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Integration of European Bond Markets

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Abstract: I investigate the time variation in the integration of EU government bond markets. The integration is measured by the explanatory power of European factor portfolios for the individual bond markets for each year. The integration of the government bond markets is stronger for EMU than non-EMU members and stronger for old than new EU members. The integration is weaker for the sovereign debt crisis countries than for other countries. The integration of the EU bond markets is decreasing over time and this appears not to be caused by the recent financial and sovereign debt crisis.

Keywords: Integration; European bond markets; Financial crises; Factor models

JEL Classifications: C23; C58; F36; G01; G12; G15

1 Introduction

I investigate the time variation in the integration of the European bond markets. I consider European Union (EU) countries, both EMU members (the euro countries) and non-EMU members. For the latter, I distinguish between old and new EU member states. The analysis begins in 2004 and covers the recent years of turmoil, first during the financial crisis and subsequently during the European sovereign debt crisis.

I use the new approach to measure integration brought forward by Punkthuanthong and Roll (2009) and further applied by Berger, Punkthuangthong and Yang (2011) and Berger and Punkthuangthong (forthcoming). They measure the integration of stock markets by the explanatory power (the R-squared value) of certain factor models: For a given year for a given country, they regress the daily stock market return on the daily returns of a number factor portfolios. The factors are constructed from the principal components of all stock markets using the weights from the previous year. An advantage of the new measure of integration is that it is simple, both conceptually and calculation-wise. Moreover, the new approach conveniently provides a measure of integration for each country for each year. Thereby, the method provides a panel of integration values that allows me to study the differences in integration across countries and across time. This paper is (to the best of my knowledge) the first to apply this methodology outside the stock market setting.

The EU government bond markets lend themselves to a number of interesting testable hypotheses. One: Before the recent crises, the bond markets of the EMU countries are effectively one market that is strongly integrated and the bonds are almost perfect substitutes. Two: During the crises, the euro bond markets become less integrated and act more as individual bond markets. This is magnified for the sovereign debt crisis countries. Three: There are differences between the level of integration of the bond markets depending on the type of the EU membership. The integration is strongest for the EMU countries, followed by the old non-EMU member states, and lowest for the new non-EMU member states.

I apply daily returns from indexes of 17 EU government bond markets. The empirical findings are overall in accordance with the presumptions outlined above. Interestingly, it appears that the reason for the downwards trend in the sample period of the integration is not the recent crises. The Punkthuanthong and Roll (2009) methodology for investigating the time variation in the integration of financial markets is thereby shown to be applicable to the bond market setting as well.

The current paper is related to previous research about the integration of European financial markets. Moerman (2008) finds that there are better diversification possibilities across industries than across countries for European stock markets. Mylonidis and Kollias (2010) find that the European stock markets become more integrating during the first decade after the introduction of the euro. Cappiello, Kadareja and Manganelli (2010) use quantile regression analysis and find that the comovement between the European stock markets increase after the introduction of the euro. Bekaert, Harvey, Lundblad and Siegel (2012) find that the integration for European stock markets is greater for EU member states than for non-EU member states. The integration of the EU stock markets is independent of their EMU membership.

Pozzi and Wolswijk (forthcoming) consider the integration of the government bond markets of five old EU countries. They find that the markets are fully integrated until the financial crisis after which they become less integrated. Abad, Chulia and Gomez-Puig (2010) consider the integration of 15 old EU countries' bond markets. They show that there are differences between the integration of EMU and non-EMU countries where the former are the most integrated with the German bond market. Ehrmann, Fratzscher, Gurkeynak and Swanson (2011) consider the convergence of the EU government bond markets. They find that there is one common government bond market for euro countries. The reason for the convergency is the adoption of the euro currency. Christiansen (2007) uses volatility spillover analysis to show that for the bond markets of the old EU countries, the EMU countries are more integrated than non-EMU countries and that bond markets become more integrated of the introduction of the euro. Cappiello, Gerard, Kadarenja and Mangenelli (2006) find some evidence of increased integration of the government bond markets of the new EU member states. Beber, Brandt and Kavajecz (2009) show that the main reason for differences in the yield of euro government bonds is differences in credit quality. Still, at times of distress liquidity is also important. Gerlach, Schulz and Wolff (2010) find that the size of the banking sector is an important determinant of the government bond yield differences across EMU countries.

