector of residuals are used to generate 100,000 artificial data sets of the actual sample size (304 observations). The "Monte Carlo" or artificial VAR parameters are re-estimated using each of these bootstrap data sets. The bias-corrected unconstrained parameter estimates are obtained by

[6] In our application the tolerance level for convergence is 10^{-8}.

adding the bias, estimated as the difference between the original parameters of the VAR and the means of the Monte Carlo distributions, to the original unconstrained estimates.

To obtain bias-corrected parameter estimates that satisfy the null hypothesis, we use these bias corrected unconstrained VAR parameters and the corresponding residuals to simulate a very long series (70,000 observations plus 1,000 starting values that are discarded), which is then subjected to the iterative estimation scheme of (12) and (13) to yield bias-corrected constrained parameters, which are used to derive the *LM* test statistics and corresponding asymptotic inference through (15).

2.2.2 Volatility measures

Although the cross equation restrictions (6) on the VAR coefficients can be tested by formal statistical tests, Campbell and Shiller (1987, 1991), among others, warn that these may lead to rejection of the rationality implications of the EH too often in practice, even though the deviations from the null hypothesis of the rational expectations hypothesis of term structure are economically minor or are generated by economically uninteresting factors, such as minor data imperfections or the use of linearizations. Furthermore rejection does not provide much insight into how the model could be improved and if it is of any use in explaining the data (Summers 1991, Engsted 2002). Hence, they suggest an additional informal way of evaluating the model's performance by computing the theoretical spread through (5) and comparing whether its standard deviation, $\sigma(S_t^*)$, is equal to that of the actual spread, $\sigma(S_t)$. The other criteria they suggested is the correlation between these two spreads, $\mathrm{Corr}(S_t^*, S_t)$, which should be close to one if the EH holds.

Sarno, Thornton and Valente (2005), on the other hand, argue that these metrics are not useful in evaluating the performance of the EH since the results often disagree with those of the LM test.

Although these metrics are intended to be free from statistical concepts we use the null DGP, the constrained VAR parameters and i.i.d. bootstrapped residuals, to assess this claim. As in Sarno et al. (2005) 25000 spreads obtained from the null DGP form the actual spreads in this context and corresponding theoretical spreads are calculated from (5). An empirical *p value* is the proportion of 25000 spreads' standard deviation ratios/correlation coefficients that are less than or equal to the sample standard deviation ratio/correlation coefficient.

2.3 Finite sample inference

It has been well documented that large sample inference can be misleading for small samples; see Campbell and Shiller (1991) and references therein, for evidence in the context of rational expectations models. OLS analysis relies on asymptotic standard errors of Newey and West (1987) whose performance deteriorates as the order of MA error increases. Furthermore, the limiting distribution of the LM test statistic is asymptotically pivotal and it is conjectured that the bootstrap provides a first order asymptotic refinement as well as improved finite sample inference.

The VAR parameters that are estimated subject to the constraint (8) of the EH, and an i.i.d bootstrap of the corresponding residuals are used as the data generating process (DGP) in the Monte Carlo analysis. [7] We create 5000 artificial data sets of the actual sample size for each maturity pair. The LM test statistic is calculated for each data set and its distribution is used to obtain an empirical p value, which is the proportion of artificial test statistics that are larger than or equal to the sample statistic in 5000 simulations.

Furthermore, the above constrained DGP of $\Delta R_{m,t}$ and $S_{(n,m),t}$ is used to create the distributions of slope coefficients and t-statistics associated with the null that the slope is one, which are used to estimate two different empirical p values: one is based on the slope coefficient itself, the other on the t-statistic. Adding the actual short term interest rate of the earliest period to the first observation of $\Delta R_{m,t}$ gives us the first observation of a series of short term interest rates that follow the EH. When this observation is added to the second observation of $\Delta R_{m,t}$ we obtain the second observation of the series, and this process is repeated until we get 304 observations. The short term interest rate series obtained in this way and the spread $S_{(n,m),t}$ from the restricted DGP is used to estimate a slope coefficient of (3), its HAC standard error and a *t-statistic* of the null hypothesis that the slope is one. The empirical p value is the minimum of the proportions of 25000 simulations that have slopes/t-statistics greater and smaller than the sample slope/*t-statistic*.

[7] The residuals are from the restricted model: $\overline{\eta}_t = y_t - q_{t-1}\overline{\theta}$.

2.4 Extension to allow conditional heteroskedasticity

Bekaert and Hodrick's (2001) methodology, and others discussed so far assume there is no higher order moment dependence in the VAR disturbances under both null and alternative hypotheses, which is only one of four possible distributional assumptions we make for the disturbances in this study. We therefore call it Case I and the methodologies are extended to accommodate three other interesting cases:

Case II) disturbances are i.i.d. under the null and heteroskedastic under the alternative;
Case III) disturbances are heteroskedastic under the null and i.i.d under the alternative;
Case IV) disturbances are heteroskedastic under both null and alternative hypotheses.

The asymptotic distribution of the LM test statistic in (15) is no longer valid for Cases III and IV and the bias adjustment procedure of the constrained VAR parameters discussed in *2.2.1* is not justified for Cases II and IV.

To bias correct unconstrained VAR parameters for Cases II and IV and make inferences for Cases III and IV, we adopt a recursive design wild bootstrap proposed by Goncalves and Kilian (2004), which is shown to be better in small samples than any other resampling scheme they consider and is comparable with the i.i.d. bootstrap when the errors are indeed i.i.d. A Bootstap sample, in this case, is generated as $\mathbf{y}_\mathbf{t}^* = \mathbf{z}_{\mathbf{t-1}}\boldsymbol{\theta} + \boldsymbol{\eta}_\mathbf{t}^*$, $\boldsymbol{\eta}_\mathbf{t}^* = \omega_t \left|\boldsymbol{\eta}_\mathbf{t}\right|$, *t=1,...,T,* where $\boldsymbol{\theta}$ and $\boldsymbol{\eta}_\mathbf{t}$ are VAR parameters and a vector of residuals at time *t* respectively, and following Davidson and Flachaire (2001) ω_t is assumed to have a Rademacher distribution, which takes negative and positive ones with equal probabilities. For Cases II and IV we do not small sample bias correct the constrained VAR parameters, and conjecture this will not cause an extremely incorrect inference, since the VAR parameter estimates are consistent, what is needed for the iterative scheme of *2.2.1*, and the LM test statistics are compared against empirical distributions that are themselves based on the biased estimates for the finite sample inference. Volatility tests of *2.2.2* and the finite sample inference arguments discussed in *2.3* are also extended to accommodate these cases, replacing i.id. bootstrap by wild one whenever conditional heteroskedasticity is allowed.

Section 3. Data and Empirical results

The dataset we use to test the EH is the UK yield curve data for maturities of 1, 3, 9 and 12 months and 2, 3, 4, and 5 years, sampled at the end of each month, for the period Jan 1979 to May 2004. One and three- month Treasury bills' rates are obtained from DataStream and the remaining series are the Bank of England's estimated zero coupon yield curve data which are calculated by a spline-based technique as discussed in Anderson and Sleath (2001).[8] The application of the latter dataset is relatively new and, to our knowledge, has only been used in Cuthbertson and Nitzsche (2003) to test the EH. While they test the EH for very long and very short interest rates, we consider all possible conventional maturity pairs between 1 month and 5 years.

The data are plotted in Figure 1. There are sharp increases in the level of interest rates in the early 80's and early 90's, with a possible structural change in the interest rates around late 1992, presumably reflecting the start of the inflation targeting in the UK October 1992.

Insert Figure 1

Before proceeding with testing the EH, we ezamine whether the rates are non stationary. Since we might anticipate the disturbances in the unit root test regression to be of the MA form, not AR as assumed in the ADF test, we provide Phillips-Perron tests in addition to ADF tests.

Insert Table 1

From the unit root tests in Panel A, we conclude that the series are all difference stationary, i.e. *I(1)*. In Panel B we reject the null hypothesis that monthly changes in shorter rates contain a unit root, which is reflected in the *p values*. Panel C shows there are some cases where we can not reject the null that the spread between long and short rates is nonstationary at the 5% level, but all reject at 10%.

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[8] Although the Bank of England's dataset covers various maturities, it is largely incomplete for maturities less than 6 months, therefore, Treasury Bill rates are used at the shortest end of the maturity spectrum. Observations are missing for March, October and November 1990 for 9 months maturity, which are filled by averaging the boundary observations of these gaps.
Web address of the data source is http://213.225.136.206/statistics/yieldcurve/index.htm.

Table 2 presents the single equation results based on the model (3), which tests whether the spread predicts the cumulative change in the short rate over the life of the long rate. The first row for each maturity pair (*n,m*) is a point estimate of α in (3). The next two rows are the Newey and West (1987) estimated asymptotic standard errors (of order *n-m-1*) and asymptotic *p-value* from a *t-test* associated with the null hypothesis that the slope is one, the theoretically implied value. The next four numbers in italics are empirical p values, which will be explained in the next section.

Insert Table 2

We can see from Table 2 that all point estimates are numerically different from one. Using either the slope coefficient or *t-statistic,* there appears to be no U shape, as reported in Campbell and Shiller (1991) among others. However, for a given short rate, the estimates approach one as the maturity of the longer rates increases. Nevertheless, Thornton (2004) argues that a slope coefficient of unity can occur even under the alternative hypothesis of no EH. The EH is not rejected when the maturity of the longer rate is high and that of the shorter rate is small, i.e. $k=n/m$ is large, although the value of k required for the EH to hold apparently reduces as the maturity of the shorter rate increases.

Table 3 provides results of the Lagrange Multiplier test. We start by estimating an unconstrained bivariate VAR whose lag length is chosen by the Akaike Information Criterion.[9]

Insert Table 3

For each maturity pair the LM test statistic, asymptotic and small sample p values and the lag length of the VAR is provided. It is interesting to see that Table 3 provides no support for the EH at the shortest end of the maturity spectrum in the whole and 2nd sub-sample, no matter what DGP is used. For 1 and 3 months of short rates, *p values* suggest a smirk shaped relationship between the validity of the EH and the maturity of the longer rate. This is in contrast to the findings of Campbell and Shiller (1991), and Rudebusch (1995), but somewhat in line with Sarno et al. (2005). Overall, the EH

[9] The maximum number of lag length considered is always $p_{max}=int(12(T/100)^{0.25})$ as in Hayashi (2000). SIC chooses shorter lags than AIC, but since absence of no autocorrelation is required for the bootsrap, we opt for longer lags. The results based on the SIC lag were not substantially different from the results here.

receives support for only maturity pairs with intermediate values of k, but this reduces as the maturity of the shorter rate increases.

Asymptotic inferences largely remain intact in the actual sample size, except for a few discrepancies. Two panels of Table 3 show that the inference of the LM test can be substantially different depending on the type of the bootstrap used to small sample bias correct the VAR parameters and to generate the null data used in simulation. For the whole sample the EH is rejected at the shortest end of the maturity spectrum. This is consistent with an idea that noise traders influence the market away from any long run equilibrium relationship to make a profit. This is also consistent with Longstaff (2000) and the Bank of England's view that Treasury bills of short maturities are not an appropriate reflection of the market's view of risk free yield, since banks and other financial institutions use these instruments to meet their liquidity requirements and back up other short term financial transactions. The EH is also rejected when k is large. This is again consistent with an idea of transaction costs and market friction (Anderson 1997), since k roughly indicates the number of times an investor has to "go to the market and buy short term instrument" (Eq 1) and EH is a no arbitrage condition in the absence of market frictions.

There seems to be more evidence for the EH in the second sub-sample which covers the period after the adoption of inflation targeting policy. Here the EH is rejected not only at the shortest end but also at the longest end of the maturity spectrum.

Empirical p values are reported in italics below the asymptotic ones in Table 2, the first row is based on the slope coefficient, the other on its t statistic. The first column is based on the iid bootstrap and the second one is on the wild bootstrap.

Our attempt to reconcile the inferences from the single equation and the VAR analysis is met with mixed results. There is often a conflict between asymptotic and small sample inferences. However, the small sample inferences based on the i.i.d. bootstrap DGP is more consistent with the asymptotic ones, slightly more consistent when the inference is based on its slope coefficient based results. Since there is no clear agreement between the inferences made in this framework, and that obtained from the LM test and there are no large discrepancies between the slope coefficient based result and that on the t- statistics we interpret findings of this section that Thornton (2004)'s claim that one can expect a unity slope coefficient even under the alternative hypothesis of no EH generalizes to the case where that slope coefficient is statistically not significantly different from unity.

Table 4 provides the ratio of standard deviations of, and the correlation between, the theoretical spread, obtained from (5), and the actual spread. Graphs of these spreads are plotted in Figure 2. It is evident that the EH contains important elements of truth according to these metrics. Correlations between two spreads are always very high, ranging between 0.825 and 0.9995 for maturity pairs of 1&3 and 12&60 months. Confirming a stylized feature of these analyses actual spread is always more volatile than the theoretical one and their volatilities tend to get closer for large *k*.

Insert Table 4

Next we consider the empirical merit of the volatility metrics in our context. Sarno et al.'s (2005) claim, that they are not helpful, is serious and worth investigating thoroughly because this informal or economic measurement of the EH fit was developed in response to a wide spread dissatisfaction among economists to the formal or statistical tests.

If we assess the EH using the standard deviation ratio of actual and theoretical spreads in this way, the theory is a complete failure. There is only one instance at the longest end of the maturity spectrum in the whole sample and two cases at the shortest and longest end in the first sub-sample at which the EH is not rejected when the wild bootstrap is used to generate the null data, and not at all when the i.i.d. bootstrap is used.

