Applied Time Series Analysis

ANALYSIS OF EUROPEAN, AMERICAN AND JAPANESE GOVERNMENT BOND YIELDS

Stationarity, cointegration, Granger causality

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1. INTRODUCTION

Investors frequently differentiate their portfolios in order to benefit from risk pooling. Various economists have argued that holding a portfolio of diversified assets results in less risk and smaller losses incurred by the portfolio owner. This also applies to the international bond markets. Often, investors hold bonds from more than one national market with the aim of reducing the risk of their portfolio. If international bond markets are strongly correlated in the long run, reducing the risk through diversification will not be as effective as in the case if the bond markets were uncorrelated and thus operated independently of each other.

Similarly, in their portfolios investors often hold bonds with dissimilar maturities. This is also a way of diversifying the risk. Again, if strong correlation occurs between bonds from the same national market with different maturities, diversification will not be effective.

An important indication of the degree to which long-run diversification is an option for international bond markets' investors is given by testing whether these markets are cointegrated.

Numerous papers have studied and analysed these relationships. A paper by Mills and Mills (1991) provides a conclusion that bond yields are not cointegrated and in the long run they are determined by their own domestic fundamentals. What is more, Clare, Maras and Thomas (1995) also find that there is no cointegration between any pair of bond indices from their sample of UK, US, German and Japanese bond returns. These two papers, however, come from the 1990s and their results may no longer be applicable to today's world. Over the last years globalization has become one of the major forces influencing the global financial markets. The surge of liberalization, combined with political, technological, and financial developments, has brought about an increased interdependence between the world's most prominent financial markets. In today's world any information reaching the news has a global rather than local impact. Therefore, we believe that the cointegration of international government bond markets may no longer be in place.

Less attention in the literature has been given to the interdependence of government bonds with respect to their maturities. One study addressing this issue was performed by Driessen, Melenberg and Nijman (2003), who found that positive correlations between bonds were driven by their term-structure. With the increasing integration of the European financial and capital markets, and especially the introduction of a common currency and common monetary policy monitored by the European Central Bank, we believe that cointegration in the European government bonds with dissimilar term structures is in place.

2. HYPOTHESES

This report has two major hypotheses:

Hypothesis I: Firstly, we believe that there is more evidence of cointegration over the recent years between international government bond markets. This hypothesis will be tested on the data obtained for government bond yields in the Euro area, USA and Japan over the period from 1 January 2005 to 31 December 2011.

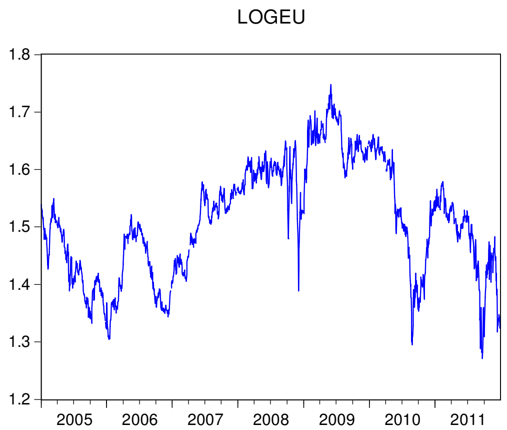
Hypothesis II: Secondly, we believe that there will be evidence of cointegration within the Euro-area for government bonds with different terms to maturity. This hypothesis will be tested on the data obtained for government bond yields in the Euro area over the period from 1 January 2005 to 31 December 2011 with maturities of 1 year, 5 years, 10 years and 15 years.

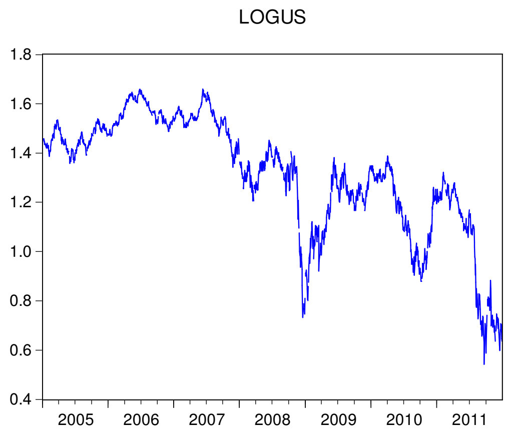
The main conclusion from these two hypotheses, if they prove correct, is that investors incorrectly believe that risk reduction is possible with portfolio diversification in the case of portfolios consisting of government bonds from different national markets and with dissimilar term structures.

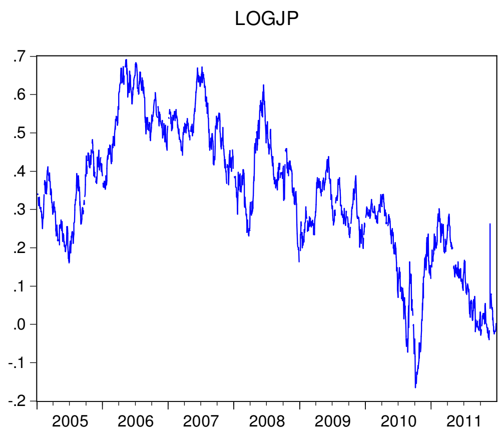
3. HYPOTHESIS I: INTERNATIONAL MARKETS ANALYSIS

3.1 Data description

The data set for testing Hypothesis I consists of daily 10-year maturity government bond yields from the Euro area (changing composition of government bonds with AAA rating), USA and Japan. All data were subject to logarithmic transformations. The data for the Euro area was obtained from the European Central Bank website. The data for USA and Japan was obtained from Datastream. Data was collected for the period from 1 January 2005 to 31 December 2011. For each country there is 1825 data points (although in some cases data was non-obtainable, for example when the Japanese capital markets closed after the 2010 earthquake). Graphs below represent the logarithmised data plots:







3.2 Augmented Dickey-Fuller test

In order to test for stationarity of the data sets we performed the Augmented Dickey-Fuller (ADF) tests with trend. First, the ADF test was applied to the level series. The ADF tests for unit root in levels for all three series were that the series are non-stationary, i.e. the null hypothesis of unit root existence cannot be rejected. In the next step, we tested for unit root existence in first order differences. The result was that all three series are difference stationary, i.e. they all are I(1).

The EViews outputs for both level and first-order differences are presented in Appendix A.

3.3 Johansen procedures

The Johansen procedure is the most common and efficient procedure for estimating and testing for cointegration. The steps of the procedure are:

(1) First, ensure that all variables Xj , j = 1, … , n are either I(1) or I(0);

(2) Determine the VAR lag order p using the multivariate information criteria;

(3) Find the cointegrating rank r by sequences of hypothesis tests and estimate β;

(4) Finally, estimate the full EC-VAR model given p and r to estimate α and all ψj .

