Sovereign bond market integration: the euro, trading platforms and financial crises

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Abstract

We disentangle different driving factors of sovereign bond market integration by studying yield co-movements of EMU countries, the UK, the US and 16 German states (Länder) since 1992. At a low frequency bond market integration has increased gradually in the course of the last 15 years in EMU countries, as well as the UK, the US and the German Länder. The current financial turmoil has abated low frequency euro-area sovereign bond bond market integration, while it has had little effect on the integration with the US and UK. Bond market integration at a high frequency band remains relatively low until October 2000, when a sharp increase in integration can be observed in all samples. The increase in high frequency integration can be attributed to electronic trading platforms becoming functional. The financial crisis does not effect high frequency integration, as no technology shock occurs.

JEL: E42, E44, F33, F37, G15

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1 Introduction

International capital markets have broadened and widened significantly in the 1990s and the early parts of this century both on a global scale as well as in Europe. In this paper, we take a closer look at patterns and determinants of international sovereign bond market integration. Two financial markets can be considered fully integrated if identical assets that are traded on two different markets have identical prices at a time and therefore grant the same yield.[1] The advent of the European Economic and Monetary Union (EMU) is regarded as a crucial driving force of European financial integration. The abolition of currency risks with the introduction of the euro together with increased bond standardization are widely seen as the main factors behind increased European bond market integration. Which mechanisms have led to the increase in co-movements of yields in EMU as documented for example in Baele, Ferrando, Hördahl, Krylova, and Monnet (2004)? Can it be attributed to the elimination of exchange rate changes, exchange rate risk, globalization of flows and finally technological improvements in price discovery processes? To disentangle different driving factors, we compare the results for euro area countries with two control groups: the US and the UK on the one hand and the German states (Länder) on the other hand. Anglo-saxon bonds reflect the global dimension of bond market integration not directly related to the creation of the euro. The unique data set on the German sub-national government bond market allows to assess integration trends in a long-standing "currency union". Finally, we distinguish low and high frequency adjustments. This allows us to disentangle the influence of fundamental factors, which drive the evolution of yields in the long run, from innovations affecting the short-term dynamics of international bond markets.

The first important finding is that low-frequency bond yield dynamics converged not only in euro area countries but also relative to the UK, the German states (Länder) and to a somewhat lesser extent with the US. For EMU participants, the heterogeneity between countries also declines over time, i.e., the increase in integration is observable for all countries. At around 1999 yields

[1] A further criterion is the equal access to instruments or services, i.e. to bank loans. As this is of minor importance for developed countries' sovereign bond markets, we do not discuss this dimension of integration here.

look almost perfectly integrated at a low frequency within the EMU.[2] Furthermore, exchange rate factors seem to be an important determinant of the convergence process. We show that controlling for the exchange rate through swap rate differentials considerably reduces the dispersion of the integration parameters for EMU countries before the introduction of the euro.

Our second major result is that on a high frequency a very different pattern of integration emerges. A strong jump in the co-movement of yields is observed during the year 2000 for the euro area countries. Futhermore, similar patterns can also be found in the UK and the US. In contrast, the integration level is almost zero for average German Länder bonds. The pronounced increase at a high frequency can be attributed to technical innovations in bond trading (electronic trading platforms) which promote price transparency and competition while reducing transaction costs. Indeed, breakpoint tests exhibit a strong break for the UK, US as well as the euro area around the date of the introduction of the Eurex-Bonds trading system. In contrast, the German Länder bonds are in general not traded on electronic platforms and therefore not well integrated at a high frequency.

Thirdly, we document that during the financial turmoil starting in summer of 2007 euro-area bond spreads have increased significantly and yield co-movements have declined. This raises the question, whether the strong co-movement of yields prior to the crisis might be attributable to benign financial and macroeconomic circumstances. Integration with the UK and US, which is more volatile due to exchange rate fluctuations, is less affected than the previously almost perfect intra-EMU integration. High frequency integration is not affected by the financial crisis, as trading technology remains unchanged.