But these DGP's seem to generate very high standard deviation ratios. Table B3 in the Appendix indicates that the standard deviation ratios between "actual" and "theoretical" spreads from the null distribution is, often very high, centered at a point in excess of two in 9, 2 and 18 cases out of 19 in the in the whole, 1st and 2nd sub-samples respectively. In fact the minimum of the ratios obtained from 25000 simulations under the null is in excess of unity in 15, 11 and 15 cases out of 19 in our three samples. This is clearly counterintuitive since both the null DGP and the "theoretical spread" obtained from this DGP are set to satisfy (5), therefore one should expect this ratio to be close to unity.

If we use the same procedure for the correlation between actual and theoretical spreads the EH is almost never rejected. The i.i.d. bootstrap DGP is again more restrictive in a sense that the EH is rejected only for this DGP except a single case in the second subsample. Rejections seem to occur for only cases where k is small.

Overall, these results indicate the inappropriateness of evaluating the merit of the volatility analysis using DGP's described above.

4. Conclusions

Since the EH theory is of fundamental importance in understanding the transmission mechanism of monetary policy and serves as a theoretical basis for policy involvement in financial markets, the theory has been studied and tested by not only academics but also policy makers. In this paper we aimed to test the theory in the UK across several conventional maturity pairs using a recently developed methodology and compare the result with that of the previous methods.

Although different methods yield different conclusions about the validity of the EH in some cases, there are some maturity pairs for which all methods seem to agree. None of the methods employed, single equation test, LM test, and volatility analysis favour the theory at the short end of the maturity spectrum, while they are all surprisingly positive about the EH at interim maturities.

Bekaert and Hodrick (2001) considered the 1 and 12 months maturity pair in the UK term structure in a more general VAR and did not reject the EH. Our result extends this analysis and show the validity of the EH is dependent on the maturity pair considered, a type of bootstrap employed to small sample bias correct the VAR parameters, and to generate artificial data, and finally, time period over which the EH is tested.

Furthermore a Monte Carlo study that is based on a restricted VAR data generating process illustrates finite sample properties of the test statistics. There is ample evidence of a remarkable robustness of the LM test statistic whose inferences are quite alike in large and finite samples as opposed to some relatively large discrepancies in the OLS framework.

We also conclude that the way the volatility metric is evaluated in Sarno et al. (2005) is not reflecting its true merit.

Thornton's (2004) argument that even when the data are generated so that the EH can not hold one can expect to have a slope coefficient of unity from the regression specification seems to generalize to the case that the slope can even be statistically indifferent from unity.

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Figure 1: UK Treasury bills rates and Zero coupon yields

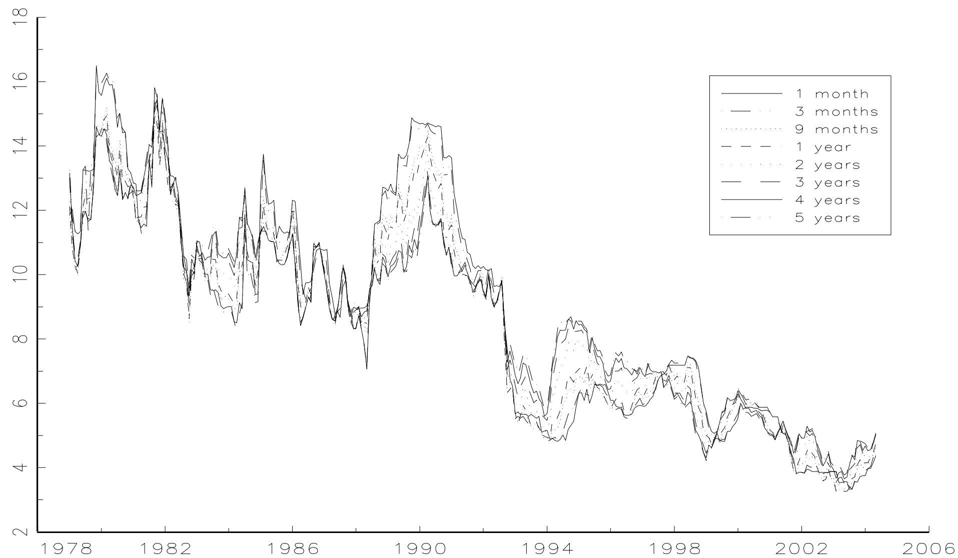


Table 1: Unit Root tests

Panel A: Rates

	m / n							
	1	***3***	***9***	***12***	***24***	***36***	***48***	***60***
ADF stat.	-1.2512	-1.4236	-1.3545	-1.3929	-1.4924	-1.5377	-1.5388	-1.5081
P value	0.6528	0.5709	0.6046	0.5860	0.5363	0.5133	0.5127	0.5284
PP stat.	-1.3516	-1.4666	-1.3733	-1.4566	-1.5904	-1.5377	-1.5388	-1.5849
P value	0.6060	0.5494	0.5955	0.5544	0.4863	0.5133	0.5127	0.4891

Panel B: Change in shorter rate

	m				
	1	***3***	***9***	***12***	***24***
ADF stat.	-17.1110	-17.4381	-16.6275	-16. 7309	-16.0837
P value	0.0000	0.0000	0.0000	0.0000	0.0000
PP stat.	-17.1270	-17.4400	-16.6299	-16.7316	-16.0779
P value	0.0000	0.0000	0.0000	0.0000	0.0000

Panel C: Spread between long and short rates

			n						
			3	***9***	***12***	***24***	***36***	***48***	***60***
m	***1***	ADF stat.	-7.4663	-5.6693	-4.8736	-3.7204	-3.2728	-3.0612	-2.9422
		P value	0.0000	0.0000	0.0001	0.0043	0.0170	0.0306	0.0418
		PP stat.	-13.8040	-5.7128	-4.8348	-3.8016	-3.4179	-3.2491	-3.1434
		P value	0.0000	0.0000	0.0001	0.0032	0.0111	0.0182	0.0245
	3	ADF stat.		-5.6336	-4.7698	-6.6146	-3.1547	-2.9382	-2.8210
		P value		0.0000	0.0001	0.0060	0.0238	0.0422	0.0565
		PP stat.		-5.6078	-4.6279	-3.5845	-3.2529	-3.2491	-2.9847
		P value		0.0000	0.0001	0.0066	0.0180	0.0182	0.0375
	12	ADF stat.				-2.9834	-2.7395	-2.6544	-2.5988
		P value				0.0376	0.0686	0.0834	0.0943
		PP stat.				-3.0163	-2.7722	-2.7433	-2.6778
		P value				0.0345	0.0635	0.0680	0.0791
	24	ADF stat.						-2.3935	
		P value						0.0427	
		PP stat.						-2.8104	
		P value						0.0580	

Note: Augmented Dickey Fuller and Philips and Perron test statistics are provided in each cell with their corresponding p- values. Intercepts are included in both unit root tests. For ADF SIC is used to choose the lag lengths, which were all zero except a lag of 1 for the spread between 1 and 3 months. Max lag considered is 15 for all series. Critical values are 3.4517, 2.8708, and 2.5718 for 1%, 5% and 10% significance levels respectively.

Table 2: Single equation test results

	Jan 1979- May 2004								Jan 1979- Sep 1992								Oct 1992- May 2004							
	1		*3*		*12*		*24*		*1*		*3*		*12*		*24*		*1*		*3*		*12*		*24*	
3	**0.51**								**0.61**								**0.55**							
	0.14								0.21								0.10							
	0.00								0.03								0.00	0.00						
	0.00	*0.01*							*0.01*	*0.12*							*0.00*	*0.00*						
	0.00	*0.00*							*0.05*	*0.10*							*0.00*	*0.00*						
9	**0.63**		**0.54**						**0.76**		**0.57**						**0.83**		**0.77**					
	0.16		0.14						0.23		0.18						0.10		0.11					
	0.01		0.00						0.15		0.01						0.05		0.02					
	0.01	*0.15*	*0.00*	*0.14*					*0.14*	*0.30*	*0.02*	*0.20*					*0.17*	*0.39*	*0.05*	*0.17*				
	0.03	*0.05*	*0.00*	*0.02*					*0.17*	*0.26*	*0.03*	*0.10*					*0.18*	*0.26*	*0.10*	*0.12*				
12	**0.65**		**0.60**						**0.80**		**0.65**						**0.80**		**0.77**					
	0.17		0.17						0.24		0.21						0.10		0.12					
	0.02		0.01						0.20		0.05						0.02		0.03					
	0.02	*0.22*	*0.01*	*0.19*					*0.20*	*0.38*	*0.07*	*0.36*					*0.11*	*0.34*	*0.11*	*0.28*				
	0.05	*0.10*	*0.03*	*0.10*					*0.21*	*0.31*	*0.10*	*0.25*					*0.12*	*0.18*	*0.13*	*0.17*				
24	**0.69**		**0.65**		**0.40**				**0.81**		**0.74**		**0.43**				**0.63**		**0.63**		**0.42**			
	0.16		0.16		0.26				0.18		0.17		0.41				0.11		0.13		0.27			
	0.02		0.01		0.01				0.15		0.07		0.08				0.00		0.00		0.02			
	0.07	*0.43*	*0.05*	*0.39*	*0.04*	*0.28*			*0.28*	*0.36*	*0.20*	*0.40*	*0.14*	*0.46*			*0.11*	*0.38*	*0.13*	*0.37*	*0.14*	*0.30*		
	0.07	*0.17*	*0.06*	*0.19*	*0.05*	*0.15*			*0.24*	*0.49*	*0.15*	*0.41*	*0.15*	*0.46*			*0.09*	*0.14*	*0.11*	*0.15*	*0.13*	*0.23*		
36	**0.79**		**0.77**		**0.51**				**0.75**		**0.70**		**0.51**				**0.59**		**0.59**		**0.49**			

	0.13		0.12		0.21				0.17		0.13		0.37				0.07		0.09		0.17			
	0.06		0.03		0.01				0.07		0.01		0.09				0.00		0.00		0.00			
	0.18	*0.41*	*0.17*	*0.40*	*0.12*	*0.44*			*0.26*	*0.28*	*0.20*	*0.29*	*0.21*	*0.38*			*0.18*	*0.47*	*0.18*	*0.45*	*0.22*	*0.48*		
	0.12	*0.31*	*0.09*	*0.30*	*0.07*	*0.21*			*0.20*	*0.46*	*0.11*	*0.44*	*0.21*	*0.46*			*0.05*	*0.08*	*0.08*	*0.11*	*0.12*	*0.26*		
48	**0.89**		**0.88**		**0.68**		**0.51**		**0.85**		**0.79**		**0.16**		**0.49**		**0.62**		**0.62**		**0.56**		**0.50**	
	0.14		0.13		0.20		0.24		0.18		0.17		0.25		0.48		0.03		0.03		0.09		0.29	
	0.22		0.17		0.06		0.02		0.21		0.11		0.00		0.14		0.00		0.00		0.00		0.04	
	0.30	*0.34*	*0.29*	*0.29*	*0.24*	*0.39*	*0.23*	*0.48*	*0.36*	*0.17*	*0.27*	*0.18*	*0.12*	*0.42*	*0.32*	*0.37*	*0.29*	*0.45*	*0.28*	*0.49*	*0.30*	*0.34*	*0.29*	*0.32*
	0.26	*0.47*	*0.23*	*0.44*	*0.17*	*0.42*	*0.11*	*0.25*	*0.33*	*0.24*	*0.24*	*0.27*	*0.07*	*0.33*	*0.29*	*0.43*	*0.01*	*0.02*	*0.02*	*0.03*	*0.09*	*0.25*	*0.26*	*0.21*
60	**0.95**		**0.96**		**0.81**				**0.72**		**0.78**		**0.09**				**0.63**		**0.63**		**0.58**			
	0.16		0.15		0.22				0.18		0.20		0.30				0.04		0.04		0.05			
	0.38		0.38		0.20				0.06		0.14		0.00				0.00		0.00		0.00			
	0.38	*0.30*	*0.38*	*0.22*	*0.35*	*0.27*			*0.20*	*0.27*	*0.28*	*0.13*	*0.12*	*0.32*			*0.36*	*0.43*	*0.33*	*0.46*	*0.34*	*0.24*		
	0.37	*0.35*	*0.37*	*0.26*	*0.30*	*0.35*			*0.19*	*0.43*	*0.28*	*0.18*	*0.12*	*0.47*			*0.09*	*0.11*	*0.08*	*0.10*	*0.06*	*0.18*		

Note: First three numbers in each cell are the estimate of the slope coefficient of (3), Newey and West standard error of order *n-m-1* and an asymptotic p value from a *t test* associated with the null hypothesis that the slope coefficient is one. The next four numbers in italics are empirical p values, the first row based on the slope coefficient, the other on its t statistic. The first column is based on the iid bootstrap and the second one is on the wild bootstrap. An Empirical critical value is the minimum of the proportions of simulated slope coefficients/t statistics that are less and greater than the sample slope/t-statistic in 25000 replications conducted by a DGP that satisfies the EH. Constrained VAR parameters and bootstrapped residuals serve as the DGP. For a detailed result see Table B2 in Appendix B.