In the previous section, using ADF test it has already been established that all three data series are I(1). The next step is to determine the VAR lag order. The output from EViews is:

VAR Lag Order Selection Criteria
Endogenous variables: LOGEU LOGUS LOGJP
Exogenous variables: C
Date: 01/29/12 Time: 22:47
Sample: 1/03/2005 12/30/2011
Included observations: 348

Lag	LogL	LR	FPE	AIC	SC	HQ
0	698.7215	NA	3.68e-06	-3.998399	-3.965191	-3.985178
1	2865.087	4282.929	1.52e-11	-16.39705	-16.26422	-16.34417
2	2897.029	62.59927	1.33e-11*	-16.52890*	-16.29644*	-16.43635*
3	2906.005	17.43615	1.33e-11	-16.52876	-16.19668	-16.39655
4	2914.371	16.10778	1.34e-11	-16.52512	-16.09341	-16.35325
5	2921.919	14.40152	1.35e-11	-16.51678	-15.98544	-16.30524
6	2925.067	5.952265	1.39e-11	-16.48314	-15.85218	-16.23195
7	2929.739	8.752679	1.43e-11	-16.45827	-15.72768	-16.16741
8	2938.034	15.39826	1.44e-11	-16.45422	-15.62400	-16.12369
9	2941.585	6.531713	1.48e-11	-16.42290	-15.49306	-16.05272
10	2946.021	8.080368	1.52e-11	-16.39667	-15.36720	-15.98682
11	2950.515	8.109530	1.56e-11	-16.37077	-15.24168	-15.92126
12	2957.682	12.81006	1.58e-11	-16.36024	-15.13152	-15.87106
13	2964.726	12.46952	1.60e-11	-16.34900	-15.02065	-15.82016
14	2976.210	20.12962*	1.58e-11	-16.36327	-14.93530	-15.79477
15	2981.882	9.844954	1.61e-11	-16.34415	-14.81655	-15.73598

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Using the Akaike information criteria (AIC) the lag order was determined to be 2.

The following step was to run the Johansen cointegration procedure. The EViews output is presented in Appendix B and Appendix C.

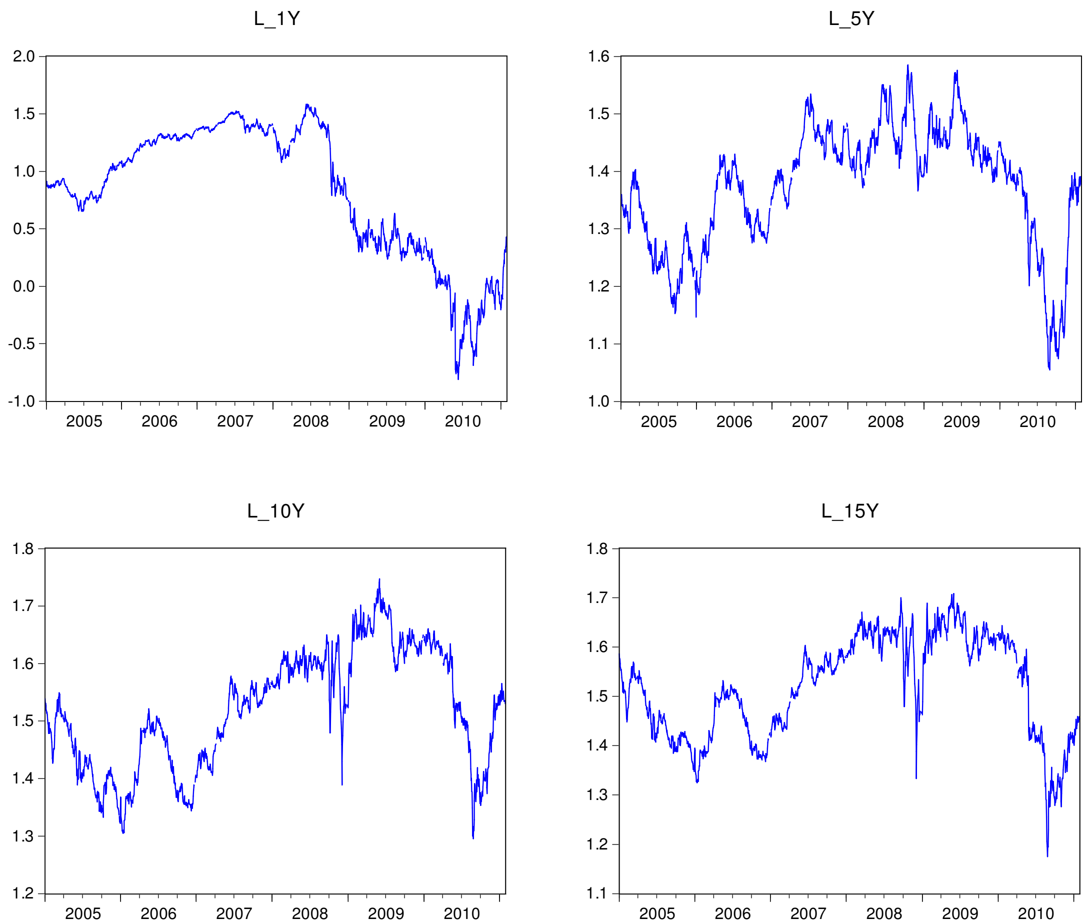
3.4 Results

The EViews output shows no evidence of cointegration between the three national government bond markets in question. Hence, our hypothesis that there will be evidence of cointegration between national government bond markets could not be proven correct. This is a surprising result considering the developments in worldwide information systems, integration of financial markets and globalisation. Nonetheless, it is also good news for investors who may benefit from portfolio diversification.

4. HYPOTHESIS II: TERM STRUCTURE ANALYSIS

4.1 Data description

The data set for testing Hypothesis II consists of government bond yields from the Euro area (changing composition of government bonds with AAA rating) with maturities of 1 year, 5 years, 10 years and 15 years. All data were subject to logarithmic transformations. The data was obtained from the European Central Bank website. Data was collected for the period from 1 January 2005 to 31 December 2011. For each term structure there is 1825 data points.



4.2 Augmented Dickey-Fuller test

In order to test for stationarity of the data sets we performed the Augmented Dickey-Fuller (ADF) tests with trend. First, the ADF test was applied to the level series. The ADF tests for unit root in levels for all four series were that the series are non-stationary, i.e. the null hypothesis of unit root existence cannot be rejected. In the next step, we tested for unit root existence in first order differences. The result was that all four series are difference stationary, i.e. they all are I(1).

The EViews outputs for both level and first-order differences are presented in Appendix D.

