Jyväskylä University School of Business and Economics

INTEGRATION CYCLES IN THE EUROZONE STOCK MARKETS

Economics
Master's thesis
July 2016
Author: Jussi Leskinen
Supervisor: Prof. Kari Heimonen

JYVÄSKYLÄ UNIVERSITY SCHOOL OF BUSINESS AND ECONOMICS

Author Jussi Leskinen	
Title Integration cycles in the Eurozone stock markets	
Major Economics	Description Master's thesis
Date July 2016	Number of pages 85+9

Abstract

In this thesis, the stock market integration in the Eurozone stock markets during the EMU era was analyzed using the Pukthuanthong & Roll (2009) integration measure. The objectives of this study were twofold. The first main contribution of this study was to examine the evolution of integration during the EMU era by utilizing this relatively new multifactor model of integration. In addition to the level of integration, the similarity of risk exposures in these stock markets (number of risk factors needed to measure integration satisfactorily) was also analyzed. The second contribution was to identify the most relevant determinants of integration, also including the effects of the global financial crisis of 2007-2009 and the following European sovereign debt crisis of 2009-2013 on integration. The sample consists of 12 Eurozone stock markets (11 original member countries + Greece), and it contains the years 1999-2014.

The main picture of integration given by this study is that there are upward and downward cycles in integration. The most integrated markets are France, Netherlands, Germany, Italy and Spain. The least integrated are Greece, Luxembourg, Portugal and Ireland. Austria, Belgium and Finland form a middle group of countries more integrated than the latter, but less integrated than the first. Integration of Austria, Finland and Portugal has increased during the period of this study. The risk exposures have become more similar during the EMU era: fewer risk factors are needed to capture the variation in stock returns.

The determinants of integration were studied using pooled OLS, fixed effects and first differences panel models with monthly and quarterly data. Financial market, macroeconomic and information variables were examined as the most plausible determinants of integration, but no reliable dependence between these variables and integration could be identified. 10 year government bond yield is the best explanatory variable for integration, but the sign of the coefficient varies over time and between stock markets. Specifically, volatility, economic policy uncertainty or government indebtedness do not have a strong dependence with integration.

With both the global financial crisis and the European debt crisis timings, evidence was obtained that the crisis increased integration for the whole sample of 12 countries, but this effect was stronger for the group of the least integrated countries. Integration did not return to its pre-crisis level after the acute crisis period.

Keywords

stock market integration, Eurozone stock markets, determinants of integration, global financial crisis, European sovereign debt crisis, European monetary union

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JYVÄSKYLÄN YLIOPISTON KAUPPAKORKEAKOULU

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Tiivistelmä

Tutkimuksessa analysoitiin euroalueen osakemarkkinoiden integraatiota euroaikana Pukthuanthong & Roll (2009) integraatiomitalla. Tutkimuksella oli kaksi päätavoitetta. Ensimmäinen tavoite oli tutkia integraation kehitystä euroalueella euroaikana käyttämällä tätä melko uutta monifaktorimalleihin perustuvaa integraatiomittaa. Integraation lisäksi tutkittiin myös riskialtistusten samankaltaisuutta (integraation selittämiseen vaadittavien faktorien määrä). Tutkimuksen toinen tavoite oli etsiä integraatiota selittäviä tekijöitä sisältäen myös tutkimuksen ajanjaksolle osuneen finanssikriisin (2007-2009) ja sitä seuranneen Euroopan valtionlainakriisin (2009-2013) vaikutuksen. Tutkimuksen aineisto koostuu 12 euroalueen maasta (11 alkuperäistä jäsenmaata + Kreikka), ja tarkasteluperiodi on vuodet 1999-2014.

Tutkimuksen antama kuva integraatiosta on, että integraatiossa on nousu- ja laskusyklejä. Integroituneimmat markkinat ovat Ranska, Alankomaat, Saksa, Italia ja Espanja, vähiten integroituneimmat Kreikka, Luxemburg, Portugali ja Irlanti. Itävallan, Belgian ja Suomen markkinat ovat integroituneemmat kuin jälkimmäisen ryhmän, mutta vähemmän integroituneet kuin ensimmäisen ryhmän. Itävallan, Suomen ja Portugalin integraatio on lisääntynyt tutkimuksen ajanjaksolla. Riskialtistukset ovat muuttuneet euroaikana yhdenmukaisemmiksi: osaketuottojen selittämiseen tarvitaan vähemmän riskifaktoreita kuin ennen.

Integraatiota selittäviä tekijöitä tutkittiin pooled OLS, fixed effects ja first differences paneelimallien avulla kuukausi ja kvartaalidatalla. Integraation determinantteina tarkasteltiin rahoitusmarkkinamuuttujia, makrotaloudellisia tekijöitä ja informaatiomuuttujia, mutta niiden yhteyttä integraatioon ei kyetty osoittamaan luotettavasti. 10 vuoden valtionlainan tuottovaatimus selittää parhaiten integraatiota, mutta vaikutuksen suunta ja suuruus vaihtelee yli ajan ja eri osakemarkkinoiden välillä. Volatiliteetin, talouspolitiikkaepävarmuuden tai valtion velkaantuneisuusasteen ei havaittu olevan vahvoja integraation determinantteja.

Sekä globaalin finanssikriisin ajoitusta että Euroopan valtionlainakriisin ajoitusta käytettäessä saatiin evidenssiä, että kriisi lisäsi koko 12 maan joukon integraatiota, mutta vaikutus oli suurempi heikoimmin integroituneille maille. Integraatio ei palannut akuutin kriisivaiheen jälkeen kriisiä edeltäneelle tasolle.

Asiasanat
osakemarkkinaintegraatio, euroalueen osakemarkkinat, integraation determinantit, finanssikriisi, Euroopan valtionlainakriisi, Euroopan talous- ja rahaliitto.

Säilytyspaikka
Jyväskylän yliopiston kauppakorkeakoulu

CONTENTS

1 INTRODUCTION

Stock market integration of both the developed and developing countries has been a vibrant field of research during the last decades. European economic integration and the Economic and Monetary Union (EMU) have been major catalysts for the studies of stock market integration in the region. There is a wide consensus that the European stock markets have been highly integrated since the mid-1990s. Although in global perspective, the European stock markets are highly integrated, there is strong evidence that integration is not complete for some of the countries in the region. For these, usually smaller countries, there are significant fluctuations in their integration over time.

The first major contribution of this study is the relatively new integration measure developed by Kuntara Pukthuanthong & Richard Roll (2009) used in this study. This measure is based on the R-squared of a multi-factor model. In the model, the common variance of the different stock markets is orthogonalized using principal component analysis, and after this procedure, the original stock market returns are regressed on these factors. To account for the changing level of integration and volatility, the regressions are conducted using moving window estimations.

The field of stock market integration has been characterized by a great methodological plurality. The choice of research method is paramount, because the results obtained by utilizing different models like factor models or GARCH–models can yield different results on the degree of integration of the countries studied. To author's knowledge, there are no studies utilizing the Pukthuanthong & Roll integration measure in the study of integration of the European stock markets. A sample of 12 stock indices of Eurozone countries – Austria, Belgium, Finland, France, Germany, Greece, Italy, Ireland, Luxembourg, Netherlands, Portugal and Spain have been chosen for the sample of this study. The countries are the original Eurozone countries + Greece. The time period considered is 1999-2014 that is, the time from the beginning of the EMU to the end of year 2014. Daily returns and an estimation window of 200 days are used in the construction of the integration measure.

The Pukthuanthong & Roll integration measure is a factor model, where risk factors are estimated using principal components. The model is valuable because it makes possible to study not only integration, but also the similarity of risk exposures, that is the number of common risk factors needed to explain integration of the stock markets satisfactorily. In addition to analyzing integration, one objective of this study is to examine the dynamics of this similarity of risk exposures in the Eurozone during the EMU era.

The second main contribution of this study is to try to identify the factors explaining integration in the Eurozone stock markets, including the effects of the global financial crisis that started in the year 2007 and the following European sovereign debt crisis.

The focus of the previous integration studies of European stock markets has mainly been on the level of integration between different countries, or the studies have tried to establish whether the European Union or the EMU have had any significant impact on stock market integration in the region. There are very few studies concerning the determinants of integration of different stock markets and the evolution of integration over time. In most cases, the studies on European stock market integration (and also stock market integration in general) have concentrated on studying the variation in integration over time using time series methodology, and not on the factors that drive these differences between countries and the ups and downs in integration over time. Often the main focus of these studies has been on examining the effect of economic or financial crises on integration.

In addition, many of the studies explaining the differences in the level of integration between countries have focused on emerging markets. So they may not be very useful in understanding integration dynamics in European stock markets, because the generalizability of the results of these studies to developed economies is not necessarily warranted. This study tries to fill this research gap.

Because there are few previous studies on the subject, a variety of possible explaining factors are considered. Some evidence is presented in previous studies that financial market variables like interest rates, macroeconomic factors like GDP and certain information variables like volatility may have a dependence with integration (See Chapter 2.3), but the results of these studies are not necessarily very robust as they can be highly sensitive on the estimation method and data chosen, and many studies also potentially suffer from serious omitted variable biases due to insufficient controls.

In this study, financial market, macroeconomic and information variables are considered potentially the most important determinants of integration. Some authors suggest that variations in stock market integration occur because changes in risk sharing between different stock markets over time is influenced by the changes in stock return discount rates (see Chapter 2.3). It is plausible that both interest rates and information variables like volatility to a degree measure economic (and more specifically financial) uncertainty, and because of that are related with stock market integration.

However, the objective of this study is not to formulate a theory of stock market integration, but to empirically identify its most important determinants. As the most potential determinants of integration, financial market variables like long- and short-term interest rates, macroeconomic factors like GDP and information variables like volatility and the relatively new Economic Policy Uncertainty index are considered.

Based on previous studies, both strongly and weakly integrated Eurozone countries have been selected for the sample of this study, and the time period includes the global financial crisis period of 2007-2009 and the European debt crisis period of 2009-2013 when the government bond yields for the crisis countries of Greece, Portugal, Ireland, Spain and Italy were the highest, and also the periods before and after the acute crisis periods. Due to these considerations, the sample is ideal for the study of integration dynamics of strongly and weakly integrated countries during normal economic conditions and crisis periods.

This study is conducted in the following manner. The degree of integration (and similarity of risk exposures) of the countries under study is first analyzed graphically. Then the determinants of integration are explained using panel models. To account for the unit roots and autocorrelation in the data, the analyses are conducted both on levels (pooled OLS and fixed effects estimations) and on first differences (first differences estimations). As additional robustness checks the, models are fitted using both monthly and quarterly data, and also dynamic panel models are estimated. Finally, to examine the stability of the coefficients between countries and over time, estimations on two-year subsamples and using moving-window estimations are conducted.

The main objectives of the study can be crystallized into two main themes. The first objective is to examine what is the level of integration and the similarity of risk exposures in the Eurozone stock markets using the Pukthuanthong & Roll integration measure. The second aim is to present evidence on the main determinants of the country differences and variation in integration over time, also including an analysis of the effects of the global financial crisis and the following European sovereign debt crisis on integration.

The structure of the research report is as follows. Main Chapter 2 consists of a brief survey of the methods used in measuring stock market integration, the most relevant previous research articles on European stock market integration and on the determinants of integration. In main Chapter 3 the data of the study and the methods used are described. Main Chapter 4 is the empirical section, and also a summary of the main results is presented. Chapter 5 consists of concluding remarks where the results of this study are evaluated in relation to previous studies.

2 STOCK MARKET INTEGRATION AS A RESEARCH FIELD

2.1 Measuring stock market integration

Since the 1970s, numerous articles on stock market integration have been published. The first of these studies were mainly concentrating on the developed economies, and their main objective was to present evidence on the degree of integration between stock markets. Most notable studies were among others Solnik (1974), who studied the effect of single international risk factor on the pricing of the stocks in the United States and European stock markets, and Jorion & Schwartz (1986), who studied the level of integration of Canadian stock market relative to the United States. The integration of the European stock markets have of course, been a vibrant field of study and the main motivating factor of these studies have been the economic and political integration in Europe (this theme is addressed more in the next chapter). During the last decades, the focus of stock market integration studies have shifted from developed to developing countries, and the time-varying nature of integration has obtained more attention (see e.g. Bekaert & Harvey 1995; Carrieri et al. 2007; Pukthuanthong & Roll 2009).

In the research literature, stock market integration has been conceptualized in many different ways[1]. In practical investing, integration is probably most commonly understood as the correlation between the returns of two the stock markets of two countries. This approach has been utilized also in

1 In addition to stock market integration, there are is also a vast field of research known as stock market cointegration. These often highly econometrically oriented pieces of research approach the comovement between stock prices in different stock markets by statistical cointegration techniques using both the levels and differences of the variables. In the cointegration models, the levels of the variables capture the long-term equilibrium between the stocks in different stock markets, and the short term variation is captured by using differences. In this study, short-term stock return comovement is emphasized, so in the literature review, only a few cointegration studies that are relevant to European stock market integration, are examined (see the next Chapter 2.3).

economic research. The early studies, like Grubel & Fadner (1971), where often based on estimating simple correlation coefficients for the whole time series used. In the newer studies, the correlation matrices are estimated as time-varying using multivariate GARCH-models (see the next chapter).

In international macroeconomics, stock market integration is often approached through the concept of interest rate parity. According to the theory of interest rate parity, utilization of arbitrage opportunities should in theory lead to a situation where the differences of the interest rates of different countries should reflect the exchange risk between the countries. The concept of stock return parity derived from the interest rate parity has also been used in describing the situation, that when the exchange risk is small, the stock returns in two exchanges should not differ dramatically (see e.g. Fratzscher 2002).

Especially studies in finance, the stock market integration the number of studies utilizing factor models, have been extensive. There are numerous articles based on the Capital Asset Pricing Model and its derivatives, where the level of integration of an individual stock market is measured as to what extent the excess returns (relative to riskless investment asset) on this stock market index can be explained with the returns of a global, regional or other stock portfolio. In the older studies, like Solnik (1974) or Stehle (1977), the risk exposure relative to a global risk factor was assumed to be constant over time. In later integration models based on CAPM, the time varying nature of the global beta-coefficient has been emphasized, and also other sources of risk, like currency risk, have been considered (see e.g. Harvey 1991; Dumas & Solnik 1995).

In addition to CAPM, also other factor models widely used in finance, have been used in numerous studies. For example, Fama & French (1998) have applied their famous three factor mode – which includes also size of corporations and book-to-market ratio as relevant factors – to test stock market integration. Very similar excercises are also the applications of more econometrically (that is less theoretically) emphasized arbitraze pricing theory pricing theory (APT), where the global or regional stock market indices or portfolios are also considered (see e.g. Mittoo 1992) and multi factor models where the variance of the returns of a single stock market is explained using multiple global or regional factors.

The latter approach has been utilized, among others, by Brooks & Del Negro (2004) who decompose the variation of returns into global, industry specific and idiosyncratic components. Chambet & Gibson (2008) use global and local risk factors, and Carrieri et al. (2007) use a global risk premium and a "super risk premium" for the stocks that are not traded globally. Finally, Bekaert et al. (2011) measure the segmentation of stock markets (the opposite of integration) with the industry specific return differences, and explain the differences between countries using country-specific and global factors.

The integration measure developed by Pukthuanthong & Roll (2009) utilized in this study belongs also to the group of multifactor models of integration. In the model, the stock market is considered more integrated, the smaller the country specific residual volatilities are. In practice, the model is estimated by regressing the returns of an individual stock market index on risk factors common to all the countries of study. These factors can be for example a global and a regional factor. Now the coefficient of determination (adjusted R^2) is the measure of integration of a stock market. In this model, the residual variances of the regressions are not assumed zero, but the size and variation of these residuals over time is the main interest of the analysis. Pukthuanthong & Roll integration measure and its estimation is described more thoroughly in the next chapter.

In this chapter, many integration measures have been discussed. However, it must also be defined what is meant by stock market integration in this study. Bekaert & Harvey (1995) define that markets are completely integrated when the assets that have the same risk, have the same expected returns despite the markets they are traded on. In this view risk is understood as exposure to common global risk factors. In finance, it is often assumed than in integrated markets, only global risk is priced in the risk premium of assets, as the local risk can be diversified away) (See e.g. Cuthbertson & Nitzsche 2004). In this study, a highly empirical approach to integration is adopted. Integration of a single Eurozone stock market is the proportion of stock returns explained by risk factors common to all Eurozone stock markets. If this proportion is high, the common sources of risk are important and if this proportion of low, the country-specific sources are important.

Due to the vast plurality of integration measures used, none of them is without its advantages and disadvantages. As has already been discussed in this chapter, in the early integration studies, sample correlations were used as measures for integration between stock markets. This approach has been widely criticized, because the procedure does not take into account the significant variation of integration over time, and it also ignores the fact, that correlation is highly dependent on the volatility of stock returns (Bekaert et al. 2009, 2597; Carrieri et al. 2007, 920; Forbes & Rigobon 2002, 2223-2224). This is of course criticism targeted towards the estimation of correlation, and it is not relevant to correlations estimated for example, using GARCH models, as is the case in newer studies.

It has been established that the correlation between stock indices or the correlation between a single stock index and a global risk factors is not a sufficient measure of integration when the integration is considered to be dependent on more than one risk factor. If an economy differs, for example in its industry structure, from a global portfiolio, a low exposure to a global risk factor can lead to a low beta coefficient for that risk factor, although the country would in reality be strongly integrated to world economy. This criticism is also valid against the basic international CAPM-models which include only one global risk factor. (Bekaert & Harvey 1995, 436; Carrieri et al. 2007, 920; Pukthuanthong & Roll 2009, 217.) There is also research based evidence that multi factor models explain the returns of a single stock market better than models consisting only of one factor (Bekaert et al. 2009, 2624–2625).

Besides their empirical validity, integration models can also be criticized on theoretical grounds. In many integration models widely used like CAPM, Fama & French model or APT model, market efficiency is assumed. Pukthuanthong & Roll consider one of the assets of their integration model, that it is not based to a specific stock pricing theory, and that stock markets can be considered globally integrated without committing to the assumption fully rational stock pricing, it is sufficient that the countries risk exposure to global shocks is similar (Pukthuanthong & Roll 2009, 215, 217). The atheoretical nature of integration measure can of course, also be considered its weakness. It is purely an empirical factor model. (for a quite similar but more theory based integration model, see the model of Carrieri et al. (2007) which is based on the international asset pricing theory by Errunza and Losq.)
However, for empirical research, the more relevant is the econometric critique presented against the integration measures based on the R^2 of multifactor models. It has been noted that during periods of high stock returns volatility, the R^2 can be inflated, which would indicate a higher degree of integration than in reality (Bekaert et al. 2005, 2; Forbes & Rigobon 2002, 2229–2233). Pukthuanthong & Rolls main counterargument to the criticism presented is that when a sufficiently long study period is chosen, what can high R^2 and small residuals indicate than high integration, so their integration model is well suited for comparison between countries and the variation of integration over time (Pukthuanthong & Roll 2009, 219). The effect of volatility on their integration measure can also be controlled using volatility as a control variable. It can also be argued that an abstract phenomenon like stock market integration cannot be measured very precisely.

2.2 Previous studies on European stock market integration

In this chapter, a brief survey of the previous studies on European stock market integration is presented. Due to the main research questions, this survey emphasizes more the short term co-movement of stock returns, and the quite extensive field of stock market cointegration research is mainly omitted.

First, studies concentrating on the differences of integration in different European stock markets and the evolution of integration over time are reviewed. After that, in the next chapter, a survey of articles attempting to identify the factors explaining the changes in integration between countries and over time is given. There are numerous articles of the first type, so only studies concentrating on European countries are examined. Latter studies, however, are less numerous, so studies on integration addressing also non-European stock markets are included.

There is a wide consensus that European stock markets have been integrated to a significant degree since the mid-1990s (Fratzscher 2002; Freimann 1998; Kim et al. 2005). Some authors have also found evidence of the significant positive impact of EMU on stock market integration of the Eurozone countries (Fratzscher 2002; Hardouvelis et al. 2006; Kim et al. 2005; Syllignakis 2003). It is of course, extremely difficult to isolate the effects of European integration or EMU membership on stock market integration from other factors having effect on integration. Often the found increase in integration has been taken as positive evidence on the impact of these institutions on European stock market integration. Bekaert et al. (2013) have established in their study that EU membership has had significant impact on integration but when EU-membership is included as a control, EMU membership does not have a significant effect on the member countries.

However, significant differences on the degree of integration between European stock markets are documented in research articles. For example Freimann has presented evidence that in the mid-1990s (the data of the study was from years 1990-1996) that Italy, Sweden and Spain were significantly less integrated than the Netherlands (Freimann 1998, 36). In a similar fashion, Hardouvelis et al. (2006) have established that the country-specific factors were significant explanatory variables in the cases of Finland and Ireland (period of study 1992-1998). Heimonen (2000) and Nummelin & Vaihekoski (2002) have found evidence of incomplete integration of Finnish stock market. Kim et al. (2005) have found that integration was not complete in the beginning of the 21st century for the small EMU member countries. Mylonidis et al. (2010) have found that there still exist differences in the level of stock market integration in the Eurozone, since Germany and France are more integrated than more peripheral Italy and Spain.

In addition, stock market integration is not a “one way street” even on the relatively highly integrated European countries. For example Bley et al. have found evidence of the decrease in integration in the 2000s (2004-2006) in the Eurozone stock markets (Bley et al., 2009, 771). And although European stock markets have been found to be relatively highly integrated in international comparison, significant differences on the level of integration between countries in the region are confirmed by research. Also Syllignakis (2003) has presented evidence on the polarization of the Eurozone stock market integration. Large Eurozone countries have become more integrated, but the smallest stock market Austria has decreased relative to Germany in years 1993-2003.

One quite influential study concerning European stock market integration worth mentioning is the article by Heston & Rouwenhorst (1994), where the authors present evidence that the country-specific factors are more important predictors of stock market excess returns on European stock markets than industry specific factors. These findings were catalyst for a number of similar country vs. industry factor studies. However, as many of these studies do not concern specifically European stock markets, these studies are further discussed in the next chapter.

The most important studies on European stock market integration (from point of view of the research topics of this study) discussed in this chapter are summarized in Table 1:

TABLE 1 Previous studies on European stock market integration

Study	Data†	Methods	Results
Heston & Rouwenhorst (1994)	AUT, BEL, DNK, FRA, DEU, ITA, NLD, NOR, ESP, CHE, GBR (1978-1992, Monthly)	Multifactor model	Country-specific factors more important in explaining excess returns than industry specific factors.
Freimann (1998)	GBR, FRA, ITA, ESP, NLD, SWE (1975-1996, Monthly)	Correlation and moving correlation	European stock markets integrated to a significant degree (Netherlands most integrated; Italy, Spain and Sweden the least).
Heimonen (2000)	USA, GBR, DEU, JPN, FIN (1987-1996, Monthly)	Cointegration and international asset pricing model	Finnish (and Japanese) Stock markets not cointegrated with the United States, UK and Germany.
Fratzscher (2002)	AUT, BEL, FIN, FRA, DEU, ITA, NLD, ESP, GBR, DNK, SWE, NOR, CHE, JPN, USA, CAN, AUS (1986-2000, Daily)	Multivariate GARCH	European stock markets have been highly integrated since 1996; The Eurozone stock markets have become the major factor explaining the returns in European stock markets (instead of the United States).
Morana & Beltratti (2002)	FRA, DEU, ESP, ITA, GBR (1988-2000, Daily)	GARCH(1,1) and Markov switching	GARCH model: No evidence of reduction in volatility caused by the EMU; Markov model: Volatility in Italian and Spanish stock markets decreased.
Nummelin & Vaihekoski (2002)	FIN (1986-1996, Monthly)	Multifactor model	Opening of the Finnish stock market in 1993 increased integration significantly, but still partly segmented after the reform.
Syllignakis (2003)	DEU, FRA, NLD, ITA, ESP, FIN, IRL, GRC, BEL, PRT, AUT, GBR (1993-2003, Weekly)	Multivariate GARCH	Integration of most of the stock indices (in relation with Germany) increased due to the EMU membership (However, integration of Austrian stock market has decreased); Especially the stock markets of France, Netherlands and Italy are highly integrated.

Kim et al. (2005)	DEU, FRA, ITA, BEL, NLD, IRL, SPA, PRT, AUT, FIN, LUX, GRC, DNK, GBR, SWE, JPN, USA(1989-2003, Daily)	Multivariate GARCH	Notable variation in integration until the mid-1990s: Integration is not perfect for the smaller EMU member states; Integration increased significantly during the years before the adoption of euro (1997-1999) and during the EMU era (since the year 1999).
Hardouvelis et al. (2006)	AUT, BEL and LUX (aggregated), FIN, FRA, DEU, IRL, ITA, NLD, PRT, ESP, GBR	International asset pricing model	Eurozone stock markets fully integrated since the mid 1990s; Prospects of the EMU membership has increased integration significantly.
Schotman & Zalewska (2006)	DEU, CZE, POL, GER, GBR, USA (1994-2004, Daily and Monthly)	One factor model and GARCH(1,1)	Period of low integration 1994-1996, period of higher integration 1997-2000, period of low integration 2001-2004.
Bley (2009)	AUT, BEL, DEU, ESP, FIN, FRA, GRC, IRL, ITA, NLD, PRT, GBR, USA (1998-2006, Daily)	Cointegration	The integration of the Eurozone stock markets increased significantly during 1998-2003; After the initial increase, there has been divergence
Jawadi et al. (2010)	DEU, AUT, BEL, ESP, FIN, FRA, GRC, IRL, ITA, NLD, PRT (1970-2007, Monthly)	Cointegration	linear model: 1970-1999, all countries segmented, 2000-2007 France, Germany, Netherlands, Belgium, Spain, Italy, Portugal and Ireland integrated; Non-linear model: France, Germany, Netherlands, Belgium, Italy, Spain and Portugal integrated
Mylonidis & Kollias (2010)	DEU, FRA, ESP, ITA (1998-2009, Daily)	Rolling cointegration	Convergence in stock returns but it is not perfect.
Bekaert et al. (2013)	33 European countries (1990-2012, Monthly and Annual)	Panel regression	EU membership has decreased segmentation (increased integration); No significant effect of EMU membership when the effect of EU membership is controlled.
Vasila (2013)	DEU, NLD, SWE, ITA (1990-2008, Daily)	Multivariate GARCH	The stock markets under study are integrated to a high degree.

†AUS = Australia, AUT = Austria, BEL = Belgium, CAN = Canada, CHE = Switzerland, DEU = Germany, DNK = Denmark, ESP = Spain, FIN = Finland, FRA = France GBR = United Kingdom, GRC = Greece, IRL = Ireland, ITA = Italy, JPN = Japan, LUX = Luxembourg, NLD = Netherlands, NOR = Norway, POL = Poland, PRT = Portugal, SWE = Sweden, USA = United States

The evidence of the research can be summarized as a follows. There still seems to be more and less integrated stock markets in Europe, and also in the Eurozone even today. There is evidence that European integration has also increased the integration of the stock markets of the member countries.