Table 3: Lagrange Multiplier test[10]

	Panel A					Homoskedastic									
	Jan 1979- May 2004					Jan 1979- Sep 1992					Oct 1992- May 2004				
	1	*3*	*9*	*12*	*24*	*1*	*3*	*9*	*12*	*24*	*1*	*3*	*9*	*12*	*24*
3	**26.42**					**7.75**					**25.16**				
	0.01					0.10					0.01				
	0.00					0.09					0.00				
	6					2					5				
9	**9.13**	**13.03**				**5.70**	**4.16**				**1.12**	**8.47**			
	0.17	0.04				0.46	0.12				0.57	0.21			
	0.16	0.04				0.49	0.12				0.61	0.22			
	3	3				3	1				1	3			
12	**8.28**	**5.76**				**4.08**	**2.04**				**2.36**	**5.43**			
	0.22	0.06				0.67	0.36				0.88	0.49			
	0.22	0.05				0.70	0.35				0.90	0.53			
	3	1				3	1				3	3			
24	**8.41**	**2.43**		**11.22**		**1.22**	**0.99**		**6.92**		**4.81**	**7.00**		**8.95**	
	0.08	0.30		0.02		0.54	0.61		0.14		0.57	0.32		0.06	
	0.07	0.29		0.02		0.55	0.62		0.15		0.61	0.35		0.06	
	2	1		2		1	1		2		3	3		2	
36	**10.54**	**9.53**	**9.44**	**2.43**		**1.52**	**0.88**	**5.79**	**1.51**		**7.77**	**9.81**	**8.61**	**8.75**	
	0.03	0.05	0.05	0.30		0.47	0.64	0.22	0.47		0.26	0.13	0.07	0.07	
	0.03	0.05	0.05	0.29		0.48	0.65	0.22	0.47		0.28	0.14	0.07	0.07	
	2	2	2	1		1	1	2	1		3	3	2	2	
48	**11.38**	**10.10**		**2.15**	**5.33**	**1.83**	**1.01**		**1.38**	**2.61**	**9.03**	**11.19**		**8.07**	**12.75**
	0.02	0.04		0.34	0.07	0.40	0.60		0.50	0.27	0.17	0.08		0.09	0.00
	0.02	0.04		0.34	0.07	0.41	0.61		0.51	0.28	0.19	0.08		0.09	0.00
	2	2		1	1	1	1		1	1	3	3		2	1
60	**11.80**	**10.09**		**1.91**		**6.55**	**1.18**		**1.32**		**9.30**	**11.70**		**7.81**	
	0.02	0.04		0.38		0.16	0.55		0.52		0.16	0.07		0.10	
	0.02	0.04		0.39		0.15	0.56		0.53		0.17	0.07		0.10	
	2	2		1		2	1		1		3	3		2	

	Panel B					Heteroskedastic									
	Jan 1979- May 2004					Jan 1979- Sep 1992					Oct 1992- May 2004				
	1	**3**	**9**	**12**	**24**	**1**	**3**	**9**	**12**	**24**	**1**	**3**	**9**	**12**	**24**
3	**26.52**					**8.16**					**24.73**				
	0.01					0.09					0.01				
	0.00					0.05					0.00				
	6					2					5				
9	**8.46**	**10.14**				**5.70**	**2.11**				**0.18**	**7.55**			
	0.21	0.12				0.46	0.35				0.91	0.27			
	0.21	0.10				0.49	0.37				0.92	0.28			
	3	3				3	1				1	3			
12	**7.46**	**2.32**				**4.53**	**0.90**				**1.61**	**4.72**			
	0.28	0.31				0.60	0.64				0.95	0.58			
	0.30	0.33				0.64	0.66				0.97	0.62			

10 The result in this table is obtained from a GAUSS code evolved from a code that is kindly provided by Daniel Thornton.

	3	1				3	1				3	3			
24	**5.09**	**0.41**		**7.31**		**3.23**	**2.22**		**2.83**		**4.54**	**6.34**		**10.02**	
	0.28	0.81		0.12		0.20	0.33		0.59		0.60	0.39		0.04	
	0.29	0.83		0.11		0.20	0.35		0.60		0.65	0.41		0.03	
	2	1		2		1	1		2		3	3		2	
36	**7.90**	**6.65**	**6.27**	**0.88**		**4.82**	**4.18**	**3.05**	**0.14**		**7.28**	**8.96**	**10.85**	**12.06**	
	0.10	0.16	0.18	0.64		0.09	0.12	0.55	0.93		0.30	0.18	0.03	0.02	
	0.08	0.15	0.19	0.65		0.08	0.13	0.57	0.94		0.31	0.17	0.02	0.01	
	2	2	2	1		1	1	2	1		3	3	2	2	
48	**9.67**	**8.91**		**1.44**	**4.53**	**6.10**	**5.99**		**0.51**	**1.40**	**8.41**	**10.22**		**15.59**	**50.61**
	0.05	0.06		0.49	0.10	0.05	0.05		0.77	0.50	0.21	0.12		0.00	0.00
	0.04	0.06		0.50	0.10	0.04	0.05		0.78	0.52	0.21	0.11		0.00	0.06
	2	2		1	1	1	1		1	1	3	3		2	1
60	**10.75**	**10.40**		**2.01**		**8.52**	**7.58**		**1.11**		**8.63**	**10.66**		**21.49**	
	0.03	0.03		0.37		0.07	0.02		0.57		0.20	0.10		0.00	
	0.02	0.03		0.37		0.07	0.02		0.59		0.20	0.09		0.00	
	2	2		1		2	1		1		3	3		2	

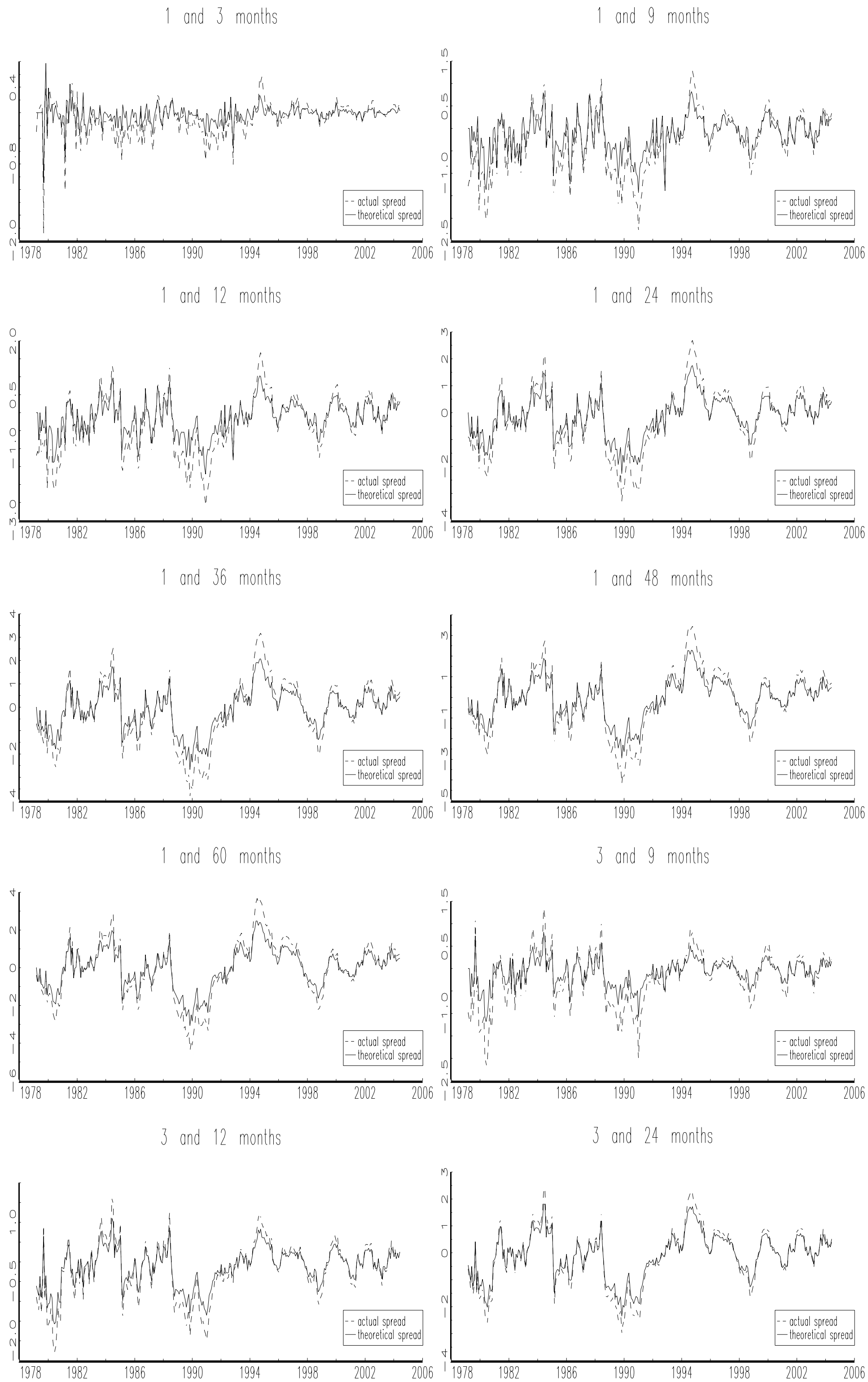
Note: First number in each cell is the LM test statistic. Next row is an asymptotic *p value,* obtained from a Chi-square distribution with twice the lag length as degrees of freedom. The third row is an empirical p value, that is the proportion of 5000 LM test statistics obtained from the restricted DGP that are greater than the sample test statistic. Cells are highlighted when the EH is rejected at 5% using the empirical p value. The last row indicates VAR lag length. *Homoskedastic* and *Heterskedastic* indicate type of bootstrap used to bias correct the unconstrained VAR parameters and to generate 5000 artificial dataset under the null. (iid bootstrap for the former and wild bootstrap for the latter).