4.3 Johansen procedure

The steps of the Johansen procedure were the same as those described in section 3.3. Having determined that all four series are I(1), we determined the VAR lag order. The EViews output is:

VAR Lag Order Selection Criteria
Endogenous variables: L_10Y L_15Y L_1Y L_5Y
Exogenous variables: C
Date: 01/30/12 Time: 00:04
Sample: 1/03/2005 1/31/2011
Included observations: 1313

Lag	LogL	LR	FPE	AIC	SC	HQ
0	5808.439	NA	1.70e-09	-8.841491	-8.825710	-8.835573
1	16170.18	20644.56	2.43e-16	-24.60042	-24.52152	-24.57083
2	16239.05	136.8035	2.25e-16	-24.68096	-24.53893*	-24.62770*
3	16250.99	23.63755	2.26e-16	-24.67477	-24.46962	-24.59784
4	16268.09	33.76861	2.26e-16	-24.67646	-24.40818	-24.57585
5	16286.51	36.25071	2.25e-16	-24.68014	-24.34875	-24.55586
6	16306.78	39.76619	2.23e-16	-24.68665	-24.29213	-24.53869
7	16326.45	38.45663	2.22e-16	-24.69223	-24.23458	-24.52060
8	16336.20	19.02583	2.24e-16	-24.68272	-24.16195	-24.48742
9	16367.13	60.11450	2.19e-16*	-24.70546*	-24.12157	-24.48649
10	16376.23	17.62454	2.21e-16	-24.69494	-24.04793	-24.45230
11	16385.76	18.40904	2.24e-16	-24.68509	-23.97495	-24.41877
12	16402.97	33.12494	2.23e-16	-24.68692	-23.91366	-24.39694
13	16417.52	27.94099	2.24e-16	-24.68473	-23.84834	-24.37107
14	16438.05	39.26722	2.22e-16	-24.69162	-23.79211	-24.35429
15	16462.13	45.91911*	2.20e-16	-24.70392	-23.74129	-24.34292

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Using the Akaike information criteria (AIC) the lag order was determined to be 9.

The following step was to run the Johansen cointegration procedure. The EViews output is presented in Appendix E and Appendix F.

From the EViews output it can be concluded that the null hypothesis of no cointegration has been rejected. The bond yields with dissimilar maturity structures seem to be cointegrated, usually with one cointegrating vector. Thus we can proceed with the Granger Causality test.

4.4 Granger Causality test

Finally, as a VAR may include many lags of variables, it is often difficult to observe which sets of variables do and which do not have significant effects on each dependent variable. The Granger Causality test aims to address this issue. The method is used to find out whether changes in x_1 cause changes in x_2. The logic behind it is that if x_1 causes x_2, lags of x_1 should be significant in the equation for x_2. If such a relationship exists then it may be assumed that x_1 'Granger causes' x_2 or that there is an unidirectional causality from x_1 to x_2. The same applies if these variables were reversed. If both sets of lags are significant, the relationship is described as a 'bi-directional causality'.

The EViews output for the Granger Causality test is presented in Appendix G.

The results show significant evidence of lead-lag interactions between the series. The yields on 1-year government bonds 'Granger cause' each of the remaining maturities at a 5% significance level, but there is no causality in the opposite direction. This is consistent with the general intuition that yields on short-term bonds might influence those with longer-term maturities.

4.5 Results

The EViews output showed that the null hypothesis of no cointegration has been rejected. Hence, our hypothesis that there will be evidence of cointegration between government bond markets with dissimilar maturities proved correct. This is not a surprising result considering the introduction of a single currency and the fact that the Euro area countries share a common monetary policy. However, it is also bad news for investors who probably will not benefit from portfolio diversification in terms of maturity structure. What is more, we have found evidence that the yields on short term (1-year) government bonds influence the yields on longer term (5-, 10-, and 15-years) bonds.

5. CONCLUSION

The results of our study are in line with the literature we have reviewed in section 1 of this report. For Hypothesis I, both approaches described in the papers by Mills and Mills (1991) and Clare, Maras and Thomas (1995), as well as our research have suggested that international bond markets are not cointegrated. This implies that investors can gain substantial diversification benefits. Clare, Maras and Thomas (1995) report that the lack of long-term integration between the markets may be due to things like heterogeneous maturity and taxation structures, as well as dissimilar investment cultures, issuance patterns and macroeconomic policies between the countries in question. This would infer that the markets operate mainly independently of one another.

For Hypothesis II, we have found that the null hypothesis of no cointegration has been rejected. Therefore, our hypothesis that there will be evidence of cointegration between government bond markets with dissimilar maturity structures was correct. This conclusion is supported by the intuition behind the functioning of financial and capital markets in the Euro area. Since the Euro area countries share a common monetary policy, the interest rates are set by the ECB for all countries which are part of the Euro area. The government bond yields are largely influenced by the interest rates and thus a common change in interest rates for these countries will have the same or similar effect on all government bond yields in the Euro area. What is more, we found that long-term bond yields may be influenced by those with short term maturity structure.

Overall, investors may benefit from diversifying their government bonds portfolio in terms of nationality, but there no evidence supporting their eagerness of benefiting from terms structure diversification.

6. REFERENCES

Clare, A., Maras, M., Thomas, S., 1995. The integration and efficiency of international bond markets. *Journal of Business Finance and Accounting* (22), 313-322

Driessen, J., Melenberg, D., Nijman, T., 2003. Common factors in international bond returns. *Journal of International Money and Finance* (22), 629-656.

Mills, T., Mills, A., 1991. The international transmission of bond market movements. *Bulletin of Economic Research* (43), 273-282

7. APPENDICES

7.1 Appendix A

ADF - Euro area bond yields (10Y maturity)

Null Hypothesis: LOGEU has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 12 (Automatic based on AIC, MAXLAG=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.833412	0.6881
Test critical values:	1% level	-3.963937	
	5% level	-3.412693	
	10% level	-3.128317	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGEU)
Method: Least Squares
Date: 01/29/12 Time: 21:15
Sample (adjusted): 1/20/2005 12/23/2011
Included observations: 1560 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGEU(-1)	-0.005598	0.003053	-1.833412	0.0669
D(LOGEU(-1))	0.090344	0.025480	3.545687	0.0004
D(LOGEU(-2))	-0.026258	0.025592	-1.026020	0.3050
D(LOGEU(-3))	0.006545	0.025635	0.255315	0.7985
D(LOGEU(-4))	-0.059661	0.025602	-2.330352	0.0199
D(LOGEU(-5))	0.061335	0.025550	2.400554	0.0165
D(LOGEU(-6))	-0.041070	0.025584	-1.605304	0.1086
D(LOGEU(-7))	-0.013044	0.025614	-0.509237	0.6107
D(LOGEU(-8))	-0.048199	0.025808	-1.867621	0.0620
D(LOGEU(-9))	0.025147	0.025656	0.980170	0.3272
D(LOGEU(-10))	0.010834	0.025658	0.422247	0.6729
D(LOGEU(-11))	0.009706	0.025560	0.379729	0.7042
D(LOGEU(-12))	-0.077801	0.025534	-3.046976	0.0024
C	0.008239	0.004487	1.836060	0.0665
@TREND(1/03/2005)	-1.86E-08	5.58E-07	-0.033266	0.9735