The remaining part of the paper is organized as follows. Section 2 explains how integration is measured. Section 3 describes the data. Section 4 contains the empirical results. Section 5 concludes.

2 Measuring Integration

I rely on the same methodology as Punkthuanthong and Roll (2009) use to measure global stock market integration. This way of accessing integration is particularly relevant, because it allows me to investigate the trends in the integration of European bond markets. Moreover, I can access the differences in integration across the European countries. In addition, it allows me to use a panel data approach to investigate the causes of integration. The new measure of integration uses several factors and is not restricted to considering just one common factor as would be the case when only one bond market index (say a broad European index) acts as the factor.

I assess the integration by the R-squared value from certain OLS regressions. The R-squared value is a measure of the explanatory power of the European factors for the individual country's bond market returns. There is one separate regression per year per country. The higher the R-squared value is, the stronger is the integration of that bond market for that year. For a given country the trend of the integration is evaluated by considering the evolution in the R-squared values over time. The R-squared value can also be used to compare the integration across countries.

It is an OLS regression of the daily returns for a particular country on the daily returns of certain bond portfolios. The bond portfolios are the most important principal components calculated using the returns from all the other countries in the sample except for the country itself. Yet, the weights for the portfolios are calculated using the previous years' data instead of the current year's data. The portfolios represent the entire European bond market and still do not include the country's own returns. The principal components are out-of-sample both with respect to time and country.

The R-squared value thus measures the proportion of the country's bond market returns that are explained by the entire European bond market returns during a given year. It is of course only true integration if the exposures to the factors are well-distributed across the factors for all countries, i.e. such that it is not different factors that matter for different countries.

3 Data

I use data for the following 17 EU bond markets: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Spain, Sweden, and the United Kingdom. I use daily log-returns from the J. P. Morgan total return index for government

bonds within the 1-year to 10-year maturity spectrum.[1] The usage of an index eliminates any idiosyncratic components from individual bonds. The returns are measured in local currency to avoid taking currency fluctuations into account. This is similar to e.g. Barr and Priestley (2004). The data cover the entire 8-year period 2004 to 2011 except for the Czech Republic and Hungary that enter the sample from 2005.[2] Certain bank holidays (Christmas, New Year, Easter, and May 1st) are excluded from the data set as the index is constant in almost all countries and thereby represents stale prices.

I consider three types of EU bond markets. The first type is EMU members that use the euro as their currency, namely Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, and Spain. The second type is old EU member states that have not adopted the euro, namely Denmark, Sweden, and the UK. The third type is the new EU countries, namely the Czech Republic, Hungary, and Poland, that join the EU in 2004. These are the largest government bond markets amongst the new EU countries, and they are also analyzed by Cappiello et al. (2006).

The sample period covers one recession. The CEPR Euro Area Business Cycle Dating Committee identifies that the euro-countries are in recession during the period from January 2008 through April 2009. This period is termed the financial crisis. Dating the European sovereign debt crisis is harder as there are no official dates available. Generally, it is considered to begin in late 2009 and it is not over yet, cf. Vitek and Bayoumi (2011). Greece is considered the country of origin of the sovereign debt crisis from where it has spread to other countries, most notably to Ireland, Portugal, and Spain, cf. Arghyrou and Kontonikas (2011). Greece, Ireland, Portugal, and Spain are thus denoted the debt crisis countries. Overall, the years that are covered in this study spread out as non-crisis/normal years (2005-2007), financial crisis years (2008-2009), and sovereign debt crisis years (2010-2011).