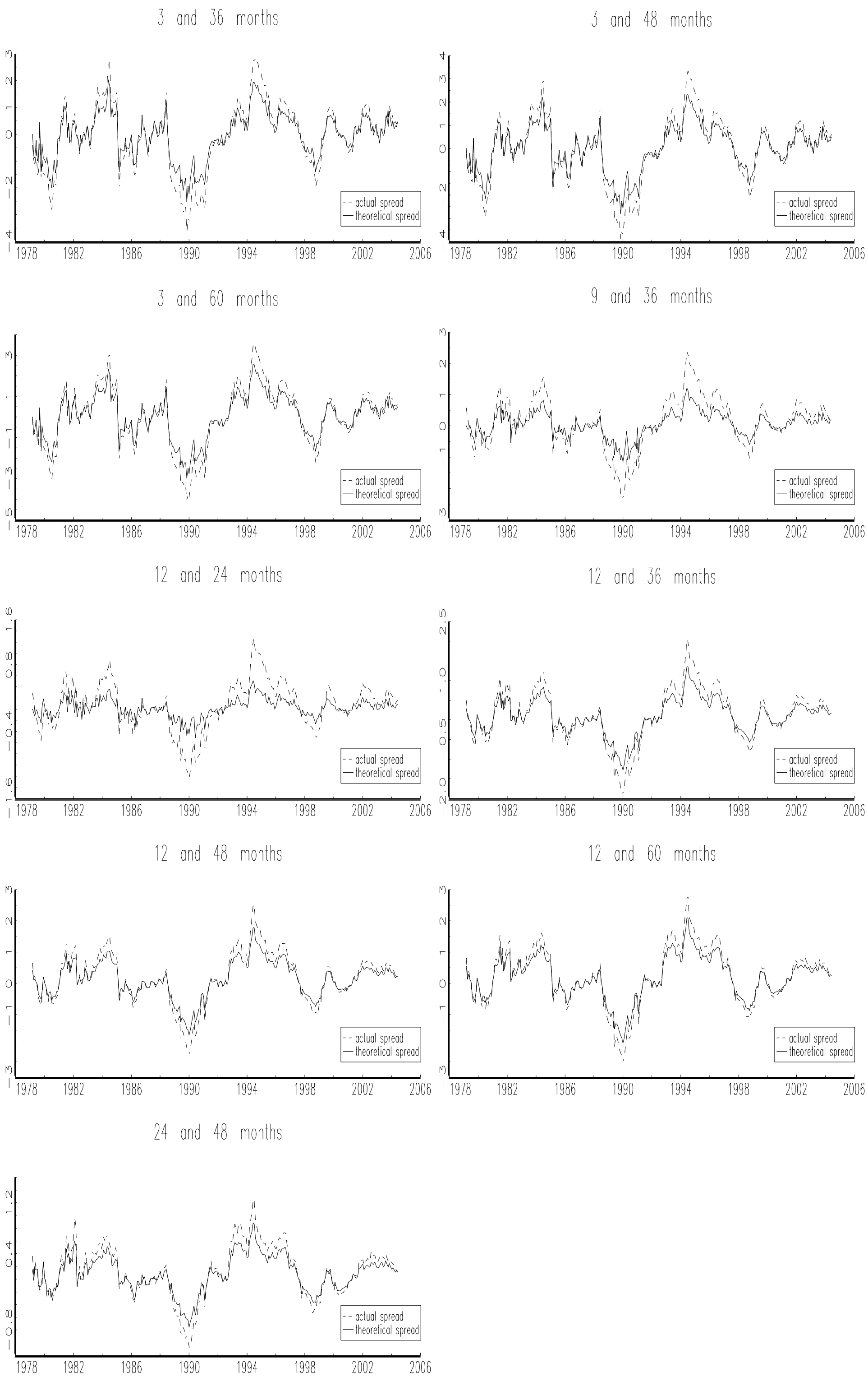
Table 4: Volatility analysis

	Jan 1979- May 2004					Jan 1979- Sep 1992					Oct 1992- May 2004				
	1	*3*	*9*	*12*	*24*	*1*	*3*	*9*	*12*	*24*	*1*	*3*	*9*	*12*	*24*
3	**0.481**					**0.601**					**0.661**				
	0.000					0.004					0.000				
	0.000					0.066					0.003				
	0.825					**0.959**					**0.829**				
	0.003					0.265					0.000				
	0.237					0.590					0.001				
9	**0.633**	**0.528**				**0.707**	**0.613**				**0.838**	**0.738**			
	0.000	0.000				0.000	0.000				0.000	0.000			
	0.000	0.001				0.000	0.013				0.000	0.000			
	0.956	**0.985**				**0.956**	**0.999**				**1.000**	**0.996**			
	0.031	0.936				1.000	0.700				0.926	0.713			
	0.426	0.945				0.999	0.831				0.791	0.846			
12	**0.620**	**0.685**				**0.686**	**0.697**				**0.801**	**0.750**			
	0.000	0.000				0.000	0.000				0.000	0.000			
	0.000	0.003				0.000	0.016				0.000	0.000			
	0.970	**1.000**				**0.970**	**0.999**				**0.998**	**0.996**			
	0.440	0.808				1.000	0.658				0.963	0.765			
	0.728	0.948				1.000	0.828				0.982	0.868			
24	**0.656**	**0.772**		**0.374**		**0.888**	**0.810**		**0.301**		**0.758**	**0.737**		**0.706**	
	0.000	0.000		0.000		0.000	0.000		0.000		0.000	0.000		0.000	
	0.000	0.003		0.003		0.021	0.022		0.002		0.000	0.000		0.007	
	0.994	**1.000**		**0.949**		**0.999**	**1.000**		**0.889**		**0.996**	**0.988**		**0.979**	
	0.953	0.688		0.001		0.522	0.718		0.001		0.908	0.484		0.259	
	0.910	0.933		0.454		0.790	0.863		0.270		0.938	0.694		0.294	
36	**0.660**	**0.670**	**0.483**	**0.663**		**0.916**	**0.862**	**0.435**	**0.587**		**0.736**	**0.728**	**0.766**	**0.765**	
	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	
	0.000	0.001	0.001	0.020		0.031	0.033	0.001	0.033		0.000	0.000	0.004	0.006	
	0.995	**0.995**	**0.982**	**0.999**		**0.999**	**1.000**	**0.967**	**1.000**		**0.993**	**0.985**	**0.991**	**0.989**	
	0.986	0.998	0.043	0.277		0.566	0.758	0.001	0.886		0.838	0.440	0.712	0.663	
	0.924	0.938	0.752	0.766		0.812	0.879	0.668	0.946		0.888	0.666	0.626	0.555	
48	**0.670**	**0.691**		**0.711**	**0.686**	**0.927**	**0.887**		**0.616**	**0.506**	**0.728**	**0.724**		**0.827**	**1.055**
	0.000	0.000		0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000		0.000	0.000
	0.001	0.001		0.014	0.134	0.036	0.038		0.022	0.084	0.000	0.000		0.005	0.002
	0.995	**0.996**		**0.999**	**0.995**	**0.999**	**1.000**		**1.000**	**0.993**	**0.993**	**0.986**		**0.995**	**0.999**
	0.998	1.000		0.239	0.048	0.585	0.773		0.832	0.293	0.860	0.498		0.939	0.999
	0.940	0.954		0.784	0.410	0.817	0.877		0.920	0.532	0.890	0.691		0.781	0.829
60	**0.679**	**0.704**		**0.749**		**0.720**	**0.896**		**0.646**		**0.728**	**0.724**		**0.877**	
	0.000	0.000		0.000		0.000	0.000		0.000		0.000	0.000		0.000	
	0.001	0.002		0.011		0.003	0.037		0.019		0.001	0.000		0.005	
	0.996	**0.997**		**1.000**		**0.993**	**1.000**		**1.000**		**0.993**	**0.987**		**0.997**	
	1.000	1.000		0.246		0.010	0.788		0.824		0.913	0.595		0.993	
	0.951	0.966		0.806		0.938	0.875		0.913		0.910	0.728		0.913	

Note: The first number in each cell is $\sigma(S_t^*)/\sigma(S_t)$, a ratio of standard deviations of theoretical and actual spreads. Two numbers below it are our empirical p values, first one is based on the i.i.d bootstrap and the second one is based on the wild bootstrap. The next number in bold is $Cor(S_t;S_t^*)$, correlation between actual and theoretical spreads with its empirical p values as above. An Empirical p value is the minimum of the proportions of simulated standard deviation ratios/correlation coefficients that are less and greater than the sample ratio/correlation in 25000 replications of these statistics obtained from a DGP that satisfies the EH. Constrained VAR parameters and bootstrapped residuals serve as a DGP. VAR lag length is the same as in Table 3. For a more detailed result, see Table B3 in Appendix B.

Figure 2: Theoretical and Actual spreads




3 and 36 months
actual spread
theoretical spread
3 and 48 months
actual spread
theoretical spread
3 and 60 months
actual spread
theoretical spread
9 and 36 months
actual spread
theoretical spread
12 and 24 months
actual spread
theoretical spread
12 and 36 months
actual spread
theoretical spread
12 and 48 months
actual spread
theoretical spread
12 and 60 months
actual spread
theoretical spread
24 and 48 months
actual spread
theoretical spread

Appendix A: Derivation of the EH restriction in Equation (7)

Companion form of the VAR:

$$z_t = Az_{t-1} + u_u$$

Then we can write

$E(z_{t+j} / z_t) = E_t(z_{t+j}) = A^j z_t$ assuming $E(u_{t+i} / z_t) = 0$, *i>=1.*

By definition, $\Delta R_t^m = h' z_t$ and taking expectations

$$E_t(\Delta R_{t+j}^m) = h' E_t(z_{t+j}) = h' A^j z_t$$

Using (1) (and (2))

(3a) $$S^{(n,m)}{}_t = \sum_{i=1}^{k-1} (1 - \frac{i}{k}) E_t(\Delta^m R_{t+im}^{(m)}) + \theta_{n,m}$$

Note $\Delta^m R_{t+im}^{(m)} = \Delta R_{t+im}^{(m)} + \Delta R_{t+im-1}^{(m)} + ... + \Delta R_{t+(i-1)m+1}^{(m)}$

Therefore

$$E_t(\Delta^m R_{t+im}^{(m)}) = E_t[\Delta R_{t+im}^{(m)} + \Delta R_{t+im-1}^{(m)} + ... + \Delta R_{t+(i-1)m+1}^{(m)}]$$
$$= h' A^{im} z_t + h' A^{im-1} z_t + ... h' A^{(i-1)m+1} z_t$$

$$= h'[A^{im} + A^{im-1} + ... A^{(i-1)m+1}] z_t$$

Substitute this result back to (3a)

(3b)

$$S^{(n,m)}{}_t = (1 - \frac{1}{k}) E_t(\Delta^m R_{t+m}^{(m)}) + (1 - \frac{2}{k}) E_t(\Delta^m R_{t+2m}^{(m)}) + ... + (1 - \frac{k-1}{k}) E_t(\Delta^m R_{t+(k-1)m}^{(m)}) + \theta_{n,m}$$

$$= \frac{k-1}{k} \{h'[A^m + A^{m-1} + ... A] z_t\}$$

$$+ \frac{k-2}{k} \{h'[A^{2m} + A^{2m-1} + ... A^{m+1}] z_t\}$$

+. . . .

$$+ \frac{1}{k} \{h'[A^{(k-1)m} + A^{(k-1)m-1} + ... A^{(k-2)m+1}] z_t\} + \theta_{n,m}$$

$$= \frac{1}{k}\{h'[(k-1)(A^m + A^{m-1} + ...A) + (k-2)(A^{2m} + A^{2m-1} + ...A^{m+1}) + .$$
$$.. + (A^{n-m} + A^{n-m-1} + ...A^{n-2m+1})]z_t\} + \theta_{n,m}$$
$$= \frac{1}{k}\{h'[A(I-A)^{-1} - A^{n-m+1}(I-A)^{-1}$$
$$+ A(I-A)^{-1} - A^{n-2m+1}(I-A)^{-1}$$
$$+ ...$$
$$+ A(I-A)^{-1} - A^{m+1}(I-A)^{-1}]z_t\} + \theta_{n,m} =$$
$$\frac{1}{k}\{h'A[(k-1)I - (I-A^m)^{-1} + A^n(I-A^m)^{-1} + I](I-A)^{-1}z_t\} + \theta_{n,m} =$$
$$= \{h'A[I - m/n(I-A^n)(I-A^m)^{-1}](I-A)^{-1}z_t\} + \theta_{n,m}$$

note $k=n/m$;

$I + A + A^2 + ... + A^{n-m-1} = (I-A)^{-1} - A^{n-m}(I-A)^{-1}$ since

$I + A + A^2 + ... = (I-A)^{-1}$ and

$I + A^m + A^{2m} + ...A^{n-m} = (I-A^m)^{-1} - A^n(I-A^m)$ since

$I + A^m + A^{2m} + ... = (I-A^m)^{-1}$.

So we will have Equation (7) in the paper as

$$S_t^{'(n,m)} = h'A[I - m/n(I-A^n)(I-A^m)^{-1}](I-A)^{-1}z_t$$

iff $\theta_{n,m}=0$ and this is assumed to be the case when we demean the dataset first.

Appendix B: Descriptive statistic and detailed results on the test statistics

Table B1: Descriptive Statistic

Series	Mean	Standard Deviation	Max	Min	Autocorrellation Lag 1	Lag 2	Lag 3	Lag 4
$R_{1,t}$	8.8190	3.5891	16.5000	3.3281	0.9835	0.9661	0.9473	0.9288
$R_{3,t}$	8.7293	3.5202	16.2656	3.3281	0.9811	0.9626	0.9426	0.9233
$R_{9,t}$	8.5380	3.2142	15.1928	3.2551	0.9828	0.9659	0.9477	0.9307
$R_{12,t}$	8.5318	3.1320	14.9556	3.2405	0.9824	0.9647	0.9468	0.9302
$R_{24,t}$	8.5967	2.9602	15.1167	3.3294	0.9812	0.9618	0.9427	0.9255
$R_{36,t}$	8.6635	2.8943	15.2649	3.5031	0.9805	0.9604	0.9407	0.9231
$R_{48,t}$	8.7200	2.8699	15.4860	3.6455	0.9806	0.9605	0.9413	0.9245
$R_{60,t}$	8.7694	2.8660	15.5410	3.7663	0.9811	0.9617	0.9439	0.9283
$\Delta R_{1,t}$	-0.0246	0.5760	3.3440	-1.4062	0.0138	0.0690	-0.0142	-0.0241
$\Delta R_{3,t}$	-0.0258	0.6060	2.8440	-2.0469	-0.0040	0.0506	-0.0239	0.0031
$\Delta R_{9,t}$	-0.0236	0.5208	2.0621	-2.0700	0.0187	0.0623	-0.0483	-0.0011
$\Delta R_{12,t}$	-0.0241	0.5073	2.0090	-2.0063	0.0455	0.0244	-0.0498	-0.0163
$\Delta R_{24,t}$	-0.0255	0.4806	1.7782	-1.7416	0.0922	0.0203	-0.0534	-0.0591
$\Delta R_{36,t}$	-0.0262	0.4698	1.8371	-1.6797	0.1157	0.0257	-0.0645	-0.0510
$\Delta R_{48,t}$	-0.0266	0.4599	1.8769	-1.6655	0.1230	0.0189	-0.0799	-0.0378
$\Delta R_{60,t}$	-0.0268	0.4468	1.8300	-1.6054	0.1237	0.0036	-0.0954	-0.0318
$S_{(1,3),t}$	-0.0897	0.2557	0.5625	-1.8907	0.3732	0.3514	0.3561	0.2819
$S_{(1,9),t}$	-0.2810	0.6406	1.2781	-2.2982	0.8066	0.6867	0.6070	0.5664
$S_{(1,12),t}$	-0.2872	0.7786	1.6802	-2.5842	0.8513	0.7492	0.6706	0.6246
$S_{(1,24),t}$	-0.2222	1.1348	2.6879	-3.2831	0.9116	0.8419	0.7756	0.7242
$S_{(1,36),t}$	-0.1555	1.3370	3.1727	-3.8701	0.9314	0.8722	0.8116	0.7620
$S_{(1,48),t}$	-0.0989	1.4631	3.4398	-4.1802	0.9399	0.8853	0.8282	0.7811
$S_{(1,60),t}$	-0.0496	1.5486	3.6742	-4.3553	0.9445	0.8926	0.8383	0.7934
$S_{(3,9),t}$	-0.1913	0.5635	1.3410	-2.1706	0.8046	0.6856	0.6060	0.5303
$S_{(3,12),t}$	-0.1976	0.6971	1.6199	-2.2890	0.8570	0.7575	0.6818	0.6084
$S_{(3,24),t}$	-0.1326	1.0588	2.3611	-3.0331	0.9158	0.8478	0.7870	0.7225
$S_{(3,36),t}$	-0.0658	1.2671	2.8770	-3.6201	0.9356	0.8772	0.8219	0.7625
$S_{(3,48),t}$	-0.0093	1.3990	3.3387	-3.9302	0.9441	0.8900	0.8375	0.7825
$S_{(3,60),t}$	0.0400	1.4898	3.6117	-4.1053	0.9484	0.8971	0.8466	0.7955
$S_{(9,36),t}$	0.1255	0.8178	2.3750	-2.3698	0.9469	0.9024	0.8526	0.8035
$S_{(12,24),t}$	0.0650	0.4272	1.2517	-1.2318	0.9453	0.8979	0.8478	0.7942
$S_{(12,36),t}$	0.1317	0.6691	2.0308	-1.9370	0.9536	0.9090	0.8631	0.8168
$S_{(12,48),t}$	0.1883	0.8198	2.5013	-2.3225	0.9562	0.9127	0.8694	0.8280
$S_{(12,60),t}$	0.2376	0.9235	2.7861	-2.5527	0.9578	0.9159	0.8746	0.8365
$S_{(24,48),t}$	0.1233	0.4132	1.2588	-1.0907	0.9456	0.8969	0.8581	0.8250

Note: The table reports the descriptive statistics of the series: yields in their levels, $R_{i,t}$, changes in shorter term rates, $\Delta R_{m,t}$, and spreads between the short and long rates, $S_{(n,m),t}$, where I is the maturity of the series we consider, m and n are the maturities of the shorter and longer rates respectively, which are all measured annualized monthly rates.