Moreover, there is no reason to assume that this integration can only increase in the future, because there is also evidence of a decrease in integration for some countries.

Based on previous studies, the most integrated stock markets in the Eurozone are Germany, France and Netherlands. The least integrated are Greece and Portugal. Other Eurozone countries Austria, Belgium, Finland, Italy, Ireland Luxemburg and Spain are less integrated than the former but more integrated than the latter. It is important to note that the level of integration of stock markets can be somewhat dependent on the methods utilized in each of the studies. However, the ranking of countries based on their integration seems to be quite robust. The degree of relative integration is also, of course, dependent on the sample of the studies. Italy and Spain may be weakly integrated relative to Germany, but quite strongly integrated compared to say Greece, or even Finland.

2.3 Studies on the determinants of integration

There are numerous studies on stock market integration of European and non-European countries. However, there are few studies on the determinants of integration, that is, analyses of the main factors contributing to integration differences between countries and the analyses explaining the time variation of integration.

In most studies concentrating on European integration, the focus has been on the effect of European Union and EMU on integration. Studies have provided evidence that factors like the reduction of exchange risk brought by the common currency in Eurozone countries has increased the integration between the stock markets of these countries (Büttner & Hayo 2009; Fratzscher 2002). However, some authors like Bekaert et al. (2013) argue that this effect of single currency for integration does not hold when the increase in integration caused by the EU membership is controlled. In a similar fashion, some evidence has been presented that integration is high when the interest rate differentials between countries are low, but this effect seems to be less important than the effect of exchange rates (Büttner & Hayo 2009).

It has been established that factors like openness of a stock market for foreign investors and a high level of financial development (Bekaert & Harvey 2011), in addition to trade openness and undiversified trade structure (Chambet & Gibson 2008) have a positive effect on stock market integration. The results are mainly obtained from studies concentrating on the emerging stock markets or comparing the stock market integration of stock markets in the developed and developing countries.

The applicability of these pieces of research to the study of the Eurozone stock markets is likely to be limited. All stock markets of this study are highly developed, and stocks traded on them have been open to foreign investors for the whole period of this study. It is also unlikely that there is such variability in factors like trade openness that have a significant effect on the differences in the stock market integration of these countries. There is also some empirical evidence that while market openness and financial institutions are significant explanatory factors for the integration of the stock markets of developing economies, investment environment and market turnover (liquidity) are more important explanatory variables for the stock markets of the developed economies (See e.g. Lehkonen 2015).

Additionally, democracy and political risk variables (See e.g. Lehkonen & Heimonen 2015), are not considered as relevant determinants of stock market integration for the countries of this study. All Eurozone countries are stable democracies in international comparison, and as members of the European Union and the European monetary union they have been obliged to meet the democracy and political stability conditions of membership. (This is not to claim that the economic difficulties endured by the crisis countries like Greece do not potentially have an effect on democracy and political stability, but it is unlikely these factors are important determinants of integration when compared, for example, with developing economies.)

Due to the sample of this study consisting of 12 highly developed economies, it can plausibly be argued that financial, macroeconomic and information variables are likely to be the most important predictors of integration, as the launch of EMU in 1999 removed the exchange risk between the countries of this study.

The close linkages between stock and bond market returns are documented by numerous articles. Stock and bond returns are highly correlated, and like the returns in different stock markets, stock-bond correlations are also time-varying (See e.g. Chiang et al. 2015; Connolly et al. 2007; Kim et al. 2006). Some authors provide evidence that the convergence in interest rates (among other things) have had a significant positive effect on European stock market integration (Fratzscher 2002; Morana & Beltratti 2002), but some have obtained evidence that this has been important only for some prospecting EMU members, but not for all (Kim et al. 2005). In a similar fashion to interest rates, some authors have argued that inflation differentials or different timing in inflation cycles affecting stock returns have an effect on stock market integration (Cai et al. 2009; Yang 2009).

Concerning the macroeconomic (or "real") determinants of integration, the focus in the research has been on the effect of recessions/booms or financial crises on integration in comparison with more stable economic conditions (I will not make a distinction between recessions and financial crises here). There is evidence that integration is higher during recessions than during periods of economic growth (Erb 1994; Longin & Solnik 2001; Pukthuanthong & Roll 2009), but also contradicting evidence that integration was lower during the last financial crisis (Bekaert & Harvey 2011). On the other hand, integration has been lower when the business cycles of economies are out of phase relative to each other than during the periods these phases have been synchronous (Büttner & Hayok 2009; Cai et al. 2009; Erb 1994).

The studies on financial and macroeconomic determinants of integration have been pronouncedly empirical, lacking theoretical explanations why the factors suggested have an effect on integration. However, there are some exceptions. Using a general equilibrium economic model Aydemir (2008) argues that risk sharing and time-varying risk aversion are the main mechanisms affecting market volatility and market correlations countercyclically over time. Overall, when there is risk sharing between countries, stock correlations are higher than economic fundamentals alone would warrant. In periods of economic turmoil, stock correlations are even higher, because the volatility of discount rates rises with the market price of risk, and this causes the investors to increase international risk sharing. (Aydemir 2008, 2, 24.) In a similar fashion Ribeiro & Veronesi (2002) argue also using a general equilibrium framework that stock market correlations are high during recessions because the investors are uncertain about the future state of the global economy.

Although the authors have validated their models by using actual integration and economic data, it is hard to compare the results of these general equilibrium studies with the more empirical studies reviewed in this chapter. However, it seems convincing, and in concordance with economic data and other studies, that economic uncertainty (measured both with financial market variables like bond yields and specific information variables like volatility) and macroeconomic factors are important (if not the most important) determinants of stock market integration for the developed stock markets.

The logic can be founded also on financial theory. In financial theory, stock prices are conventionally modeled as the present value of future dividend payments discounted by the cost of capital (interest rate). These numerous different models can be categorized under the label of dividend-discount models. (See e.g. Cuthbertson & Nitzsche 2004.)

It is therefore evident that both financial and macroeconomic variables potentially have an important effect on stock prices. It is likely that financial market variables and specific information variables like volatility and other indices measuring uncertainty are correlated to a significant degree because they measure the same thing: economic uncertainty (also including specifically financial market).

Despite this linkage, it is less clear how these financial and macroeconomic variables affect the integration between stock markets. As mentioned before, Aydemir (2009) suggested that this is because there are fluctuations in the level of international risk sharing between countries caused by changes in the discount rate of stock dividends.

Due to these considerations, in this study, analyzing the effect of economic uncertainty on integration is essential. In some empirical studies, a positive relationship between volatility and integration has been established (Cai et al. 2009; Connolly et al. 2007; Lehkonen 2015). There is evidence, that this dependence holds both for developed and emerging markets (Lehkonen 2015). In these three studies VIX Index is used as a measure of volatility, and in Lehkonen (2015), world volatility index is also included, and its coefficient is negative. However, for example Longin & Solnik (2001) have presented contrasting evidence that volatility itself does not increase integration. It is that recessions are connected to higher integration, and volatility is increases during periods of economic turmoil. In this study, a European volatility index VSTOXX is chosen as a measure of volatility as it is likely to measure the volatility of European stock markets better, and for the data of this study, this also proves to be the case (this choice is discussed more thoroughly in Chapter 3.1).

When discussing the determinants of integration, the studies evaluating the importance of industry specific factors versus country specific factors in explaining the variation in stock returns must briefly be mentioned. Probably the most influential study (already discussed in the previous chapter) is Heston & Rouwenhorst (1994) where the authors establish evidence (using a sample of 12 European countries) that differences between countries explain a vastly larger proportion of the stock return variation than industry differences. Based on the evidence it seems to be the case that country factors are still more important than industry ones (Bekaert et al. 2009; Rouwenhorst 1999). However, evidence has been established that the importance of industry factors is increasing and that financial market liberalization is a central mechanism behind this (Bekaert et al. 2009; Campa et al. 2006; Dutt et al. 2013).

The results of the studies highlight the importance of country-specific factors when studying the determinants of stock market integration. Risk factors of Pukthuanthong & Roll integration measure can be interpreted as industry factors. (However, the importance of country vs. industry effects in explaining integration differences between countries is not a central theme in this study. It would not even be possible to analyze this theme satisfactorily with the stock market level data of this study.)

As there are notable differences in the economies (size of the economy, living standards, industry structure) and financial markets (e.g. number of companies traded on the stock exchange of a country) it is likely that country-specific variables are of utmost importance as determinants of integration of the 12 Eurozone countries. However, factors common to all Eurozone countries like common monetary policy of the ECB or integration of the bond markets can also promote convergence for the stock markets of these countries. Due to this, both variables common to all Eurozone countries and specific to individual countries are considered as relevant determinants of integration. For some determinants of integration, using European level variables was a necessity. For example, there are not widely available volatility indices for individual Eurozone stock markets.

The most important macroeconomic, financial market and other determinants of integration suggested by previous research are presented in the following table. Only the empirical and the most relevant pieces of research regarding the research topics of this study are included.

TABLE 2 Previous studies on the determinants of integration

Study	Data[†]	Methods	Effect on integration (+ increases / - decreases / 0 no effect)
Erb (1994)	USA, CAN, FRA, DEU, ITA, JPN, GBR (1970-1993, Monthly)	Rolling correlation	Recession / financial crisis (+) Growth period (-) Similarity of business cycles (+)
Longin & Solnik (2001)	USA, GBR, FRA, DEU, JPN (1959-1996, Monthly)	Multivariate GARCH	Recession / financial crisis (+) Similarity of business cycles (+) Volatility (0)
Fratzcscher (2002)	AUT, BEL, FIN, FRA, DEU, ITA, NLD, ESP, GBR, DNK, SWE, NOR, CHE, JPN, USA, CAN, AUS	Multivariate GARCH	Exchange rate risk (-)
Connolly et. al (2007)	GER, GBR, USA (1992-2002, Daily)	Multivariate GARCH and regime switching	Volatility (+)
Chambet & Gibson (2008)	24 countries (1995-2003, Monthly and Annual)	Multivariate GARCH and panel regression	Recession / financial crisis (-)
Büttner & Hayo (2009)	EU countries (1997-2007, Daily)	Multivariate GARCH and panel regression	Exchange rate risk (-) Interest rate differentials (-) Stock market capitalization (+)
Cai et al. (2009)	USA, GBR, FRA, DEU, HKG, JAP (1991-2007, Daily)	Smooth transition regression	Similarity of business cycles (+) Volatility (+) Similarity of inflation (+)
Pukthuanthong & Roll (2009)	80 countries (1991-2007, Daily)	Pukthuanthong & Roll integration measure	Recession (+)
Lehkonen (2015)	60 emerging and 23 developed markets (1987-2011, Daily, Monthly and Annual)	Pukthuanthong & Roll integration measure and panel regression	Volatility (+) World volatility (-)

[†]AUS = Australia, AUT = Austria, BEL = Belgium, CAN = Canada, CHE = Switzerland, DEU = Germany, DNK = Denmark, ESP = Spain, FIN = Finland, FRA = France, GBR = United Kingdom, GRC = Greece, HKG = Hong Kong, IRL = Ireland, ITA = Italy, JPN = Japan, LUX = Luxembourg, NLD = Netherlands, NOR = Norway, POL = Poland, PRT = Portugal, SWE = Sweden, USA = United States

In this study financial, macroeconomic and specific information variables are considered as determinants of integration. Variables measuring economic uncertainty are likely to be essential when studying the variation in integration. In most of the previous studies addressing the topic, the relationship between volatility and integration was examined. One of the objectives of this study is to analyze the topic further by also examining the effect of the previously largely omitted variables of long-term (10 year) government bond yield the relatively new bond yield and Economic Policy Uncertainty (EPU) index on integration. Long-term government bond yield is widely used to measure the state of government financial position and more general economic outlook of a country. In this study, these three variables are considered to be the major variables capturing the effect of economic uncertainty on integration.

In the relatively highly integrated Eurozone stock markets, many factors explaining the differences between stock markets suggested by previous articles are likely to be insignificant. However, other financial variables besides long-term government bond yield and other macroeconomic variables besides GDP are likely to have impact on integration. To limit the number of variables, only one additional financial market variable, 3 month Euribor rate, is included. Euribor is widely used as a benchmark rate for short-term interest rates. Nominal GDP is included as the only macroeconomic variable, and it is assumed that GDP captures the effect of all real variables (like trade flows) possibly affecting integration. An measure of integration external to the Eurozone is also included to control the effect of (possible) global integration not captured by the integration measure estimated only using data from the 12 Eurozone countries (for description of the variables, See Chapter 3.1).

3 DATA AND METHODS

3.1 Description of the data and variables

The data used to estimate the Pukthuanthong & Roll integration measure consists of 12 daily Eurozone stock market indices during the period 1.1.1999-4.12.2014. The indices have been obtained from Thomson Reuters Datastream. Dividend corrected total return indices have been used when available, and broad indices have been selected, as using more restricted indices could overstate the degree of integration.

All indices used are nominated in Euro. For Greece during the years 1999 to 2000 the time series have been converted to Euros using Datastream currency converter. Daily logarithm returns $ln(p_t) - ln(p_{t-1})$ have been used in constructing the integration measure. The countries selected for the study are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. The chosen countries have had well developed and sufficiently large stock markets for the whole period, and the data has been easily available. Summary of the countries and indices used in the study is presented in Table 3.

TABLE 3 Stock indices used in the estimation of the integration measures

Country	Index	Datastream code
Austria	AUSTRIA-DS Market - TOT RETURN IND (~E)	TOTMKOE(RI)~E
Belgium	BELGIUM-DS Market - TOT RETURN IND (~E)	TOTMKBG(RI)~E
Finland	OMX HELSINKI (OMXH) - TOT RETURN IND (~E)	HEXINDX(RI)~E
France	FRANCE-DS Market - TOT RETURN IND (~E)	TOTMKFR(RI)~E
Germany	HDAX (XETRA) - TOT RETURN IND (~E)	PRIMHDX(RI)~E
Greece	ATHEX COMPOSITE - TOT RETURN IND (~E)	GRAGENL(RI)~E
Ireland	IRELAND-DS Market - TOT RETURN IND (~E)	TOTMKIR(RI)~E
Italy	ITALY-DS Market - TOT RETURN IND (~E)	TOTMKIT(RI)~E
Luxembourg	LUXEMBOURG SE LUXX - TOT RETURN IND (~E)	LXLUXXI(RI)~E
Netherlands	NETHERLAND-DS Market - TOT RETURN IND (~E)	TOTMKNL(RI)~E
Portugal	PORTUGAL PSI ALL-SHARE - TOT RETURN IND (~E)	POPSIGN(RI)~E
Spain	MADRID SE GENERAL (IGBM) - PRICE INDEX (~E)	MADRIDI(PI)~E

The risk factors and integration measures are estimated using the log-returns computed from the 12 stock indices presented in the table. With the exception of Spain, dividend corrected stock return indices are used. For Spain, only price index was available. Estimation of the risk factors and integration measures is described in the next chapter. Due to the fact that the return time series consists of data from different countries (problems caused by national holidays and "thin" trading) and different time zones (different closing times for stock markets), estimations conducted using this data can potentially suffer from serious biases. These biases and attempts to correct them are also discussed in the next chapter.

Stock return data was only available for 3310 days of the original 4172 for each of the 12 countries, as a large number of days were lost due to omitting the returns for holidays. For the integration time series, 2909 daily observations were available as 400 days were lost due to moving-windows estimations (using 200 day time windows) and additional 1 day was lost for adding the first factor lag for the integration measure estimations.

In this study, after analyzing the evolution of integration during the EMU era graphically, panel models are estimated to identify the determinants of integration. Description of the variables used in these analyzes are described in Table 4.

TABLE 4 Description of the variables used in the study

Variable	Description	Variable type
integration	Pukthuanthong & Roll -integration measure (as in Pukthuanthong & Roll 2009). The integration measure is (adjusted) R^2 from multifactor model estimated using moving-window regressions and daily data for 12 eurozone countries, risk factors are estimated using moving-window principal components (see Chapter 3.2)	country-specific
dissimilarity of risk exposures	dissimilarity measure is constructed as the difference in integration estimated using an optimal number of factors (8) - the measure estimated using one factor	country-specific
10 year government bond yield (%)	10 year government bond yield (%, annual), EMU Converge Criterion Series [code: irt_lt_mcby_m] , monthly frequency, source: Eurostat	country-specific
3 month Euribor (%)	3 month Euribor (%, annual), monthly frequency, source: ECB	common
GDP [10 milliard €, long scale]	quarterly national GDP (working day and seasonally adjusted), source: Eurostat	country-specific
volatility (VSTOXX)	EURO STOXX 50 Volatility (VSTOXX) index, daily frequency, source: Datastream	common
volatility (VIX) [index values / 100]	CBOE Volatility Index, daily frequency, source: Datastream	common
EPU index [index values / 100]	Economic Policy Uncertainty (EPU) index, Europe Monthly Index, Source: http://www.policyuncertainty.com/europe_m	common
EPU index (national) [index values / 100]	National EPU indices for Germany, France, Italy and Spain, source: see above	country-specific
external integration [index values / 1000]	integration external to the Eurozone (constructed by regressing daily MSCI World stock index on 12 estimated integration factors and using the model residuals as a variable, source: Datastream	common
inflation (HICP)	Harmonized Index of Consumer Prices, monthly frequency, source: Eurostat	country-specific
money supply (M1, M2 and M3) [billion €, long scale]	Euro area money aggregates (M1, M2 and M3), monthly frequency, source: ECB	common
government debt (%)	national government debt (percentage of GDP), quarterly frequency, source: Eurostat.	country-specific
government debt (nominal) [billion €, long scale]	national government debt (nominal), consolidated government gross debt, quarterly frequency, source: Eurostat.	country-specific

As was discussed in the previous chapter, in this study, financial, macroeconomic and information variables are considered as the potentially most important determinants of integration. Variables representing economic uncertainty are considered as essential determinants of integration for the highly developed Eurozone stock markets. These are 10 year government bond yield, VSTOXX index measuring the volatility of the largest European corporations, and Economic Policy Uncertainty (EPU) –index. However, also other variables as 3 month Euribor and quarterly national GDP have been included. The former is a widely used as a reference rate for short term interest rates, and the GDPs of the Eurozone member states have been included to capture the effect of real (non-financial) variables on integration.

Most of the variables presented in the table are widely used in financial market and integration studies and the importance of these variables were also thoroughly discussed in the previous chapter. Due to these considerations, further reflection is not needed. However, certain variables need to be discussed briefly as these variables are not either widely used, several almost equally plausible candidates of variables are available, or the construction of theses variables need to briefly described.

In this study, for a measure of volatility, VSTOXX (EURO STOXX 50 VOLATILITY) index is chosen. It is a measure of implied volatility for EURO STOXX 50 index options, and it is calculated as a basket of index options for the index mentioned. VSTOXX can be considered as a European version of VIX Index (CBOE Volatility Index), a volatility index measuring the volatility of the US S&P 500. VSTOXX was chosen over the more widely used VIX as the former is more likely to measure the volatility of European stock markets more satisfactorily (although it is constructed from a smaller number of companies than VIX). When the matter was analyzed further VSTOXX proves to be a better measure of volatility for European equities (See correlations at the end of this chapter and estimations conducted on Chapter 4.3.1).

Economic Policy Uncertainty (EPU) index is a publicly available index, which is constructed by using newspaper articles concerning policy uncertainty (for more information, see the reference in Table 4). For the same reason than for volatility, in this study, the European version of the index is used, and as an additional robustness check indices for France, Germany, Italy and Spain are used (for more information about EPU, See Table 4 in Chapter 3.1).

As an additional control, a variable capturing the effect of integration external to the Eurozone countries is in the models, because only the countries mentioned in this chapter are used when constructing the integration measures. This variable has been formed by regressing the MSCI world stock index on the estimated factors and using the residuals in panel regressions. It measures the common variation in world stock returns not captured (if such variation exist at all) by the risk factors estimated using the 12 Eurozone countries.

In graphical analyzes of integration and the similarity of risk exposures, daily time series are used. Excluding the GDP, which is in quarterly frequency, the panel variables are measured in daily or monthly frequencies. In panel models, monthly and quarterly data are used. When necessary, the variables have been aggregated to monthly or quarterly frequency using arithmetic averages. The descriptive summary for the variables is presented in Table 5. (The units of the variables have been described in the previous table)

TABLE 5 Summary statistics for the variables of the study

	N	Mean	SD	Skew.	Kurt.	Min.	Median	Max.
Stock returns (daily)								
Austria	3310	0.01	1.19	-0.34	8.19	-8.10	0.05	9.69
Belgium	3310	0.01	1.21	-0.11	5.70	-8.13	0.03	8.24
Finland	3310	-0.01	1.87	-0.23	6.46	-17.17	0.05	14.56
France	3310	0.01	1.35	-0.02	4.59	-8.41	0.05	9.94
Germany	3310	0.00	1.50	-0.07	4.26	-8.23	0.07	10.93
Greece	3310	-0.03	1.86	-0.13	4.18	-13.67	0.01	13.43
Ireland	3310	-0.01	1.40	-0.59	7.33	-13.34	0.03	9.13
Italy	3310	0.01	1.38	-0.14	4.58	-8.61	0.06	10.51
Luxembourg	3310	0.01	1.33	-0.56	9.11	-11.44	0.05	9.10
Netherlands	3310	0.00	1.34	-0.26	6.09	-9.20	0.06	9.32
Portugal	3310	-0.02	1.13	-0.24	8.61	-10.65	0.04	10.11
Spain	3310	0.00	1.47	0.10	5.73	-9.68	0.07	13.74
Panel variables (monthly)								
integration	1956	0.59	0.20	-0.70	-0.40	0.03	0.64	0.92
dissimilarity of risk exp.	1956	0.02	0.03	2.31	7.72	-0.05	0.01	0.20
government bond yield	1956	4.28	2.31	4.90	36.65	0.92	4.10	29.24
3 month Euribor	1956	2.19	1.48	0.30	-1.06	0.10	2.13	5.11
GDP	1956	19.09	20.00	7.82	16.03	7.84	0.76	68.13
volatility (VSTOXX)	1956	16.99	8.24	13.69	15.63	5.11	8.32	48.94
volatility (VIX)	1956	9.67	1.65	9.54	9.67	1.92	5.87	13.42
EPU index (European)	1956	1.34	0.54	1.27	1.30	0.56	0.48	3.05
EPU index (national)†	652	1.24	0.64	1.10	1.16	0.50	0.23	4.07
external integration	1956	-0.10	0.66	-0.12	-0.15	0.68	-1.27	1.84
inflation (HICP)	1956	105.57	9.02	105.85	105.45	10.85	86.27	124.38
money supply (M1)	1956	3.83	1.05	3.83	3.83	1.39	2.11	5.68
money supply (M2)	1956	7.06	1.63	7.36	7.10	2.10	4.38	9.48
money supply (M3)	1956	8.02	1.65	8.65	8.12	1.74	5.08	10.09
government debt (%)††	1260	77.09	35.49	75.65	76.47	38.92	6.70	177.40
government debt (nom.)††	1260	0.63	0.69	0.31	0.53	0.29	0.00	2.20

variable units: see Table 4; † data only for France, Germany, Italy and Spain;
†† data only for years 2006-2014

It can be seen that the mean level of integration for the whole sample of 12 countries and the whole time period of 2001-2014 is 0.59, which means that the common risk factors explain on average 59% of the variation in the stock returns of the countries of the study. The dissimilarity of risk exposures variable is constructed as a difference in integration measure constructed using 8 risk factors minus the measure estimated using only one factor. Mean value for dissimilarity is very small, and there also is very little variation in the variable.

Many of the variables presented in Table 5 do not follow normal distribution. The log-returns for the stock time series have excess kurtosis (fat tails), and some of main variables used in most of the panel models, like government bond yield, volatility and GDP are highly leptokurtic (and inflation and government debt used as additional determinants of integration are even more leptokurtic). To get an overview of the dependence between the main variables of the study, a correlation matrix is presented in Table 6 (for division into high and low integration countries, see Chapter 4.3):

TABLE 6 Correlation matrices for the main variables of the study

Correlation matrix A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
integration (1)	1.000							
	(0.000)							
dissimilarity of risk exp. (2)	0.037	1.000						
	(0.104)	(0.000)						
government bond yield (3)	-0.301	-0.048	1.000					
	(0.000)	(0.032)	(0.000)					
3 month Euribor (4)	-0.038	0.255	0.083	1.000				
	(0.094)	(0.000)	(0.000)	(0.000)				
GDP (5)	0.572	0.049	-0.165	-0.008	1.000			
	(0.000)	(0.030)	(0.000)	(0.738)	(0.000)			
volatility (VSTOXX) (6)	0.041	0.027	0.134	0.350	-0.015	1.000		
	(0.071)	(0.233)	(0.000)	(0.000)	(0.498)	(0.000)		
EPU index (7)	0.174	-0.205	0.111	-0.457	0.008	0.280	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.728)	(0.000)	(0.000)	
external integration (8)	0.002	-0.014	-0.084	-0.304	0.019	-0.497	0.123	1.000
	(0.920)	(0.524)	(0.000)	(0.000)	(0.391)	(0.000)	(0.000)	(0.000)

Correlation matrix B	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
integration (1)		-0.114	-0.108	-0.099	0.435	-0.031	0.215	0.030
		(0.000)	(0.000)	(0.000)	(0.000)	(0.270)	(0.000)	(0.280)
dissimilarity of risk exp. (2)	0.214		0.140	0.263	0.024	-0.004	-0.237	-0.013
	(0.000)		(0.000)	(0.000)	(0.383)	(0.871)	(0.000)	(0.646)
government bond yield (3)	-0.191	-0.158		0.618	-0.043	0.384	-0.284	-0.449
	(0.000)	0.000		(0.000)	(0.123)	(0.000)	(0.000)	(0.000)
3 month Euribor (4)	0.038	0.240	-0.199		-0.013	0.350	-0.457	-0.304
	(0.333)	(0.000)	(0.000)		0.645	0.000	0.000	0.000
GDP (5)	-0.062	-0.184	0.318	0.041		-0.021	0.013	0.029
	(0.116)	(0.000)	(0.000)	(0.299)		(0.448)	(0.630)	(0.299)
volatility (VSTOXX) (6)	0.207	0.101	0.038	0.350	-0.033		0.280	-0.497
	(0.000)	(0.010)	(0.328)	(0.000)	(0.399)		(0.000)	(0.000)
EPU index (7)	0.256	-0.134	0.384	-0.457	-0.045	0.280		0.123
	(0.000)	(0.001)	(0.000)	(0.000)	(0.256)	(0.000)		(0.000)
external integration (8)	-0.046	-0.019	0.097	-0.304	-0.011	-0.497	0.123	
	(0.243)	(0.636)	(0.013)	(0.000)	(0.780)	(0.000)	(0.002)	

The values presented are standard Pearson correlation coefficients (significance levels in parentheses); Correlation matrix A: full sample of 12 countries, correlation matrix B: correlations separately for high (upper diagonal) and low (lower diagonal) integration country subsamples

It can be seen that among the correlations estimated for the whole sample of 12 countries, GDP is most strongly correlated with integration (correlation coefficient 0.572). This is not surprising as the dependence between integration and business cycles has been confirmed in previous studies, because levels of GDP and integration differ between the countries of this study and because GDP is correlated with many financial and macroeconomic variables. For the high integration group of countries, the correlation is almost as high 0.435, but for the group of low integration countries correlation is practically zero (-0.062). The high correlation between integration and GDP for the high integration countries is to a large degree caused by the fact that among this group the countries with highest integration, are also the largest economies (See Chapter 4.1).