R-squared	0.027001	Mean dependent var	-0.000214
Adjusted R-squared	0.018184	S.D. dependent var	0.011309
S.E. of regression	0.011205	Akaike info criterion	-6.135299
Sum squared resid	0.193987	Schwarz criterion	-6.083833
Log likelihood	4800.533	Hannan-Quinn criter.	-6.116164
F-statistic	3.062414	Durbin-Watson stat	1.991245
Prob(F-statistic)	0.000105		

Null Hypothesis: D(LOGEU) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 11 (Automatic based on AIC, MAXLAG=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.58279	0.0000
Test critical values:	1% level	-3.963937	
	5% level	-3.412693	
	10% level	-3.128317	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGEU,2)
Method: Least Squares
Date: 01/29/12 Time: 21:13
Sample (adjusted): 1/20/2005 12/23/2011
Included observations: 1560 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGEU(-1))	-1.101588	0.087547	-12.58279	0.0000
D(LOGEU(-1),2)	0.188761	0.083606	2.257751	0.0241
D(LOGEU(-2),2)	0.158968	0.079569	1.997864	0.0459
D(LOGEU(-3),2)	0.162132	0.075203	2.155911	0.0312
D(LOGEU(-4),2)	0.098822	0.070226	1.407212	0.1596
D(LOGEU(-5),2)	0.156828	0.065365	2.399273	0.0165
D(LOGEU(-6),2)	0.112189	0.060514	1.853952	0.0639
D(LOGEU(-7),2)	0.095741	0.055662	1.720043	0.0856
D(LOGEU(-8),2)	0.044255	0.049126	0.900856	0.3678
D(LOGEU(-9),2)	0.066505	0.042422	1.567717	0.1172
D(LOGEU(-10),2)	0.074304	0.034608	2.147025	0.0319
D(LOGEU(-11),2)	0.081052	0.025492	3.179541	0.0015
C	7.86E-05	0.000571	0.137704	0.8905
@TREND(1/03/2005)	-3.30E-07	5.32E-07	-0.620712	0.5349

R-squared	0.467086	Mean dependent var	-3.54E-06
Adjusted R-squared	0.462604	S.D. dependent var	0.015297
S.E. of regression	0.011214	Akaike info criterion	-6.134408
Sum squared resid	0.194409	Schwarz criterion	-6.086373
Log likelihood	4798.838	Hannan-Quinn criter.	-6.116548
F-statistic	104.2329	Durbin-Watson stat	1.991561
Prob(F-statistic)	0.000000		

ADF - US bond yields (10Y maturity)

Null Hypothesis: LOGUS has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 16 (Automatic based on AIC, MAXLAG=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.885924	0.6607
Test critical values:	1% level	-3.971586	
	5% level	-3.416430	
	10% level	-3.130531	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGUS)
Method: Least Squares
Date: 01/29/12 Time: 21:16
Sample (adjusted): 2/10/2005 12/23/2011
Included observations: 681 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGUS(-1)	-0.011172	0.005924	-1.885924	0.0597
D(LOGUS(-1))	-0.071255	0.040001	-1.781318	0.0753
D(LOGUS(-2))	-0.090119	0.039983	-2.253928	0.0245
D(LOGUS(-3))	-0.056369	0.040953	-1.376440	0.1692
D(LOGUS(-4))	-0.047371	0.039984	-1.184748	0.2365
D(LOGUS(-5))	-0.033304	0.038835	-0.857583	0.3914
D(LOGUS(-6))	0.022603	0.039013	0.579366	0.5625
D(LOGUS(-7))	0.085009	0.038680	2.197746	0.0283
D(LOGUS(-8))	0.063145	0.039629	1.593406	0.1115
D(LOGUS(-9))	0.010931	0.039896	0.273994	0.7842
D(LOGUS(-10))	0.040411	0.038983	1.036634	0.3003
D(LOGUS(-11))	-0.035975	0.039405	-0.912938	0.3616
D(LOGUS(-12))	0.044306	0.040615	1.090877	0.2757
D(LOGUS(-13))	0.015870	0.040974	0.387317	0.6986
D(LOGUS(-14))	0.004744	0.040365	0.117530	0.9065
D(LOGUS(-15))	0.030122	0.040123	0.750727	0.4531
D(LOGUS(-16))	-0.050299	0.039349	-1.278271	0.2016
C	0.019107	0.009802	1.949287	0.0517
@TREND(1/03/2005)	-5.83E-06	2.43E-06	-2.401690	0.0166

R-squared	0.041534	Mean dependent var	-0.000705
Adjusted R-squared	0.015473	S.D. dependent var	0.020022
S.E. of regression	0.019866	Akaike info criterion	-4.972109
Sum squared resid	0.261264	Schwarz criterion	-4.845901
Log likelihood	1712.003	Hannan-Quinn criter.	-4.923260
F-statistic	1.593720	Durbin-Watson stat	1.963874
Prob(F-statistic)	0.055943		

Null Hypothesis: D(LOGUS) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 15 (Automatic based on AIC, MAXLAG=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.883988	0.0000
Test critical values:	1% level	-3.971586	
	5% level	-3.416430	
	10% level	-3.130531	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGUS,2)
Method: Least Squares
Date: 01/29/12 Time: 21:11
Sample (adjusted): 2/10/2005 12/23/2011
Included observations: 681 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGUS(-1))	-1.222825	0.177633	-6.883988	0.0000
D(LOGUS(-1),2)	0.143173	0.171033	0.837111	0.4028
D(LOGUS(-2),2)	0.043269	0.163029	0.265406	0.7908
D(LOGUS(-3),2)	-0.025401	0.156116	-0.162703	0.8708
D(LOGUS(-4),2)	-0.085314	0.149866	-0.569267	0.5694
D(LOGUS(-5),2)	-0.131769	0.143588	-0.917687	0.3591
D(LOGUS(-6),2)	-0.122181	0.138132	-0.884526	0.3767
D(LOGUS(-7),2)	-0.049334	0.132257	-0.373016	0.7093
D(LOGUS(-8),2)	-0.000737	0.124575	-0.005915	0.9953
D(LOGUS(-9),2)	-0.002852	0.116318	-0.024523	0.9804
D(LOGUS(-10),2)	0.027209	0.108176	0.251522	0.8015
D(LOGUS(-11),2)	-0.018569	0.100007	-0.185681	0.8528
D(LOGUS(-12),2)	0.017451	0.088565	0.197038	0.8439
D(LOGUS(-13),2)	0.025316	0.075202	0.336642	0.7365
D(LOGUS(-14),2)	0.024485	0.058782	0.416537	0.6772
D(LOGUS(-15),2)	0.051589	0.039419	1.308741	0.1911
C	0.000852	0.001548	0.550569	0.5821
@TREND(1/03/2005)	-2.27E-06	1.53E-06	-1.484497	0.1382