Table B2: Detailed Result on Single Equation Analysis

Case1: Jan 1979- May 2004

	Panel A. Results obtained from I.i.d. bootstrap DGP															
	α	**Emp .p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**	***t***	**Emp. p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**
$R_{1,t}$&$R_{3,t}$	0.51	0.00	0.11	1.01	0.79	0.83	1.20	1.23	-3.44	0.00	1.10	0.17	-1.96	-1.61	1.97	2.33
$R_{1,t}$&$R_{9,t}$	0.63	0.01	0.16	1.01	0.69	0.74	1.28	1.34	-2.35	0.03	1.26	0.10	-2.39	-1.97	2.16	2.56
$R_{1,t}$&$R_{12,t}$	0.65	0.02	0.18	1.02	0.67	0.73	1.32	1.38	-2.03	0.05	1.30	0.15	-2.42	-1.97	2.28	2.75
$R_{1,t}$&$R_{24,t}$	0.69	0.07	0.23	1.03	0.58	0.65	1.40	1.47	-2.00	0.06	1.47	0.19	-2.73	-2.18	2.57	3.16
$R_{1,t}$&$R_{36,t}$	0.79	0.19	0.28	1.03	0.48	0.57	1.49	1.58	-1.59	0.12	1.68	0.21	-3.12	-2.49	2.98	3.64
$R_{1,t}$&$R_{48,t}$	0.89	0.30	0.32	1.05	0.42	0.52	1.56	1.67	-0.78	0.26	1.90	0.29	-3.48	-2.72	3.39	4.18
$R_{1,t}$&$R_{60,t}$	0.95	0.37	0.35	1.05	0.35	0.48	1.61	1.73	-0.31	0.36	2.11	0.34	-3.83	-2.96	3.74	4.68
$R_{3,t}$&$R_{9,t}$	0.54	0.00	0.15	1.01	0.72	0.76	1.26	1.31	-3.34	0.00	1.25	0.09	-2.41	-1.98	2.13	2.56
$R_{3,t}$&$R_{12,t}$	0.60	0.01	0.16	1.01	0.70	0.74	1.27	1.32	-2.39	0.03	1.29	0.05	-2.47	-2.06	2.16	2.56
$R_{3,t}$&$R_{24,t}$	0.65	0.05	0.22	1.01	0.58	0.65	1.38	1.45	-2.19	0.06	1.48	0.07	-2.86	-2.30	2.48	3.02
$R_{3,t}$&$R_{36,t}$	0.77	0.17	0.28	1.03	0.47	0.57	1.50	1.59	-1.91	0.09	1.68	0.21	-3.09	-2.46	2.94	3.65
$R_{3,t}$&$R_{48,t}$	0.88	0.29	0.32	1.04	0.40	0.51	1.57	1.67	-0.95	0.23	1.89	0.27	-3.43	-2.67	3.29	4.11
$R_{3,t}$&$R_{60,t}$	0.96	0.39	0.35	1.05	0.35	0.47	1.63	1.74	-0.30	0.37	2.09	0.32	-3.80	-2.95	3.65	4.64
$R_{9,t}$&$R_{36,t}$	0.58	0.12	0.39	1.03	0.26	0.40	1.67	1.81	-2.22	0.07	1.66	0.12	-3.21	-2.54	2.86	3.48
$R_{12,t}$&$R_{24,t}$	0.40	0.04	0.37	1.02	0.30	0.42	1.64	1.77	-2.33	0.05	1.44	0.07	-2.80	-2.29	2.46	2.97
$R_{12,t}$&$R_{36,t}$	0.51	0.12	0.43	1.01	0.16	0.30	1.71	1.86	-2.33	0.07	1.64	0.05	-3.21	-2.59	2.70	3.34
$R_{12,t}$&$R_{48,t}$	0.68	0.25	0.49	1.00	0.02	0.19	1.81	1.97	-1.55	0.17	1.83	0.00	-3.67	-2.93	2.97	3.68
$R_{12,t}$&$R_{60,t}$	0.81	0.35	0.54	1.01	-0.06	0.13	1.88	2.05	-0.83	0.31	2.05	0.03	-4.21	-3.28	3.32	4.18
$R_{24,t}$&$R_{48,t}$	0.51	0.22	0.64	0.98	-0.30	-0.08	2.03	2.24	-2.02	0.10	1.63	-0.06	-3.39	-2.72	2.56	3.17

	Panel B. Results obtained from wild bootstrap DGP															
	α	**Emp .p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**	***t***	**Emp. p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**
$R_{1,t}$&$R_{3,t}$	0.51	0.01	0.23	0.99	0.58	0.63	1.36	1.41	-3.44	0.00	1.28	-0.02	-2.43	-2.05	2.12	2.51
$R_{1,t}$&$R_{9,t}$	0.63	0.15	0.31	0.96	0.36	0.45	1.47	1.57	-2.35	0.05	1.27	-0.22	-2.84	-2.39	1.77	2.13
$R_{1,t}$&$R_{12,t}$	0.65	0.23	0.39	0.94	0.21	0.32	1.59	1.72	-2.03	0.10	1.34	-0.28	-3.12	-2.59	1.78	2.15
$R_{1,t}$&$R_{24,t}$	0.69	0.44	0.59	0.79	-0.31	-0.14	1.80	1.98	-2.00	0.18	1.54	-0.63	-3.93	-3.27	1.73	2.15
$R_{1,t}$&$R_{36,t}$	0.79	0.42	0.74	0.66	-0.75	-0.54	1.91	2.16	-1.59	0.31	1.75	-0.86	-4.63	-3.86	1.76	2.29
$R_{1,t}$&$R_{48,t}$	0.89	0.34	0.89	0.53	-1.15	-0.90	2.03	2.34	-0.78	0.47	1.96	-1.07	-5.40	-4.50	1.82	2.43
$R_{1,t}$&$R_{60,t}$	0.95	0.30	1.05	0.42	-1.55	-1.26	2.20	2.58	-0.31	0.34	2.23	-1.28	-6.17	-5.14	1.96	2.63
$R_{3,t}$&$R_{9,t}$	0.54	0.13	0.36	0.93	0.28	0.37	1.58	1.70	-3.34	0.02	1.36	-0.33	-3.06	-2.59	1.88	2.30
$R_{3,t}$&$R_{12,t}$	0.60	0.19	0.32	0.88	0.23	0.34	1.39	1.47	-2.39	0.10	1.43	-0.52	-3.55	-2.97	1.67	2.13
$R_{3,t}$&$R_{24,t}$	0.65	0.39	0.43	0.76	-0.09	0.04	1.44	1.55	-2.19	0.19	1.62	-0.85	-4.34	-3.65	1.64	2.11
$R_{3,t}$&$R_{36,t}$	0.77	0.40	0.65	0.59	-0.68	-0.50	1.65	1.85	-1.91	0.29	1.86	-1.11	-5.27	-4.37	1.62	2.16
$R_{3,t}$&$R_{48,t}$	0.88	0.29	0.73	0.45	-0.94	-0.74	1.66	1.87	-0.95	0.44	2.08	-1.44	-6.25	-5.20	1.49	2.03
$R_{3,t}$&$R_{60,t}$	0.96	0.22	0.83	0.30	-1.23	-1.02	1.68	1.92	-0.30	0.26	2.37	-1.82	-7.38	-6.07	1.42	1.98
$R_{9,t}$&$R_{36,t}$	0.58	0.50	0.61	0.54	-0.75	-0.53	1.47	1.61	-2.22	0.24	1.71	-1.19	-5.04	-4.19	1.33	1.79
$R_{12,t}$&$R_{24,t}$	0.40	0.29	0.51	0.65	-0.48	-0.27	1.39	1.49	-2.33	0.15	1.43	-0.89	-3.89	-3.35	1.36	1.80
$R_{12,t}$&$R_{36,t}$	0.51	0.43	0.56	0.57	-0.64	-0.43	1.42	1.56	-2.33	0.21	1.66	-1.14	-4.82	-4.03	1.31	1.80
$R_{12,t}$&$R_{48,t}$	0.68	0.39	0.63	0.47	-0.82	-0.61	1.46	1.62	-1.55	0.43	1.94	-1.46	-5.86	-4.89	1.25	1.77
$R_{12,t}$&$R_{60,t}$	0.81	0.27	0.69	0.35	-1.03	-0.81	1.47	1.65	-0.83	0.35	2.25	-1.83	-7.22	-5.92	1.17	1.73
$R_{24,t}$&$R_{48,t}$	0.51	0.49	0.77	0.50	-1.04	-0.81	1.73	1.94	-2.02	0.25	1.75	-1.03	-4.91	-4.04	1.61	2.23

Note: Table provides an estimate of slope coefficient and a *t* statistic that the slope is one in Equation (3). It also gives empirical p values based on these two and standard deviations, means, 2.5%, 5%, 95%, and 97.5% quantiles from their empirical distributions of 25000 slope coefficients and *t*-statistics estimated under the null for each maturity pair. The restricted VAR parameters and bootstrapped (i.i.d. for Panel A and wild for Panel B) residuals serve as a DGP.

Panel B: Jan 1979- Sep 1992

	B.1. Results obtained from I.i.d. bootstrap DGP															
	α	**Emp .p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**	***t***	**Emp. p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**
$R_{1,t}\&R_{3,t}$	**0.61**	0.01	0.17	0.99	0.66	0.72	1.26	1.32	-1.85	0.05	1.09	-0.03	-2.16	-1.82	1.76	2.13
$R_{1,t}\&R_{9,t}$	**0.76**	0.15	0.26	1.03	0.52	0.60	1.45	1.53	-1.02	0.18	1.32	0.16	-2.47	-2.00	2.32	2.79
$R_{1,t}\&R_{12,t}$	**0.80**	0.19	0.29	1.05	0.49	0.58	1.52	1.61	-0.86	0.20	1.40	0.25	-2.48	-2.01	2.56	3.10
$R_{1,t}\&R_{24,t}$	**0.81**	0.28	0.35	1.01	0.32	0.44	1.57	1.69	-1.05	0.24	1.70	0.05	-3.37	-2.69	2.75	3.42
$R_{1,t}\&R_{36,t}$	**0.75**	0.26	0.42	1.01	0.19	0.32	1.70	1.85	-1.48	0.21	2.19	0.05	-4.43	-3.41	3.56	4.49
$R_{1,t}\&R_{48,t}$	**0.85**	0.36	0.48	1.02	0.09	0.25	1.80	1.98	-0.82	0.34	2.81	0.12	-5.41	-4.20	4.62	5.97
$R_{1,t}\&R_{60,t}$	**0.72**	0.19	0.50	1.13	0.12	0.30	1.93	2.13	-1.53	0.19	3.58	0.90	-5.86	-4.27	6.79	8.82
$R_{3,t}\&R_{9,t}$	**0.57**	0.02	0.21	1.01	0.59	0.66	1.35	1.42	-2.39	0.03	1.30	0.03	-2.53	-2.08	2.15	2.57
$R_{3,t}\&R_{12,t}$	**0.65**	0.07	0.25	1.01	0.53	0.61	1.41	1.49	-1.63	0.10	1.37	0.07	-2.63	-2.13	2.29	2.81
$R_{3,t}\&R_{24,t}$	**0.74**	0.19	0.35	1.03	0.34	0.46	1.60	1.70	-1.51	0.15	1.73	0.17	-3.23	-2.59	2.98	3.68
$R_{3,t}\&R_{36,t}$	**0.70**	0.20	0.43	1.05	0.21	0.35	1.75	1.89	-2.20	0.10	2.18	0.26	-4.07	-3.11	3.80	4.80
$R_{3,t}\&R_{48,t}$	**0.79**	0.27	0.49	1.07	0.10	0.27	1.87	2.05	-1.24	0.23	2.85	0.42	-5.12	-3.88	5.03	6.45
$R_{3,t}\&R_{60,t}$	**0.78**	0.27	0.53	1.08	0.01	0.22	1.94	2.14	-1.07	0.28	3.60	0.59	-6.60	-4.82	6.45	8.29
$R_{9,t}\&R_{36,t}$	**0.50**	0.18	0.64	1.08	-0.20	0.01	2.12	2.34	-1.82	0.14	2.18	0.27	-4.09	-3.17	3.76	4.74
$R_{12,t}\&R_{24,t}$	**0.43**	0.15	0.63	1.08	-0.16	0.06	2.10	2.31	-1.39	0.15	1.65	0.18	-3.13	-2.46	2.87	3.53
$R_{12,t}\&R_{36,t}$	**0.51**	0.21	0.68	1.05	-0.29	-0.08	2.17	2.41	-1.34	0.20	2.06	0.15	-3.92	-3.09	3.49	4.31
$R_{12,t}\&R_{48,t}$	**0.16**	0.12	0.76	1.04	-0.48	-0.23	2.30	2.55	-3.39	0.07	2.59	0.12	-5.24	-4.03	4.21	5.38
$R_{12,t}\&R_{60,t}$	**0.09**	0.11	0.82	1.05	-0.59	-0.29	2.40	2.67	-3.07	0.12	3.33	0.19	-6.57	-4.97	5.51	7.22
$R_{24,t}\&R_{48,t}$	**0.49**	0.33	1.00	0.94	-1.07	-0.70	2.58	2.91	-1.06	0.30	2.09	-0.16	-4.41	-3.54	3.15	3.97