Insert **Figure 1**: Time Series of Returns
Insert **Table 1**: Descriptive Statistics

Figure 1 shows that the returns are highly erratic over time and that they roughly vary around zero. Table 1 shows the descriptive statistics of the daily returns. The average daily returns are just above zero (around 0.002 for most countries) except for Greece and Portugal for which it is slightly negative. On

[1] Barr and Priestley (2004) also use J.P. Morgan government bond indexes.
[2] The data for the Czech Republic and Hungary are only available from November 08, 2004.

a yearly basis the average return for say Austria is about 0.05. There are some extreme observations, most notably for Finland on June 22, 2007. Apart from this outlier, the largest returns are observed for Greece and Portugal. None of the return series are normal according to the Jarque and Bera (1980) test, mainly due to lepto kurtosis.

4 Empirical Evidence of Integration

4.1 Factor Portfolios

The number of factor portfolios is decided from the principal components for all countries.[3] Table 2 shows the cumulative explanatory power of the principal components for each year in the sample.

Insert **Table 2**: Explanatory Power of Principal Components

The first five principal components account for at least 90% of the variation in the data for each of the years of the sample period. I therefore use five factors. The bond portfolios are based upon the weights of the five first principal components from the previous year excluding the country under investigation.

4.2 Factor Model Regressions

Table 3 shows the R-squared values from the regressions described in Section 2 above. The figure 0.997 for Austria is the R-squared in a regression of daily returns of the Austrian bond index during 2005 on the five contemporaneous portfolios. The portfolios are constructed from the portfolio weights of the first five principal components for the year 2004 for all other countries than Austria. Figure 2 has the same information as Table 3 just in a graphical presentation.[4]

Insert **Table 3**: R-Squared Values Across Countries and Years
Insert **Figure 2**: R-Squared Values Across Countries

[3] For 2004 the Czech Republic and Hungary are excluded.

[4] For Finland the R-squared value for 2007 is strongly influenced by the outlier on June 22, 2007. When this this observation is included unaltered the R-squared is only 0.02. In the table this observation is set to zero.

In the beginning of the sample period (2005) the euro countries are strongly integrated which is seen by the fact that the R-squared values are very large, all above 0.95 and some even close to unity. Thus, in 2005 there is effectively just one market for sovereign bonds within the euro area.

Up to and during the financial crisis the level of integration declines in the euro-countries, for instance for Germany the R-squared values is 0.86 in 2009.

For the countries that are particularly exposed to the sovereign debt crisis, the integration with the European bond markets decreases markedly from the late part of the financial crisis; i.e. from 2009 and onwards. For instance the R-squared value for Greece drops to 0.42 in 2009. In 2011 the integration is even lower. Again looking towards Greece the R-squared is as low as 0.20. So, during the recent crisis periods the bond markets behave as separate markets, instead of acting as one big euro bond market as they did before the crises. The findings about the debt countries fulfills my expectations.

For the old non-EMU countries, the integration also decrease during the sample period. Due to the policy of fixed exchange rate against the euro, the Danish bond market behaves almost like the euro countries that are not in debt crisis. For Sweden the integration is also decreasing over time but from a much lower starting point. Sweden is less strongly correlated with the European bond markets than Denmark; the R-squared is 0.81 in 2005 and drops to 0.54 in 2011. The UK is less integrated with the European bond markets; it starts out with an R-squared of 0.60. However, the integrations stays at about the same level throughout the sample period. From the previous literature, it is expected that there are differences between EMU and non-EMU bond markets.

For the new EU member states the integration with Europe is weak in the beginning of the sample period, e.g. for the Czech Republic the R-squared is 0.16 for 2006. The integration of the new EU member states increases somewhat during the sample period, but the increase is only temporary. By 2011 the integration is back at around the initial level. For Poland the 2011 R-squared is 0.23. Thus, even thought the Czech Republics, Hungary, and Poland have been EU members for seven years when the sample period ends, this is apparently not enough time for these countries to have become integrated with the European bond markets at the same level as the old EU countries are. From the previous literature, it is expected that there are differences between old and new EU member states.