Among the most plausible explanatory variables for integration, government bond yield is moderately negatively correlated with integration (-0.301) and there is also weak correlation for both the low integration (-0.191) and high integration group of countries (-0.108). There is very weak correlation (-0.099) between 3 month Euribor measuring short-term interest rates and integration for the group of high integration countries, but for the two other groups, correlation is zero.

Among the specific information variables, Economic Policy Uncertainty (EPU index) is moderately correlated with integration when a sample of 12 countries (correlation 0.174) is used and slightly higher for high (0.215) and low integration country (0.265) subsamples. Correlation between volatility and integration (0.207) is about the same magnitude than government bond yield and EPU index for the group of low integration countries, but it is practically zero for high integration countries and for the whole sample.

Variable measuring integration external to the Eurozone countries included as control variable for panel models, does not seem to be correlated with integration almost at all. Dissimilarity of risk exposures measure seems to be weakly negatively correlated with EPU index and three month Euribor. There is also negative correlation with dissimilarity variable GDP, but only for the group low integration countries.

The main explanatory variables are also correlated with each other. EPU index is weakly correlated with volatility (0.280). Based on this rudimentary evaluation, volatility and EPU index seems to partly measure the same thing. EPU is moderately negatively correlated with Euribor (-0.457) These two variables are common to all countries under study, so there are no differences in correlation coefficients between the three samples.

For the full sample, government bond yield is weakly and positively correlated with volatility (0.134) and EPU index (0.111). Correlation with bond yield and volatility is even higher for the high integration group (0.384), but virtually zero for the low integration group (0.038). Government bond yield is moderately and positively correlated with EPU index for the low integration group (0.384), but weakly negatively correlated for the high integration group (-0.284). For the highly integrated countries, government bond yield is strongly positively correlated with Euribor (0.618), but weakly negatively correlated for the low integration group (-0.199) and for the full sample the coefficient is near zero (0.083).

In this study, VSTOXX index was used as a measure of volatility. On the one hand, for European stock indices, VSTOXX should be a better measure of volatility for the stock indices under study than VIX, because the former measures volatility of European companies and the latter for the US companies. On the other hand, VIX is computed using a larger number of companies, which can potentially make it a more satisfactory proxy for European equities also. For the data of this study, VSTOXX seems to be a better measure of integration, as the correlation between integration and VIX is almost non-existing (-0.085). This matter is analyzed more thoroughly in Chapter 4.3.1.

It can be concluded that most of the explanatory variables of this study are moderately or weakly correlated with each other. Using a large number of control variables is needed to avoid omitted variables bias when estimating the effects of the determinants of integration. In the next Chapter (3.2.), estimation of the Putkhuanthong & Roll integration measure is described, and after that (in Chapter 3.3) a review of the panel models utilized in this study, is presented.

3.2 Estimation of the Pukthuanthong & Roll integration measure

In this study, stock market integration is measured using the method developed by Kuntara Pukthuanthong & Richard Roll (2009). In the method, returns of a single stock market are regressed on n factors estimated by principal component analysis. In this model, the proportion of variance explained by common factors (the coefficient of determination: R^2) is the measure for integration. Because the level of integration and the volatility of stock returns change over time, the regression models are estimated using overlapping moving window (or "rolling") regressions. Lagged terms of factors can also be included in the model if considered necessary.

As discussed in the previous chapter, data of this study consists of logarithmic stock returns from 12 Eurozone stock indices. When the return a of a stock market index $i = 1 \dots k$ on time t is denoted by $r_{i,t}$, $f_{i,t}$ is the factor loading of principal component f on time t, and the time window used is w-observations, the estimated models can be presented in matrix form as follows:

$$r_t = \alpha_t + \boldsymbol{F}_t \boldsymbol{\beta}_t \qquad (1)$$

where $\boldsymbol{F}_t = \begin{bmatrix} f_{1,t} & f_{2,t} & \cdots & f_{k,t} \\ f_{1,t-1} & f_{2,t-1} & \cdots & f_{k,t-1} \\ \cdots & \cdots & \ddots & \vdots \\ f_{1,t-w} & f_{2,t-w} & \cdots & f_{k,t-w} \end{bmatrix}$

The estimation is conducted by using OLS, and as mentioned, the measure of integration is the R^2 of the regression model. Then, the smaller the squared residuals are, the greater the degree of integration, because $R^2 = 1 - \frac{SS_{res}}{SS_{tot}}$, where SS_{res} is the residual sum of squares of the regression and SS_{tot} is the models total sum of squares. Often, adjusted $\bar{R}^2 = 1 - \frac{n-1}{n-k-1}\frac{SS_{res}}{SS_{tot}}$ is used, because it penalizes adding variables that do not actually improve the fit of the model. In this study, adjusted $\bar{R}^2$ used as a measure of integration.

The factors used are estimated using principal components. In principal components analysis, the variation of k correlated group of variables $p_1, p_2, \dots, p_k$ can be presented using a new group of uncorrelated k variables $p'_1, p'_2, \dots, p'_k$.

Each principal component is estimated as a linear combination of the original variables by selecting coefficients $\alpha_{i,j}$ that explain largest possible proportion of the variation of the original variables:

$$p'_1 = \alpha_{11}x_1 + \alpha_{12}x_2 + \cdots + \alpha_{1k}x_k \qquad (2)$$
$$p'_2 = \alpha_{21}x_1 + \alpha_{22}x_2 + \cdots + \alpha_{2k}x_k$$
$$\vdots$$
$$p'_k = \alpha_{k1}x_1 + \alpha_{k2}x_2 + \cdots + \alpha_{kk}x_k$$

Because the principal components are linear combinations of the original variables, they are independent relative to each other. First principal component p_1 is estimated to explain most of the variance of the original variables, and after that more principal components are estimated. Because the variances could be maximized by setting infinitely large weights, the sum of the principal component weights is constrained to 1:

$$\sum_{j=1}^{k} \alpha_{i,j}^2 = 1 \qquad (3)$$

The maximum number of components estimated is equal to the number of original variables, in which case the components explain 100% of the variation of the original variables. Objective is to reduce the number of variables, by explaining a large proportion of the variation by using as few components as needed.

Equation (2) can be represented in matrix form:

$$\boldsymbol{p} = \boldsymbol{AX} \qquad (4)$$

where p is the vector of principal components, $\boldsymbol{X}$ is the matrix of original variables and $\boldsymbol{A}$ is matrix of k-rows, where on row i is a $\boldsymbol{\alpha}'_i$, $i = 1, \ldots, k$ vector containg the principal component weights. These vectors are the eigenvectors of matrix $\boldsymbol{X}$, and the single cells (weights) are the principal component loadings, computed from the variance-covariance matrix (or correlation matrix) of the original variables.

After the principal components have been estimated, these principal components can be used in statistical analyses instead of the original variables by computing the principal component scores F as multiplying the original variables (standardized by mean and standard deviation) with principal component loadings (eigenvectors):

$$\boldsymbol{F} = \boldsymbol{XA} \qquad (5)$$

In this study, the risk factors (principal components) are estimated using the log-returns from the same sample of countries that is used when estimating the integration measures (however, due to bias corrections, the number of countries used in the actual estimations for risk factors is 11 instead of 12, for more information: see the end of this chapter). When $r_{t,i}$ is used to denote the logarithmic return of a stock market index $i = 1 \ldots k$ on time t, and the length of the time window is w-observations, the estimated models for the risk factors can be represented in matrix notation as follows (notation is otherwise as in Equation 4, but with time indices t):

$$\boldsymbol{p}_t = \boldsymbol{A}_t \boldsymbol{X}_t, \tag{6}$$

where $X_t = \begin{bmatrix} r_{1,t} & r_{2,t} & \cdots & r_{k,t} \\ r_{1,t-1} & r_{2,t-1} & \cdots & r_{k,t-1} \\ \cdots & \cdots & \ddots & \vdots \\ r_{1,t-w} & r_{2,t-w} & \cdots & r_{k,t-w} \end{bmatrix}$

No trivial rule of thumb exist, how many principal components should be included in the regression models. The proportion of variance that needs to be explained is dependent on the research question. In further analyses, 8 principal components are used. They explain almost 95% of the average variation of the original variables. This choice is discussed more thoroughly in Chapter 4.2.

Also, the length of time window used can have effect on the variance explained by the principal components. In Figure 1 the average cumulative variance explained by 1…12 principal components is presented.

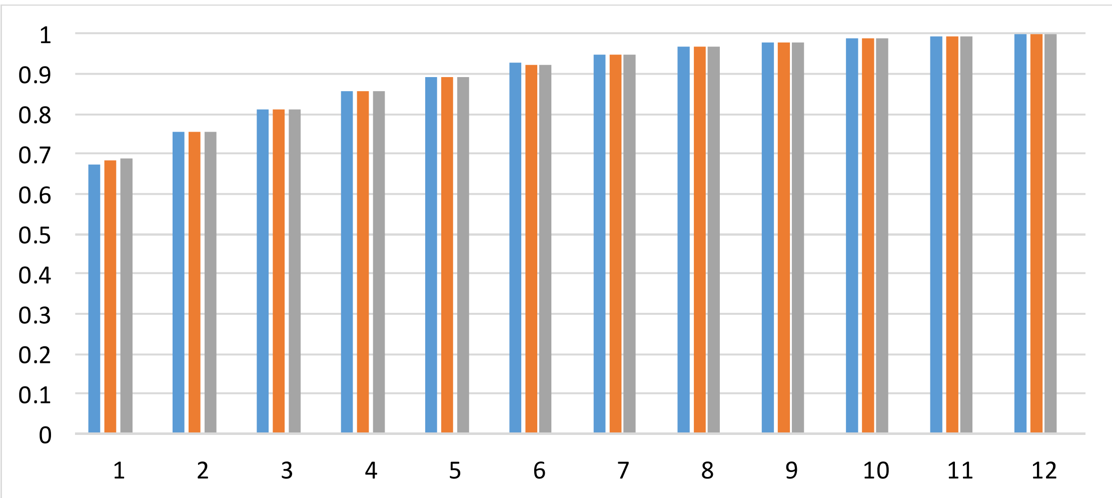

FIGURE 1 The average cumulative ratio of variance explained using 1-12 risk factors and 100, 200 and 300 day time windows

In this study, the risk factors have been estimated using a 200 day estimation window length. As a robustness check, 100 and 300 day windows were also used, but the chosen time window does not on average (the sample average of the cumulative variance explained using 1…12 risk factors during the period of this study) seem to have any notable effect on the variance explained. However, the length of the estimation window has an effect on the integration measures estimated using moving-window regressions (See Chapter 4.1.1).

Besides choosing the optimal estimation window, some other considerations must also be taken into account when estimating the Putkhuanthong & Roll integration measure, otherwise the integration estimated could be seriously biased. First potential concern for bias arises from the case of national holidays. Different dates for national holidays (in the Datastream indices used, value for last trading day is recorded for these holidays), or because very small trading volume for some stock indices (so called "thin trading" or stale prices) can lead to asynchroneity in stock returns in different countries under study.

In this study, the problem of national holidays is corrected by including only returns, which time distance to the last and next trading day is 1 (Tuesday, Wednesday, Thursday), distance to the last trading day 1 and distance to the next is 3 (Friday), or distance to the last trading day is 3 and distance to the next is 1 (Monday), and also excluding the returns where the index value is the same than for previous day (holidays). The problem of "thin trading" is likely to be smaller for the data of this study consisting of the 12 relatively developed Eurozone stock markets than for example studies consisting of very small and underdeveloped stock markets. However, as an attempt to correct the problem, one factor lag for all factors is included when estimating the integration of a stock market.

Different closing times for stock exchanges (mainly due to time zone differences) are also a source for potential bias. Stock market, which closing time is the latest, can react to information that for the stock markets already closed is absorbed only in the next morning when the stock market opens again. To remedy this potential bias, Pukthuanthong & Roll (2009) suggest including the lagged return for the stock market that closes the latest. However, different closing times are likely to be a smaller problem for the data of this study consisting only of European stock indices than if for example, North American countries would be present. Due to this, no correction for the different closing times is made.

In addition to the potential biases caused by the data, the estimation technique utilizing principal component analysis and moving-window regressions, can render the integration measures seriously biased. If the risk factors and integration measures are estimated using the same data, the integration measures can be upward biased. In this study, an attempt to remedy this potentially serious bias has been done by estimating the integration measures with risk factors where the dependent variable used in the estimation of the integration has been omitted from the data used in the estimation of the risk factors. For example, when estimating the integration measures for Germany, a data of 11 (12 – Germany) stock return indices were used in the estimation of risk factors. As an additional precautionary measure, sample weights from previous day were used when computing the risk factors: the principal components scores were computed by multiplying the stock returns by the factor loadings estimated for the previous day.

In addition to the biases already discussed, volatility could also prove to be problematic when estimating the integration measures. Volatility highly affects the R^2:s used as integration measures. There could be changes in the measure due to volatility even if the level of integration was really constant. Using moving-window regressions remedies this bias to a degree, but it does not remove it entirely. In this study, no specific corrections for volatility are made, as volatility is used as a determinant of integration in the panel models.

To assess the degree of this bias caused by volatility, in Chapter 4.1.1 estimations are conducted where volatility (measured by VSTOXX and VIX indices) are included as first factors when estimating the integration measures. In overall, the effect is not large. However, volatility seems to have more effect on the integration measures for the least integrated Eurozone countries like Greece than for the most integrated like France.

It can be concluded that estimating risk factors with principal component analysis is little more laborious than using a regional stock index like EUROSTOXX. However, the major asset of the former method is that it captures only the common variation to all countries under study. Using this methodology, it is also possible to analyze how many factors are required to explain the variation of returns in Eurozone stock markets, and how has the number of factors required been changed during the EMU era. If a small number of factors can sufficiently explain this variation, the risk exposure of Eurozone stock markets is quite similar. However, if a larger number of factors is needed, the exposure is more heterogeneous.

In the next chapter, the panel models used in the panel regressions for the determinants of integration are described.

3.3 Description of the panel models used

The relationship between integration and the factors explaining it is analyzed in this study with panel regressions. In this chapter, a brief survey of the panel models used is given. (The models are presented mainly as in Cameron & Trivedi 2005.) When studying the determinants of integration, fixed effects regressions are conducted, and as a robustness check to correct for non-stationarity and autocorrelation present in the data, first-differences models, and dynamic panel models using data in levels and in first-differences are estimated. Pooled OLS estimations are utilized when analyzing the effect of the financial crisis on integration. Due to the large T small N dimension of the panel data of this study, regression coefficient standard errors are estimated using the procedure proposed by Driscoll & Kraay (1998) suitable for this type of "long" panel.

To save space, stationarity tests for the time series used are presented in Appendix 1. For the same reason, a rather lengthy derivation of the estimation procedure for the Driscoll-Kraay standard errors is discussed in Appendix 2.

The exact model equations are described in the empirical section, and only for the main models.

3.3.1 Pooled OLS and fixed effects models

In its most general form, a panel regression model can be represented in matrix form as follows:

$$y_{i,t} = \alpha_{i,t} + \boldsymbol{x}'_{i,t}\boldsymbol{\beta}_{i,t} + \varepsilon_{i,t}, \qquad (7)$$

where $i = 1, \dots, N$ describes the panels, and $t = 1, \dots T$ describes the time units. In this equation both the regression slopes and constants are allowed to vary over individuals and over time. However, this model cannot be estimated, because the number of parameters exceed the number of observations. Due to this, the general model must restricted.

Basically the simplest panel model is the pooled OLS (POLS) estimator:

$$\boldsymbol{y}_{i,t} = \alpha + \boldsymbol{x}'_{i,t}\boldsymbol{\beta} + \varepsilon_{i,t} \qquad (8)$$

In POLS estimator the panel dimension of the data is ignored and simple cross-section regression model is estimated. If the explanatory factors $\boldsymbol{x}_{i,t}$ are uncorrelated with the model error term $\varepsilon_{i,t}$ the model is equally valid as other panel estimators. However, in most cases, because panel data consists of serial observations, the error term $\varepsilon_{i,t}$ is correlated across time within each panel. In this case POLS estimator is inconsistent, whether there are fixed effects in the data, and often the standard errors are significantly downward biased.

In practice, it is not often realistic to assume, that effect of explanatory variables on the dependent variable would the same in all panels. A more realistic case is that the panels and time units are allowed to have their own constants $\alpha_{i,t}$, but the slopes are estimated for each panel β_i.

This fixed effects model can be estimated by simply adding panel α_i and time dummies γ_t to POLS model:

$$y_{i,t} = \alpha_i + \gamma_t + \boldsymbol{x}'_{i,t}\boldsymbol{\beta} + \varepsilon_{i,t} \qquad (9)$$

In FE model, a time invariant constant term α_i is estimated for each panel, and the slope coefficients β for variables of interest are assumed to be constant between panels and also over time. In this model, the time constant intercepts α_i are allowed to correlate with the explanatory variables x_{it}. However, the idiosyncratic error term ε_{it} is assumed to be independent of the explanatory variables. If it is the case that all panel and time intercepts are zero, pooled OLS is unbiased, and FE is identical to POLS.

The model presented in equation (10) is also called least squares dummy variables –estimator (LSDV), because due to a large number of panels in most microeconometric datasets, it is more practical to estimate the model by subtracting the panel means from the dependent and the explanatory variables (so called entity demeaning):

$$y_t - \overline{y_i} = (\boldsymbol{x}_{it} - \overline{\boldsymbol{x}}_i)\boldsymbol{\beta} + (\boldsymbol{z}_i - \overline{\boldsymbol{z}}_i)\boldsymbol{\delta} + (u_i\text{-}\bar{u}_i) + (\varepsilon_{it} - \overline{\varepsilon_i}) \qquad (10)$$

Because $\boldsymbol{z}_i$ and u_i are time invariant, it follows that $\overline{\boldsymbol{z}}_i = \boldsymbol{z}_i$ ja $\bar{u}_i = u_i$. In this case $\boldsymbol{z}_i - \overline{\boldsymbol{z}}_i = 0$ ja $u_i - \bar{u}_i = 0$ and the equation 10 is reduced to form:

$$\tilde{y}_{it} = \widetilde{\boldsymbol{x}}_{it}\boldsymbol{\beta} + \tilde{e}_{it} \qquad (11)$$

when we denote $\tilde{y}_{it} = y_t - \overline{y_i}$ ja $\widetilde{\boldsymbol{x}}_{it} = \boldsymbol{x}_{it} - \overline{\boldsymbol{x}}_i$. This equation can be consistently estimated with OLS. This estimated effect is called entity fixed effects. Time fixed effects can be estimated equivalently by subtracting time means from the dependent and explanatory variables or by using time dummies. The major asset of the fixed effects model compared with pooled OLS, is its ability to remove the effect of time-invariant variables, which are correlated with the dependent variable, but which cannot be measured or for some other reason included in the model. In pooled OLS, the variables omitted from the model are correlated with the model error term $\varepsilon_{i,t}$, which leads to biased estimates for the coefficients (so called omitted variable bias). The fixed effects (within) transformation removes this bias. The regression coefficients can then be estimated using the traditional OLS equation in a similar way to the POLS model:

$$\widehat{\boldsymbol{\beta}}_{\boldsymbol{OLS}} = (\boldsymbol{X}'\boldsymbol{X})^{-1}\boldsymbol{X}'\boldsymbol{y} \qquad (12)$$

The standard errors can also be estimated as in standard OLS procedure. However, it is not advisable because when panel data is used, there is usually serial correlation (in addition to heteroscedasticity and spatial clustering) in the model residuals, which can lead to severely biased estimates for the coefficient standard errors. This is especially the case in finance panels. In microeconometric panels the usual practice is to estimate the so called (one way) cluster-robust standard errors, which allow both the model residuals to be clustered within panels (autocorrelation), but the residuals are assumed to be uncorrelated between clusters (See e.g. Cameron & Trivedi 2005).

Cluster errors are widely used in finance, but a great concern for using cluster errors for “long” finance panels like the data of this study is that the asymptotics of cluster robust standard errors relies on the large number of clusters (panels). In the data of this study the number of longtitudinal observations in each panel is large (T = 163 using monthly data), but the number of panels is very small (N = 12). In addition, estimations are done on subsamples of countries, where there are as few as 3 panels in some estimations.

Clearly the asymptotic properties of cluster errors are not fulfilled. In the case of few panels, the cluster robust errors can be seriously downward biased, in other words, they underestimate the standard errors. In addition, to take into account the potential spatial correlation in the model residuals, two-way cluster errors should be computed. However, spatial correlation is likely to be of less greater concern than autocorrelation in long finance panels.

Due to the large T small N dimension of the data of this study, the standard errors proposed by Driscoll & Kraay (1998) suitable for long finance panels are utilized in this study. When estimating the DK errors, the residual moment conditions are allowed to vary between panels and over time, and after that the cross-sectional averages of this moment-condition matrix for each time period is taken. Autocorrelation in the model residuals is taken into account by making an autocorrelation correction as a decaying function of this matrix (in a similar way to the univariate procedure for estimating Newey-West errors). As a result of these transformations, the DK errors are robust against heteroscedasticity, autocorrelation and spatial clustering in the residuals. The rather lengthy estimation procedure of DK errors is described in detail in Appendix 2.

3.3.2 First-differences and dynamic panel models

Many of the variables used in this study are not stationary, so as a robustness check, estimations are conducted using data in first differences. In OLS regression, the time series used are required to be stationary. In other words, the mean, standard deviation and the autocorrelation coefficient estimated from the data should remain constant over time. Estimation of OLS regression models using non-stationary data can lead to inflated t-test statistics and goodness of fit measures (R^2), leading to possible false inferences of a statistically significant relationship between independent variables (so called spurious regression). Some of the time series used in this study contain unit roots (for stationarity tests, see Appendix 1). By the definition of a unit root, time series containing unit roots can be transformed into stationary ones by taking first differences.

In first differences (FD) panel estimator, instead of subtracting panel means from the dependent and explanatory variables, the transformation is performed by taking first differences, that is, the first lagged value is subtracted from the variable:

$$y_t - y_{i,t-1} = (\boldsymbol{x}_{i,t} - \boldsymbol{x}_{i,t-1})'\boldsymbol{\beta} + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad (13)$$

As a result of differencing, the time-invariant intercept terms α_i wil be removed from the equation. When the differences in the model are replaced with the difference operators

$$\Delta y_{i,t} = (\Delta \boldsymbol{x}_{i,t})'\boldsymbol{\beta} + \Delta\varepsilon_{i,t}, \quad (14)$$

it is clearly noticeable that this model can – in a similar manner to FE – be estimated using OLS. The model is simply a linear regression model using differenced data.

As an additional robustness check, dynamic fixed effects models – that is models including the lagged dependent variable - are estimated. Dynamic panel models are often used in finance to remedy the problem of autocorrelation in the static model residuals. However, using dynamic models in the case where there is not a strong theoretical reason to assume that dependent variable should be influenced by its previous values is not necessarily optimal. In the worst case, adding the autoregressive coefficient can mask the effect of the cross-section variables, because there is usually a strong autoregressive component present in high-frequency time series data. In this study, the dynamic models are estimated as a robustness check to static models, to assess the effect of autocorrelation in model residuals to the estimated cross-section variables of interest. Estimation of the dynamic FE and FD models estimated are similar to the static models presented in this chapter apart from the fact that they include lagged dependent variables.

In fixed effects models containing lagged dependent variables, OLS estimates for the lagged dependent variable coefficients are potentially biased because the fixed effects (whether dummies or demeaned variables) are correlated with the lagged dependent variable (the so called Nickell bias, See Nickell 1981). Because of the biased estimate for the autoregressive parameter, estimates for the coefficients for the other variables of interest are also potentially biased.

It has been established that for short panels (even for T as large as 30), this bias can be severe, but the bias should not be of great concern for long finance panels, because the size of the bias is in theory and also in practice inversely related to the length of the panel time dimension T (See e.g. Flannery & Hankins 2013). For this study, the time dimension of the panel data is very large (T = 165 for monthly data, T = 55 for quarterly data), so using dynamic fixed effects models should not yield overly biased estimates for the lagged dependent variables or for the other variables of interest. It is very likely that omitting the fixed effects and estimating pooled OLS would bias the results to a far greater degree (at least when monthly data is used) than estimating dynamic FE models.

The standard errors for the first-differences and dynamic panel models can be estimated in a similar way to the fixed effects models.