	B.2. Results obtained from wild. bootstrap DGP															
	α	**Emp .p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**	***t***	**Emp. p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**
$R_{1,t}\&R_{3,t}$	**0.61**	0.12	0.31	0.98	0.43	0.50	1.48	1.55	-1.85	0.10	1.35	-0.09	-2.79	-2.32	2.05	2.42
$R_{1,t}\&R_{9,t}$	**0.76**	0.30	0.36	0.96	0.27	0.38	1.57	1.69	-1.02	0.25	1.27	-0.26	-2.97	-2.46	1.68	2.01
$R_{1,t}\&R_{12,t}$	**0.80**	0.38	0.45	0.95	0.11	0.24	1.71	1.88	-0.86	0.31	1.35	-0.31	-3.27	-2.68	1.68	2.04
$R_{1,t}\&R_{24,t}$	**0.81**	0.37	0.63	0.62	-0.51	-0.36	1.73	1.93	-1.05	0.48	1.96	-1.23	-5.81	-4.81	1.50	1.94
$R_{1,t}\&R_{36,t}$	**0.75**	0.28	0.75	0.34	-0.92	-0.77	1.68	1.93	-1.48	0.46	2.66	-2.15	-8.63	-7.04	1.25	1.73
$R_{1,t}\&R_{48,t}$	**0.85**	0.17	0.80	0.08	-1.19	-1.04	1.56	1.87	-0.82	0.24	3.34	-3.11	-11.29	-9.24	1.01	1.61
$R_{1,t}\&R_{60,t}$	**0.72**	0.27	1.41	-0.06	-2.74	-2.29	2.40	2.94	-1.53	0.42	3.19	-2.44	-9.83	-8.13	1.97	2.83
$R_{3,t}\&R_{9,t}$	**0.57**	0.20	0.36	0.88	0.20	0.30	1.48	1.59	-2.39	0.10	1.42	-0.52	-3.56	-2.95	1.68	2.10
$R_{3,t}\&R_{12,t}$	**0.65**	0.36	0.43	0.81	-0.03	0.10	1.51	1.63	-1.63	0.24	1.55	-0.69	-4.10	-3.44	1.64	2.05
$R_{3,t}\&R_{24,t}$	**0.74**	0.40	0.58	0.59	-0.51	-0.35	1.56	1.74	-1.51	0.40	2.02	-1.33	-6.09	-4.98	1.49	2.04
$R_{3,t}\&R_{36,t}$	**0.70**	0.29	0.71	0.31	-0.94	-0.79	1.52	1.74	-2.20	0.44	2.80	-2.33	-9.13	-7.58	1.28	1.86
$R_{3,t}\&R_{48,t}$	**0.79**	0.18	0.78	0.03	-1.24	-1.10	1.45	1.72	-1.24	0.28	3.67	-3.50	-12.67	-10.32	1.02	1.73
$R_{3,t}\&R_{60,t}$	**0.78**	0.12	0.88	-0.29	-1.70	-1.50	1.32	1.66	-1.07	0.18	4.82	-5.06	-16.88	-13.84	0.74	1.49
$R_{9,t}\&R_{36,t}$	**0.50**	0.32	0.93	0.03	-1.80	-1.52	1.55	1.81	-1.82	0.48	2.35	-2.08	-7.71	-6.32	1.03	1.57
$R_{12,t}\&R_{24,t}$	**0.43**	0.46	0.78	0.28	-1.42	-1.12	1.44	1.60	-1.39	0.46	1.67	-1.39	-5.20	-4.37	1.04	1.52
$R_{12,t}\&R_{36,t}$	**0.51**	0.38	0.82	0.23	-1.38	-1.15	1.56	1.78	-1.34	0.46	2.31	-1.86	-7.39	-6.11	1.20	1.76
$R_{12,t}\&R_{48,t}$	**0.16**	0.41	0.89	-0.01	-1.64	-1.41	1.50	1.81	-3.39	0.34	3.10	-2.83	-10.54	-8.50	0.99	1.66
$R_{12,t}\&R_{60,t}$	**0.09**	0.32	0.99	-0.29	-2.01	-1.76	1.46	1.87	-3.07	0.47	4.16	-4.14	-14.63	-11.97	0.83	1.63
$R_{24,t}\&R_{48,t}$	**0.49**	0.37	1.06	0.13	-1.88	-1.58	1.91	2.24	-1.06	0.43	2.28	-1.68	-7.01	-5.71	1.45	2.12

Note: See the note to Panel A

Panel C: Oct 1992- May 2004

	C.1. Results obtained from i.i.d. bootstrap DGP															
	α	**Emp .p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**	***t***	**Emp. p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**
$R_{1,t}$&$R_{3,t}$	**0.55**	0.00	0.09	0.98	0.79	0.82	1.12	1.14	**-4.62**	0.00	1.16	-0.23	-2.49	-2.13	1.67	2.03
$R_{1,t}$&$R_{9,t}$	**0.83**	0.17	0.13	0.95	0.68	0.73	1.15	1.19	**-1.67**	0.18	1.43	-0.45	-3.43	-2.85	1.79	2.25
$R_{1,t}$&$R_{12,t}$	**0.80**	0.11	0.14	0.97	0.67	0.73	1.18	1.22	**-2.00**	0.12	1.51	-0.29	-3.46	-2.84	2.07	2.60
$R_{1,t}$&$R_{24,t}$	**0.63**	0.11	0.23	0.91	0.44	0.52	1.27	1.34	**-3.48**	0.09	2.07	-0.76	-5.34	-4.30	2.27	2.96
$R_{1,t}$&$R_{36,t}$	**0.59**	0.18	0.30	0.86	0.26	0.37	1.36	1.46	**-5.97**	0.05	2.82	-1.23	-7.62	-6.08	2.73	3.75
$R_{1,t}$&$R_{48,t}$	**0.62**	0.29	0.36	0.82	0.13	0.25	1.42	1.55	**-12.96**	0.01	3.85	-1.75	-10.85	-8.43	3.60	5.06
$R_{1,t}$&$R_{60,t}$	**0.63**	0.36	0.40	0.79	0.03	0.16	1.48	1.63	**-8.74**	0.09	5.18	-2.48	-14.89	-11.53	4.56	6.40
$R_{3,t}$&$R_{9,t}$	**0.77**	0.05	0.12	0.98	0.73	0.77	1.16	1.19	**-2.01**	0.09	1.37	-0.21	-2.98	-2.48	1.98	2.43
$R_{3,t}$&$R_{12,t}$	**0.77**	0.10	0.15	0.97	0.65	0.71	1.20	1.24	**-1.92**	0.13	1.50	-0.27	-3.36	-2.78	2.09	2.60
$R_{3,t}$&$R_{24,t}$	**0.63**	0.13	0.25	0.92	0.40	0.49	1.32	1.39	**-2.91**	0.11	2.02	-0.60	-4.97	-4.03	2.43	3.15
$R_{3,t}$&$R_{36,t}$	**0.59**	0.18	0.32	0.88	0.22	0.34	1.40	1.50	**-4.78**	0.08	2.75	-0.96	-7.14	-5.63	3.02	4.06
$R_{3,t}$&$R_{48,t}$	**0.62**	0.27	0.38	0.84	0.10	0.23	1.46	1.60	**-10.95**	0.02	3.80	-1.44	-10.14	-7.78	3.84	5.41
$R_{3,t}$&$R_{60,t}$	**0.63**	0.34	0.42	0.82	0.01	0.15	1.53	1.66	**-8.84**	0.08	5.14	-2.02	-13.95	-10.71	5.01	7.04
$R_{9,t}$&$R_{36,t}$	**0.51**	0.22	0.47	0.87	-0.08	0.08	1.63	1.78	**-3.63**	0.10	2.47	-0.65	-6.03	-4.76	3.04	4.03
$R_{12,t}$&$R_{24,t}$	**0.42**	0.15	0.46	0.89	-0.07	0.11	1.62	1.76	**-2.15**	0.14	1.74	-0.38	-4.04	-3.28	2.37	2.96
$R_{12,t}$&$R_{36,t}$	**0.49**	0.22	0.52	0.87	-0.18	0.01	1.70	1.87	**-3.04**	0.12	2.33	-0.55	-5.56	-4.44	2.96	3.86
$R_{12,t}$&$R_{48,t}$	**0.56**	0.30	0.56	0.84	-0.29	-0.10	1.75	1.93	**-4.71**	0.09	3.19	-0.84	-7.83	-6.16	3.83	5.10
$R_{12,t}$&$R_{60,t}$	**0.58**	0.34	0.60	0.82	-0.39	-0.17	1.81	2.02	**-8.07**	0.06	4.38	-1.24	-11.08	-8.57	5.05	6.89
$R_{24,t}$&$R_{48,t}$	**0.50**	0.29	0.73	0.86	-0.68	-0.37	2.02	2.29	**-1.76**	0.25	2.52	-0.46	-5.86	-4.56	3.35	4.36

	C.2. Results obtained from wild. bootstrap DGP															
	α	**Emp .p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**	***t***	**Emp. p**	**emp. sd.**	**mean**	**0.025**	**0.05**	**0.95**	**0.975**
$R_{1,t}$&$R_{3,t}$	**0.55**	0.00	0.11	0.94	0.69	0.74	1.09	1.11	**-4.62**	0.00	1.19	-0.60	-3.01	-2.59	1.31	1.69
$R_{1,t}$&$R_{9,t}$	**0.83**	0.39	0.20	0.87	0.45	0.53	1.17	1.21	**-1.67**	0.26	1.45	-0.83	-3.90	-3.29	1.37	1.81
$R_{1,t}$&$R_{12,t}$	**0.80**	0.34	0.23	0.90	0.42	0.50	1.27	1.33	**-2.00**	0.17	1.58	-0.67	-4.18	-3.39	1.68	2.16
$R_{1,t}$&$R_{24,t}$	**0.63**	0.38	0.42	0.77	-0.01	0.11	1.50	1.63	**-3.48**	0.14	2.28	-1.22	-6.51	-5.28	2.05	2.70
$R_{1,t}$&$R_{36,t}$	**0.59**	0.48	0.58	0.67	-0.33	-0.19	1.71	1.92	**-5.97**	0.08	3.12	-1.70	-8.76	-7.09	2.74	3.74
$R_{1,t}$&$R_{48,t}$	**0.62**	0.45	0.69	0.62	-0.56	-0.40	1.87	2.13	**-12.96**	0.02	4.17	-2.19	-11.82	-9.42	3.91	5.28
$R_{1,t}$&$R_{60,t}$	**0.63**	0.43	0.79	0.59	-0.74	-0.54	2.01	2.31	**-8.74**	0.11	5.68	-2.71	-15.60	-12.25	5.55	7.61
$R_{3,t}$&$R_{9,t}$	**0.77**	0.17	0.18	0.94	0.57	0.63	1.21	1.25	**-2.01**	0.12	1.38	-0.45	-3.30	-2.78	1.75	2.18
$R_{3,t}$&$R_{12,t}$	**0.77**	0.29	0.24	0.91	0.40	0.49	1.29	1.36	**-1.92**	0.17	1.53	-0.53	-3.84	-3.15	1.79	2.30
$R_{3,t}$&$R_{24,t}$	**0.63**	0.37	0.45	0.80	-0.07	0.05	1.55	1.68	**-2.91**	0.15	2.14	-0.95	-5.81	-4.72	2.16	2.82
$R_{3,t}$&$R_{36,t}$	**0.59**	0.44	0.63	0.71	-0.44	-0.28	1.77	1.98	**-4.78**	0.10	2.94	-1.31	-7.99	-6.42	2.90	3.85
$R_{3,t}$&$R_{48,t}$	**0.62**	0.49	0.74	0.64	-0.71	-0.50	1.90	2.15	**-10.95**	0.03	4.03	-1.79	-10.99	-8.58	3.89	5.26
$R_{3,t}$&$R_{60,t}$	**0.63**	0.44	0.82	0.58	-0.88	-0.67	2.01	2.31	**-8.84**	0.10	5.55	-2.56	-15.62	-12.09	5.12	7.26
$R_{9,t}$&$R_{36,t}$	**0.51**	0.48	0.56	0.53	-0.57	-0.40	1.44	1.60	**-3.63**	0.20	2.63	-1.96	-8.28	-6.77	1.48	2.17
$R_{12,t}$&$R_{24,t}$	**0.42**	0.30	0.52	0.66	-0.47	-0.27	1.45	1.59	**-2.15**	0.23	1.80	-1.07	-5.12	-4.22	1.54	2.08
$R_{12,t}$&$R_{36,t}$	**0.49**	0.49	0.59	0.49	-0.70	-0.51	1.41	1.59	**-3.04**	0.26	2.52	-1.95	-8.10	-6.55	1.32	1.94
$R_{12,t}$&$R_{48,t}$	**0.56**	0.35	0.65	0.30	-0.98	-0.76	1.35	1.55	**-4.71**	0.25	3.58	-3.14	-11.96	-9.79	1.10	1.88
$R_{12,t}$&$R_{60,t}$	**0.58**	0.25	0.67	0.13	-1.19	-0.95	1.24	1.47	**-8.07**	0.17	4.92	-4.58	-16.99	-13.76	0.88	1.79
$R_{24,t}$&$R_{48,t}$	**0.50**	0.32	1.12	1.04	-1.16	-0.84	2.83	3.13	**-1.76**	0.21	2.85	0.13	-5.65	-4.33	4.71	5.91

Note: See the note to Panel A.