Our paper relates to an important literature on bond market integration in EMU. Pagano and von Thadden (2004) note that euro area sovereign and private bond markets have become more integrated in the wake of monetary unification. They notice that governments laid the institutional framework for an integrated market, but that integration was also significantly promoted by the response of financial intermediaries for example in the form of pan-European trading platforms. Baele, Ferrando, Hördahl, Krylova, and Monnet (2004) and several ECB publications (e.g., European Central Bank (2008))

[2] We concentrate on the EMU-12, which Greece joined in 2001.

investigate co-movements of sovereign bond yields in EMU with the German benchmark. Using monthly yield data, the authors show that EMU countries' yield changes follow more closely the changes of the benchmark country, Germany, after 1999. Moreover, this literature documents a strong decrease in yield spreads in the run-up to EMU. Barr and Priestley (2004), using a conditional asset pricing model in the spirit of Bekaert and Harvey (1995), find that national sovereign bond markets are partially integrated into the global market, but market idiosyncratic risk remains.[3]

The present paper links the literature on bond integration with a small but growing literature on electronic trading and its implications for financial systems. Sato and Hawkins (2001) provide an overview of the issues. The literature focuses on equity markets as they were the first to introduce electronic trading beyond the posting of indicative quotes. Grünbichler, Longstaff, and Schwartz (1994) find that screen traded Dax futures lead floor traded Dax stocks by a larger amount than in markets, where spot and futures are both traded on the floor. They argue that this is consistent with the hypothesis that screen trading accelerates the price discovery process. Kempf and Korn (1998) investigate the effect of screen based versus floor based trading systems on different measures of market integration of the Dax future and the Dax index. They find that integration is higher in electronic screen based systems and argue that this effect is driven by lower market frictions which facilitate arbitrage trading. Regarding fixed income markets, to our knowledge no study so far has investigated the impact of electronic inter-dealer trading systems on sovereign bond market integration. Gravelle (2002) notes that electronic trading systems have increased centralization in government securities markets allowing dealers to solicit quotes from a number of dealers at one moment on one screen. Cheung, de Jong, and Rindi (2005) study the microstructure of the MTS global market bond trading system. They find that Euro MTS and country MTS markets are, despite their apparent fragmentation, closely connected in terms of liquidity.

Finally, our paper is also naturally related to the literature on sovereign bond spreads in Europe and Germany. This literature documents, on the basis of low frequency data, that sovereign bonds of EMU are still not considered to be perfect substitutes as spreads remain. Imperfect yield correlations can

[3]In an update to that study, Lamedica and Reno (2007) broadly confirm their findings.

therefore not automatically be ascribed to imperfect bond market integration but also reflect imperfect substitutability.[4] Indeed, recently one has observed a remarkable increase in spreads of EMU countries relative to Germany.[5] In fact, fundamental risk factors are found to matter in EMU (Beber, Brandt, and Kavajecz (forthcoming), Hallerberg and Wolff (2008)) as well as in Germany (Heppke-Falk and Wolff 2008) while the importance of liquidity factors has declined with EMU (Codogno, Favero, and Missale (2003), Pagano and von Thadden (2004), Gómez-Puig (2006)). However Favero, Pagano, and von Thadden (2008) demonstrate, that EMU bond yield spreads are affected by an aggregated risk factor and the interaction of this risk factor and liquidity differentials between the considered bonds. In contrast, they find evidence for a direct influence of liquidity on the spread only in a sub-set of countries. Geyer, Kossmeier, and Pichler (2004) find within the framework of a state space model, that the spread of four EMU countries' bond yields to Germany can be explained by a common risk factor, but not by measures of liquidity.[6] For the pre-EMU period, Favero, Giavazzi, and Spaventa (1997) find that long-run spread movements in Europe are determined by exchange rate factors, while country specific shocks drive short-term cycles.