4 EMPIRICAL ANALYSIS

4.1 Integration cycles during the EMU era

The time varying nature of stock market integration has been confirmed by numerous studies, and there is also strong evidence that there are differences in the level of integration between the Eurozone stock markets (see Chapters 2.2 and 2.3). One of the main objectives of this study is to evaluate the degree of integration of the Eurozone stock markets by using the Pukthuanthong & Roll -integration measure. The integration of the 12 Eurozone countries under study during 2001-2014 is presented in Figure 2. The integration measures presented are estimated using 8 risk factors and a 200 day estimation window

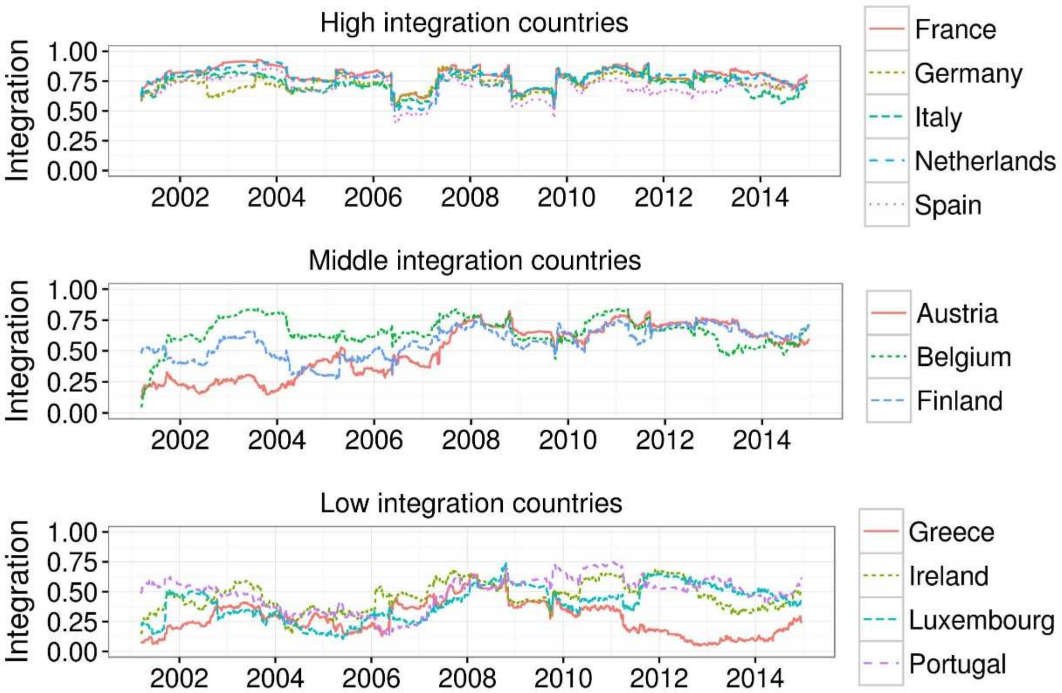

FIGURE 2 Integration of the Eurozone stock markets in 2001-2014 (daily frequency)

The results confirm the picture given by previous research. There still are more integrated and less integrated stock markets in the Eurozone. The cyclical nature of integration is also evident. France, Germany, Netherlands, Italy and Spain (not in order of integration) form the group of the most highly integrated Eurozone countries. For these countries, the levels of integration stay relatively high all the time, but there is still significant cyclicality. For this group of countries, the level of integration varies between 70-80% and it, except for very short periods of time, never drops below 60 per cent. For Germany, France and Netherlands this result was as expected. It also seems that Spain and Italy are as integrated.

The group of the least integrated stock markets consists of Greece, Ireland, Luxembourg and Portugal. For this group of countries, when the whole period of 2001-2014 is taken into account there have been large upward and downward trends in integration. During the period of 2001-2007, in the low phase, integration for the group was around 25%, and during the high phase it was about 50%. Since the year 2008 integration of Ireland, Luxembourg and Portugal has varied in a range of 30-50%, but the integration of Greece has, after a peak of nearly 70% (integration reached is highest daily value of 68 % in January 2008), fallen to a level of 20-30%, and occasionally, it has been below 10% for almost a year in 2012-2013. Greece, is by far, the least integrated Eurozone country.

Upon inspection of Figure 2, Greece seems to be an outlier compared to the other countries of the study. Integration of Greece has declined dramatically since 2011 relative to other Eurozone countries. It is possible that this is connected to more severe economic difficulties faced by this country than other Eurozone countries. However, after controlling for the effect of the cross section determinants of integration, the financial crisis actually increased integration for the Eurozone counties (also for Greece) rather than decreasing it (See Chapter 4.3.2). For (a non-crisis country) Luxembourg, small stock index of the country, but also its status as an international financial center, might be the primary cause of low integration relative to other Eurozone countries and very large ups and downs in integration. The crisis period is evaluated more thoroughly in the later chapters of this study in (See Chapters 4.3.2 and 4.3.3).

Austria, Belgium and Finland are less integrated than the first group but more integrated than the second group. This group of countries can be labeled as the middle integration countries. During the latter part of this study (2008-2014), the integration of this group of countries has varied between 50% and 75%, very rarely falling below 50 %. However, during the first years 2001-2004 the integration of Austria was at a very low level of around 25%. Same kind of increase in integration, albeit less strongly, can be observed for Finland. This matter is analyzed further later in this chapter.

One probably very minor factor affecting the results may be that the integration measures in this study have been estimated using only data from the Eurozone countries. The residual term contains (in addition to measurement error) the amount of residual that would explained by a global risk factor if it were included in the model. If the risk exposures of some Eurozone countries relative to United States, for example, is dissimilar to most EMU countries, the integration measure can give a biased estimate of integration for this country. Global integration is controlled in the panel regressions in Chapter 4.3.

It can be difficult to perceive the level and change of integration with graphs. In Table 7, the means and standard deviations of integration time series have been presented for the whole period of the study 2001-2014 and for the already discussed two equal length sub-periods of 2001-2007 and 2008-2014.

TABLE 7 The means and standard deviations of the integration measures (daily frequency)

	Mean				Standard deviation			
	2001-2014	2001-2007	2008-2014	chg.	2001-2014	2001-2007	2008-2014	chg.
Austria	0.521	0.345	0.680	0.334	0.199	0.138	0.070	-0.068
Belgium	0.655	0.661	0.650	-0.011	0.115	0.131	0.097	-0.034
Finland	0.577	0.494	0.652	0.159	0.120	0.112	0.065	-0.047
France	0.798	0.807	0.790	-0.017	0.072	0.080	0.063	-0.016
Germany	0.732	0.717	0.745	0.028	0.063	0.066	0.057	-0.009
Greece	0.276	0.285	0.268	-0.017	0.149	0.124	0.168	0.044
Ireland	0.467	0.426	0.503	0.077	0.118	0.117	0.107	-0.010
Italy	0.730	0.724	0.736	0.011	0.076	0.075	0.076	0.000
Luxembourg	0.408	0.295	0.509	0.214	0.144	0.105	0.087	-0.019
Netherlands	0.775	0.774	0.776	0.002	0.088	0.111	0.059	-0.053
Portugal	0.489	0.393	0.576	0.183	0.140	0.129	0.079	-0.050
Spain	0.702	0.716	0.690	-0.026	0.090	0.110	0.064	-0.046

The degree of integration in different Eurozone stock markets can clearly be seen on the averages calculated on the whole period 2001-2014. The means presented in the table confirm the picture obtained by graphical analysis. Based on the sample averages for the latter period of 2008-2014, the most integrated are France (average integration: 79%), Netherlands (78%), Germany (75%), Italy (74%) and Spain (69%), and the least integrated are Greece (27%), Ireland (50%), Luxembourg (51%) and Portugal (58%). Austria (68%), Finland (65%) and Belgium (65%) and can be situated between these two group of countries. With the exception of Greece, for all stock markets, common European factors explain over 50% of the variation of stock returns, and the national factors less than half.

One notable observation is that Germany seems to be less integrated than France and also the Netherlands. There is a possibility that the German stock market leads the other Eurozone stock markets, which leads to a lower estimate of integration, or that the stock indices used are not entire comparable.

Based on these findings, one would we tempted to conclude that integration of Austria, Finland and Portugal seem to have risen since then introduction of EMU in 1999. Standard two- sample t-tests (one sided test, equal variances assumed) were also conducted for these three countries. Based on the tests, the mean integration of Austria ($t = 83.49$, $p < 0.001$), Finland ($t = 47.32$; $p < 0.001$) and Portugal ($t = 46.73$; $p < 0.001$) are higher during the second period than during the first. This matter is analyzed further in this chapter, and this result is confirmed (Luxembourg's mean integration is also higher during the second period than during the first, t = 59.93; p <0.001, but the stock index used was not available before the year 1999 to investigate the matter further).

In addition to their higher level of integration, the standard deviations of the most integrated countries France, Netherlands, Germany, Italy and Spain are also smaller than the less integrated Eurozone countries. There has not been major increases or decreases in the standard deviation for any of the countries between the time periods of 2001-2007 and 2008-2014.

To further examine the changes in integration during the period of this study, linear trend models were estimated and the trends evaluated with t-tests. Linear trend model depicts non-linear trends poorly but the results can be used for rough comparisons. Because the time series were characterized with strong autocorrelation, the standard errors were computed using heteroscedasticity and autocorrelation robust Newey-West standard errors (See e.g. Greene 2004). Using t-tests in trend model for comparisons between countries is not very robust for the time window used when estimating the integration measures. Because of this, the models have been estimated using 100, 200 and 300 day windows. The results are presented in Table 8.

TABLE 8 The t-statistics for linear trend models

	Values of t-statistics for linear trends		
	100	200	300
Austria	7.03	12.27	8.96
Belgium	0.18	-0.42	-3.55
Finland	3.81	8.21	5.21
France	-2.62	-1.73	-5.51
Germany	-0.74	3.02	-0.65
Greece	-2.05	-2.10	-3.16
Ireland	1.46	2.34	0.86
Italy	-1.70	-0.82	-1.97
Luxembourg	2.95	6.50	5.33
Netherlands	-2.89	-1.54	-4.78
Portugal	1.99	4.00	4.07
Spain	-3.61	-2.32	-6.75

The t-statistics for linear trend models using 100, 200 and 300 day moving-window regressions for the integration time series; standard errors for the t-statistics have been computed using autocorrelation-corrected Newey-West estimator (daily frequency); lag length is chosen based on the Newey-West formula presented in Appendix 2

Based on the t-statistics for trend models, it can be seen that of slopes for linear trends are upward for Austria, Finland, Portugal and Luxembourg. All t-statistics for trends for these three countries reported on the previous table are statistically significant when 95% confidence level is used (and many of the statistics also with higher confidence levels). As mentioned in this chapter, the integration of Austria, Finland, Portugal and Luxembourg seems to have risen during the period of this study. To investigate whether this is caused by an upward trend or whether this has been only an upward phase in integration cycle, the integration measures Austria, Finland and Portugal were estimated using data from a longer time period of 1994-2014. For Luxembourg, the used stock index LuxX Index was not available before the year 1999. Due to this limitation, the integration measures prior the year 1999 were not estimated for Luxembourg.

Not including Luxembourg in the estimation of the risk factors and using a different index for Portugal (only price index was available before year 1999) also has a marginal effect on the integration of Austria, Finland and Portugal. In Figure 3, integration for these three countries mentioned for years 1996-2014 (3819 observations of total 5459 were available, as observations were lost due to removing holidays, estimation windows and adding a factor lag) is plotted together with the original integration time series (presented in Figure 3):

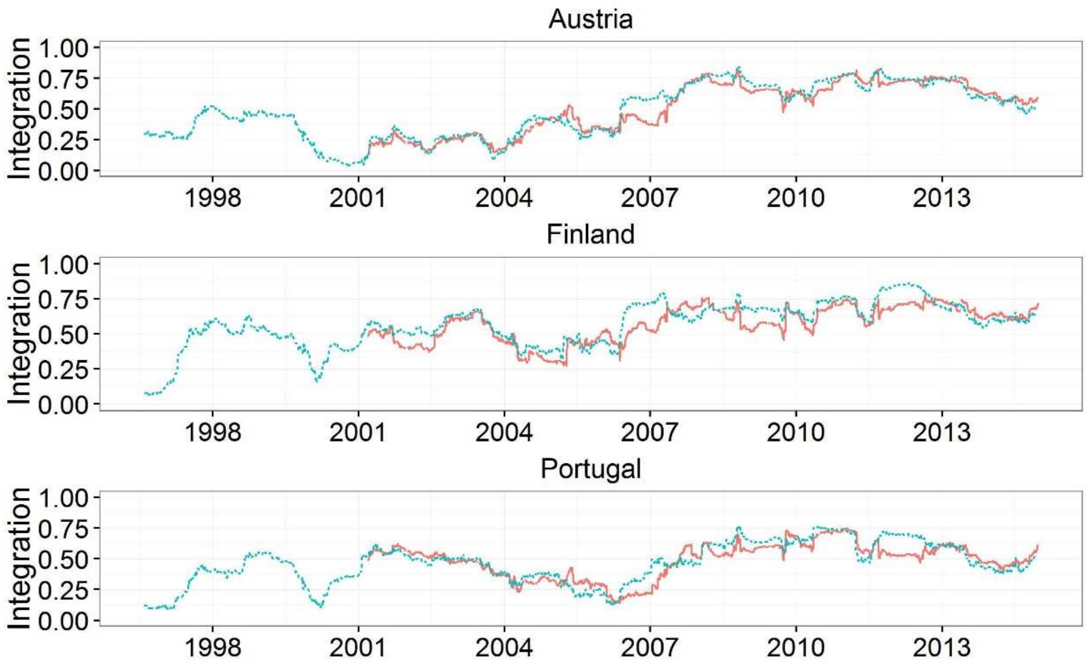

FIGURE 3 Integration of Austria, Finland and Portugal in a longer perspective (blue dashed line: 1996-2014 data, red line: 2001-2014 data)

The estimations reveal that for Austria, Finland and Portugal, the integration in the period of 2008-2014 seems to be higher than during the period of 1996-2007. Although integration for Austria was in a phase of very low integration around 20% during the years of 2000-2004 (mean integration for the period: 0.23), and the previous upward phase reached its peak in 1999 at 50%, even after taking this period of low integration into account, it is clear that integration has increased: the mean integration for period 1997-2007 was 0.35 and it was 0.69 for the period 2008-2014. In a similar fashion, the mean integration for Finland was 0.49 during the first period and 0.69 during the second period, and for Portugal the means for the first and second period were 0.40 and 0.61.

The results presented in this chapter can briefly be summed up as follows. France, Netherlands, Germany, Italy and Spain (in order integration based on the average integration during the time period of 2008-2014), are the most integrated stock markets in the Eurozone. For this group of countries, the integration measured with the Pukthuanthong & Roll integration measure stayed most of the time within the range of around 70-80%. There are upward and downwards cycles in integration but – with the exception of very short time intervals – integration never drops below 60%.

The least integrated counties are Greece, Ireland, Luxembourg and Portugal. There are very large upward and downward swings in the integration of these countries. The integration for Ireland, Luxembourg and Portugal has varied in the range of 40-55% for the latter period. Greece is notably less integrated, its average integration has been around 25% during the latter period of this study. However, even the integration of Greece can occasionally rise to a moderately high level of almost 70%. From this group of countries, integration has increased only for Portugal during the period of this study.

The integration of Austrian, Belgian and Finnish stock markets is situated between these two groups. Austria, Belgium and Finland form a group of countries, which are less integrated than the first mentioned group, but more integrated than the last mentioned one. Integration for this "middle" group of countries has been between 60 and 70% on average since the year 2008, and there has not been large downward phases in integration. Integration for Austria and Finland has increased during the period of this study.

The similarity of risk exposures, that is the number of factors needed to satisfactorily explain the variation in stock returns of the 12 Eurozone countries, is analyzed in Chapter 4.2. After that, the determinants of integration are analyzed using panel regressions in Chapter 4.3. Robustness of the integration measures estimated is evaluated by conducting additional estimations in the next sub-chapter 4.1.1.

4.1.1 Robustness of the estimated integration measures

In light of the discussions of the previous chapters, it is clear that integration measures estimated using the method presented by Pukthuanthong & Roll can potentially be highly biased if some relatively simple corrections are not made during the estimation procedure (See Chapter 3.2). In this chapter the effect of the corrections made in this study is evaluated through additional estimations with and without these corrections. The effect of the estimation-window length on results is also addressed.

In this study, an attempt to remedy the problem of national holidays causing asynchroneity in stock returns in different countries, is made by excluding stock returns for holidays, and one factor lag is also included in the integration measure estimations to control the problem of stale prices.

To reduce the severity of the bias caused by estimating the risk factors and integration measures using the same data, returns for a country are excluded from data when its risk factors are estimated, and also principal component weightings from previous day are used when computing the principal component scores.

To assess the impact of the corrections made, in this chapter, integration time series with and without corrections are presented. As it is the case that the biases discussed have different effects on high and low integration countries, the analyses are conducted separately for France, a typical high integration country, and for Greece, the least integrated Eurozone country.

The integration time series estimated with and without the corrections mentioned are presented in Figure 4. (The time series are shorter for the corrected estimations, because quite a large number of days were omitted, and there are also gaps, which are visible when there are several successive holidays, See Chapters 3.1 and 3.2):

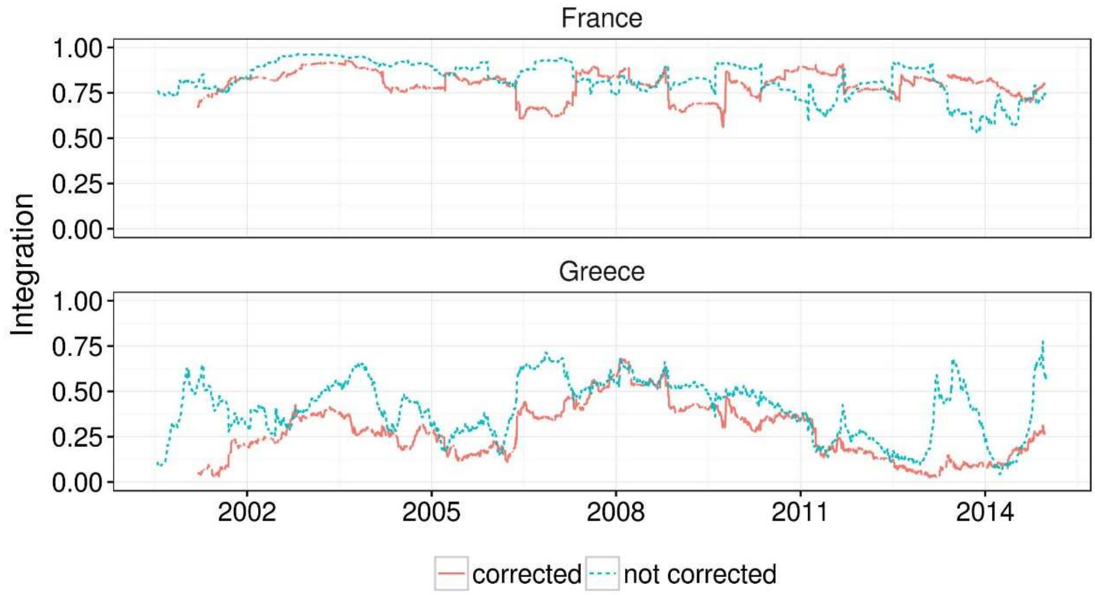

FIGURE 4 Integration time series for France and Greece estimated with and without bias corrections

It can be seen that these corrections have a notable effect on the integration measures. For both a high-integration France and a low integration Greece, this effect is time-varying: making the correction seem to either increase or decrease the integration depending on the time period. For France, integration is not systematically higher of lower whether the corrections are conduced or not. For Greece, not making the bias corrections seems to overstate integration dramatically for periods of low integration, but for the highest periods of integration, the difference in integration between the corrected and not-corrected time series is not very large.

The effects of the bias corrections on other high integration countries are quite similar to the case of France, and the effects on other low integration countries are similar to Greece (to save space, results not shown in the research report). Similarly, results for the effects of the individual corrections are not presented in this research report, but it can briefly be mentioned that not excluding a stock market in the risk factor estimation phase seems to induce the largest bias to the integration time series. Effects of not correcting for holidays or are not insignificant, but they are of smaller magnitude.

No volatility correction has been made when estimating the integration measures in this study, as volatility is modelled separately in panel regressions on the determinants of integration. Integration measures estimated using the Pukthuanthong & Roll integration measure can be upward biased, because R^2:s as suggested by Forbes & Rigobon (2002) often increase due to times of high volatility.

The effect of this bias is next analyzed, by plotting integration time series where two volatility indices (VSTOXX and VIX) are included as first and second factors when estimating the integration measures: the third factor is the first original factor, the fourth factor is the second, and subsequent factors are estimated in a similar manner. The results of these estimations are presented in Figure 5 (The gaps in the time series are caused by the adjusted R^2 for the models consisting of the volatility proxies only actually being negative for some time periods and only positive values are presented in the figure):

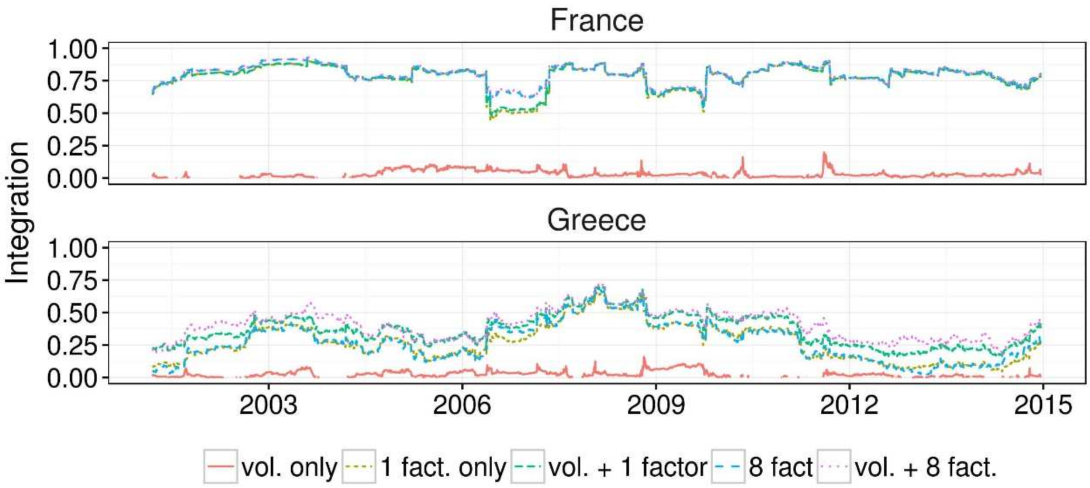

FIGURE 5 Integration time series with and without volatility correction

It can be seen that the two volatility factors alone explain a very small fraction of integration. For France, the effect of including volatility has a very miniscule effect on integration. For Greece, the effect is larger, but not as notable as the effect of not making the other corrections discussed before. Overall, although volatility can bias the integration time series to a degree, not including the volatility factors has no major implications for the main results and interpretations of this study. This, of course, is not to suggest, that the integration model used is immune to bias caused by volatility.

One final source of bias must be briefly mentioned. Different trading hours for stock exchanges mainly due to time zone differences can bias the results. Stock market that closes the latest can react to information, to which the other stock markets react only in the next morning. This bias can potentially have an effect on estimated integration, but because there is only two hour difference in the time zones of the Eurozone countries, this bias was not considered severe in this study and was not specifically addressed.

In addition to the potential biases discussed, length of the estimation window for integration measures can have an impact on the view of integration obtained. If a too short time-window is used, there can be artificial ups and downs in integration and the estimates for the R^2:s can be unstable. When a too long estimation window is chosen, the assumption of constant volatility does not hold. The effect of the estimation window length on the integration time series is analyzed by estimating the integration time series (and risk factors) using time windows of 100, 200, 300 and 600 days. The results of these estimations are presented in Figure 6:

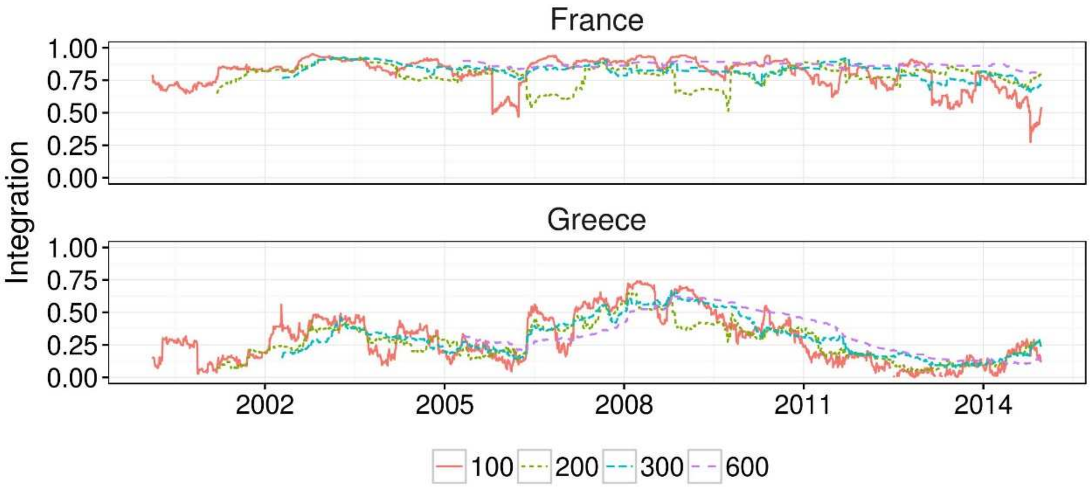

FIGURE 6 Estimation results for integration using 100, 200, 300 and 600 day estimation windows

Based on a graphical inspection of the figure, it is of course evident that the picture of integration one obtains is somewhat dependent on the length of the estimation window chosen. When a short 100 day window is used, there is quite large short-term variation in integration, and if a very long 600 day window is used, this variation is totally absent. For France, the variation in integration is very low when the longest estimation window, but for Greece, the upward and downward phases of integration cycles are still clearly visible. However, in overall, the results are not overly sensitive to the time window chosen, unless an extremely long time window is chosen. A 200 day time window is used in all integration estimations in this study, but the results would have not probably differed dramatically had a shorter or longer time window been used. Using a 200 day window seems to be ideal, because it smooths some short-term variation in the integration time series, not too many observations are lost to estimations, and the assumption of constant volatility is more realistic (although probably not entirely realistic) than for longer estimation windows.

4.2 Similarity of risk exposures

Estimated risk factors provide a mean to evaluate the degree of similarity of risk exposures in the Eurozone stock markets. The smaller the number of common risk factors required to explain the return variations of single stock market adequately, more similar is the risk exposure of these stock markets. In the case of perfect similarity, one factor would be sufficient. In the case of very heterogeneous risk exposures, the number of factors would be large (a maximum is the total number of stock indices). In Figure 7 the proportion of the variance explained by the risk factors is plotted over time:

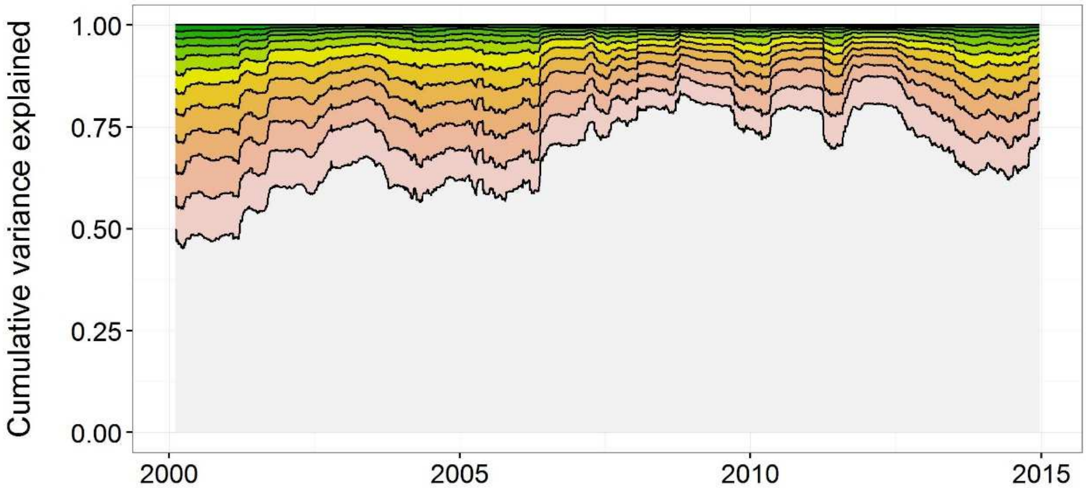

FIGURE 7 The evolution of the cumulative variance explained by 1-12 estimated risk factors during the EMU era (daily frequency)

The cumulative variance explained describes the proportion (a percentage presented as a ratio 0...1) of variance of the original variables explained by the estimated principal components using n factors (principal components). As was to be expected, one risk factor explain the return variations to a significant degree. In the beginning of the year 2000[2], one factor explained about half of the variation. In the end of the year 2014 this proportion has risen to about 70 per cent. However, there is cyclical variation also in this similarity measure: at its highest daily value, the cumulative variance explained was 83.9% in October 2008 and it took until October 2009 before it dropped below 75%. The increase of over 20 percentage points from the beginning of year 2000 to the end of year 2014, is can be taken as evidence, that the similarity of risk exposures of the Eurozone stock markets has increased during the EMU era. There is some cyclicality in the cumulative variance explained by the number of risk factors, but the long-term trend can be easily observed.