Table B3: Detailed Result on Volatility Analysis

Case1: Jan 1979- May 2004

	Panel A. Actual and Theoretical Spreads' Standard Deviations Ratio															
	i.i.d. bootstrap DGP result								***wild bootstrap DGP result***							
	coef	**emp. p**	**mean**	**min**	**0.025**	**0.05**	**0.95**	**0.975**	**coef**	**emp. p**	**mean**	**min**	**0.025**	**0.05**	**0.95**	**0.975**
$R_{1,t}\&R_{3,t}$	**0.481**	0.000	1.042	0.526	0.832	0.868	1.220	1.258	**0.481**	0.000	1.113	0.463	0.733	0.783	1.433	1.477
$R_{1,t}\&R_{9,t}$	**0.633**	0.000	2.351	1.408	1.859	1.935	2.767	2.847	**0.633**	0.000	2.202	0.618	1.233	1.367	3.085	3.237
$R_{1,t}\&R_{12,t}$	**0.620**	0.000	2.772	1.609	2.150	2.249	3.299	3.405	**0.620**	0.000	2.561	0.642	1.291	1.451	3.785	4.017
$R_{1,t}\&R_{24,t}$	**0.656**	0.000	2.133	1.600	1.885	1.921	2.355	2.405	**0.656**	0.000	1.933	0.416	1.023	1.121	3.075	3.415
$R_{1,t}\&R_{36,t}$	**0.660**	0.000	2.197	1.704	1.962	1.995	2.408	2.451	**0.660**	0.000	1.981	0.396	0.997	1.101	3.290	3.667
$R_{1,t}\&R_{48,t}$	**0.670**	0.000	2.228	1.749	2.000	2.036	2.432	2.477	**0.670**	0.001	2.006	0.418	0.993	1.094	3.380	3.804
$R_{1,t}\&R_{60,t}$	**0.679**	0.000	2.248	1.780	2.025	2.061	2.446	2.488	**0.679**	0.001	2.018	0.458	0.991	1.096	3.422	3.858
$R_{3,t}\&R_{9,t}$	**0.528**	0.000	1.832	1.008	1.443	1.506	2.157	2.221	**0.528**	0.001	1.702	0.428	0.826	0.938	2.560	2.726
$R_{3,t}\&R_{12,t}$	**0.685**	0.000	1.428	1.101	1.258	1.284	1.579	1.610	**0.685**	0.003	1.462	0.455	0.856	0.936	2.104	2.265
$R_{3,t}\&R_{24,t}$	**0.772**	0.000	1.685	1.387	1.532	1.555	1.820	1.849	**0.772**	0.003	1.738	0.512	0.958	1.056	2.606	2.831
$R_{3,t}\&R_{36,t}$	**0.670**	0.000	2.110	1.650	1.888	1.922	2.307	2.347	**0.670**	0.001	1.895	0.417	0.949	1.050	3.138	3.493
$R_{3,t}\&R_{48,t}$	**0.691**	0.000	2.164	1.743	1.949	1.981	2.355	2.397	**0.691**	0.001	1.940	0.448	0.953	1.060	3.261	3.668
$R_{3,t}\&R_{60,t}$	**0.704**	0.000	2.196	1.788	1.988	2.019	2.383	2.423	**0.704**	0.002	1.966	0.461	0.963	1.072	3.326	3.754
$R_{9,t}\&R_{36,t}$	**0.483**	0.000	1.735	1.242	1.515	1.548	1.932	1.975	**0.483**	0.001	1.544	0.288	0.739	0.823	2.628	2.958
$R_{12,t}\&R_{24,t}$	**0.374**	0.000	1.156	0.589	0.933	0.969	1.352	1.392	**0.374**	0.003	1.019	0.181	0.492	0.551	1.670	1.856
$R_{12,t}\&R_{36,t}$	**0.663**	0.000	1.295	0.960	1.145	1.168	1.427	1.454	**0.663**	0.020	1.352	0.320	0.685	0.762	2.160	2.384
$R_{12,t}\&R_{48,t}$	**0.711**	0.000	1.456	1.139	1.312	1.334	1.582	1.610	**0.711**	0.014	1.519	0.400	0.770	0.852	2.436	2.698
$R_{12,t}\&R_{60,t}$	**0.749**	0.000	1.553	1.264	1.414	1.436	1.673	1.699	**0.749**	0.011	1.618	0.473	0.829	0.916	2.584	2.857
$R_{24,t}\&R_{48,t}$	**0.686**	0.000	0.972	0.651	0.813	0.838	1.114	1.145	**0.686**	0.134	1.015	0.262	0.516	0.574	1.598	1.760
	Pnel B. Actual and Theoretical Spreads' Correlation Coefficient															
	i.i.d. bootstrap DGP result								***wild bootstrap DGP result***							
$R_{1,t}\&R_{3,t}$	**0.825**	0.003	0.952	0.645	0.880	0.899	0.985	0.988	**0.825**	0.237	0.870	0.366	0.697	0.732	0.961	0.969
$R_{1,t}\&R_{9,t}$	**0.956**	0.031	0.975	0.910	0.954	0.958	0.989	0.991	**0.956**	0.426	0.955	0.562	0.886	0.902	0.990	0.993
$R_{1,t}\&R_{12,t}$	**0.970**	0.440	0.970	0.923	0.949	0.953	0.985	0.987	**0.970**	0.728	0.948	0.391	0.872	0.891	0.988	0.991
$R_{1,t}\&R_{24,t}$	**0.994**	0.953	0.990	0.971	0.984	0.985	0.994	0.995	**0.994**	0.910	0.951	0.394	0.791	0.840	0.996	0.998
$R_{1,t}\&R_{36,t}$	**0.995**	0.986	0.990	0.975	0.984	0.985	0.994	0.994	**0.995**	0.924	0.943	0.300	0.755	0.810	0.996	0.998
$R_{1,t}\&R_{48,t}$	**0.995**	0.998	0.990	0.977	0.984	0.985	0.993	0.994	**0.995**	0.940	0.940	0.260	0.733	0.796	0.996	0.997
$R_{1,t}\&R_{60,t}$	**0.996**	1.000	0.989	0.977	0.985	0.985	0.993	0.994	**0.996**	0.951	0.939	0.249	0.725	0.791	0.996	0.997
$R_{3,t}\&R_{9,t}$	**0.985**	0.936	0.970	0.902	0.946	0.951	0.986	0.988	**0.985**	0.945	0.930	-0.103	0.797	0.840	0.985	0.990
$R_{3,t}\&R_{12,t}$	**1.000**	0.808	0.999	0.989	0.997	0.998	1.000	1.000	**1.000**	0.948	0.991	0.825	0.953	0.965	1.000	1.000
$R_{3,t}\&R_{24,t}$	**1.000**	0.688	1.000	0.993	0.998	0.999	1.000	1.000	**1.000**	0.933	0.991	0.751	0.953	0.965	1.000	1.000
$R_{3,t}\&R_{36,t}$	**0.995**	0.998	0.989	0.976	0.984	0.985	0.993	0.994	**0.995**	0.938	0.942	0.243	0.745	0.805	0.996	0.998
$R_{3,t}\&R_{48,t}$	**0.996**	1.000	0.989	0.975	0.984	0.985	0.993	0.993	**0.996**	0.954	0.939	0.221	0.728	0.792	0.996	0.997
$R_{3,t}\&R_{60,t}$	**0.997**	1.000	0.989	0.975	0.984	0.985	0.993	0.993	**0.997**	0.966	0.938	0.228	0.721	0.788	0.996	0.997
$R_{9,t}\&R_{36,t}$	**0.982**	0.043	0.988	0.970	0.981	0.982	0.992	0.993	**0.982**	0.752	0.932	0.297	0.712	0.777	0.995	0.997
$R_{12,t}\&R_{24,t}$	**0.949**	0.001	0.983	0.928	0.968	0.971	0.992	0.993	**0.949**	0.454	0.931	0.324	0.729	0.781	0.995	0.997
$R_{12,t}\&R_{36,t}$	**0.999**	0.277	0.999	0.989	0.997	0.998	1.000	1.000	**0.999**	0.766	0.991	0.793	0.953	0.966	1.000	1.000
$R_{12,t}\&R_{48,t}$	**0.999**	0.239	1.000	0.991	0.998	0.998	1.000	1.000	**0.999**	0.784	0.991	0.780	0.953	0.966	1.000	1.000
$R_{12,t}\&R_{60,t}$	**1.000**	0.246	1.000	0.993	0.998	0.999	1.000	1.000	**1.000**	0.806	0.992	0.795	0.955	0.967	1.000	1.000
$R_{24,t}\&R_{48,t}$	**0.995**	0.048	0.999	0.972	0.993	0.995	1.000	1.000	**0.995**	0.410	0.992	0.782	0.959	0.969	1.000	1.000

See Note to *Case 2.*

Case2: Jan 1979- Sep 1992

	Panel A. Actual and Theoretical Spreads' Standard Deviations Ratio															
	i.i.d. bootstrap DGP result								***wild bootstrap DGP result***							
	coef	**emp.p**	**mean**	**min**	**0.03**	**0.05**	**0.95**	**0.98**	**coef**	**emp.p**	**mean**	**min**	**0.03**	**0.05**	**0.95**	**0.98**
$R_{1,t}\&R_{3,t}$	**0.601**	0.004	1.031	0.413	0.723	0.771	1.302	1.353	**0.601**	0.066	1.058	0.205	0.510	0.573	1.531	1.601
$R_{1,t}\&R_{9,t}$	**0.707**	0.000	3.427	1.484	2.370	2.521	4.369	4.548	**0.707**	0.000	3.486	0.662	1.849	2.085	4.981	5.297
$R_{1,t}\&R_{12,t}$	**0.686**	0.000	3.956	1.533	2.654	2.843	5.141	5.390	**0.686**	0.000	3.936	0.753	1.922	2.182	5.915	6.362
$R_{1,t}\&R_{24,t}$	**0.888**	0.000	1.565	1.237	1.408	1.431	1.713	1.748	**0.888**	0.021	1.741	0.454	0.906	0.996	2.733	3.014
$R_{1,t}\&R_{36,t}$	**0.916**	0.000	1.590	1.300	1.450	1.470	1.722	1.754	**0.916**	0.031	1.787	0.444	0.886	0.982	2.896	3.233
$R_{1,t}\&R_{48,t}$	**0.927**	0.000	1.602	1.335	1.471	1.491	1.725	1.755	**0.927**	0.036	1.810	0.437	0.881	0.975	2.979	3.348
$R_{1,t}\&R_{60,t}$	**0.720**	0.000	1.563	1.312	1.437	1.457	1.678	1.702	**0.720**	0.003	1.810	0.461	0.887	0.971	3.240	3.742
$R_{3,t}\&R_{9,t}$	**0.613**	0.000	1.097	0.749	0.922	0.948	1.257	1.291	**0.613**	0.013	1.203	0.356	0.665	0.731	1.788	1.917
$R_{3,t}\&R_{12,t}$	**0.697**	0.000	1.233	0.888	1.067	1.090	1.388	1.422	**0.697**	0.016	1.366	0.362	0.741	0.814	2.061	2.230
$R_{3,t}\&R_{24,t}$	**0.810**	0.000	1.436	1.155	1.295	1.316	1.570	1.599	**0.810**	0.022	1.615	0.416	0.823	0.907	2.572	2.836
$R_{3,t}\&R_{36,t}$	**0.862**	0.000	1.503	1.217	1.375	1.395	1.624	1.652	**0.862**	0.033	1.703	0.415	0.829	0.921	2.803	3.116
$R_{3,t}\&R_{48,t}$	**0.887**	0.000	1.537	1.266	1.417	1.435	1.650	1.676	**0.887**	0.038	1.746	0.415	0.837	0.927	2.910	3.254
$R_{3,t}\&R_{60,t}$	**0.896**	0.000	1.557	1.316	1.443	1.461	1.663	1.687	**0.896**	0.037	1.772	0.415	0.846	0.937	2.960	3.329
$R_{9,t}\&R_{36,t}$	**0.435**	0.000	1.191	0.875	1.033	1.058	1.340	1.375	**0.435**	0.001	1.396	0.327	0.634	0.702	2.613	3.032
$R_{12,t}\&R_{24,t}$	**0.301**	0.000	0.799	0.439	0.618	0.645	0.976	1.017	**0.301**	0.002	0.925	0.207	0.420	0.468	1.679	1.933
$R_{12,t}\&R_{36,t}$	**0.587**	0.000	1.095	0.763	0.937	0.962	1.241	1.276	**0.587**	0.033	1.270	0.291	0.565	0.628	2.230	2.539
$R_{12,t}\&R_{48,t}$	**0.616**	0.000	1.231	0.931	1.081	1.105	1.367	1.399	**0.616**	0.022	1.428	0.320	0.626	0.697	2.554	2.920
$R_{12,t}\&R_{60,t}$	**0.646**	0.000	1.312	1.039	1.172	1.194	1.439	1.469	**0.646**	0.019	1.520	0.339	0.673	0.746	2.713	3.119
$R_{24,t}\&R_{48,t}$	**0.506**	0.000	0.825	0.452	0.652	0.677	0.992	1.031	**0.506**	0.084	0.963	0.132	0.397	0.455	1.708	1.930