4.3 Panel Regression

I run a panel least squares regression of the R-squared values on a number of explanatory variables: $R2_{it} = X_{it}^{'}c + e_{it}$. Here $R2_{it}$ is the R-squared value where the subscripts denote country i and year t. X_{it} are the associated explanatory variables, c is the coefficient vector, and e_{it} is the residual. The explanatory variables are the following: constant, indicator variable for new EU member state, indicator variable for EMU member, indicator for the debt country, time trend, indicator for the financial crisis period, and indicator for the sovereign debt crisis period.

Insert **Table 4**: Panel Regression of R-Squared Values

The findings from the panel regression by and large confirm the conclusions in the discussion in Section 4.2 above. The explanatory power of the panel regression is very strong (81%) so the explanatory variables explain a large degree of the variation in the R-squared values. All the explanatory variables are significant.

The effect from the country being a new EU country is very large negative (the estimated coefficient is -0.45), so that new EU countries are far less integrated than old EU countries. The effect from the country being an EMU member is positive and fairly large (0.19). The EMU countries are more strongly integrated than other EU countries. The effect of the country being within the group of debt countries is negative, but less strong than the previous effect (-0.10). This confirms the presumption that the countries most heavily influenced by the sovereign debt crisis are less integrated than other EU countries.

Generally, the integration is decreasing over time; the coefficient to the time trend is negative (-0.08). The movement of the integration of the European bond markets goes in the opposite direction of that of the stock markets. The integration is stronger during the financial crisis and the sovereign debt crisis period. It appears that it is not the recent crisis periods that make the European bond markets become less integrated. This finding is surprising and it is only evident from the panel regression analysis, not by considering the evolution of the integration country by country.

5 Conclusion

In this paper I use the methodology of Punkthuanthong and Roll (2009) to analyze the integration of the EU government bond markets. The integration

is measured by the explanatory power of certain factor portfolios for the bond market returns for the individual country for a given year.

The empirical findings are to a large degree as expected: The EMU countries are more integrated than the non-EMU countries. The new EU countries are less integrated than the old EU countries. The sovereign debt crisis countries are less integrated than the other EU countries.

I use a panel regression to confirm that the integration of the EU government bond markets is decreasing over the sample period. However, it appears that this is neither caused by the financial crisis nor the sovereign debt crisis.

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Table 1: Descriptive Statistics

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Obs.
Austria	0.00018	0.0126	-0.0125	0.0022	-0.1	6.5	2047
Belgium	0.00016	0.0166	-0.0172	0.0022	0.0	11.5	2047
Czech	0.00019	0.0528	-0.0525	0.0037	0.2	138.1	1828
Denmark	0.00020	0.0096	-0.0137	0.0020	-0.1	5.7	2047
Finland	0.00029	0.2085	-0.0103	0.0050	35.1	1459.7	2047
France	0.00017	0.0100	-0.0102	0.0019	-0.1	5.9	2047
Germany	0.00018	0.0094	-0.0098	0.0019	0.0	5.0	2047
Greece	-0.00044	0.2402	-0.0945	0.0094	7.7	240.2	2047
Hungary	0.00028	0.0373	-0.0489	0.0043	-1.2	24.2	1828
Ireland	0.00010	0.0622	-0.0429	0.0047	0.9	34.1	2047
Italy	0.00012	0.0370	-0.0272	0.0027	1.6	45.5	2047
Netherlands	0.00019	0.0092	-0.0094	0.0019	0.0	5.2	2047
Poland	0.00024	0.0118	-0.0226	0.0020	-0.8	15.7	2047
Portugal	-0.00001	0.0894	-0.0921	0.0052	-0.5	103.3	2047
Spain	0.00015	0.0378	-0.0147	0.0026	2.4	37.0	2047
Sweden	0.00021	0.0126	-0.0191	0.0020	-0.1	10.1	2047
UK	0.00023	0.0104	-0.0094	0.0021	0.0	5.0	2047

The table shows the descriptive statistics for the daily returns for the bond indices for the various countries.