[2] The time period is longer here than for integration time series, as only 200 days are lost due to moving-window estimations (in addition to holiday corrections). The first daily observation available is 11 February 2000.

The factors have been estimated using a 200 day time window, but the estimations were repeated using 100 and 300 day windows the results being the same. However, the shorter the time window used, the more short-term variation is present in the cumulative variances.

After examining the similarity of risk exposures for the whole Eurozone countries, it is also of interest to analyze the proportion of integration for individual stock markets that can be explained by a specific number of factors. It is not necessarily the case that the number of risk factors needed to explain the return variations sufficiently is the same in all stock markets under study.

First, in Figure 8, the average integration measures for the individual Eurozone stock markets are presented using differing number of risk factors. The values are presented both for estimations without (standard R^2) and with (adjusted R^2) penalizing the integration measure for the number of factors included.

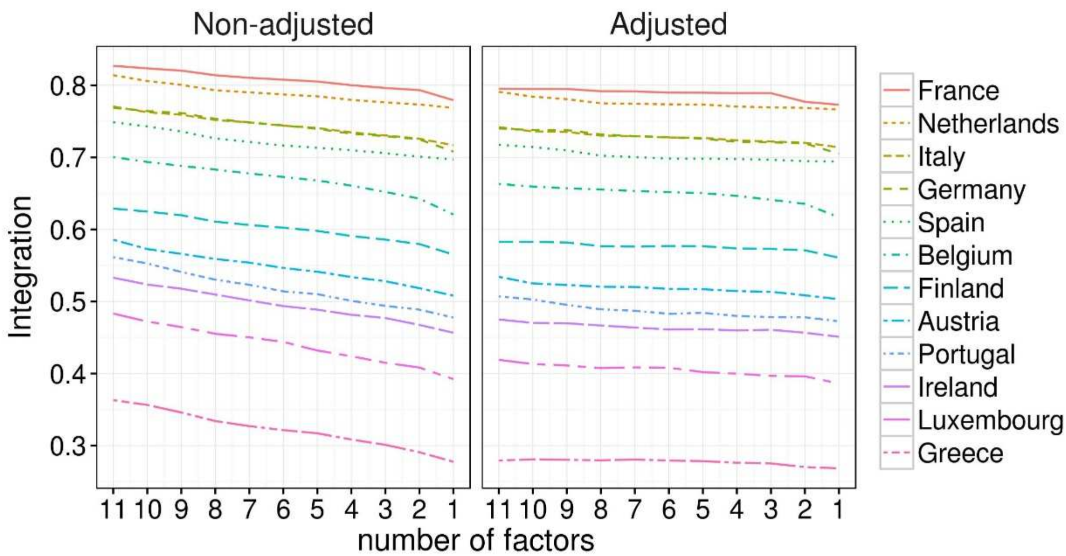

FIGURE 8 The level of integration estimated using a regression model including n risk factors

Based on the non-adjusted values in Figure 8, one could conclude that on average, one factor is not enough to explain the number of integration for most of the Eurozone countries. However, when the integration measures are penalized for adding factors that do not contribute to the model fit, the differences between 1 and 11 factors became practically non-existent for all of the Eurozone stock markets. As the integration measure used in this study is based on adjusted R^2, one could be tempted to use only 1 factors in analyzes, but this is not necessarily a viable strategy, since the level on integration measured with more than one factor change over time. When the matter is analyzed further (later in this chapter) it proves to be the case that there seems to be on average very little difference between the adjusted integration measures estimated with 1 or with 11 risk factors, because the difference 11-1 factors gets positive or negative values on different time periods, and these positive and negative values cancel out each other.

To get a more detailed picture of the similarity of risk exposures in different Eurozone countries and over time, a specific dissimilarity of risk exposures (opposite of similarity) measure was constructed as the difference in integration measured using 8 factors – integration measured using only one factor (why 8 factor were chosen, is discussed later in this chapter). Dissimilarity measures for the 12 Eurozone countries over time are presented in Figure 9:

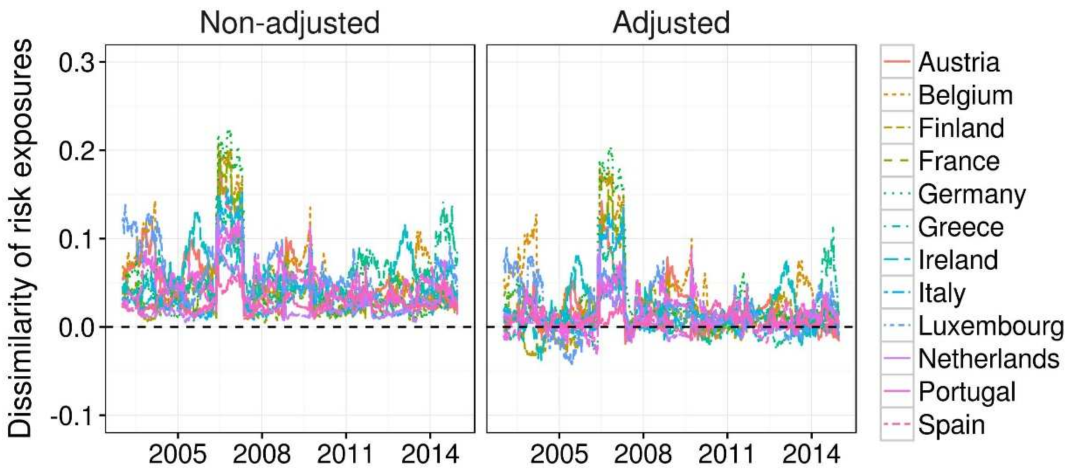

FIGURE 9 The dissimilarity of risk exposures (= opposite of similarity) in the Eurozone stock markets in 2001-2014

Based on Figure 9 it can be seen that the risk exposures of the Eurozone countries under study are quite similar. The dissimilarity index varies between 0 and 0.10 most of the time for all of the countries. Like in the previous figure, in this figure also the results are presented for non-adjusted and adjusted integration measures. There are not large differences between countries, or between estimations conducted using non-adjusted or adjusted integration measures. With the exception of Germany for a very brief time period during the years 2006-2008, the dissimilarity measure does not exceed 0.1 (10%), and even for Germany for the period mentioned, the difference is less than 0.20. No reason for this German “quirk” is found, it is likely caused by the estimation procedure without any specific economic importance.

While it is evident that like in the integration measure, there is a cyclicality in the dissimilarity measure also, the fluctuations are miniscule compared to the fluctuations in the level of integration. Overall, it is difficult to give the fluctuations any meaningful economic interpretation, or rule out that these fluctuations are caused by the estimation procedure.

The choice of the optimal number of factors to use when measuring integration is somewhat arbitrary. Using too few factors can results a too low integration being measured for an individual country, and using too many factors can lead to “overfitting”, that is the factors capturing meaningless noise in the data. However, for the data of this study, these do not seem to be major concerns, since the integration obtained is not highly sensitive to the number of factors chosen (if adjusted R^2 is used). From a purely statistical point of view, for some countries of this study, adding even the 11th factor leads a positive contribution to integration measured. The number of factors with which the maximum adjusted R^2 is obtained changes between countries and over time. For most of the countries and most of the time periods, this number of factors seem to 8.

Since, there are no major drawbacks for using an integration measure estimated with a large number of factors (as the integration measured is in most cases higher and in some cases marginally lower than the integration estimated using only 1 factor), and because optimal number of factors is time-varying, a highly conservative approach of using 8 factors in following panel estimation in order to measure integration in a most accurate manner for all of the time periods. After all, for most of the countries, the adjusted dissimilarity measured is positive, meaning that 8 factors measure a higher integration than 1 factor.

It can be concluded that the similarity of risk exposures for all 12 Eurozone countries has increased during the time period of this study when it is measured as the number of common factors needed to explain the variation in the Eurozone stock markets. However, when the dissimilarity of risk exposures measure (constructed as difference in integration estimated using 8 risk factors – integration estimated using only factor) was used, and adjusted R^2 was used as measure of integration, adding more than one factor increased integration of most countries under study, but this effects was on average, highly marginal. However, at the largest, the value was 10% (if the German exception is not taken into account). Due to this variation over time in the similarity of risk exposures, including 8 factors for integration measures used in the graphical analyzes and in panel estimations seems to be prudent choice that integration will be measured without bias for all time periods.

Overall, when the range of 0…1 of the integration variable is taken into account, the dissimilarity of integration measured using high and low number of factors is highly stable over time and between countries. The results of this study are not in disagreement with the interpretation that risk factors used in multifactor integration models can be considered to measure industry factors.

In the next chapter, determinants integration are analyzed using fixed effects and first differences panel models.

4.3 Panel estimations on the determinants of integration

In the following chapters of the empirical section of the study, the main determinants of integration in the Eurozone stock markets are examined using fixed effects and first differences panel models. In this chapter, panel models for the whole sample of the study are estimated. In the next subchapter, the relative importance of the determinants of integration (4.3.1) is evaluated, in subchapter

4.3.2 the effect of the financial crisis on integration is analyzed and the subchapter 4.3.3 consist of analyzing the effect of the financial crisis on the determinants of integration. In chapter 4.4, a summary of the main empirical results of this study is presented. In the following chapters, many estimations are conducted separately for high and low integration countries. In these estimations Greece, Portugal, Luxembourg and Ireland are considered low integration countries, and other 8 countries high integration countries.

First the determinants of integration are analyzed by estimating fixed effects –models for the whole sample of the study, which consists of years 2001-2014[3]. The static FE model estimated is of the following form, and the dynamic model is the same with a one dependent variable lag added (the variables having variation between countries and over time are denoted with subscripts i and t and the variables having variation only over time are denoted with a subscript t):

$$\begin{aligned} integration_{i,t} = & \\ \beta_0 + \beta_1 government\ bond\ yield_{i,t} + \beta_2 euribor_t + \beta_3 GDP_{i,t} \\ + \beta_4 volatility_t + \beta_5 EPU_t + \beta_6 external\ integration_t \\ + country\ dummies_i + \ year\ dummies_t + \varepsilon_{i,t} \end{aligned} \tag{15}$$

The results of these estimations are presented in Table 9. Because the country specific intercept terms are of interest, the models were estimated using least squares dummy variable (LSVD) estimator. When the degrees of freedom of the FE model are corrected for the number of estimated panel means, the results for the two models are identical. (Later FE models in this study are estimated as entity demeaned fixed effects.) For comparison, the models were estimated also as dynamic by including the lagged dependent variable (integration), and as additional robustness check, the models were estimated for both monthly and quarterly data. Dynamic models are potentially biased because the lagged dependent variable values are correlated with the OLS error term (so called Nickell-bias). However, this bias should not be very large on the large T small N data of this study (See Chapter 3.3.2).

[3] Monthly data from the years 2001-2014 has been used in panel regressions. The data used in estimations is a balanced panel from March 2001 to September 2014. Due to omitting holidays, moving-window estimations, including one factor lag, and not all panel variables being available for the whole period of the study, 163 observations were available for each panel, and 1956 observations in total. For quarterly data, the respective numbers were 55 and 660.

TABLE 9 Static and dynamic fixed effects (LSVD) models for the determinants of integration

	Monthly data		Quarterly data	
	LSDV	Lagged LSDV	LSDV	Lagged LSDV
dependent variable: integration				
$integration_{t-1}$		0.936 ***		0.850 ***
		(0.012)		(0.024)
government bond yield	-0.017 ***	-0.002 ***	-0.017 ***	-0.005 ***
	(0.002)	(0.000)	(0.002)	(0.001)
3 month Euribor rate	0.014	0.005	0.002	-0.018
	(0.018)	(0.007)	(0.025)	(0.011)
GDP	-0.021 ***	-0.002 **	-0.021 **	-0.005 *
	(0.005)	(0.001)	(0.006)	(0.002)
volatility (VSTOXX)	-0.002	-0.001	-0.003 ***	-0.002 **
	(0.001)	(0.001)	(0.001)	(0.001)
EPU Index	0.041 **	0.015	0.070 *	0.063 ***
	(0.014)	(0.008)	(0.028)	(0.015)
external integration	-0.001	0.007	0.000	0.016
	(0.023)	(0.011)	(0.032)	(0.023)
constant	1.936 ***	0.172 **	1.994 ***	0.555 ***
	(0.283)	(0.054)	(0.398)	(0.145)
F test for country effects (sig.)	115.138	2.856	84.014	4.925
	(0.000)	(0.002)	(0.000)	(0.000)
F test for year effects (sig.)	19.641	2.511	24.292	17.410
	(0.000)	(0.004)	(0.000)	(0.000)
N	1956	1944	660	648
R^2	0.754	0.976	0.765	0.948
R^2 lagged integration		0.973		0.926
R^2 country effects	0.633	0.633	0.635	0.635
R^2 other cross section variables	0.419	0.419	0.438	0.438
R^2 year effects	0.094	0.094	0.100	0.100
adjusted R^2	0.750	0.976	0.754	0.945

The values presented in the table are regression coefficients of FE models (standard errors in parentheses); reference group for country effects: Germany; reference group for year effects: 2001; country and year dummies omitted from table; significance levels: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Overall, the goodness of fit for the estimated models was excellent. For the static model estimated on monthly data, the R^2 was 0.754 and for the model estimated on quarterly data 0.765. As is often the case with financial and macroeconomic data, adding a dependent lagged variable increases the goodness of fit even more (0.976 for monthly data and 0.948 for quarterly data).

When dynamic models were estimated, one can notice that the coefficient for the autoregressive term is highly statistically significant. For the model fitted on monthly data, the autoregressive coefficient is 0.936 and for the model fitted on quarterly data 0.850. However, there is not a theoretical reason why lagged integration terms should be in the models (for example, why would the integration of the last quarter still have an effect on the integration of the present quarter). In time series models, the lagged terms almost without exceptions explain the variation in the dependent variable well. Because of that, they can mask the dependencies between the dependent variable and the cross section variables included. However, dynamic models are useful as robustness checks.

All country dummies (not shown in the table) are negative and statistically significant relative to the reference group Germany. The relative ranking of countries also mostly stays the same. Germany, France, Netherlands, Italy and Spain are the most integrated countries, Greece Portugal, Ireland and Luxembourg are the least integrated. Austria, Belgium and Finland are situated between these two groups. The most notable difference between this regression and the graphical analyzes of the previous chapter is that now Germany is the most integrated country, and the difference to the second most integrated France is statistically significant.

Models using subgroups of variables were also estimated, and the goodness of fit statistics R^2 for these models were analyzed. These R^2 do not sum up to one, because the explanatory variables are not independent of each other, so it is not possible to clearly state that for example, the cross section variables would explain the variation in dependent variables in a more (or less) satisfactory manner than the year effects. However, as is stated before, the lagged integration is a very good explanatory variable for integration (R^2 using monthly data 0.973 and 0.926 for quarterly data). Also, differences between countries (country fixed effects) explain about 60%, and other cross section variables about 40% of the variation in integration.

Country fixed effects were jointly (and also individually) highly significant predictors of integration. Ignoring the panel dimension and estimating pooled OLS, would lead to biased estimates for the variables of interest. Regarding time fixed effects, only some of the year dummies differed statistically significantly from the comparison year 2001. However, year dummies were jointly highly significant for both static and dynamic models, and for models estimated both monthly and quarterly data (see the results for F-tests). Because of this, year effects have been included in the estimated models in this and in the following chapters. Seasonality was also tested for by using monthly and quarterly dummies but the coefficients were not jointly or individually significant, so seasonal dummies have been omitted from all the following models estimated. It can be stated that there is no evidence of seasonality in integration.

Financial, macroeconomic and information variables are the main explanatory variables for integration in this study. As the financial variables, 10 year government bond yield and 3 month Euribor are included. Government bond yield is used to measure the effect of long-term interest rates on integration, Euribor measures the effect of short-term rates.

In previous studies, other financial market variables like inflation (e.g. the inflation differentials between countries) and money supply have also been suggested to have a potential effect on integration, but in this study they are omitted from the main models in order to avoid adding too many closely correlated variables. It is assumed that short-term interest rates captures the effect of these variables satisfactorily, but the effect the omitted variables is analyzed briefly in the next chapter.

The only macroeconomic variable in this study is nominal GDP. It is assumed that GDP sufficiently captures the effect of all macroeconomic factors having an effect on integration. In addition to financial and macroeconomic variables, two information variables often used to measure economic uncertainty are included: volatility measured by volatility index VSTOXX and the relatively new Economic Policy Uncertainty (EPU) index.

It is of course the case, that many of the financial variables mentioned in this chapter potentially measure economic uncertainty. For example long-term government bond yield can be used to make evaluations on the general economic outlook of a country in the future, on the state of government finances and on the long-term bond markets in general, not just sovereign debt markets. One of the main objectives of this study is to evaluate, which of these financial or specific information variables capture the effect of economic uncertainty on integration most satisfactorily. The last cross section variable, integration external to the Eurozone countries, is included to control the world integration not explained by the risk factors estimated using the sample of 12 Eurozone countries (more on this variable, see Chapter 3.1).

Based on the estimations conducted, it seems that 10 year government bond yield has a negative and statistically significant effect on integration for all the estimated models. There is actually not a difference at all between the estimations conducted on monthly (coefficient value for government bond yield: –0.017) and quarterly data (-0.017). Adding dependent variable lags, decrease the coefficients, but they are still negative and significant (-0.002 for monthly data and -0.005 for quarterly data), but of much smaller magnitude. The results (obtained using static models) can be interpreted as follows. For the model estimated on monthly data and when other determinants of integration are taken into account, an increase of one percentage point in government bond yield estimates a decrease in integration of 1.7 percentage points.

The regression coefficient for volatility is negative for the static models estimated both for data in monthly (-0.002) and in quarterly (-0.003) frequency, but the coefficient is statistically significant only for the latter model. When dynamic models are estimated and quarterly data is used, the effect of volatility on integration seems to be the about the same magnitude (-0.002) and the coefficient is statistically significant, but it is weaker (and non-significant) when monthly data is used (-0.001). Overall, these coefficients, despite being statistically significant on some of the estimations, are extremely small when it is taken into account that the volatility variable has been transformed by dividing by 100.

The coefficient for EPU index is positive and statistically significant when static models using data in monthly (0.041) and quarterly frequency (0.070) is used. Dynamic model estimated for quarterly data is also positive and significant (0.063), but the model estimated on monthly data is positive (0.015) and non-significant. Like volatility variable, EPU index is also transformed by dividing by 100, which must be taken into account when interpreting the results. Without the transformation, the absolute value for this coefficient is much smaller than for government bond yield.

Among other explanatory variables included, the coefficient for GDP is negative and statistically significant for all the estimated models. GDP is correlated with many financial and macroeconomic variables, and also evidence of business cycles having an effect on integration is presented (See Chapter 2.3). This matter needs to be investigated further. Coefficients for 3 month Euribor were in all estimations non-significant and switched signs, so no evidence of the effect of short-term interest rates on integration was obtained. Similarly, all coefficients for external integration, a variable included to control integration external to the Eurozone, were non-significant and the coefficient switched sings. Because the estimations for external integration yielded non-significant coefficients, it can be concluded that the risk factors estimated using data from these 12 countries seem also capture in a fairly satisfactory manner, the effects of the events originating outside the Eurozone and having an effect on the Eurozone stock markets.

Many time series of this study contain unit roots (for unit root tests, See Appendix 1). In OLS-estimation, the non-stationarity of time series can significantly inflate the model fit (R^2) and the t-statistics for the regression coefficients, which can lead to false inferences of statistically significant relationships between independent variables (so called spurious regression). As a remedy for non-stationarity, the determinants of integration were modelled by fitting the panel models also for first differenced time series. As an additional benefit, first differences (FD) transformation drastically reduces (at least in static panel models) the autocorrelation in the model residuals. Residual autocorrelation can lead to biased estimates for the standard errors. Like entity demeaning, the FD-transformation removes the effect of time-invariant variables in the panel data, so it can be considered an alternative form of fixed effects estimator. The static version estimated is the following equation, and the dynamic version can be obtained by adding a lagged (differenced) dependent variable:

$$\begin{aligned}&\Delta integration_{i,t} = \qquad (16)\\ &\beta_0 + \beta_1 \Delta government\ bond\ yield_{i,t} + \beta_2 \Delta euribor_t + \beta_3 \Delta GDP_{i,t}\\ &+\beta_4 \Delta volatility_t + \beta_5 \Delta EPU_t + \beta_6 \Delta external\ integration_t\\ &+year\ dummies_t + \varepsilon_{i,t}\end{aligned}$$

where Δ is used to describe a first difference of a variable. Year dummies are included in levels. The results of fitted FD models for the whole data are presented in Table 10.

TABLE 10 Static and dynamic first differences models for the determinants of integration

	Monthly data				Quarterly data			
	FD		Lagged FD		FD		Lagged FD	
Dependent variable: integration								
$integration_{t-1}$			0.151				0.114	
			(0.088)				(0.060)	
government bond yield	-0.004		-0.003		-0.010		-0.010	
	(0.003)		(0.003)		(0.006)		(0.006)	
3 month Euribor rate	0.032		0.028		0.024		0.026	
	(0.023)		(0.025)		(0.021)		(0.020)	
GDP	0.007		0.008		0.008		0.005	
	(0.008)		(0.008)		(0.013)		(0.013)	
volatility (VSTOXX)	0.002		0.001		0.000		0.000	
	(0.001)		(0.001)		(0.001)		(0.001)	
EPU Index	0.006		0.006		0.018		0.019	
	(0.006)		(0.007)		(0.017)		(0.017)	
external integration	-0.004		-0.008		0.007		0.010	
	(0.019)		(0.019)		(0.043)		(0.047)	
constant	0.023	***	0.017	**	0.060	***	0.063	***
	(0.004)		(0.006)		(0.012)		(0.014)	
F test for year effects (sig.)	4.052		1.683		7.510		4.823	
	(0.000)		(0.069)		(0.000)		(0.000)	
N	1944		1932		648		636	
R^2	0.135		0.152		0.209		0.216	
R^2 lagged integration			0.008				0.024	
R^2 cross section variables	0.054		0.099		0.043		0.098	
R^2 year effects	0.065		0.094		0.168		0.172	
adjusted R^2	0.126		0.101		0.185		0.119	

The values presented in the table are regression coefficients of FD models (standard errors in parentheses); reference group for year effects: 2001; year dummies omitted from the table; significance levels: * p<0.05, ** p<0.01, *** p<0.001

The goodness of fit for FD models (R^2) is inferior compared with the FE models for all estimated models (fit for the models estimated on quarterly data is slightly higher than for the monthly data). The most plausible explanation for the inferior model fit compared with the FE-estimations is that the short-term variation in integration (like the variation in stock returns) is highly random. Most of the year dummies (in levels) are not individually statistically significant, but their joint significance indicates that they should be included also in the FD models. Now the lagged integration term does not explain the variation in integration very well: the autoregressive terms are positive but very small compared to the models estimated with data in levels for both monthly (0.151) and quarterly data (0.114). However, these coefficients are higher than the coefficients for the cross-section determinants. The smaller autoregressive coefficients in the FD models compared with the FE models are probably due to the fact that differencing data reduces autocorrelation drastically. However, the FE and FD models are not directly comparable, because the dependent variable is different. Conceptually, it is also different to model levels of integration and the changes in integration.

Possibly at least partly due to there being unit roots in the panel variables, all the coefficients for the cross-section explanatory variables lose significance. However, while they are not significant, the coefficient for government bond yield is negative for all estimated models, and the coefficient for EPU index is positive for all estimated models. Estimated coefficients for volatility are practically zero all of the models estimated, for also literally zero up to four decimals for some of the models. This is in contrast with the estimations conducted using data in levels, where all coefficients which were significant, were positive. As mentioned before, other cross-section explanatory variables included, are also not significant. This applies also to GDP, which was highly significant for the estimations conducted using data in levels.

4.3.1 The relative importance of the determinants

Variables of this study are measured on highly differing scales, which can make the relative importance of these variables somewhat difficult to evaluate. In this chapter, the matter is examined by fitting models using mean and variance standardized variables, and after that analyzing the coefficients and the coefficients of determination R^2 for the estimated models. Sensitivity of the included determinants of integration to omitted variable bias is also briefly evaluated. The results of the estimations using standardized variables are presented in Table 11.

TABLE 11 Fixed effects and first differences estimations on the determinants of integration using standardized variables

	Monthly data		Quarterly data	
	FE	FD	FE	FD
Dependent variable: integration				
government bond yield	-0.194 ***	-0.044	-0.196 ***	-0.114
	(0.022)	(0.035)	(0.027)	(0.074)
3 month Euribor rate	0.105	0.240	0.017	0.181
	(0.132)	(0.169)	(0.181)	(0.156)
GDP	-2.059 ***	0.679	-2.082 **	0.845
	(0.449)	(0.819)	(0.622)	(1.229)
volatility (VSTOXX)	-0.082	0.062 *	-0.133 ***	-0.004
	(0.042)	(0.031)	(0.035)	(0.030)
EPU Index	0.111 **	0.017	0.171 *	0.045
	(0.038)	(0.017)	(0.068)	(0.041)
external integration	-0.003	-0.013	0.000	0.023
	(0.076)	(0.064)	(0.103)	(0.140)
N	1956	1944	660	648
R^2	0.330	0.135	0.357	0.209

The values presented in the table are regression coefficients of FE and FD models (standard errors in parentheses); constant and year effect coefficients omitted from table; significance levels: * p<0.05, ** p<0.01, *** p<0.001

From the table it can be seen that based on the estimations conducted using data in levels, government bond yield and GDP have the strongest relationship with integration. The values for coefficients using the FE estimations are -0.194 for monthly data and -0.196 for quarterly data for government bond, and for GDP the respective values are -2.059 and -2.082. When results from the FD models are examined, the coefficients decrease and are not significant, but for the government bond yield, coefficient signs are consistently negative with all estimations. For GDP, the coefficients switch sign from negative to positive when FD models are used (although the positive coefficients are not significant), which makes the importance of GDP as determinant of integration somewhat suspect.