	Panel B. Actual and Theoretical Spreads' Correlation Coefficient															
	i.i.d. bootstrap DGP result								***wild bootstrap DGP result***							
$R_{1,t}\&R_{3,t}$	**0.959**	0.265	0.967	0.536	0.878	0.904	0.997	0.998	**0.959**	0.590	0.929	0.373	0.761	0.801	0.993	0.996
$R_{1,t}\&R_{9,t}$	**0.956**	1.000	0.785	0.604	0.711	0.723	0.843	0.853	**0.956**	0.999	0.819	0.478	0.695	0.718	0.902	0.915
$R_{1,t}\&R_{12,t}$	**0.970**	1.000	0.776	0.595	0.703	0.716	0.834	0.844	**0.970**	1.000	0.817	0.411	0.688	0.712	0.903	0.916
$R_{1,t}\&R_{24,t}$	**0.999**	0.522	0.998	0.979	0.993	0.994	1.000	1.000	**0.999**	0.790	0.986	0.537	0.926	0.946	1.000	1.000
$R_{1,t}\&R_{36,t}$	**0.999**	0.566	0.998	0.982	0.994	0.995	1.000	1.000	**0.999**	0.812	0.984	0.495	0.915	0.939	1.000	1.000
$R_{1,t}\&R_{48,t}$	**0.999**	0.585	0.998	0.984	0.994	0.995	1.000	1.000	**0.999**	0.817	0.983	0.470	0.909	0.936	1.000	1.000
$R_{1,t}\&R_{60,t}$	**0.993**	0.010	0.998	0.979	0.995	0.996	1.000	1.000	**0.993**	0.938	0.926	0.188	0.673	0.750	0.995	0.997
$R_{3,t}\&R_{9,t}$	**0.999**	0.700	0.997	0.949	0.986	0.989	1.000	1.000	**0.999**	0.831	0.987	0.540	0.934	0.951	1.000	1.000
$R_{3,t}\&R_{12,t}$	**0.999**	0.658	0.997	0.963	0.989	0.991	1.000	1.000	**0.999**	0.828	0.986	0.413	0.929	0.948	1.000	1.000
$R_{3,t}\&R_{24,t}$	**1.000**	0.718	0.998	0.979	0.993	0.994	1.000	1.000	**1.000**	0.863	0.985	0.380	0.919	0.942	1.000	1.000
$R_{3,t}\&R_{36,t}$	**1.000**	0.758	0.998	0.984	0.994	0.995	1.000	1.000	**1.000**	0.879	0.983	0.404	0.908	0.935	1.000	1.000
$R_{3,t}\&R_{48,t}$	**1.000**	0.773	0.998	0.986	0.995	0.996	1.000	1.000	**1.000**	0.877	0.983	0.433	0.903	0.932	1.000	1.000
$R_{3,t}\&R_{60,t}$	**1.000**	0.788	0.999	0.987	0.995	0.996	1.000	1.000	**1.000**	0.875	0.982	0.445	0.901	0.932	1.000	1.000
$R_{9,t}\&R_{36,t}$	**0.967**	0.001	0.996	0.936	0.986	0.989	1.000	1.000	**0.967**	0.668	0.913	0.102	0.620	0.707	0.993	0.996
$R_{12,t}\&R_{24,t}$	**0.889**	0.001	0.988	0.746	0.953	0.963	0.999	0.999	**0.889**	0.270	0.909	0.081	0.623	0.705	0.993	0.996
$R_{12,t}\&R_{36,t}$	**1.000**	0.886	0.997	0.956	0.987	0.990	1.000	1.000	**1.000**	0.946	0.980	0.511	0.889	0.921	1.000	1.000
$R_{12,t}\&R_{48,t}$	**1.000**	0.832	0.998	0.961	0.990	0.992	1.000	1.000	**1.000**	0.920	0.979	0.474	0.883	0.919	1.000	1.000
$R_{12,t}\&R_{60,t}$	**1.000**	0.824	0.998	0.968	0.992	0.993	1.000	1.000	**1.000**	0.913	0.980	0.476	0.884	0.921	1.000	1.000
$R_{24,t}\&R_{48,t}$	**0.993**	0.293	0.994	0.902	0.972	0.978	1.000	1.000	**0.993**	0.532	0.981	0.563	0.895	0.925	1.000	1.000

Note: Table provides a sample standard deviation ratio and a correlation coefficient between actual and theoretical spreads for each maturity pair in **bolds**. Also provided is an empirical p value, which is a proportion of 25000 st.dev ratios/correlation coef-s, obtained from the null DGP, that are less than the sample statistic. Mean, minimum and 0.025%, 0.05%, 0.95% and 0.975% quantiles are given too.

Case3: Oct 1992- May 2004

	Panel A. Actual and Theoretical Spreads' Standard Deviations Ratio															
	i.i.d. bootstrap DGP result								***wild bootstrap DGP result***							
	coef	**emp.p**	**mean**	**min**	**0.03**	**0.05**	**0.95**	**0.98**	**coef**	**emp.p**	**mean**	**min**	**0.03**	**0.05**	**0.95**	**0.98**
$R_{1,t}\&R_{3,t}$	**0.661**	0.000	1.003	0.578	0.833	0.862	1.132	1.155	**0.661**	0.003	0.990	0.471	0.776	0.817	1.124	1.142
$R_{1,t}\&R_{9,t}$	**0.838**	0.000	3.485	1.894	2.722	2.879	3.957	4.022	**0.838**	0.000	3.489	1.331	2.552	2.735	4.024	4.088
$R_{1,t}\&R_{12,t}$	**0.801**	0.000	3.672	1.304	2.491	2.685	4.606	4.776	**0.801**	0.000	3.731	0.630	2.102	2.340	5.065	5.297
$R_{1,t}\&R_{24,t}$	**0.758**	0.000	5.059	1.400	2.886	3.181	7.123	7.536	**0.758**	0.000	5.251	0.607	2.055	2.413	8.693	9.333
$R_{1,t}\&R_{36,t}$	**0.736**	0.000	5.655	1.446	3.031	3.374	8.425	9.065	**0.736**	0.000	5.986	0.471	1.905	2.279	11.01	12.11
$R_{1,t}\&R_{48,t}$	**0.728**	0.000	5.961	1.663	3.143	3.476	9.124	9.939	**0.728**	0.000	6.413	0.290	1.828	2.200	12.48	13.93
$R_{1,t}\&R_{60,t}$	**0.728**	0.000	6.136	1.644	3.222	3.573	9.505	10.37	**0.728**	0.001	6.686	0.235	1.807	2.172	13.40	15.05
$R_{3,t}\&R_{9,t}$	**0.738**	0.000	2.382	1.132	1.804	1.907	2.805	2.874	**0.738**	0.000	2.407	0.858	1.679	1.805	2.937	3.016
$R_{3,t}\&R_{12,t}$	**0.750**	0.000	3.126	1.255	2.171	2.320	3.869	3.994	**0.750**	0.000	3.181	0.918	1.932	2.130	4.173	4.333
$R_{3,t}\&R_{24,t}$	**0.737**	0.000	4.744	1.369	2.720	2.998	6.645	7.034	**0.737**	0.000	4.939	0.655	2.020	2.355	7.991	8.578
$R_{3,t}\&R_{36,t}$	**0.728**	0.000	5.435	1.516	2.943	3.241	8.084	8.673	**0.728**	0.000	5.768	0.485	1.913	2.283	10.39	11.50
$R_{3,t}\&R_{48,t}$	**0.724**	0.000	5.791	1.490	3.064	3.407	8.865	9.606	**0.724**	0.000	6.245	0.487	1.856	2.230	11.95	13.37
$R_{3,t}\&R_{60,t}$	**0.724**	0.000	5.997	1.513	3.177	3.506	9.270	10.14	**0.724**	0.000	6.547	0.546	1.834	2.212	12.90	14.53
$R_{9,t}\&R_{36,t}$	**0.766**	0.000	5.049	1.080	2.615	2.941	7.479	8.032	**0.766**	0.004	5.231	0.252	1.405	1.792	9.470	10.31
$R_{12,t}\&R_{24,t}$	**0.706**	0.000	3.131	0.506	1.579	1.797	4.511	4.766	**0.706**	0.007	3.194	0.211	1.053	1.324	5.153	5.477
$R_{12,t}\&R_{36,t}$	**0.765**	0.000	4.563	0.866	2.337	2.620	6.798	7.265	**0.765**	0.006	4.757	0.224	1.289	1.635	8.501	9.259
$R_{12,t}\&R_{48,t}$	**0.827**	0.000	5.362	1.307	2.736	3.051	8.184	8.858	**0.827**	0.005	5.699	0.185	1.443	1.867	10.67	11.79
$R_{12,t}\&R_{60,t}$	**0.877**	0.000	5.859	1.354	2.979	3.312	9.126	9.869	**0.877**	0.005	6.325	0.244	1.571	2.035	12.15	13.62
$R_{24,t}\&R_{48,t}$	**1.055**	0.000	6.601	0.745	3.071	3.524	9.647	10.17	**1.055**	0.002	6.829	0.181	2.304	2.874	10.45	10.97
	Panel B. Actual and Theoretical Spreads' Correlation Coefficient															
	i.i.d. bootstrap DGP result								***wild bootstrap DGP result***							
$R_{1,t}\&R_{3,t}$	**0.829**	0.000	0.979	0.804	0.942	0.952	0.995	0.996	**0.829**	0.001	0.971	0.698	0.914	0.930	0.993	0.994
$R_{1,t}\&R_{9,t}$	**1.000**	0.926	0.998	0.971	0.993	0.994	1.000	1.000	**1.000**	0.791	0.999	0.950	0.991	0.994	1.000	1.000
$R_{1,t}\&R_{12,t}$	**0.998**	0.963	0.989	0.842	0.962	0.971	0.998	0.999	**0.998**	0.982	0.977	0.597	0.909	0.930	0.997	0.998
$R_{1,t}\&R_{24,t}$	**0.996**	0.908	0.985	0.792	0.954	0.963	0.997	0.997	**0.996**	0.938	0.963	-0.052	0.826	0.878	0.996	0.997
$R_{1,t}\&R_{36,t}$	**0.993**	0.838	0.983	0.787	0.951	0.960	0.996	0.997	**0.993**	0.888	0.954	-0.310	0.766	0.840	0.995	0.997
$R_{1,t}\&R_{48,t}$	**0.993**	0.860	0.982	0.780	0.949	0.959	0.995	0.996	**0.993**	0.890	0.949	-0.460	0.734	0.820	0.995	0.997
$R_{1,t}\&R_{60,t}$	**0.993**	0.913	0.982	0.788	0.949	0.959	0.995	0.996	**0.993**	0.910	0.948	-0.526	0.720	0.813	0.995	0.997
$R_{3,t}\&R_{9,t}$	**0.996**	0.713	0.991	0.887	0.970	0.977	0.999	0.999	**0.996**	0.846	0.985	0.774	0.946	0.958	0.998	0.999
$R_{3,t}\&R_{12,t}$	**0.996**	0.765	0.989	0.857	0.964	0.971	0.998	0.999	**0.996**	0.868	0.981	0.592	0.925	0.942	0.998	0.998
$R_{3,t}\&R_{24,t}$	**0.988**	0.484	0.985	0.817	0.953	0.962	0.997	0.997	**0.988**	0.694	0.966	-0.052	0.849	0.890	0.996	0.997
$R_{3,t}\&R_{36,t}$	**0.985**	0.440	0.983	0.769	0.951	0.960	0.996	0.997	**0.985**	0.666	0.958	-0.337	0.793	0.858	0.996	0.997
$R_{3,t}\&R_{48,t}$	**0.986**	0.498	0.982	0.781	0.950	0.959	0.995	0.996	**0.986**	0.691	0.954	-0.377	0.765	0.842	0.996	0.997
$R_{3,t}\&R_{60,t}$	**0.987**	0.595	0.982	0.806	0.950	0.959	0.995	0.996	**0.987**	0.728	0.953	-0.450	0.754	0.835	0.996	0.997
$R_{9,t}\&R_{36,t}$	**0.991**	0.712	0.984	0.855	0.956	0.963	0.996	0.997	**0.991**	0.626	0.973	-0.605	0.863	0.910	0.998	0.999
$R_{12,t}\&R_{24,t}$	**0.979**	0.259	0.983	0.737	0.949	0.959	0.996	0.997	**0.979**	0.294	0.978	-0.876	0.895	0.930	0.998	0.999
$R_{12,t}\&R_{36,t}$	**0.989**	0.663	0.983	0.838	0.954	0.961	0.996	0.997	**0.989**	0.555	0.975	-0.896	0.876	0.916	0.998	0.999
$R_{12,t}\&R_{48,t}$	**0.995**	0.939	0.983	0.868	0.954	0.961	0.995	0.996	**0.995**	0.781	0.975	-0.843	0.877	0.919	0.998	0.999
$R_{12,t}\&R_{60,t}$	**0.997**	0.993	0.982	0.872	0.954	0.961	0.995	0.996	**0.997**	0.913	0.976	-0.749	0.881	0.922	0.998	0.999
$R_{24,t}\&R_{48,t}$	**0.999**	0.999	0.986	0.917	0.966	0.971	0.995	0.996	**0.999**	0.829	0.995	0.857	0.982	0.986	0.999	1.000

See Note to *Case 2*.