Table 2: Explanatory Power of Principal Components

PC no	2004	2005	2006	2007	2008	2009	2010	2011
1	83%	66%	65%	84%	62%	48%	82%	56%
2	96%	87%	85%	97%	88%	76%	89%	76%
3	97%	96%	92%	99%	91%	85%	94%	84%
4	98%	99%	97%	99%	94%	88%	96%	90%
5	98%	100%	98%	99%	96%	91%	97%	95%
6	99%	100%	99%	100%	97%	93%	98%	97%
7	99%	100%	100%	100%	98%	96%	99%	98%
8	99%	100%	100%	100%	99%	98%	99%	98%
9	100%	100%	100%	100%	99%	98%	99%	99%
10	100%	100%	100%	100%	100%	99%	99%	99%
11	100%	100%	100%	100%	100%	99%	100%	99%
12	100%	100%	100%	100%	100%	99%	100%	100%
13	100%	100%	100%	100%	100%	100%	100%	100%
14	100%	100%	100%	100%	100%	100%	100%	100%
15	100%	100%	100%	100%	100%	100%	100%	100%
16		100%	100%	100%	100%	100%	100%	100%
17		100%	100%	100%	100%	100%	100%	100%

The table shows the cumulative explanatory power for the principal components separate for each year.

Table 3: R-Squared Values Across Countries and Years

Year	Austria	Belgium	Czech	Denmark	Finland	France	Germany	Greece	Hungary
2005	0.997	0.997		0.965	0.974	0.997	0.998	0.978	
2006	0.994	0.996	0.164	0.921	0.994	0.996	0.996	0.978	0.207
2007	0.813	0.831	0.294	0.813	0.978	0.836	0.842	0.812	0.175
2008	0.976	0.981	0.212	0.740	0.974	0.988	0.978	0.827	0.333
2009	0.882	0.914	0.070	0.807	0.906	0.918	0.855	0.418	0.294
2010	0.765	0.566	0.098	0.770	0.904	0.887	0.850	0.635	0.458
2011	0.820	0.470	0.213	0.792	0.908	0.731	0.858	0.195	0.150

Year	Ireland	Italy	Netherl.	Poland	Portugal	Spain	Sweden	UK
2005	0.958	0.994	0.997	0.148	0.986	0.997	0.810	0.597
2006	0.966	0.993	0.996	0.219	0.983	0.996	0.780	0.692
2007	0.820	0.801	0.837	0.171	0.827	0.836	0.709	0.615
2008	0.951	0.900	0.986	0.239	0.977	0.974	0.701	0.694
2009	0.602	0.782	0.930	0.282	0.834	0.921	0.488	0.490
2010	0.634	0.640	0.882	0.357	0.847	0.624	0.559	0.535
2011	0.504	0.474	0.907	0.234	0.498	0.412	0.536	0.593