R-squared	0.533411	Mean dependent var	0.000570
Adjusted R-squared	0.521447	S.D. dependent var	0.028773
S.E. of regression	0.019904	Akaike info criterion	-4.969688
Sum squared resid	0.262668	Schwarz criterion	-4.850122
Log likelihood	1710.179	Hannan-Quinn criter.	-4.923410
F-statistic	44.58537	Durbin-Watson stat	1.958672
Prob(F-statistic)	0.000000		

ADF - Japanese bond yields (10Y maturity)

Null Hypothesis: LOGJP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on AIC, MAXLAG=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.251035	0.0750
Test critical values:	1% level	-3.963680	
	5% level	-3.412567	
	10% level	-3.128243	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGJP)
Method: Least Squares
Date: 01/29/12 Time: 21:16
Sample (adjusted): 1/05/2005 12/30/2011
Included observations: 1631 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGJP(-1)	-0.011004	0.003385	-3.251035	0.0012
C	0.006380	0.002050	3.112137	0.0019
@TREND(1/03/2005)	-3.46E-06	1.15E-06	-3.009436	0.0027

R-squared	0.007244	Mean dependent var	-0.000497
Adjusted R-squared	0.006025	S.D. dependent var	0.018374
S.E. of regression	0.018318	Akaike info criterion	-5.160016
Sum squared resid	0.546280	Schwarz criterion	-5.150089
Log likelihood	4210.993	Hannan-Quinn criter.	-5.156333
F-statistic	5.939904	Durbin-Watson stat	2.023774
Prob(F-statistic)	0.002690		

Null Hypothesis: D(LOGJP) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 12 (Automatic based on AIC, MAXLAG=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.629128	0.0000
Test critical values:	1% level	-3.969549	
	5% level	-3.415436	
	10% level	-3.129943	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGJP,2)
Method: Least Squares
Date: 01/29/12 Time: 21:12
Sample (adjusted): 1/31/2005 12/22/2011
Included observations: 801 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGJP(-1))	-0.998994	0.130945	-7.629128	0.0000
D(LOGJP(-1),2)	-0.053707	0.126098	-0.425915	0.6703
D(LOGJP(-2),2)	-0.075377	0.119687	-0.629784	0.5290
D(LOGJP(-3),2)	-0.014070	0.113659	-0.123796	0.9015
D(LOGJP(-4),2)	0.031847	0.107816	0.295381	0.7678
D(LOGJP(-5),2)	0.064665	0.101857	0.634862	0.5257
D(LOGJP(-6),2)	0.072623	0.096326	0.753928	0.4511
D(LOGJP(-7),2)	0.043239	0.090287	0.478914	0.6321
D(LOGJP(-8),2)	-0.036586	0.083486	-0.438225	0.6613
D(LOGJP(-9),2)	-0.121302	0.075836	-1.599529	0.1101
D(LOGJP(-10),2)	-0.125335	0.065554	-1.911922	0.0562
D(LOGJP(-11),2)	-0.040380	0.051513	-0.783873	0.4334
D(LOGJP(-12),2)	-0.015186	0.033441	-0.454118	0.6499
C	4.81E-05	0.001198	0.040122	0.9680
@TREND(1/03/2005)	-1.46E-06	1.17E-06	-1.252734	0.2107

R-squared	0.533538	Mean dependent var	-0.000186
Adjusted R-squared	0.525229	S.D. dependent var	0.025076
S.E. of regression	0.017278	Akaike info criterion	-5.260204
Sum squared resid	0.234647	Schwarz criterion	-5.172454
Log likelihood	2121.712	Hannan-Quinn criter.	-5.226496
F-statistic	64.21592	Durbin-Watson stat	2.041713
Prob(F-statistic)	0.000000		

7.2 Appendix B

Johansen procedure – summary

Sample: 1/03/2005 12/30/2011
Included observations: 1252
Series: LOGEU LOGUS LOGJP
Lags interval: 1 to 2

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

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	0	0	0	0	0
Max-Eig	0	0	0	0	0

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

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	10470.00	10470.00	10472.26	10472.26	10473.41
1	10474.14	10478.86	10480.39	10480.60	10481.67
2	10477.04	10482.78	10483.22	10484.22	10484.70
3	10477.11	10483.23	10483.23	10485.85	10485.85
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	-16.69649	-16.69649	-16.69530	-16.69530	-16.69234
1	-16.69352	-16.69946*	-16.69870	-16.69744	-16.69596
2	-16.68856	-16.69453	-16.69364	-16.69205	-16.69121
3	-16.67909	-16.68407	-16.68407	-16.68346	-16.68346
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	-16.62270*	-16.62270*	-16.60921	-16.60921	-16.59396
1	-16.59514	-16.59697	-16.58802	-16.58265	-16.57298
2	-16.56558	-16.56335	-16.55836	-16.54857	-16.54364
3	-16.53151	-16.52419	-16.52419	-16.51128	-16.51128

7.3 Appendix C

Johansen procedure – final output

Sample (adjusted): 1/06/2005 12/30/2011
Included observations: 1373 after adjustments
Trend assumption: Linear deterministic trend
Series: LOGEU LOGUS LOGJP
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008245	16.73867	29.79707	0.6593
At most 1	0.003902	5.371990	15.49471	0.7681
At most 2	2.99E-06	0.004103	3.841466	0.9476

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.008245	11.36668	21.13162	0.6107
At most 1	0.003902	5.367887	14.26460	0.6949
At most 2	2.99E-06	0.004103	3.841466	0.9476