For EPU index, when data in levels is used, the values of the coefficients using monthly (0.111) data are smaller compared with government bond yield or GDP, but using quarterly data the coefficient (0.171) is of similar magnitude with the two variables mentioned. The coefficients for EPU are positive with all estimations, but significant only for the estimations conducted in levels.

Coefficient for volatility is a statistically significant determinant (-0.133) of integration when the FE model estimated on quarterly data is examined. However, coefficients for other estimations are notable smaller, and for the FD model using on monthly data, the coefficient is actually positive and statistically significant.

Of the other main variables, 3 month Euribor has comparative large and consistently positive coefficient with all estimations except for the FE model fitted using quarterly data. However, due to the large standard errors, the coefficients are not significant for any of the models. Coefficients for the external integration are non-significant and near zero with all estimations.

Although the main objective of the empirical section of this study is to identify the determinants of integration, it is also of interest to examine how large proportion of the variation in integration the determinant variables actually explain. This is analyzed by examining the coefficients of determination (R^2) of estimated sub-models containing only the single explanatory variables. All the models are estimated as (country) fixed effects. The results of these estimations are presented in Table 12.

TABLE 12 Coefficients of determination (R^2) for the determinants of integration

	Monthly data		Quarterly data	
	No year effects	With year effects	No year effects	With year effects
government bond yield	0.082	0.053	0.011	0.056
3 month Euribor rate	0.004	0.000	0.009	0.001
GDP	0.009	0.011	0.012	0.012
volatility (VSTOXX)	0.005	0.000	0.001	0.001
EPU Index	0.082	0.008	0.097	0.009
external integration	0.000	0.000	0.000	0.000

The values are R^2:s of (country) fixed effects regressions including the listed variables. Models also including year effects are estimated by regressing both integration and explanatory variables on year dummies 2002-2014 (reference group: 2001) and using the residuals of these estimations in FE models.

The results of the estimated models are very illustrative. The models were estimated with and without year effects. Models with year effects were estimated by deseasonalizing data by first regressing both integration and the explanatory variable on year dummies, and using the residuals of these regressions in FE-estimations.

For the models estimated without year effects on monthly data, government bond yield and EPU index are the most important explanatory variables (R^2: 0.082 for both of the variables), but when yearly variation is controlled, government bond yield alone is clearly the most important predictor (0.053). For quarterly data without the year effects, the situation is that EPU index is the most important predictor (0.097), and government bond yield (0.011) is not any better than the other variables besides EPU. However, when year effects are included, government bond yield alone is again the best explanatory variable (0.056), the second best now being GDP with a much lower R^2 (0.012). Volatility and other variables besides the ones discussed are inferior explanatory variables compared with EPU.

It seems that if the year effects are not in the model, yearly variation being a major determinant of integration, the variables omitted from regressions seem to bias the coefficients of determination (R^2) for individual regressors. When this bias is corrected by including time effects, the results support the evidence obtained from previous estimations. Government bond yield is the single most important cross-section explanatory variable for integration. However, the yield alone is not a very good predictor of integration, as it only explains over 5% of the variation in integration.

Financial market variables and information variables like volatility and EPU index measure at least partly the same thing, economic uncertainty. These variables are also connected with macroeconomic factors. Because of this, the coefficients for these variables can potentially change depending on the other variables included in the models. So as an additional robustness check, models were estimated using subgroups of explanatory variables. The models are fitted for the sample containing all 12 countries.

TABLE 13 Robustness check estimations for the determinants of integration using subgroups of explanatory variables

	[1]	[2]	[3]	[4]
FE: government bond yield	-0.016 ***	-0.017 ***	-0.016 ***	-0.013 ***
	(0.002)	(0.002)	(0.002)	(0.002)
	[1]	[2]	[3]	[4]
FD: government bond yield	-0.003	-0.004	-0.003	-0.004
	(0.003)	(0.003)	(0.003)	(0.003)
	[1]	[2]	[3]	[4]
FE: 3 month Euribor rate	0.005	0.015	0.003	0.009
	(0.021)	(0.021)	(0.017)	(0.018)
	[1]	[2]	[3]	[4]
FD: 3 month Euribor rate	0.040	0.041	0.031	0.032
	(0.026)	(0.026)	(0.023)	(0.022)
	[1]	[2]	[3]	[4]
FE: volatility (VSTOXX)	0.000	-0.001	-0.002	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)
	[1]	[2]	[3]	[4]
FD: volatility (VSTOXX)	0.002 ***	0.002 *	0.002 ***	0.002 *
	(0.001)	(0.001)	(0.000)	(0.001)
	[1]	[2]	[3]	[4]
FE: EPU Index	0.033 *	0.031 *	0.043 **	0.040 **
	(0.013)	(0.013)	(0.014)	(0.014)
	[1]	[2]	[3]	[4]
FD: EPU Index	0.012	0.010	0.007	0.006
	(0.008)	(0.006)	(0.007)	(0.006)

The values presented in the table are regression coefficients of FE and FD models (standard errors in parentheses); * p<0.05, ** p<0.01, *** p<0.001
Model 1: time effects, GDP and external integration as controls
Model 2: model 1 variables + financial variables (govt. bond yield and Euribor) as controls
Model 3: model 1 variables + information variables (volatility and EPU) as controls
Model 4: full model (all variables)

The relationship between government bond yield and integration stays the same whether (other) financial, or information variables are included or not. Using the data in levels, the coefficient is negative and statistically significant despite the other variables included in the model. When data in first differences is used, the coefficient is robust to including other variables also in this case, being consistently negative with all estimations, but the coefficients are not significant. Similarly, the coefficient for EPU stays positive for all the models estimated.

Coefficients for volatility are near zero for all estimations and switch signs in FE estimations. Although the coefficients are statistically significant for the FD models, the coefficients are near zero also in this case, the standard error being very small. For Euribor, which has not proven to be a very good determinant of integration, the coefficients are positive but non-significant for all the models estimated.

In the previous chapter, it was elaborated that other financial variables like inflation and money supply are highly correlated with short-term interest rates, and they can have an effect on integration. Due to this, they can bias the results, especially for the coefficient of 3 month Euribor. To analyze this further, inflation (measured with national HICP indices) and money supply

(Eurozone M2 money aggregate) were included in the FE models. M2 money aggregate was selected over M1 or M3 aggregates, because it explained integration marginally (and insignificantly) better than M1 or M3 aggregates. Government debt (as percentage of GDP) is also included to assess whether including it has an effect on the coefficient for government bond yield. The results of these estimations are presented in Table 14.

TABLE 14 Fixed effects estimations on the determinants of integration when other plausible determinants are included

Dependent variable: integration							
govt. bond yld.	-0.017 ***	-0.017 ***	-0.017 ***	-0.017 ***	-0.015 ***		-0.013 ***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)		(0.002)
3 month Euribor	0.014	0.014	0.015	0.015	0.034 *	0.022	0.031 *
	(0.018)	(0.018)	(0.017)	(0.017)	(0.017)	(0.016)	(0.014)
GDP	-0.021 ***	-0.021 ***	-0.021 ***	-0.021 ***	0.004	0.010	0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)	(0.007)	(0.007)
volatility	-0.002	-0.002	-0.002 *	-0.002 *	-0.001	0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
EPU Index	0.041 **	0.040 **	0.041 **	0.040 **	0.035 *	0.037 *	0.041 **
	(0.014)	(0.014)	(0.014)	(0.014)	(0.016)	(0.017)	(0.015)
external integ.	-0.001	-0.002	-0.009	-0.009	0.049	0.061	0.047
	(0.023)	(0.023)	(0.021)	(0.021)	(0.042)	(0.040)	(0.040)
inflation (HICP)		0.001		0.001			-0.007 *
		(0.002)		(0.002)			(0.003)
money (M2)			0.048	0.044			0.066
			(0.047)	(0.051)			(0.059)
govt. debt (%)					0.000	-0.001 *	-0.001 *
					(0.001)	(0.000)	(0.001)
N	1956	1956	1956	1956	1260	1260	1260
R^2	0.330	0.331	0.332	0.332	0.384	0.310	0.394

The values presented in the table are regression coefficients of FE models (standard errors in parentheses); year effect and constant coefficients omitted from table; data for models including government debt: years 2006-2014; data for other models: years 2001-2014; monthly frequency; significance levels: * p<0.05, ** p<0.01, *** p<0.001

It can be seen that inflation and money supply are not important determinants of integration at all, and the coefficients for Euribor or the coefficients for other explanatory variables do not change whether these two variables are included or not. It is also evident that government debt (as percentage from national GDP) is much inferior explanatory variable for integration than government bond yield (results were the same when nominal debt instead of debt as percentage of GDP was used, results not shown in table). It seems that integration of a stock market is not very sensitive to government debt. The slightly better model fit statistics (R^2) for the models including government debt are a result of different data used. Government debt variables were available only for years 2006-2014. Based on these estimations it is clear, that the estimations are not likely to suffer serious estimation biases due to omitting the variables discussed here from the models.

Additionally, the effect of choosing VSTOXX as a measure of volatility rather than the more widely used VIX is examined briefly. As already confirmed, VSTOXX is more correlated with integration of the 12 Eurozone stock markets than VIX and it is theoretically better volatility measure, because it measures volatility of European equities (See Chapter 3.1). This assumption also proved to be the true when models similar to the ones presented in Table 9 in Chapter 4.3 were estimated using VIX as a measure of volatility. The coefficient for VIX was negative, but not statistically significant for the models including only VIX and for the models including both VIX and VSTOXX. The results obtained in this study regarding the chosen volatility measure are also robust, since including VIX did not have a significant effect on the coefficient for VSTOXX.

It can be concluded that government bond yield is the most satisfactory determinant of integration, although even the coefficient for this variable is quite small and yield does not explain a very large proportion in the variation in integration. EPU index is clearly inferior to government bond yield, but still more important than volatility measured using VSTOXX or VIX. Importance of EPU index was also analyzed further, as national EPU indices were available for Germany, France, Italy and Spain (See Chapter 3.1). However, when models including either European or national EPU were estimated for this group of countries, the European level EPU index actually proved stronger determinant of integration than the national ones.

No evidence was found that government debt (as percentage of GDP) or inflation were good determinants of integration either. The coefficients for government bond yield and EPU seem to be quite robust to inclusion of other variables into the models. (However, evidence is presented in Chapter 4.3.3 that the coefficients for the government bond yield, and not surprisingly also for volatility and EPU), are not stable over time or between countries.) The effect of the financial crisis on integration is analyzed in the next chapter.

4.3.2 The effect of the financial crisis on integration

The period of this study 1999-2014 (sample of 2001-2014 is used in panel regressions) is relatively long. Financial time series are characterized by structural breaks and crises, so the relationship between integration and the effect of factors explaining it does not necessarily stay the same during the period of over 15 years. Many factors like European economic integration, stock market integration in Europe and the globalization of the world economy and stock markets (and other financial markets) can have an effect on this relationship.

The most severe economic event during the period of this study was of course the "great" financial crisis, which origin could be dated to the US subprime crisis, leading to a global financial crisis in 2007-2009 and further to recession and to European sovereign debt crisis starting at the end of year 2009. The debt crisis hit hard on many European countries. Of these countries, Greece, Portugal, Ireland, Spain and Italy (so called PIIGS countries) are included in this study. During the crisis, some Eurozone countries like Greece, Portugal and Ireland were unable to pay or refinance their government debt, and eventually were forced into bailout programs.

In previous studies, the effect of financial crises on integration has been confirmed, but in some studies, evidence is presented that this effect is positive, and in other studies negative (See Chapter 2.3). The global financial crisis of 2007-2009 and the European sovereign debt crisis since 2009 are of course the most interesting crisis periods to study in the time period of this study. In this chapter, the effect of the financial crisis is analyzed with pooled OLS panel regressions including period dummies for the crisis periods.

It is clear, however, that whether a country is considered a crisis country, does not necessarily have to have a substantial effect on its integration. For example, despite being considered crisis countries during the financial and economic crisis, the integration of Spanish and Italian stock markets stayed at their high level of integration for whole of the period of this study (See Chapter 4.1).

However, as already noted, there are countries in the sample, like Greece, Portugal and Ireland, which suffered severely during the crisis, and for which there is large variation in the level of integration for this group of countries. Nevertheless, it must be mentioned, that all weakly integrated stock markets in the Eurozone are not crisis countries: Luxembourg is among the least integrated stock markets in the Eurozone. Factors contributing to the weak integration of Luxembourg stock market are probably the small size of the country compared to other countries under study, and the small number of companies in the stock index used (leading to smaller daily volume of trades and less diversification), but also the status of this country as an international financial center.

Since the sample of this study consists of 12 Eurozone countries, dating of the crisis is not straightforward. Should timing of the acute global financial crisis of 2007-2009 used, or the time period since 2009 when the European economies actually were in the most severe period of economic turmoil, if the severity of economic difficulties is measured, for example, with long-term (10 year) government bond yields indicating fiscal difficulties. A dual approach has been adopted in this study. The effect of the financial crisis on integration has been examined by using two crisis period timings: global and European.

In the global timing, the acute crisis period for monthly frequency is 8/2007-6/2009. The start data is the date when the stock prices in the United States (and also in European stock markets, like France) started to decrease dramatically. The end date is the date when the US National Bureau of Economic Research considered the recession in the United States to end. The timing is the same that is used by Lehkonen (2015) when studying the determinants of integration for developed and developing economies using the same integration measure that is utilized in this study, so an interested reader can also compare the results between these studies.

The European crisis period is dated based on the data, as the period where the government bond yields (indicating macroeconomic, financial and fiscal difficulties) for the crisis countries of Greece, Portugal, Ireland, Spain and Italy were the highest. The bond yields for these countries (+ Germany as a benchmark) and yield risk premium relative to Germany are presented in Figure 10:

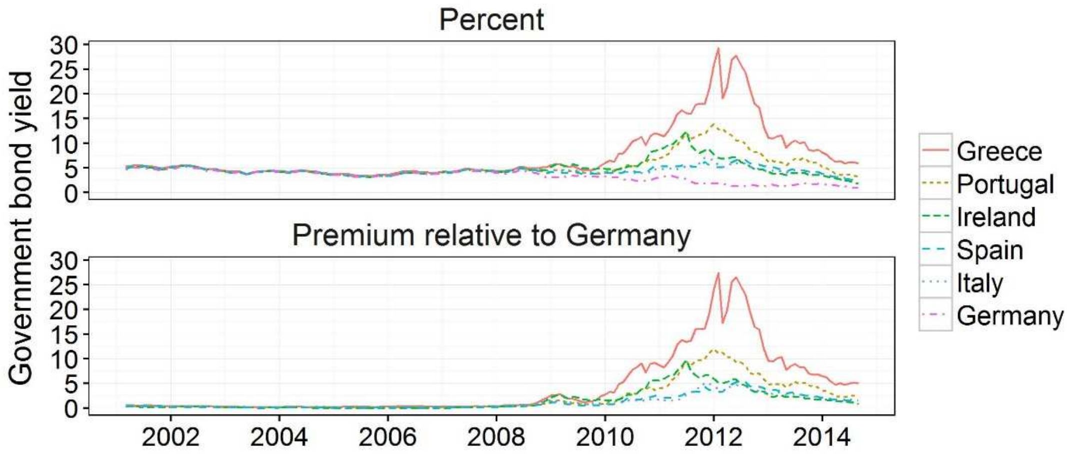

FIGURE 10 Government bond yields for the European debt crisis countries (+ Germany)

The problems of using the global financial crisis as the timing of the European crisis are evident. European economies were not in the most serious phase of economic difficulties during the period of the acute global financial crisis of 7/2008-6/2009, since the government bond yields for the crisis countries started to increase only at the end of year 2009. This can be most clearly seen for Greece, the crisis country that suffered the most from the European sovereign debt crisis, the government yields started to increase dramatically only at the end of year 2009. Even at June 2009, the period which the recession was declared to end in the United States, bond yields were very low and the spread to Germany was miniscule compared to the levels it reached during the most acute crisis period that occurred later. Additionally, for other crisis countries, bonds yields started to increase only in the year 2010.

In this study, period of 10/2009-2/2013 is considered the most acute phase of the European debt crisis, as during that period the government bond yield spreads relative to Germany were the highest. October 2009 is the month when Greek government bond yield spread started to increase dramatically. February 2012 is the month when the Greek government bond yield spread began to decline rapidly from its highest value of 27.39, and in February 2013 the spread had fallen to 9.41, and since then the rapid decrease in spread halted to a more gradual decrease. At the end of the time period of this study (9/2014), the spread was 4.97, still higher than before the crisis, and higher than during the acute global crisis period. Bond yield spreads relative to Germany also increased for the other crisis countries during the crisis period, but they did not reach such extreme levels.

It is of course the case that for the countries that suffered most heavily during the crisis (especially Greece), the European debt crisis was not completely over in February 2013 or even at the end of the time period of this study 9/2014. However, in this study, the end of the acute crisis period is dated on February 2013, because then also the post-crisis period can be evaluated. If the effects of the crisis have not diminished, the coefficient for the post-crisis period of 3/2013-9/2014 should be high as well.

One important factor must be taken into account when analyzing this group of 12 highly heterogeneous economies and stock markets. Spreads between Germany and the non-crisis countries increased very little during the crisis period, which indicates that financial markets of not only Germany but also the other non-crisis countries to a degree (despite the economic difficulties of the crisis countries also having an effect on the non-crisis countries) became "safe-havens" in relation to the crisis countries. It is evident that these two groups must be analyzed separately, as the effect of the crisis on the integration for these two groups of countries can be different.

To study the effect of the financial crisis on integration, pooled OLS models for the all countries of this study are estimated. To assess the effect of the crisis periods on integration, dummy terms for the pre-crisis, crisis and post-crisis periods, dummy for the least integrated countries, and the interaction terms for these two variables are then analyzed. With the exception of Luxembourg, all the low integration countries of this study are crisis countries, and with the exception of Spain and Italy, all high integration countries are non-crisis countries.

For consistency, in this chapter, same grouping into high and low integration countries is used than elsewhere in this study, although it is possible that being a crisis country is a more important factor here than being a low integration country. Due to this, as a robustness, check estimations are also conducted by excluding the non-crisis country Luxembourg for the low integration group and excluding crisis-countries of Spain and Italy from the high integration group.

The results of the pooled OLS estimations including crisis dummies, low integration country dummy and their interaction terms, are presented in Table 15:

TABLE 15 Pooled OLS models for the effect of the financial crisis on integration

	Pooled OLS			
dependent variable: integration				
government bond yield	-0.015 ***	-0.018 ***	-0.016 ***	-0.020 ***
	(0.002)	(0.002)	(0.002)	(0.002)
3 month euribor	0.037 ***	0.039 ***	0.044 ***	0.046 ***
	(0.008)	(0.008)	(0.012)	(0.012)
GDP	0.003 ***	0.003 ***	0.003 ***	0.003 ***
	(0.000)	(0.000)	(0.000)	(0.000)
volatility (VSTOXX)	-0.002	-0.002	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
EPU Index	0.051 **	0.052 ***	0.041 *	0.042 *
	(0.015)	(0.015)	(0.018)	(0.018)
external integration	-0.051 ***	-0.054 ***	-0.060 **	-0.060 **
	(0.013)	(0.013)	(0.022)	(0.023)
low integration country	-0.186 ***	-0.242 ***	-0.184 ***	-0.204 ***
	(0.011)	(0.017)	(0.011)	(0.016)
8/2007-6/2009	0.080 ***	0.029		
	(0.019)	(0.023)		
low integ. x 8/2007-6/2009		0.146 ***		
		(0.025)		
7/2009-9/2014	0.161 ***	0.131 ***		
	(0.029)	(0.031)		
low integ. x 7/2009-9/2014		0.108 ***		
		(0.024)		
10/2009-2/2013			0.180 ***	0.150 ***
			(0.033)	(0.033)
low integ. x 10/2009-2/2013				0.104 ***
				(0.029)
3/2013-9/2014			0.178 ***	0.174 ***
			(0.048)	(0.047)
low integ x 3/2013-9/2014				0.005
				(0.022)
constant	0.469 ***	0.494 ***	0.463 ***	0.481 ***
	(0.024)	(0.025)	(0.037)	(0.037)
N	1956	1956	1956	1956
R^2	0.594	0.612	0.580	0.589

The values presented in the table are regression coefficients of pooled OLS models (standard errors in parentheses); significance levels: * p<0.05, ** p<0.01, *** p<0.001

The dummy for the group of the least integrated countries – Greece, Portugal, Ireland and Luxembourg – is negative and statistically significant for all the models fitted. This confirms the already obtained results that there are more and less integrated countries in the data of this study. Because the models are estimated using Pooled OLS, this low-integration country dummy also controls country-specific differences in integration. Integration differences between countries in the high and low integration groups of countries are smaller than the differences in the whole sample of countries.

The estimation results presented in Table 15 can be taken as evidence that the global financial crisis and the European sovereign debt crisis increased integration for both the most and least integrated Eurozone countries. Results concerning the coefficients for the crisis periods are not entirely consistent, but the main picture is clear: after controlling for other factors having an effect on integration, the crisis periods did increase integration.

When the global financial crisis timing is used, the period dummy for the crisis period 8/2007-6/2009 is higher (0.080) compared with the pre-crisis period 3/2001-5/2009, and this coefficient is statistically significant. However, the dummy coefficient for the post-crisis period 7/2009-9/2014 is even higher (0.161) and statistically significant compared with the period before the crisis. When interaction terms for the periods and low integration countries are included, the interaction terms are positive and significant for the acute crisis period (0.146) and for the post crisis period (0.108). After the interaction terms are included, dummy for the post-crisis period stays about the same magnitude (0.131) is significant, but the coefficient for the acute crisis period becomes smaller and loses significance (0.029). This suggest that integration has risen to a higher level after the acute crisis period ended in June 2009, and this increase has been greater for the low integration group of countries.

When the European sovereign debt crisis timing is used for the acute crisis period, results are somewhat different. For the models estimated without interaction terms, the acute crisis period of 10/2009-2/2013 (0.180) and post-crisis period dummies 3/2009-9/2014 (0.178) are positive and differ statistically significantly from the reference period of 3/2001-/9/2009. The interaction effect for low integration country and the acute crisis period dummy is positive (0.104) and significant, but the coefficient for the post-crisis interaction effect is near zero (0.005). Unlike in the case of the global financial crisis timing, adding the interaction effects does not have a significant effect on the period dummies.

It seems evident that both for the high and low integration Eurozone countries, integration has increased since the beginning of the financial crisis in the United States in August 2007. However, no convincing evidence has been found that integration was higher during the acute global financial crisis period of 8/2007-6/2009 or during the acute phase of the European sovereign debt crisis 10/2009-2/2013. Although the coefficients were higher during the acute crisis periods compared with pre-crisis periods, integration remained at the higher level even during the post-crisis period, which is since 7/2009 for the global crisis and 3/2013 for the European sovereign debt crisis. (The marginally higher coefficient for the interaction term low integration country x of 8/2007-6/2009 (0.146) compared with the interaction term for the interaction low integration country x 7/2009-9/2014 (0.108) cannot be taken as convincing evidence that integration was higher during the acute crisis period for the least integrated countries compared with the post-crisis period.)

In Table 15, only effects conditional on including the control variables are presented. However, as was evident upon inspection of the integration time series (See Figure 2 in Chapter 4.1), at least for the least integrated Eurozone country, Greece, integration seems actually be lower after the beginning of the global financial crisis in 2007. To further evaluate the matter, panel regressions similar to the ones presented in the previous table, but with crisis dummies only, with cross section controls (the same model than in Table 15) and also with a linear trend added to control for the possible trend in integration that can bias the crisis dummy coefficients. The results of these estimations are presented in Table 16:

TABLE 16 Pooled OLS estimations of the effect of financial crisis on integration, without controls, with cross-section controls and with cross-section controls and linear trend

	Global financial crisis		European sovereign debt crisis	
Crisis dummies only	Main effect	Interaction	Main effect	Interaction
	8/2007-6/2009	*8/2007-6/2009*	*10/2009-2/2013*	*10/2009-2/2013*
	0.117 ***	0.132 ***	0.086 ***	0.007
	(0.025)	(0.023)	(0.018)	(0.022)
	7/2009-9/2014	*7/2009-9/2014*	*3/2013-9/2014*	*3/2013-9/2014*
	0.086 ***	0.032	0.009	-0.044 *
	(0.018)	(0.021)	(0.018)	(0.021)
With controls†	Main effect	Interaction	Main effect	Interaction
	8/2007-6/2009	*8/2007-6/2009*	*10/2009-2/2013*	*10/2009-2/2013*
	0.080 ***	0.146 ***	0.180 ***	0.104 ***
	(0.019)	(0.025)	(0.033)	(0.029)
	7/2009-9/2014	*7/2009-9/2014*	*3/2013-9/2014*	*3/2013-9/2014*
	0.161 ***	0.108 ***	0.178 ***	0.005
	(0.029)	(0.024)	(0.048)	(0.022)
With controls and linear trend	Main effect	Interaction	Main effect	Interaction
	8/2007-6/2009	*8/2007-6/2009*	*10/2009-2/2013*	*10/2009-2/2013*
	0.113 *	0.146 ***	0.131 ***	0.101 ***
	(0.046)	(0.025)	(0.033)	(0.029)
	7/2009-9/2014	*7/2009-9/2014*	*3/2013-9/2014*	*3/2013-9/2014*
	0.190 ***	0.109 ***	0.114 *	0.004
	(0.049)	(0.023)	(0.045)	(0.022)

The values presented in the table are regression coefficients from pooled OLS estimations (standard errors in parentheses); constant, control variable, and linear trend coefficients (when included) are omitted from the table; main effects: crisis dummies; interaction effect: low integration country x crisis dummies; † same model that is presented in Table 15; significance levels: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

It can be seen that when the model is estimated without control variables and European debt crisis timing is used, coefficient for the last period 3/2013-9/2014 and the interaction term for the first period 10/2009-2/2013 lose significance, and the interaction term for low integration country and the last period 3/2013-9/2014 is actually (-0.044) negative and statistically significant. When the global financial crisis timing is used, the interaction term for the post-crisis period 7/2009-9/2014 also loses significance. As it is clear from the previous estimations, when cross section controls are included and European timing is used, all crisis and post-crisis dummies, with the exception of the interaction effect for low integration country and the post-crisis are positive and statistically significant (and the non-significant term is also positive but near-zero).

The negative coefficient for the interaction term for low integration country and period 3/2014-9/2014 when there are no controls in the model is a result of the integration of Greece decreasing dramatically since the beginning of the financial crisis. When estimations were conducted separately for the Greek panel, the coefficient discussed was negative and statistically significant without control variables, and positive and statistically significant with the controls. Similarly, when the estimations presented in Table 16 were repeated to a sample of countries where the Greek panel was excluded, the coefficient was positive also without control variables. It is possible that this exception for the Greek stock market is caused by the economic difficulties of the country being more severe than for other low-integration crisis countries. However, this matter is not analyzed further in this study.