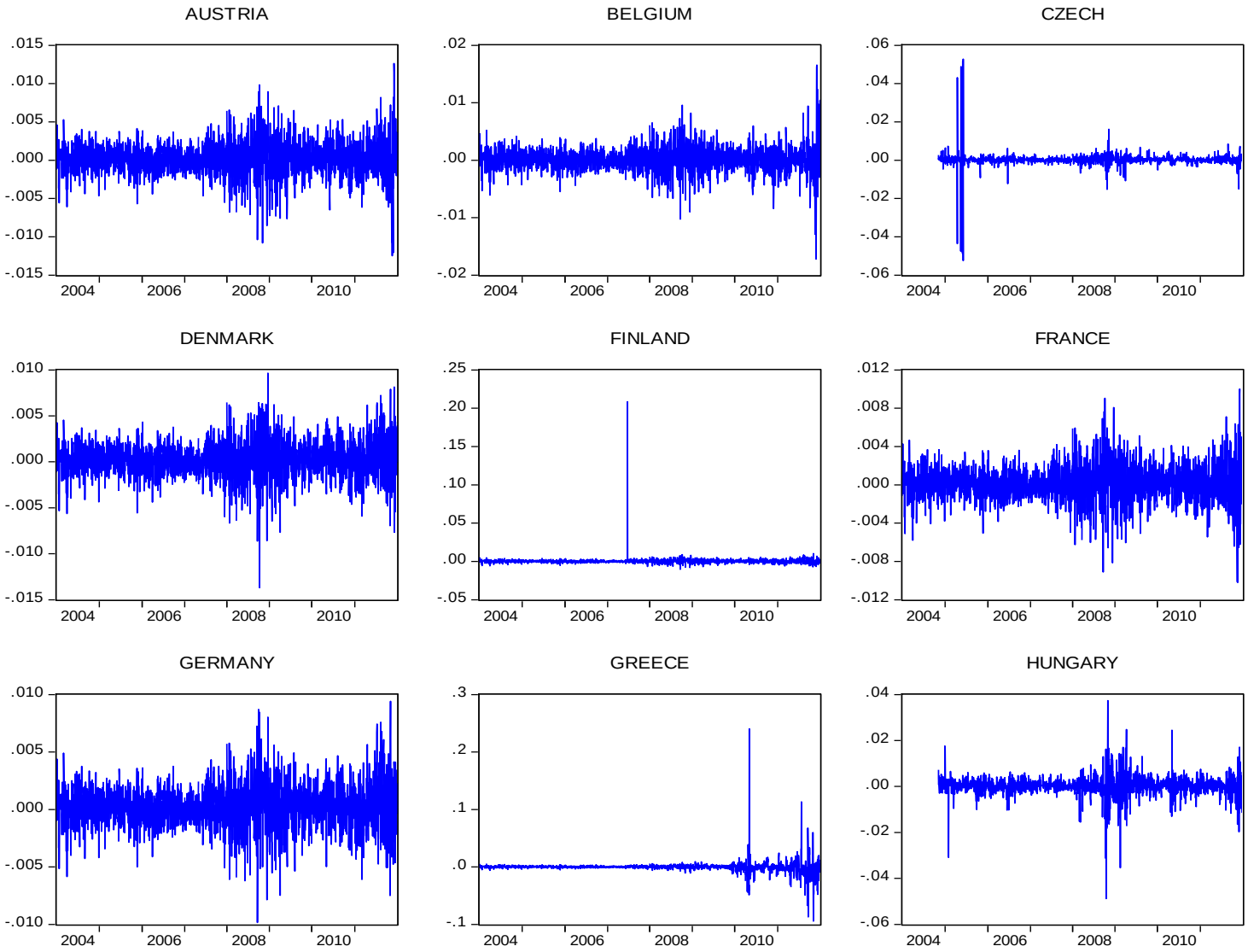
The table shows the R-squared values from the regression of the daily returns on the first five principal components using weights from last year for each country for each year.

Table 4: Panel Regression of R-Squared Values

Variable	Coefficient	Std. Error
constant	0.84 ***	(0.03)
1[New EU Country]	-0.45 ***	(0.04)
1[EMU Member State]	0.19 ***	(0.03)
1[Debt Country]	-0.10 ***	(0.03)
Trend	-0.08 ***	(0.02)
1[Financial Crisis Period]	0.14 ***	(0.05)
1[Debt Crisis Period]	0.17 **	(0.08)
R-squared	0.81	

The table shows the panel least squares regression of the R-squared values on a constant, an indicator for new EU country, an indicator for EMU member state, an indicator for debt crisis country, a time trend, an indicator for the financial crisis, and an indicator for the debt crisis. ***/**/* indicates significance at the 1%/5%/10% level of significance.