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

7.4 Appendix D

ADF - Euro area bond with maturity of 1 year

Null Hypothesis: L_1Y has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 14 (Automatic based on AIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.790299	0.7092
Test critical values:	1% level	-3.965050	
	5% level	-3.413237	
	10% level	-3.128640	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(L_1Y)
Method: Least Squares
Date: 01/29/12 Time: 23:52
Sample (adjusted): 1/24/2005 1/31/2011
Included observations: 1313 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
L_1Y(-1)	-0.004088	0.002284	-1.790299	0.0736
D(L_1Y(-1))	0.076781	0.027588	2.783094	0.0055
D(L_1Y(-2))	-0.041513	0.027632	-1.502352	0.1332
D(L_1Y(-3))	-0.027701	0.027613	-1.003200	0.3160
D(L_1Y(-4))	-0.068330	0.027564	-2.478982	0.0133
D(L_1Y(-5))	0.028245	0.027638	1.021969	0.3070
D(L_1Y(-6))	0.036448	0.027811	1.310558	0.1902
D(L_1Y(-7))	-0.013942	0.027813	-0.501257	0.6163
D(L_1Y(-8))	-0.047066	0.027851	-1.689940	0.0913
D(L_1Y(-9))	-0.026789	0.027889	-0.960537	0.3370
D(L_1Y(-10))	0.050936	0.027947	1.822559	0.0686
D(L_1Y(-11))	-0.091491	0.027866	-3.283258	0.0011
D(L_1Y(-12))	0.002973	0.027975	0.106271	0.9154
D(L_1Y(-13))	0.042685	0.028097	1.519199	0.1290
D(L_1Y(-14))	-0.076281	0.028190	-2.706018	0.0069
C	0.006985	0.003935	1.775405	0.0761
@TREND(1/03/2005)	-4.75E-06	2.89E-06	-1.642776	0.1007

R-squared	0.038155	Mean dependent var	9.25E-06
Adjusted R-squared	0.026281	S.D. dependent var	0.036719
S.E. of regression	0.036233	Akaike info criterion	-3.784812
Sum squared resid	1.701459	Schwarz criterion	-3.717743
Log likelihood	2501.729	Hannan-Quinn criter.	-3.759660
F-statistic	3.213196	Durbin-Watson stat	2.013435
Prob(F-statistic)	0.000018		

Null Hypothesis: D(L_1Y) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 13 (Automatic based on AIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.77206	0.0000
Test critical values:	1% level	-3.965050	
	5% level	-3.413237	
	10% level	-3.128640	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(L_1Y,2)
Method: Least Squares
Date: 01/29/12 Time: 23:53
Sample (adjusted): 1/24/2005 1/31/2011
Included observations: 1313 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(L_1Y(-1))	-1.173590	0.108948	-10.77206	0.0000
D(L_1Y(-1),2)	0.248828	0.104888	2.372316	0.0178
D(L_1Y(-2),2)	0.205560	0.100194	2.051618	0.0404
D(L_1Y(-3),2)	0.176286	0.095295	1.849907	0.0646
D(L_1Y(-4),2)	0.106531	0.090746	1.173942	0.2406
D(L_1Y(-5),2)	0.133518	0.085419	1.563093	0.1183
D(L_1Y(-6),2)	0.168521	0.080018	2.106023	0.0354
D(L_1Y(-7),2)	0.153051	0.074849	2.044803	0.0411
D(L_1Y(-8),2)	0.104543	0.069321	1.508086	0.1318
D(L_1Y(-9),2)	0.076424	0.062898	1.215037	0.2246
D(L_1Y(-10),2)	0.126131	0.055279	2.281709	0.0227
D(L_1Y(-11),2)	0.033316	0.047861	0.696102	0.4865
D(L_1Y(-12),2)	0.035279	0.038906	0.906784	0.3647
D(L_1Y(-13),2)	0.077137	0.028209	2.734448	0.0063
C	0.000918	0.002000	0.458901	0.6464
@TREND(1/03/2005)	-1.29E-06	2.15E-06	-0.598961	0.5493

R-squared	0.485004	Mean dependent var	4.86E-05
Adjusted R-squared	0.479048	S.D. dependent var	0.050243
S.E. of regression	0.036264	Akaike info criterion	-3.783865
Sum squared resid	1.705667	Schwarz criterion	-3.720742
Log likelihood	2500.107	Hannan-Quinn criter.	-3.760193
F-statistic	81.43122	Durbin-Watson stat	2.013603
Prob(F-statistic)	0.000000		

ADF - Euro area bond with maturity of 5 years

Null Hypothesis: L_5Y has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic based on AIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.213322	0.4812
Test critical values:	1% level	-3.964101	
	5% level	-3.412773	
	10% level	-3.128365	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(L_5Y)
Method: Least Squares
Date: 01/29/12 Time: 23:54
Sample (adjusted): 1/05/2005 1/31/2011
Included observations: 1518 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
L_5Y(-1)	-0.006151	0.002779	-2.213322	0.0270
D(L_5Y(-1))	0.023556	0.025708	0.916300	0.3597
C	0.008315	0.003768	2.206621	0.0275
@TREND(1/03/2005)	1.61E-07	6.41E-07	0.250811	0.8020

R-squared	0.003659	Mean dependent var	7.67E-06
Adjusted R-squared	0.001685	S.D. dependent var	0.011336
S.E. of regression	0.011326	Akaike info criterion	-6.120725
Sum squared resid	0.194228	Schwarz criterion	-6.106693
Log likelihood	4649.631	Hannan-Quinn criter.	-6.115501
F-statistic	1.853498	Durbin-Watson stat	2.012874
Prob(F-statistic)	0.135553		

Null Hypothesis: D(L_5Y) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on AIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-38.10015	0.0000
Test critical values:	1% level	-3.964101	
	5% level	-3.412773	
	10% level	-3.128365	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(L_5Y,2)
Method: Least Squares
Date: 01/29/12 Time: 23:55
Sample (adjusted): 1/05/2005 1/31/2011
Included observations: 1518 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(L_5Y(-1))	-0.979406	0.025706	-38.10015	0.0000
C	7.40E-05	0.000580	0.127538	0.8985
@TREND(1/03/2005)	-8.31E-08	6.32E-07	-0.131429	0.8955

R-squared	0.489318	Mean dependent var	2.50E-05
Adjusted R-squared	0.488644	S.D. dependent var	0.015859
S.E. of regression	0.011341	Akaike info criterion	-6.118813
Sum squared resid	0.194856	Schwarz criterion	-6.108289
Log likelihood	4647.179	Hannan-Quinn criter.	-6.114894
F-statistic	725.8115	Durbin-Watson stat	2.012759
Prob(F-statistic)	0.000000		