As an additional robustness check, in Table 16, results of models including a linear trend to control for a possible trend, as even a very weak upward trend can bias the results, and integration for Austria, Finland and Portugal has increased significantly during the time period of this study. However, adding the trend had only a very marginal effect of the crisis dummies and interactions.

One methodological choice possibly having an effect on the results presented in this chapter is that high and low integration group of countries were used instead of crisis and non-crisis countries. The effects of the crisis periods on integration would be diminished, because there is a non-crisis country, Luxembourg in the group of low integration countries, and there are two crisis countries, Italy and Spain on the high integration country group. (However, including these countries is, of course, actually weakening the coefficient for the interaction term and making the argument presented here stronger.)

To investigate the matter further, models similar to the ones presented in Table 15 were estimated for samples where Luxembourg, Italy and Spain were excluded but there were no notable differences in the interaction coefficients. This suggest that regarding the effect of the financial crisis on integration, being a crisis country is not as important as being a low integration country (of which 3 out 4 were crisis countries). This is not surprising as Spain and Italy were high integration countries for the whole period of the study despite being also crisis countries.

Based on the findings of this chapter, it can be argued that the general European economic crisis which was initially caused by the acute financial crisis, is likely to have had a greater impact on integration on the Eurozone countries than the acute financial crisis period or the acute European debt crisis period itself. It is possible that the "back to normalcy" in the Eurozone stock markets that suffered most heavily from the crisis has not occurred even at the end of the period of this study in September 2014. This can have an effect on integration for not only the crisis countries, but also for all Eurozone countries. Additionally, the most severe part of the crisis did not necessarily occur at the same time for all of the countries under study, which can have an effect on the results. It is also possible that some of the increase in integration since 2007 is caused by normal cyclical variation in integration.

The last theme of this study is to analyze the (possible) effect of the financial crisis on the determinants of integration. This is the topic of the next chapter.

4.3.3 Determinants of integration and the financial crisis

The sample of countries and the time period used in this study offers an opportunity to analyze whether the effect of the determinants of integration stay the same during financial or economic crises. In this study, variables measuring economic uncertainty are considered potentially the strongest determinants of integration. In the estimations conducted in the previous chapters, evidence was obtained that 10 year government bond yield seems to most satisfactorily capture this effect of economic uncertainty on integration, and that this relationship is negative. However, in this chapter, evidence is presented that this negative coefficient for government bond is not stable over time and that it differs significantly between the stock markets of this study.

In the previous chapter, the effect of financial crisis period for the level of integration was examined by fitting models which included crisis dummies, dummy for the group of the least integrated Eurozone countries, and the interaction terms of these variables. Two timings for the crisis period were used. The first was based on the global financial crisis, for which acute period was during 8/2007-6/2009. The second timing was the period where the European crisis countries were actually in the most serious phase of the crisis. This was the period of 10/2009-2/2013.

It is not necessarily the case that the determinants of integration stay the same during financial or economic crises than in a more stable economic environment, The effect of the crisis on the determinants of integration can also differ between countries, especially between high and low integration countries (or between non-crisis and crisis countries).

Due to the limited number of countries in the data of this study, and to avoid complex three-way interaction terms, in this chapter, fixed effects regressions have been estimated on financial crisis period subsamples, and separately for high and low integration countries. Linear time trends are included to control for possible upward or downward trends. To reduce the number of estimated models, only fixed effects estimations are conducted.

The results of the panel regressions for the determinants of integration estimated using pre-crisis, crisis and post-crisis subsamples for the full sample of 12 countries, and separately on the high and low integration countries are presented in Table 17:

TABLE 17 Fixed effects estimations on the determinants of integration conducted on pre-crisis, crisis and post-crisis samples

	Global financial crisis timing			European debt crisis timing		
	Countries: all	High	Low	Countries: all	High	Low
Dependent variable: integration						
Pre-crisis						
govt. bond yld.	0.052	0.019	0.060 *	0.045 ***	0.002	0.067 ***
	(0.030)	(0.037)	(0.030)	(0.013)	(0.022)	(0.017)
Euribor	-0.020	-0.024	0.013	0.046 ***	0.056 ***	0.034 *
	(0.032)	(0.029)	(0.043)	(0.010)	(0.010)	(0.014)
GDP	-0.021 *	-0.038 ***	0.298 ***	-0.033 ***	-0.038 ***	0.225 ***
	(0.010)	(0.008)	(0.035)	(0.005)	(0.005)	(0.048)
volatility	0.004	0.004	0.005	-0.004 **	-0.005 ***	0.001
	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.002)
EPU Index	0.003	-0.010	0.015	0.072 **	0.064 *	0.060 *
	(0.026)	(0.024)	(0.031)	(0.024)	(0.026)	(0.025)
external integ.	-0.046	-0.032	-0.081	-0.076 *	-0.077 *	-0.083 *
	(0.043)	(0.037)	(0.061)	(0.034)	(0.034)	(0.037)
time trend	0.003 **	0.003 *	0.000	0.002 ***	0.002 ***	0.000
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
constant	-0.844	-0.021	-1.097 *	-0.22	0.639 *	-1.197 ***
	(0.634)	(0.857)	(0.546)	(0.195)	(0.272)	(0.206)
N	924	616	308	1236	824	412
R^2	0.121	0.163	0.460	(0.259)	(0.197)	(0.569)
Crisis						
govt. bond yld.	-0.020	0.030	-0.069 **	-0.015 ***	-0.031 ***	-0.007 ***
	(0.012)	(0.021)	(0.021)	(0.003)	(0.006)	(0.002)
Euribor	0.014 ***	0.008	0.010 *	0.060 *	0.071 **	0.044
	(0.003)	(0.004)	(0.004)	(0.023)	(0.021)	(0.036)
GDP	0.019 **	0.001	0.362 ***	0.003	-0.007	0.143 ***
	(0.006)	(0.004)	(0.063)	(0.009)	(0.006)	(0.027)
volatility	-0.002 *	-0.002 *	-0.001	0.002	0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)
EPU Index	0.072 *	0.078 *	0.055	-0.002	-0.005	0.067 **
	(0.027)	(0.028)	(0.031)	(0.031)	(0.032)	(0.019)
external integ.	0.037	0.031	-0.004	0.101	0.114	-0.015
	(0.035)	(0.038)	(0.045)	(0.080)	(0.081)	(0.065)
time trend	0.000	-0.003	0.005	-0.002	-0.002	-0.001
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
constant	0.277	2.469	-3.621	1.637	2.454	0.586
	(1.375)	(1.410)	(1.812)	(1.799)	(1.808)	(1.606)
N	276	184	92	492	328	252
R^2	0.557	0.784	0.597	0.268	0.219	0.456

(continues)

TABLE 17 (continues)

Post-crisis												
govt. bond yld.	-0.008	**	-0.009		-0.007	***	-0.008	**	-0.009		-0.007	***
	(0.003)		(0.008)		(0.002)		(0.003)		(0.008)		(0.002)	
Euribor	0.043		0.044	*	0.044		0.043		0.044	*	0.044	
	(0.024)		(0.021)		(0.036)		(0.024)		(0.021)		(0.036)	
GDP	0.021	***	0.011	*	0.143	***	0.021	***	0.011	*	0.143	***
	(0.005)		(0.005)		(0.027)		(0.005)		(0.005)		(0.027)	
volatility	-0.004		-0.006	**	-0.001		-0.004		-0.006	**	-0.001	
	(0.002)		(0.002)		(0.003)		(0.002)		(0.002)		(0.003)	
EPU Index	0.063	**	0.065	*	0.067	**	0.063	**	0.065	*	0.067	**
	(0.023)		(0.026)		(0.019)		(0.023)		(0.026)		(0.019)	
external integ.	0.018		0.030		-0.015		0.018		0.030		-0.015	
	(0.061)		(0.070)		(0.065)		(0.061)		(0.070)		(0.065)	
time trend	-0.003		-0.003		-0.001		-0.003		-0.003		-0.001	
	(0.002)		(0.003)		(0.003)		(0.002)		(0.003)		(0.003)	
constant	1.732		1.991		0.586		1.732		1.991		0.586	
	(1.415)		(1.499)		(1.606)		(1.415)		(1.499)		(1.606)	
N	756		504		252		756		504		252	
R^2	0.276		0.244		0.456		0.276		0.244		0.456	

The values presented in the table are regression coefficients of FE models (standard errors in parentheses); year effect and constant coefficients omitted from table; Global financial crisis timing: pre-crisis: 3/2001-7/2007, crisis: 8/2007-6/2009, post-crisis: 7/2009-9/2014; European crisis timing, pre-crisis: 3/2001-9/2009, crisis: 10/2009-2/2013, post-crisis: 3/2013-9/2014; significance levels: * p<0.05, ** p<0.01, *** p<0.001

Upon first inspection it would seem that when estimations are conducted for the whole sample of 12 countries and the global financial crisis timing is used, the coefficients for government bond yield, the most promising determinant of integration, is more negative for the crisis 8/2007-6/2009 (-0.020) and post-crisis periods 7/2009-9/2014 (-0.008) than for the pre-crisis period of 3/2002-5/2009 (0.052). The results are confirmed when the European sovereign debt crisis timing is used. For estimations conducted using a full sample of 12 countries, coefficient for government bond yield is positive and statistically significant (0.045) for the pre-crisis period 3/2001-9/2009, negative and significant (-0.015) for crisis period of 10/2009-2/2013 and negative and significant (-0.008) for the post-crisis period of 3/2013-9/2014.

As all the statistically significant coefficients for government bond yield are from crisis or post-crisis periods whether the global financial crisis or the European debt crisis timings are used, one would be tempted to conclude that the effect of government bond yield on integration has been more negative during the financial crisis than before the crisis. However, when the matter is further analyzed later in this chapter, it becomes evident that the coefficients are not stable over time.

No reliable evidence of the systematic differences for the effect of the government bond yield on integration between high and low integration countries could be established either. When the European sovereign debt crisis timing was used, the coefficient for government bond yield was of the same sign for both groups of countries (although there were cases where coefficients did not differ from zero) for all estimations. When the global financial crisis timing was used, the coefficient for government bond yield for the both groups was of the same sign during the pre-crisis and post-crisis periods. For the acute crisis period the coefficient for government bond yield for the low integration countries was negative and significant (-0.069) and for the high integration countries it was positive (0.030) but not significant. However, when the European debt crisis timing was used, although the coefficient for both groups were negative, the coefficient for the high group of countries was actually much more negative (-0.031) than for the low group of countries (-0.007). There is not any credible evidence that the effect of government bond yield on integration is stronger (more negative) during the crisis periods.

For volatility, there are both positive and negative coefficients, but all the significant ones are negative. For EPU index, whether the global financial crisis or European sovereign debt crisis timing is used, there are both positive and negative coefficients, but all statistically significant coefficients are positive. These findings are in agreement with the results obtained in chapter 4.3. However, no convincing evidence of the effect of EPU being different for the pre-crisis, crisis and post crisis periods or between the high and low integration group of countries could be established.

To further elaborate the effect of the financial crisis on the Eurozone crisis countries, estimations similar to the ones presented in Table 17 were also conducted on a sample of crisis (low integration countries excluding Luxembourg) and non-crisis countries (high integration countries excluding Italy and Spain), but there were no notable differences in the results. In addition to the variables discussed in this chapter, also other variables, most notably GDP, seem to be highly significant for certain time periods, and especially for the group of low integration countries. However, it is not clear what is the economic interpretation of this, as GDP has in general not been a strong determinant of integration in this study.)

As a final step, to obtain a view of whether the effect of government bond yield on integration is more negative during the crisis period and post-crisis period than in the pre-crisis period, additional estimations were conducted on two-year subsamples of data. The results of these estimations are presented in Table 18:

TABLE 18 Coefficients for government bond yield estimated for two year samples

With linear trend only			
2001-2002	*2003-2004*	*2005-2006*	*2007-2008*
-0.004	-0.073 **	0.004	0.054
(0.029)	(0.020)	(0.025)	(0.036)
2009-2010	*2011-2012*	*2013-2014*	
-0.006 *	-0.004	-0.019 **	
(0.003)	(0.004)	(0.006)	
With all controls			
2001-2002	*2003-2004*	*2005-2006*	*2007-2008*
0.002	-0.052 ***	0.015	-0.006
(0.016)	(0.013)	(0.018)	(0.020)
2009-2010	*2011-2012*	*2013-2014*	
-0.008 ***	-0.003	-0.021 **	
(0.002)	(0.003)	(0.007)	

The values presented in the table are regression coefficients of FE models for government bond yield (standard errors in parentheses); constants omitted from the table; 288 observations for 2 year periods for the years 2001-2012 (228 for 2013-2014); Significance levels: * p<0.05, ** p<0.01, *** p<0.001

As mentioned before, based on these estimations, it cannot be concluded that the coefficient for government bond yield is more negative during the time after the beginning of the global financial crisis in 2007. Despite not being as strong determinant of integration as government bond yield, similar estimations were also conducted for EPU index. The coefficients for this variable were not more positive during the crisis (in the main models the coefficients for EPU were positive), and the coefficients also switched sign, which was expected as these were not even as stable as the coefficients for government bond yield in panel estimations conducted before. To further investigate the effect of the government bond yield on integration over time, overlapping moving-window OLS estimations with 50 month time windows were conducted separately on each panel. The results are presented in Figure 11:

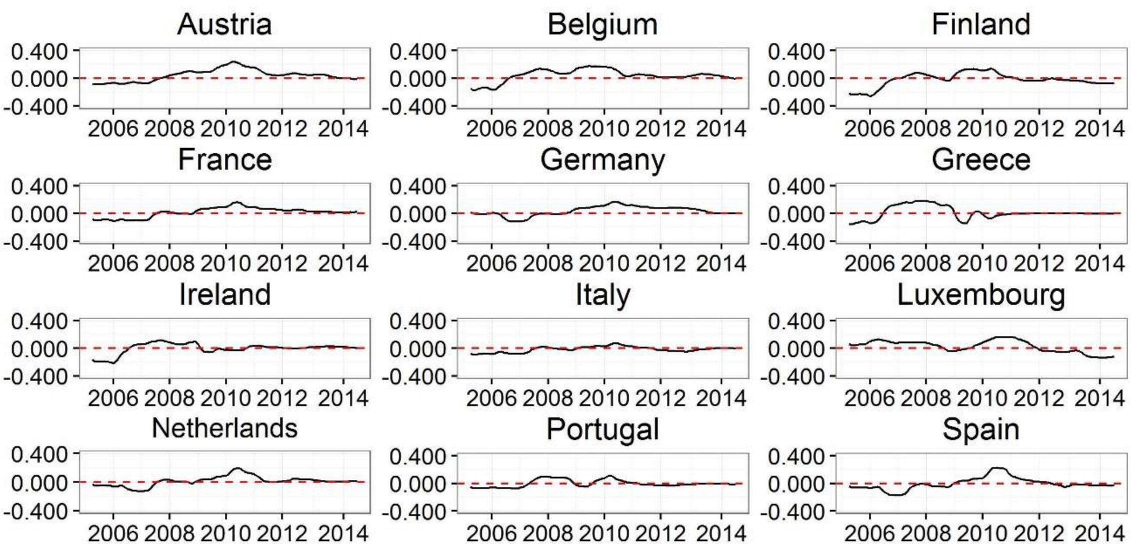

FIGURE 11 Moving-window estimations for the effect of government bond yield on integration using overlapping 50 month time windows (dashed line in red indicates 0)

The results confirm the previous image obtained in this study that no evidence of the effect of government bond yield on integration being more negative (or more positive either) during the financial crisis period or the period after it, than during the period before the crisis. The effect of government bond yield on integration seems to be highly varying over time and there are also major differences between the Eurozone countries in this effect. Specifically, being a high or low integration, or a crisis or non-crisis country does not seem to be a particularly important factor in this matter, as no credible systematic differences between high and low integration group of countries or between crisis and non-crisis countries could be established.

4.4 Summary of the results

In this chapter a summary of the most important empirical findings of this study is presented. The results are presented briefly, and the discussion in relation to previous studies is left to the concluding chapter.

In this thesis, the stock market integration in the Eurozone stock markets during the EMU era 1999-2014 was analyzed using a multifactor model of integration by Pukthuanthong & Roll (see Chapter 3.2). The first main contribution of this research was to study the integration and the similarity of risk exposures (the number of factors common to all the countries needed to explain the integration of a single stock market). The second main contribution was to present evidence on the most important determinants of integration, including also the effects of the 2007-2009 global financial crisis and the following European debt crisis of 2009-2013 on integration. As the sample of this study, 12 Eurozone stock market indices were selected: Austria, Belgium, Finland, France, Germany, Greece, Italy, Ireland, Luxembourg, Netherlands, Portugal and Spain. These are the original EMU member countries + Greece. The sample consists the years 1999-2014, and the data is measured in daily frequency. During this period, all the countries selected have had developed stock markets, and high quality data is available for all of the countries. The stock indices have been obtained from Thomson Reuters Datastream.

Using the data described, Pukthuanthong & Roll integration measure was constructed by creating risk factors capturing the common variation in the log returns of the Eurozone stock markets by using principal component analysis, and estimating the level of integration of a single stock market by regressing the stock returns on these principal components created. The measure of integration is the coefficient of determination (adjusted R^2) of this regression. To account for the variation in the levels of integration and the changing volatility, the principal components and regression estimations were estimated using overlapping moving time windows, and also bias corrections against the most common biases likely to have an effect on the integration measured were conducted (See chapters 3.2 and 4.1.1).

The main picture of integration obtained in this study is that there are upward and downward cycles in integration. The most integrated countries are France, Netherlands, Germany, Italy and Spain. The least integrated are Greece, Luxembourg, Portugal and Ireland. Austria, Belgium and Finland form a middle group more integrated than the latter, but less integrated than the first group of countries. Integration for Austria, Finland and Portugal has increased during the years of 1999-2014.

For the group of the most integrated countries, the integration varied in a range of 70-80%. The integration stayed at the high level all the time, except for very short fluctuations. The integration of the middle group of countries stayed mostly in the range of 60-70% during the latter part of this study (2008-2014), and there have not been major downward fluctuations. For the least integrated group of countries, there were quite large fluctuations in integration. For example, for the least integrated country Greece, the average integration was 25%, but at its highest point, integration was nearly 70%, and its lowest point, it stayed below 10% for over a year. For other low integration countries, there has also been notable fluctuations in integration, but not nearly as extreme than for Greece.

The similarity of risk exposures has increased, if it is measured as the number of factors needed to capture the common variation in these markets satisfactorily. Cumulative variance explained by one principal component was about 50% in 2000 and it is about 70 percent in 2014. However, there is cyclical variation also in this similarity measure: at its highest daily value, the cumulative variance explained was nearly 84% in October 2008 and it took until October 2009 before it dropped below 75%. Similarity of risk exposures was also studied by constructing a dissimilarity measure (an inverse of similarity) by subtracting the integration estimated with 1 factor from integration estimated with 8 factors. Values of this dissimilarity measure are time-varying, having a range of -0.1-0.2 (or -10%...20%). Negative values are due to the integration measure being adjusted R^2, which penalizes adding factors that do not improve the model fit. There are no notable differences in this dissimilarity measure between the stock markets of this study, and when compared to the range of integration variable (0…1), these fluctuations in the number of factors needed are quite small. The number of factors needed to explain integration satisfactorily is quite stable over time, so these factors can be interpreted as industry factors, and further that industry structure of the Eurozone countries has become more similar during the EMU era.

The cross-section determinants of integration were studied using fixed effects and first differences panel regressions. Some variables contained unit roots, so analyses were conducted using both levels (fixed effects models) and differences (first differences models). This also reduces autocorrelation in the data. In all estimations, autocorrelation robust Driscoll-Kraay standard errors suitable for long panel data with few panels were used, and as additional robustness checks to correct for model residual autocorrelation, dynamic FE and FD models were estimated. Stability of the coefficients between panels and over time was analyzed by estimating models on high and low integration subsamples and conducting two-year and moving-window estimations. In the panel models Greece, Portugal, Luxembourg and Ireland were considered low integration countries, and other 8 Eurozone countries high integration countries.

As determinants of integration, financial market variables, macroeconomic variables and specific information variables were used. As financial market determinants, 10 year government bond yield was used to measure the effect of long-term interest rates on integration and 3 month Euribor was included to capture the effect of short-term rates. GDP was included to measure for macroeconomic factors potentially having an effect on integration. Volatility (VSTOXX index) and Economic Policy Uncertainty (EPU) index were added as important information variables and integration external to the Eurozone was included as an additional control.

To avoid too many correlated regressors being included in the models, no additional financial market, macroeconomic or other variables were included in the main models. However, possible omitted variable bias was addressed by also including controls like inflation, money supply and government debt (as percentage of GDP) to the models, but they did not have a significant effect on the estimated coefficients for the variables of interest. The relative importance of the explanatory variables was examined by conducting estimations on standardized variables and also examining the proportion of integration explained by individual regressors. The stability of the coefficients was evaluated by conducting estimations on sub-samples of countries, on different time periods, and with moving time windows.

Time variation in integration was modelled by including year dummies. There were notable yearly fluctuations in integration, but not monthly or quarterly seasonality. None of the cross-section variables included explained integration particularly well. 10 year government bond yield was the most satisfactory explanatory variable, but its effect, while being statistically significant on numerous models, was not stable. The coefficient differed from positive to negative over time and between stock markets. Volatility, economic policy uncertainty and government debt were inferior predictors of integration compared with government bond yield.

Regarding the determinants of integration, it can be concluded that no reliable determinants of integration could be identified. Neither financial or macroeconomic factors, nor specific information variables were very helpful in predicting the fluctuations in integration. Specifically, volatility, economic policy uncertainty or government indebtedness do not seem to be strong determinants of integration,

The effect of the financial crisis on integration since its beginning in the year 2007 was studied using pooled OLS models and crisis dummies. Because both the global financial crisis occurring in 2007-2009 and the European sovereign debt crisis, for which the most acute phase occurred during the years 2009-2013, took place in the time period of this study, two different timings for the crisis was used. The acute crisis period for the global financial crisis was dated as the period of From August 2007 to June 2009. The timing for the European crisis is based on the most acute phase of the European sovereign debt crisis (the period where the government bond yields indicating economic distress were actually highest for the European crisis countries of Greece, Portugal, Ireland, Spain and Italy). This crisis is the period from October 2009 to February 2013.

For the whole sample of 12 countries, models including cross-section controls, and with both crisis timings, coefficients for the crisis and post-crisis periods were positive and statistically significant. This indicates that the financial crisis beginning in the year 2007 has increased the integration of both the high and low integration group of countries. The interaction terms for low integration countries and the crisis periods were also for the most models positive and statistically significant, suggesting that this effect is higher for the low integration countries. No evidence was found that integration was higher during the acute global financial crisis period of 2007-2009 or during the acute European sovereign debt crisis period 2009-2013 than the period after the crisis.

5 CONCLUSION

Stock market integration is methodologically a very diverse field of research. Usually integration is conceptualized as co-movement of stock returns in different stock markets, but research is conducted using a vast variety of different methodologies, and these methods do not necessarily yield similar estimates of the degree of integration between stock markets. And, based on the literature review, the sample of countries (or indices) and time periods chosen, can also affect the view about the degree of integration between the countries under study.

The first main contribution of the study was to use a relatively new multifactor model of integration developed by Pukthuanthong & Roll (2009) to measure the level of integration in the Eurozone stock markets. To author's knowledge, the measure has not been used in the study of European stock market integration before. Using broad stock market indices and data from 12 Eurozone countries, it can stated that the Eurozone stock markets are not even at the end of the year 2014 perfectly integrated.

The results of this study confirm that there are significant differences in the level of integration between the 12 Eurozone countries, and the integration seems to have a cyclical movement over time. Especially for the least integrated countries Greece, Luxembourg, Portugal and Ireland, these fluctuations are notable. The time varying-nature of integration has been the mainstream view in integration studies since the early 1990s (See e.g. Harvey 1991). The results of this study are in concordance with this mainstream view. During the EMU era since 1999, there have been significant upward and downward cycles in integration even for the most integrated Eurozone countries. Fairly robust evidence was found that the integration for Austria, Finland and Portugal has increased during the period of 1999-2014. However, in general, based on the results of this study, it should be emphasized that great care should be taken when identifying trends in integration based on relatively short time periods, as there are cyclical fluctuations in integration. An upward cycle could easily be mistaken as a trend.

Risk exposures have become more similar during the period of this study: fewer common risk factors are needed to explain the variation in stock returns in the year 2014 than in year 2000. However, there is also cyclical variation the number of factors needed. However, as this variation is quite small compared to the larger trend, the estimated factors can be interpreted as industry factors, and it can be argued that the industry structures of the Eurozone countries have become more similar during the EMU era.

The second main contribution of this study was to present evidence of the factors affecting integration, also including the effects of the global financial crisis of 2007-2009 and the following European sovereign debt crisis of 2009-2013. Identifying the cross-section determinants of integration is a significantly understudied area of stock market integration, perhaps because of the lack of an established theory on the factors contributing to integration, and because of the difficulty of establishing causal relationships due to the limitations of the data.

No reliable determinants of integration could be identified in this study either. Neither financial or macroeconomic factors, nor specific information variables were very helpful in predicting the fluctuations in integration. 10 year government bond yield explained integration better than other financial market, macroeconomic or information variables, but the sign of this effect was not stable over time or between stock markets.

Specifically, no relationship between volatility and integration could be established. This is in agreement with the results obtained by Longin & Solnik (2001) and in disagreement with some other studies (Cai et al. 2009; Connolly et al. 2007; Lehkonen 2015). The differences in the finding between the three studies and this one can be a result of different sample of countries, different time period, or different estimation techniques utilized. However, as estimations conducted in this study revealed, it is unlikely to be caused by the different volatility measure (VSTOXX) used. Additionally, it seems that economic policy uncertainty measured with EPU index or government indebtedness are not strong determinants of integration either.

Some of the previous studies reviewed (Erb 1994; Longin & Solnik 2001; Pukthuanthong & Roll 2009) present evidence that financial crises (or economic recessions) increase integration between stock markets, but also contradicting evidence has been obtained that integration was lower during the last financial crisis (Bekaert & Harvey 2011). This study confirms the results of increasing integration during the financial crisis for the 12 countries of this study. Integration for the countries of this study has been higher since the beginning of the financial crisis in 2007 than on the period before the crisis. However, integration was not higher during the acute global financial crisis period of 2007-2009 or during the European sovereign debt crisis period of 2009-2013, than it was after the crisis. In this study, this result is interpreted that the general economic turmoil is likely to have a more important effect on the integration of the countries under study than the effects of the acute financial crisis. Evidence was also obtained that integration increased more for the least integrated Eurozone countries of Greece, Portugal, Luxembourg and Ireland than for the whole sample of 12 countries.