Figure 1: Time Series of Returns



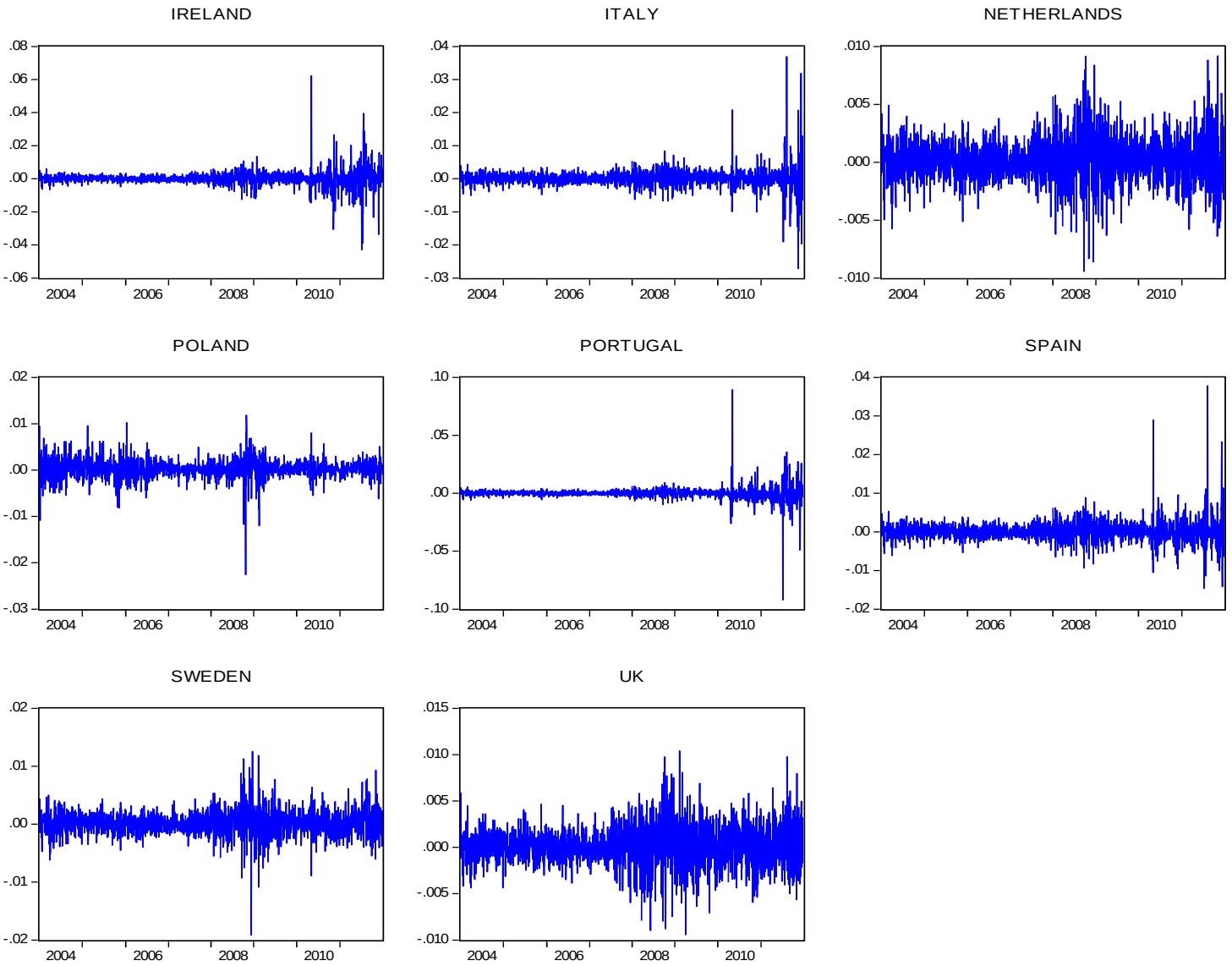

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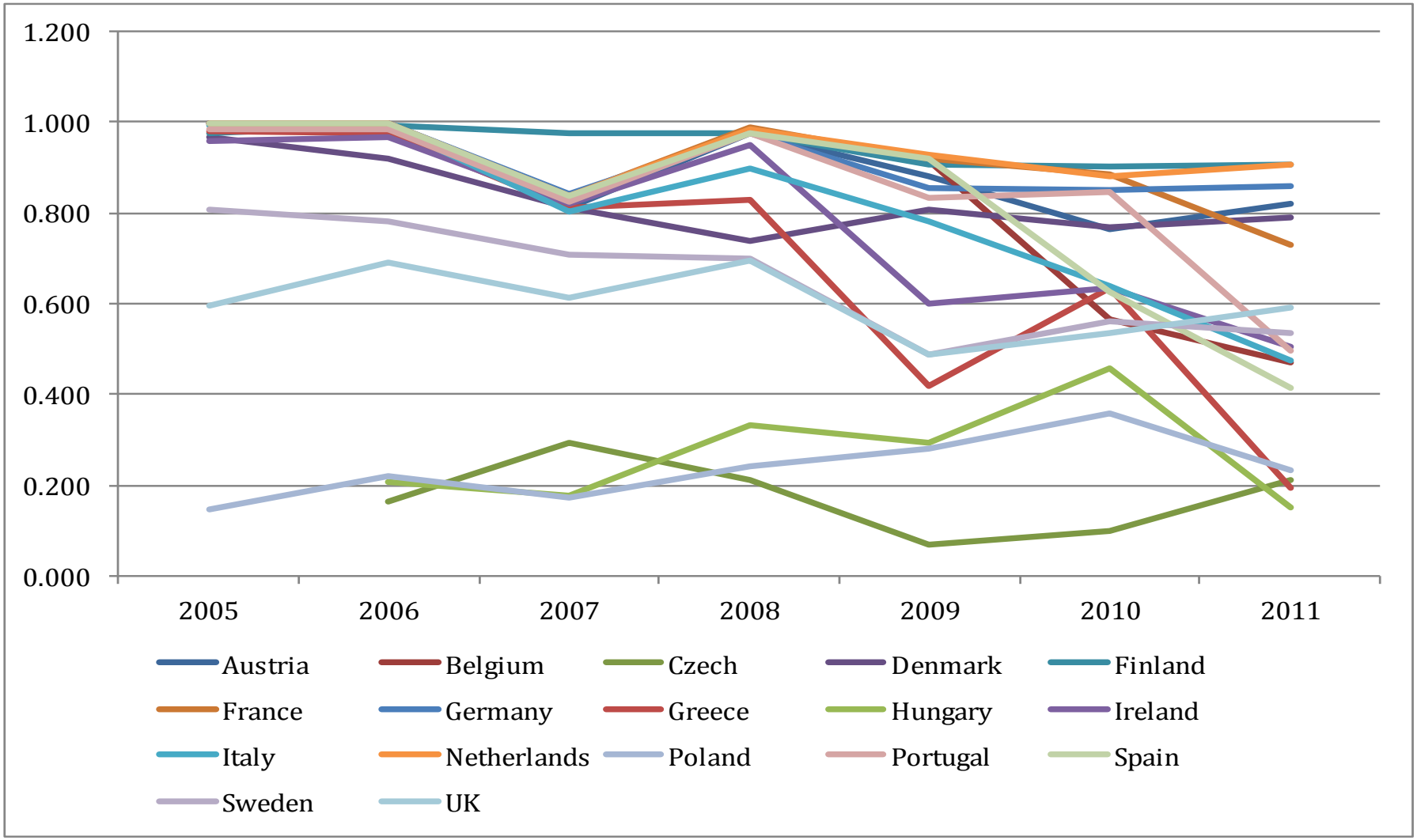
Figure 2: R-squared Values across Countries



The figure is a graphical presentation of the information in Table 3.

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