ADF - Euro area bond with maturity of 10 years

Null Hypothesis: L_10Y has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 8 (Automatic based on AIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.327837	0.4179
Test critical values:	1% level	-3.964608	
	5% level	-3.413021	
	10% level	-3.128512	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(L_10Y)
Method: Least Squares
Date: 01/29/12 Time: 23:58
Sample (adjusted): 1/14/2005 1/31/2011
Included observations: 1401 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
L_10Y(-1)	-0.007450	0.003200	-2.327837	0.0201
D(L_10Y(-1))	0.124520	0.026829	4.641215	0.0000
D(L_10Y(-2))	-0.039335	0.027062	-1.453533	0.1463
D(L_10Y(-3))	0.032348	0.026972	1.199355	0.2306
D(L_10Y(-4))	-0.026413	0.026967	-0.979466	0.3275
D(L_10Y(-5))	0.048893	0.026777	1.825901	0.0681
D(L_10Y(-6))	-0.066960	0.026756	-2.502585	0.0124
D(L_10Y(-7))	-0.004747	0.026742	-0.177504	0.8591
D(L_10Y(-8))	-0.059505	0.026609	-2.236278	0.0255
C	0.010444	0.004588	2.276449	0.0230
@TREND(1/03/2005)	8.86E-07	6.97E-07	1.271549	0.2037

R-squared	0.029308	Mean dependent var	-0.000158
Adjusted R-squared	0.022325	S.D. dependent var	0.010310
S.E. of regression	0.010194	Akaike info criterion	-6.326124
Sum squared resid	0.144459	Schwarz criterion	-6.284943
Log likelihood	4442.450	Hannan-Quinn criter.	-6.310730
F-statistic	4.196847	Durbin-Watson stat	1.988924
Prob(F-statistic)	0.000009		

Null Hypothesis: D(L_10Y) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 7 (Automatic based on AIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.58721	0.0000
Test critical values:	1% level	-3.964608	
	5% level	-3.413021	
	10% level	-3.128512	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(L_10Y,2)
Method: Least Squares
Date: 01/29/12 Time: 23:58
Sample (adjusted): 1/14/2005 1/31/2011
Included observations: 1401 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(L_10Y(-1))	-1.021207	0.070007	-14.58721	0.0000
D(L_10Y(-1),2)	0.142274	0.065041	2.187460	0.0289
D(L_10Y(-2),2)	0.098810	0.059968	1.647706	0.0996
D(L_10Y(-3),2)	0.127331	0.055208	2.306376	0.0212
D(L_10Y(-4),2)	0.096881	0.049297	1.965258	0.0496
D(L_10Y(-5),2)	0.142426	0.043043	3.308904	0.0010
D(L_10Y(-6),2)	0.071697	0.035274	2.032590	0.0423
D(L_10Y(-7),2)	0.063509	0.026596	2.387956	0.0171
C	-0.000160	0.000545	-0.294596	0.7683
@TREND(1/03/2005)	1.55E-08	5.89E-07	0.026273	0.9790

R-squared	0.447964	Mean dependent var	-6.70E-05
Adjusted R-squared	0.444392	S.D. dependent var	0.013698
S.E. of regression	0.010211	Akaike info criterion	-6.323661
Sum squared resid	0.145022	Schwarz criterion	-6.286224
Log likelihood	4439.724	Hannan-Quinn criter.	-6.309666
F-statistic	125.4182	Durbin-Watson stat	1.988978
Prob(F-statistic)	0.000000		

ADF - Euro area bond with maturity of 15 years

Null Hypothesis: L_15Y has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 14 (Automatic based on AIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.983983	0.6090
Test critical values:	1% level	-3.965050	
	5% level	-3.413237	
	10% level	-3.128640	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(L_15Y)
Method: Least Squares
Date: 01/29/12 Time: 23:59
Sample (adjusted): 1/24/2005 1/31/2011
Included observations: 1313 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
L_15Y(-1)	-0.006521	0.003287	-1.983983	0.0475
D(L_15Y(-1))	0.161107	0.027812	5.792731	0.0000
D(L_15Y(-2))	-0.017867	0.028171	-0.634230	0.5260
D(L_15Y(-3))	-0.014818	0.028103	-0.527255	0.5981
D(L_15Y(-4))	-0.091055	0.028071	-3.243710	0.0012
D(L_15Y(-5))	0.058805	0.028192	2.085903	0.0372
D(L_15Y(-6))	-0.052692	0.028164	-1.870899	0.0616
D(L_15Y(-7))	0.008882	0.028192	0.315069	0.7528
D(L_15Y(-8))	-0.074247	0.028273	-2.626040	0.0087
D(L_15Y(-9))	0.016063	0.028130	0.571028	0.5681
D(L_15Y(-10))	0.031238	0.028183	1.108393	0.2679
D(L_15Y(-11))	-0.066917	0.028045	-2.386079	0.0172
D(L_15Y(-12))	-0.042144	0.027987	-1.505807	0.1324
D(L_15Y(-13))	0.031345	0.027839	1.125958	0.2604
D(L_15Y(-14))	-0.066347	0.027904	-2.377655	0.0176
C	0.009548	0.004895	1.950658	0.0513
@TREND(1/03/2005)	2.85E-08	7.16E-07	0.039795	0.9683

R-squared	0.054530	Mean dependent var	-0.000257
Adjusted R-squared	0.042858	S.D. dependent var	0.012083
S.E. of regression	0.011822	Akaike info criterion	-6.024927
Sum squared resid	0.181114	Schwarz criterion	-5.957859
Log likelihood	3972.365	Hannan-Quinn criter.	-5.999776
F-statistic	4.671680	Durbin-Watson stat	1.983532
Prob(F-statistic)	0.000000		

Null Hypothesis: D(L_15Y) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 13 (Automatic based on AIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.43128	0.0000
Test critical values:	1% level	-3.965050	
	5% level	-3.413237	
	10% level	-3.128640	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(L_15Y,2)
Method: Least Squares
Date: 01/30/12 Time: 00:00
Sample (adjusted): 1/24/2005 1/31/2011
Included observations: 1313 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(L_15Y(-1))	-1.167936	0.102170	-11.43128	0.0000
D(L_15Y(-1),2)	0.325684	0.097580	3.337609	0.0009
D(L_15Y(-2),2)	0.303540	0.092727	3.273490	0.0011
D(L_15Y(-3),2)	0.284858	0.088126	3.232395	0.0013
D(L_15Y(-4),2)	0.190057	0.083771	2.268762	0.0234
D(L_15Y(-5),2)	0.245420	0.078957	3.108296	0.0019
D(L_15Y(-6),2)	0.189169	0.073502	2.573657	0.0102
D(L_15Y(-7),2)	0.194913	0.068725	2.836119	0.0046
D(L_15Y(-8),2)	0.116944	0.063125	1.852589	0.0642
D(L_15Y(-9),2)	0.129709	0.057949	2.238346	0.0254
D(L_15Y(-10),2)	0.157282	0.050942	3.087511	0.0021
D(L_15Y(-11),2)	0.087010	0.044226	1.967389	0.0494
D(L_15Y(-12),2)	0.041739	0.036417	1.146137	0.2519
D(L_15Y(-13),2)	0.070259	0.027866	2.521294	0.0118
C	-7.65E-05	0.000653	-0.117206	0.9067
@TREND(1/03/2005)	-2.68E-07	7.01E-07	-0.381628	0.7028