The estimation technique of using principal components and moving-window regressions when estimating the integration measures can potentially cause serious biases to the estimated integration measures. When estimating the integration models, several corrections described in Chapters 3.2 and 4.1.1 were conducted to ensure the unbiasedness of the integration measures estimated.

However, when interpreting the results presented in this study, several qualifications have to be taken into consideration. It is possible that even after controlling for volatility by conducting estimation of the integration time series using moving time windows and including a volatility index for the panel regressions, the results can be somewhat biased due to changing volatility.

Especially during periods of high volatility, R^2:s are often upward biased. This is potentially a serious problem when analyzing the effect of the financial crisis on integration. Additionally, residuals of the integration time series and the panel model estimations for the determinants of integration are likely to be autocorrelated to a degree. Finally, time-zone differences of the Eurozone stock markets were not corrected, which may also bias the results. However, compared to many integration studies including stock markets from multiple continents, in this study, the potential source of bias is likely to be smaller. It can plausible be argued that while these biases can have an effect on the integration measured, these shortcomings do not change the main results and interpretations of this study.

It can concluded that identifying the determinants of stock market integration is an interesting but methodologically challenging field of research. Strength of the effect of the determinants of integration are likely to change between countries and over time, or even switch signs, which makes using some kind of piecewise or non-linear estimation technique a requirement, but the explanatory variables are usually also correlated with each other, requiring the use of a relative large number of control variables. These things combined may necessitate the use of relatively complex models.

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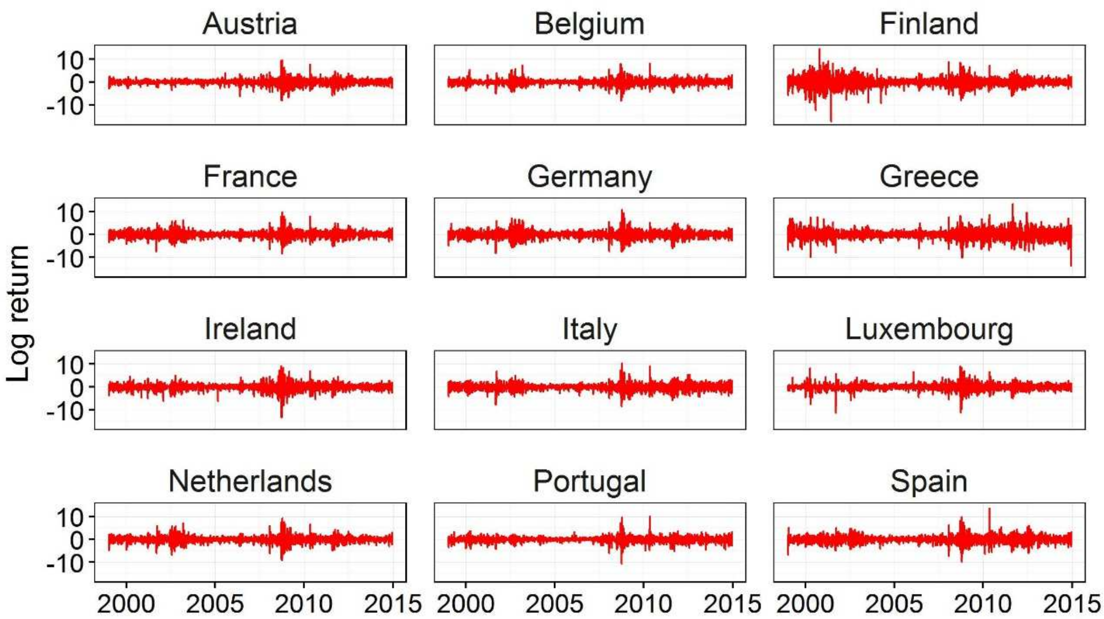
APPENDIX 1: Stationarity of the time series

In OLS estimations the time series used have to be stationary. Otherwise the t- and F -test statistics, and R^2:s can be inflated, falsely indicating a significant relationship between two independent variables (spurious regression). In this appendix, the stationarity of the time series used, is analyzed graphically and by conducting stationarity tests. First, stationarity of the stock return time series used in estimation of the integration measures is evaluated, and after that a similar evaluation is conducted for panel variables.

Plots for the original log returns for the 12 Eurozone stock markets are presented in Figure A.1.1:



FIGUREA1.1 Stock return time series for the 12 Eurozone stock markets

Based on the graphical examination, as was expected, the time series for all of the 12 stock markets log-returns seem to be stationary. However, there are volatility spikes (volatility clustering).

In addition to graphical inspection, the stationarity of the time series is tested. Two univariate unit root tests – Augmented Dickey-Fuller (ADF) and Phillips-Perron tests) are conducted on individual panels. Standard univariate unit root tests are ideal for the large T, small N data of this study, because their asymptotics rely on T being large. (For the tests used, and the process of unit root testing in univariate context in general, See e.g. Enders 2009.)

The base ADF test estimated in this study is of the standard form

$$\Delta y_t = \alpha + \rho y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t \qquad (A1.1)$$

where the main variable of interest is the autoregressive coefficient ρ. The null hypothesis of the test is $\rho = 1$ indicating a unit root case, and the alternative hypothesis is stationarity: $\rho < 1$. The same test, with constant, but without a deterministic trend, is conducted for all the variables (this is discussed briefly below).

Likewise, The PP test utilized is the standard test, based on the ("non-augmented") Dickey-Fuller equation:

$$\Delta y_t = \alpha + \rho y_{t-1} + \varepsilon_t \qquad (A1.2)$$

where autocorrelation robust Newey-West standard errors are used.

For ADF tests the number of lags included is determined using the AIC-information criterion. AIC suggested the use of one lag for all variables.
For the PP test 4 kernel lags based on Newey-West criterion (same formula that is presented in Appendix 2) have been included. Using wrong test specification (e.g. omitting a linear trend where present in the data generating process) or using incorrect number of lags, could lead to the case of autocorrelation in the model residuals. This would render the test results biased. Based on graphical examination, most variables of the study seemed to be more difference than trend stationary, so an intercept was included, but no trend. As a robustness check, the models were estimated with lag lengths of from 1 up to 12 lags (the frequency of the monthly data). Results for the ADF and PP unit root tests for the stock return time series are presented in Table A1.1:

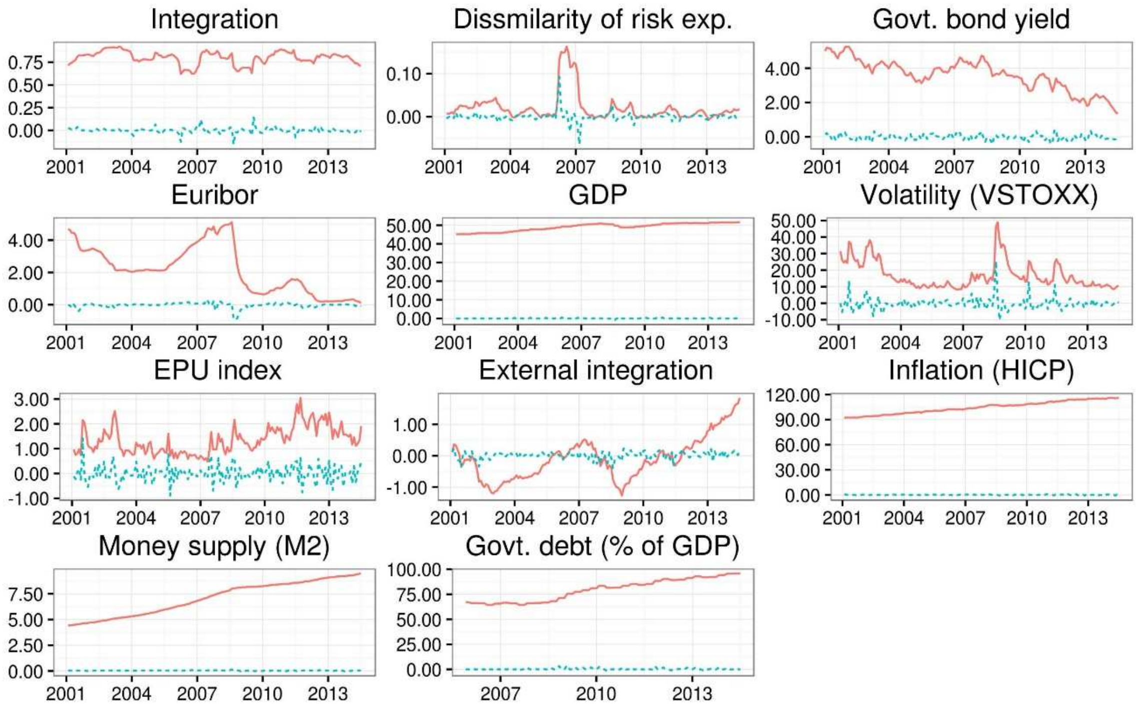
TABLEA1.1 Results of the unit root tests for the stock returns used in estimation of the integration measures

	ADF	PP
Austria	-39.93	-52.07
Belgium	-39.05	-53.41
Finland	-41.87	-57.68
France	-42.31	-57.16
Germany	-41.55	-56.74
Greece	-39.51	-52.57
Ireland	-40.21	-54.63
Italy	-40.94	-57.61
Luxembourg	-39.57	-53.18
Netherlands	-40.60	-55.33
Portugal	-40.06	-53.31
Spain	-42.35	-57.27

ADF: Augmented Dickey Fuller Test with constant (1 ADF lags for all variables; chosen by AIC); PP: Phillips-Perron test with constant (9 kernel lags for all variables; chosen by Newey-West criterion); Critical values for test statistics:
ADF: -3.46 (1%), -2,88 (5%), -2.57 (10%); PP: -3.43 (1%), -2.87 (5%), -2.57 (10%)

Again, the results confirm the picture given by graphical inspection. As can be seen from the very large negative t-statistics, the null hypothesis of unit root being present in the time series, was rejected for all stock markets when the suggested lag values of 1 for the ADF test 9 for the PP test were used. Even when 12 lags were included for both of the tests, the unit root was rejected.

Next, stationarity of the panel variables was analyzed. First, the time series in levels and in first differences are plotted. To save space, the graphs are presented for the French panel only (for consistency, French panel is used, because France is used also in the robustness check estimations of Chapter 4.1.1):

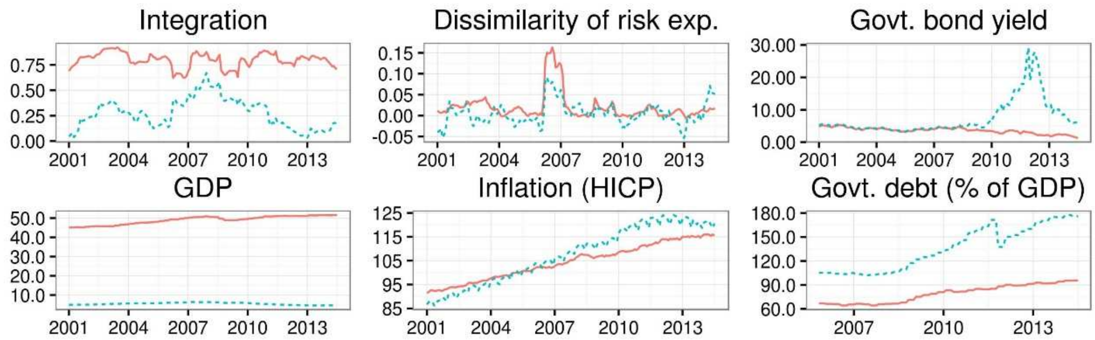


FIGUREA1.2 Time series of the variables of this study in levels (red line) and in first differences (blue line) for the French panel [for variable descriptions and units, see Table 4 in Chapter 3.1]

Upon graphical inspection, it is clear that some of the time series are not stationary. Money supply variable has a deterministic trend, and in the 3 month Euribor and the 10 year government bond yield variables, there are large changes in mean over the period of 2001-2014. Integration variable for France has also its ups and downs, but the time series seem to revert back to its mean quite rapidly. However, as can be seen later in this appendix, this is not the case for Greece, the least integrated Eurozone stock market. In the similarity of risk exposures variable there are also large ups and downs, but in overall, the variation in this variable is very miniscule when it is taken into account that the largest difference for France is less than 0.1, and the integration measure has a value range from 0 to 1.

For variables in first differences, all time series seem to be stationary, however there are notable volatility spikes (volatility clustering) for some variables. Not surprisingly these spikes are largest for volatility (measured using VSTOXX index) and economic policy uncertainty (measured using EPU index).

As already mentioned, the time series for different panels do not follow the same patterns. To examine this heterogeneity, plots for two panels France and Greece – are examined. France is one of the most integrated countries and one of the leading economies in the Eurozone (and France is also used in estimations in Chapter 4.1.1), and Greece is the least integrated Eurozone country, and the country that suffered most heavily from the European sovereign debt crisis. In Figure A1.3 the variables (in levels) which have variation between panels are plotted together for comparison:



FIGUREA1.3 Time series of the variables of this study in levels for French and Greek panels (red solid line: French panel, blue dashed line: Greek panel)

It can be seen that the behavior of the times series for French and Greek panels differ vastly for some of the variables. There are more fluctuations in the mean of the integration measure for the Greek panel than for the French panel. In overall, French integration variable seems to be more stationary than the Greek one.

In contrast, the time series for the similarity of risk exposures are quite similar for France and Greece. Greek government bond yield increased dramatically after the sovereign debt crisis hit the Eurozone countries, while at the same time bond yield for France decreased. At its highest monthly value in February 2012, the annual government bond yield for Greece was over 29%, and at the same period, at the same time, government bond yield for France was 3.02%.

The estimations were conducted separately on French and Greek panels. The results of the initial estimations are presented in the table below:

TABLEA1.2 Results of the unit root tests

	Panel: France		Panel: Greece	
	ADF	PP	ADF	PP
integration	-3.22	-3.11	-2.18	-1.93
Δintegration	-8.46	-10.65	-9.32	-9.06
dissimilarity of risk exposures	-3.53	-2.91	-4.45	-3.56
Δdissimilarity of risk exposures	-8.38	-7.98	-9.78	-9.62
government bond yield	-1.04	-0.58	-1.63	-1.51
Δgovernment bond yield	-9.11	-9.53	-10.96	-11.47
3 month Euribor	-1.80	-1.42	-1.80	-1.42
Δ3 month Euribor	-5.25	-5.23	-5.25	-5.23
quarterly national GDP	-1.59	-1.46	-0.24	-0.36
Δquarterly national GDP	-9.80	-13.50	-8.87	-12.71
volatility (VSTOXX)	-3.51	-3.20	-3.51	-3.20
Δvolatility (VSTOXX)	-10.41	-10.38	-10.41	-10.38
EPU Index	-3.44	-3.74	-3.44	-3.74
ΔEPU Index	-10.51	-16.01	-10.51	-16.01
external integration	0.36	0.29	0.36	0.29
Δexternal integration	-7.41	-10.67	-7.41	-10.67
government debt (% of GDP)	0.24	0.16	-0.48	-0.36
Δgovernment debt (% of GDP)	-8.21	-11.02	-7.33	-10.42
inflation (HICP)	-1.06	-1.20	-1.73	-2.29
Δinflation (HICP)	-7.23	-11.13	-10.21	-12.40
money (M2)	-3.94	-3.78	-3.94	-3.78
Δmoney (M2)	-5.06	-8.28	-5.06	-8.28

ADF: Augmented Dickey Fuller Test with constant (1 ADF lags for all variables; chosen by AIC); PP: Phillips-Perron test with constant (4 kernel lags for all variables; chosen by Newey-West criterion); Critical values for test statistics: ADF: -3.46 (1%), -2.88 (5%), -2.57 (10%); PP: -3.47 (1%), -2.88 (5%), -2.58 (10%)

The results of the unit root tests mainly confirm the picture given by graphical inspection. For the dependent variables of integration and dissimilarity of risk exposures, the test results are mixed (in all of the tests, 5% confidence interval is used). If 1 lag for ADF test and 4 lags for PP test are included, the null hypothesis of a unit root for integration can be rejected for the French panel, but not for the Greek panel. For France, the null hypothesis is rejected with PP test even with 12 lags and with ADF test using 4 lags. Unit root for the dissimilarity measure is still rejected for Greek when 12 lags with both tests are included, and for France when 4 lags are used.

Some of the explanatory variables are clearly not stationary, which is not surprising given the graphical analyzes conducted before. For government bond yield, for example, both ADF test and PP test fail to reject the null hypothesis of stationary when the suggested values of 1 ADF lag and 4 PP lags are used.

When data in first differences and the suggested lag lengths for the tests are used, the null hypothesis of unit root is rejected for all of the variables. For the PP test, this result holds even with 12 lags. When ADF test is used, test for France fails to reject unit roots for Euribor, external integration, government debt, inflation and money supply. For France, also unit root of GDP cannot be rejected. A lag length of 12 is clearly too large, as unit roots cannot be rejected for variables, which based on graphical evaluation are almost straight horizontal lines.

The results of this appendix can be concluded that that many of the time series used contain unit roots. Due to this, it is likely that the significance of coefficients estimated using OLS estimations are inflated by this non-stationarity. To remedy this, estimations are conducted using data both in levels and in first differences. All variables of this study measured in first-differences can be assumed to be stationary. However, for some of the variables, there are clear volatility spikes (volatility clustering), and the standard deviation is also greater for the group of least integrated countries. As an additional robustness check, panel estimations are conducted using high and low integration group of countries.

APPENDIX 2: Estimation of the Driscoll-Kraay standard errors

Standard errors proposed by Driscoll & Kraay (1998) suitable for long finance panels are utilized in this study, and the estimation procedure is described in this appendix. Results of the sensitivity analysis concerning the robustness of the errors estimated is also presented.

When estimating regression standard errors, assumption of exogeneity of the explanatory variables is the benchmark case. When the explanatory variables are assumed to be exogenous (uncorrelated with the model error term), using matrix notation, the covariance matrix for the regression coefficients can presented in the following general form:

$$\hat{\boldsymbol{V}}_{\boldsymbol{OLS}} = (\boldsymbol{X}'\boldsymbol{X})^{-1}\boldsymbol{\Omega}(\boldsymbol{X}'\boldsymbol{X})^{-1} \qquad (A2.1)$$

where $\boldsymbol{\Omega} = E[\hat{\boldsymbol{\varepsilon}}\hat{\boldsymbol{\varepsilon}}'|\boldsymbol{X}]$. When we assume that the errors terms are uncorrelated with the explanatory variables, which rules out heteroscedasticity, autocorrelation and spatial correlation in the errors, we get $\boldsymbol{\Omega} = E[\boldsymbol{\varepsilon}\boldsymbol{\varepsilon}'|\boldsymbol{X}] = \sigma^2 \boldsymbol{I}$, where $\sigma^2 = \boldsymbol{\varepsilon}'\boldsymbol{\varepsilon}/(n-k)$, and the covariance matrix can be computed as follows:

$$\hat{\boldsymbol{V}}_{\boldsymbol{OLS}} = \sigma^2(\boldsymbol{X}'\boldsymbol{X})^{-1} = \left((\boldsymbol{\varepsilon}'\boldsymbol{\varepsilon})/(n-k)\right)(\boldsymbol{X}'\boldsymbol{X})^{-1}) \qquad (A2.2)$$

where $\boldsymbol{X}$ is the matrix of explanatory variables, $\boldsymbol{\varepsilon}$ is the matrix (vector) of regression residuals ($\boldsymbol{\varepsilon} = \boldsymbol{y} - \boldsymbol{X\beta}$), and n the number of rows and k the number of columns in $\boldsymbol{X}$. The OLS standard errors can be obtained by taking square-roots of the diagonal elements of the covariance matrix $\hat{V}_{OLS}$.

However, assuming $E[\boldsymbol{\varepsilon}\boldsymbol{\varepsilon}'|X] = \sigma^2 I$ (that is sum of squared residuals is independent of the explanatory variables) is not recommended, because when panel data is used, there is usually serial correlation and possibly spatial clustering (in addition to heteroscedasticity) in the model residuals, which can lead to severely biased estimates for the coefficient standard errors.

The DK errors are an extension of the widely used Newey-West (See e.g. Greene 2004) autocorrelation robust standard errors for panel data[4]. Errors are estimated by computing a matrix of the individual moment conditions

$$\boldsymbol{h}_{i,t} = \boldsymbol{x}_{i,t}\hat{\varepsilon}_{i,t} \qquad (A2.3)$$

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[4] The estimation procedure described in this chapter follows mainly that of Hoechle (2007). Hoechle also provides estimation package for Stata, but the standard errors can be estimated with any matrix algebra software using the formulas presented in this appendix. Driscoll also provides sample estimation code in his website: http://www.johncdriscoll.net/. Notice also that in Hoechle's derivation unlike the one presented by Driscol and Kraay, the number of cross-section obervations for different time periods is allowed to differ, which makes the formula suitable for unbalanced panels. The data of this study is a balanced panel, so Driscoll-Kraay (1998) and Hoechle (2007) formulations are equivalent.

where errors are allowed to vary between panels and over time, and then taking cross- sectional averages of this matrix for each time period, making the consistency of the estimator independent of the number of panels N:

$$\boldsymbol{h}_t = \sum_{i=1}^{N} \boldsymbol{h}_{i,t}. \qquad (A2.4)$$

Then the covariance matrix is computed by making autocorrelation correction as a decaying function of l matrix (in a similar way to the univariate procedure for estimating Newey-West errors):

$$\widehat{\boldsymbol{S}_t} = \widehat{\boldsymbol{\Omega}}_0 + \sum_{l=1}^{L} \left(1 - \frac{l}{L+1}\right) [\widehat{\boldsymbol{\Omega}}_l + \widehat{\boldsymbol{\Omega}}_l'] \qquad (A2.5)$$

where

$$\widehat{\boldsymbol{\Omega}}_{\boldsymbol{l}} = \sum_{t=l+1}^{T} \boldsymbol{h_t}\, \boldsymbol{h}_{t-l}{}' \qquad (A2.6)$$

and $\widehat{\boldsymbol{\Omega}}_0$ is the standard White-heteroscedasticity robust covariance matrix

$$\boldsymbol{\Omega}_0 = \frac{n}{n-k} \sum_{i}^{n} \hat{e}_i{}^2 \boldsymbol{x}_i{}' \, \boldsymbol{x}_i. \qquad (A2.7)$$

The Driscoll-Kraay procedure makes the standard errors robust to heteroscedasticity, autocorrelation and spatial correlation in the model residuals. Now the covariance matrix can be computed in the usual manner by substituting basic $\boldsymbol{\Omega}$ for $\boldsymbol{S}_t$:

$$\widehat{\boldsymbol{V}}_{\boldsymbol{Driscoll-Kraay}}(\widehat{\boldsymbol{\beta}}) = (\boldsymbol{X}'\boldsymbol{X})^{-1} \widehat{\boldsymbol{S}_t} (\boldsymbol{X}'\boldsymbol{X})^{-1} \qquad (A2.8)$$

and taking square-roots of the diagonal elements of this matrix. The main issue of reliability when using Driscoll-Kraay errors is the selection of maximum lags L. Choosing a too small number of lags can lead to autocorrelation remaining in the model residuals, and because of that too small standard errors. Using too many lags weakens the statistical power of the t-tests for coefficient significance. Similar rules of maximum length criterion can be utilized as in the case of univariate Newey-West errors. The usual practice is to select the maximum lag length L by utilizing the following formula

$$L = 4(T/100)^{(2/9)} \qquad (A2.9)$$

and rounding down to the nearest integer. In this study, lags based on this criterion are used. For the models using data in monthly frequency, 4 lags is chosen, and for the quarterly data 3 lags is chosen. Robustness checks for models estimated using different lag lengths up to 162 (panel length – 1 for data in levels) were conducted, but in most cases including additional lags did not have significant impact on the statistical significance of the regression coefficients. Sensitivity analysis using different lag lengths for the main models for the determinants of integration (entity demeaned fixed effects and first differences models similar to ones presented in Tables 9 and 10) are presented in Table A2.1:

TABLEA2.1 Driscoll-Kraay standard errors estimated using different lag lengths

	Lags used			
	1	4	12	162/161†
Dependent variable: integration				
Fixed effects				
government bond yield	-0.016 ***	-0.016 ***	-0.016 ***	-0.016 ***
	(0.001)	(0.002)	(0.002)	(0.001)
3 month Euribor rate	0.028 *	0.028 *	0.028	0.028
	(0.011)	(0.014)	(0.017)	(0.016)
GDP	-0.020 ***	-0.020 ***	-0.020 **	-0.020 **
	(0.003)	(0.004)	(0.006)	(0.007)
volatility (VSTOXX)	-0.003 **	-0.003 **	-0.003 ***	-0.003 ***
	(0.001)	(0.001)	(0.001)	(0.001)
EPU Index	0.044 ***	0.044 ***	0.044 **	0.044 ***
	(0.011)	(0.012)	(0.015)	(0.011)
external integration	-0.020	-0.020	-0.020	-0.020
	(0.018)	(0.019)	(0.020)	(0.015)
N	1956	1956	1956	1956
First differences				
government bond yield	-0.004	-0.004	-0.004	-0.004 ***
	(0.003)	(0.003)	(0.003)	(0.001)
3 month Euribor rate	0.017	0.017	0.017	0.017 *
	(0.024)	(0.022)	(0.017)	(0.008)
GDP	-0.002	-0.002	-0.002	-0.002
	(0.008)	(0.008)	(0.007)	(0.003)
volatility (VSTOXX)	0.002 *	0.002 *	0.002 *	0.002 ***
	(0.001)	(0.001)	(0.001)	(0.000)
EPU Index	0.007	0.007	0.007	0.007 *
	(0.006)	(0.007)	(0.007)	(0.003)
external integration	0.007	0.007	0.007	0.007
	(0.019)	(0.019)	(0.022)	(0.010)
N	1944	1944	1944	1944

The values presented in the table are regression coefficients of FE and FD models (standard errors in parentheses); year effect and constant coefficients omitted from the table; † for data in first differences, the first observation is lost due to differencing; significance levels: * p<0.05, ** p<0.01, *** p<0.001

It can be seen that the choice of lag length does not seem to have a large effect on the size of the errors. Whether data in levels or in differences is used, the results are nearly identical with 1, 4 and 12 lags. However, using lag length of 162 (or 161 for the data in differences) can have a significant effect on standard errors. As mentioned before, based on the conventional criteria, for the models using data in monthly frequency, 4 lags is chosen, and for the quarterly data 3 lags is chosen. These choices of lag length are not necessarily optimal as it is based on crude formula independent of the degree of autocorrelation present in the data, but the standard errors and the statistical significance for the regression coefficients are not likely to be significantly different whether 1, 4 or 12 lags were chosen.