R-squared	0.440506	Mean dependent var	-2.54E-05
Adjusted R-squared	0.434035	S.D. dependent var	0.015731
S.E. of regression	0.011835	Akaike info criterion	-6.023418
Sum squared resid	0.181664	Schwarz criterion	-5.960295
Log likelihood	3970.374	Hannan-Quinn criter.	-5.999746
F-statistic	68.07760	Durbin-Watson stat	1.983904
Prob(F-statistic)	0.000000		

7.5 Appendix E

Johansen procedure - summary

Sample: 1/03/2005 1/31/2011
Included observations: 1386
Series: L_10Y L_15Y L_1Y L_5Y
Lags interval: 1 to 9

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

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

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

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	17315.76	17315.76	17316.42	17316.42	17316.66
1	17330.52	17331.19	17331.84	17334.02	17334.07
2	17341.50	17342.45	17342.60	17349.41	17349.42
3	17342.79	17346.71	17346.71	17354.58	17354.58
4	17342.79	17347.50	17347.50	17357.74	17357.74
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	-24.77887	-24.77887	-24.77405	-24.77405	-24.76862
1	-24.78864	-24.78815	-24.78476	-24.78647	-24.78221
2	-24.79293	-24.79142	-24.78874	-24.79569*	-24.79282
3	-24.78325	-24.78457	-24.78313	-24.79015	-24.78872
4	-24.77171	-24.77273	-24.77273	-24.78173	-24.78173
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	-24.23506*	-24.23506*	-24.21514	-24.21514	-24.19460
1	-24.21461	-24.21036	-24.19563	-24.19356	-24.17797
2	-24.18870	-24.17963	-24.16940	-24.16879	-24.15837
3	-24.14880	-24.13880	-24.13358	-24.12927	-24.12406
4	-24.10705	-24.09297	-24.09297	-24.08686	-24.08686

7.6 Appendix F

Johansen procedure – final output

Date: 01/30/12 Time: 01:10
Sample (adjusted): 1/06/2005 1/31/2011
Included observations: 1498 after adjustments
Trend assumption: Linear deterministic trend
Series: L_1Y L_5Y L_10Y L_15Y
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.021367	69.34365	47.85613	0.0002
At most 1 *	0.017943	36.98920	29.79707	0.0062
At most 2	0.005558	9.865758	15.49471	0.2912
At most 3	0.001012	1.517202	3.841466	0.2180

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.021367	32.35445	27.58434	0.0113
At most 1 *	0.017943	27.12344	21.13162	0.0063
At most 2	0.005558	8.348556	14.26460	0.3444
At most 3	0.001012	1.517202	3.841466	0.2180

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

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

L_1Y	L_5Y	L_10Y	L_15Y
-5.421626	33.53275	-64.59555	34.04066
2.307438	2.356576	37.61943	-43.28202
-1.158170	-1.193407	-20.67035	12.41073
0.773794	4.036806	-13.38889	8.429569

Unrestricted Adjustment Coefficients (alpha):

D(L_1Y)	0.000559	0.002123	0.001725	-0.000656
D(L_5Y)	-0.000508	0.000296	0.000667	0.000177
D(L_10Y)	0.000424	0.000841	0.000364	0.000177
D(L_15Y)	0.000171	0.001437	0.000197	9.91E-05

1 Cointegrating Equation(s): Log likelihood 18621.68

Normalized cointegrating coefficients (standard error in parentheses)

L_1Y	L_5Y	L_10Y	L_15Y
1.000000	-6.184998	11.91442	-6.278680
	(0.59847)	(0.82863)	(0.98518)

Adjustment coefficients (standard error in parentheses)

D(L_1Y)	-0.003032
	(0.00492)
D(L_5Y)	0.002755
	(0.00159)
D(L_10Y)	-0.002298
	(0.00142)
D(L_15Y)	-0.000929
	(0.00162)

2 Cointegrating Equation(s): Log likelihood 18635.25

Normalized cointegrating coefficients (standard error in parentheses)

L_1Y	L_5Y	L_10Y	L_15Y
1.000000	0.000000	15.68151	-16.98906
		(1.83032)	(1.81279)
0.000000	1.000000	0.609068	-1.731671
		(0.31691)	(0.31388)

Adjustment coefficients (standard error in parentheses)

D(L_1Y)	0.001866	0.023754
	(0.00534)	(0.03046)
D(L_5Y)	0.003437	-0.016343
	(0.00172)	(0.00984)
D(L_10Y)	-0.000358	0.016191
	(0.00154)	(0.00879)
D(L_15Y)	0.002386	0.009133
	(0.00175)	(0.00998)

3 Cointegrating Equation(s): Log likelihood 18639.42

Normalized cointegrating coefficients (standard error in parentheses)

L_1Y	L_5Y	L_10Y	L_15Y
1.000000	0.000000	0.000000	-99.12780
			(31.2755)
0.000000	1.000000	0.000000	-4.921931
			(1.24306)
0.000000	0.000000	1.000000	5.237935
			(1.98200)

Adjustment coefficients (standard error in parentheses)

D(L_1Y)	-0.000132	0.021695	0.008065
	(0.00543)	(0.03044)	(0.07019)
D(L_5Y)	0.002665	-0.017139	0.030162
	(0.00175)	(0.00983)	(0.02266)
D(L_10Y)	-0.000779	0.015757	-0.003272
	(0.00157)	(0.00879)	(0.02027)
D(L_15Y)	0.002157	0.008897	0.038897
	(0.00178)	(0.00998)	(0.02301)

7.7 Appendix G

Granger causality - results

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 01/30/12 Time: 02:33
Sample: 1/03/2005 1/31/2011
Included observations: 1518

Dependent variable: L_10Y

Excluded	Chi-sq	df	Prob.
L_15Y	3.242882	2	0.1976
L_1Y	12.18306	2	0.0023
L_5Y	3.499220	2	0.1738
All	22.18631	6	0.0011

Dependent variable: L_15Y

Excluded	Chi-sq	df	Prob.
L_10Y	25.05469	2	0.0000
L_1Y	7.548990	2	0.0229
L_5Y	3.613910	2	0.1642
All	54.82395	6	0.0000

Dependent variable: L_1Y

Excluded	Chi-sq	df	Prob.
L_10Y	0.066374	2	0.9674
L_15Y	0.971378	2	0.6153
L_5Y	1.001297	2	0.6061
All	9.951341	6	0.1267

Dependent variable: L_5Y

Excluded	Chi-sq	df	Prob.
L_10Y	1.637658	2	0.4409
L_15Y	5.914305	2	0.0520
L_1Y	8.209471	2	0.0165
All	14.72832	6	0.0225