The remainder of the paper is structured as follows. The next section introduces our approach to measuring integration at high, medium and low frequency and presents the data. Section 3 discusses the results and shows robustness with respect to different methods. The last section concludes.

2 Empirical approach

A useful starting point for an investigation of international bond market integration is the covered interest parity. The covered interest parity condition states that two risk free assets, i.e., two assets without default and transaction cost risk, should have the same yields adjusted for the expected exchange rate

[4] This point was already made by Bekaert and Harvey (1995) in the context of international bond market integration.

[5] Trichet already remarked on spread increases as early as March 2008. "Trichet warning over bond spreads in Europe" Financial Times, March 6, 2008.

[6] The countries are Austria, Belgium, Italy and Spain. The variation of the common risk factor is best explained by corporate bond spreads.

change:

$$(1 + is_{j,t,T}) = (1 + is_{g,t,T}) \left(\frac{F_{t+T}}{S_t} \right)^{\frac{1}{T}}, \tag{1}$$

where $is_{j,t,T}$ is the spot interest rate at time t with maturity T for country j, and F is the future exchange rate. The benchmark country, Germany, is denoted by g. Suppose the asset of country j has a default probability of p relative to the benchmark Bund, then the arbitrage condition states

$$(1 + r_{j,t,T})(1 - p) + p(1 - \tau)(1 + r_{j,t,T}) = (1 + r_{g,t,T}) \left(\frac{F_{t+T}}{S_t} \right)^{\frac{1}{T}} \tag{2}$$

where τ is the fraction of investment lost in case of default. Combining equations (1) and (2), the arbitrage condition can be rewritten as

$$(1 + r_{j,t,T})(1 - \tau p) = (1 + r_{g,t,T}) \frac{(1 + is_{j,t,T})}{(1 + is_{g,t,T})} \tag{3}$$

If we define

$$d_{j,t,T} = \frac{\tau p}{1 - \tau p} \tag{4}$$

then equation (3) can be rewritten as

$$\frac{(1 + r_{j,t,T})}{(1 + r_{g,t,T})} = (1 + d_{j,t,T}) \frac{(1 + is_{j,t,T})}{(1 + is_{g,t,T})} \tag{5}$$

Taking logs of (5) gives approximately

$$r_{j,t,T} = r_{g,t,T} + log(1 + d_{j,t,T}) + is_{j,t,T} - is_{g,t,T} \tag{6}$$

Thus, in the absence of exchange rates and transaction and default costs, interest rates of sovereign bonds of country j should equal the interest rates of sovereign bonds of the benchmark country g. Regressing the benchmark yield on the yield of country j's bonds, the local yields, should give a constant of zero and a slope coefficient of one (we address the stationarity of the time series below). This is a commonly used indicator of financial market integration. It is based on the intuition that the more integrated the market is, the more bond yields should react to common factors instead of local factors.[7] In perfectly integrated markets, one would expect that common news is reflected one-to-one in the local yields. A deviation of the slope coefficient from one indicates changes in the interest rate of the benchmark country are not fully reflected in the interest rate of the country j. This can result from the omission of an

[7]See, inter alia, Baele, Ferrando, Hördahl, Krylova, and Monnet (2004).

exchange rate adjustment term if exchange rate variations are not orthogonal to yields. Alternatively, it can result from changes in default and liquidity risk. Finally it can result from a separation of markets due to high transactions costs, which could result from capital controls, information barriers and other factors.

In the first set of regressions, we consider sovereign bond market integration in the absence of capital market frictions. We will discuss measured integration and sources of bond heterogeneity with the presentation of our results. We test for the co-movement of yields relative to German bonds (Bunds), which serve in most studies of the long term euro area bond market as the benchmark. We estimate on a rolling-window, which allows to plot the evolution of the integration measure since the beginning of our sample.

In a second set of regressions we adjust for exchange rate changes as contracted in the exchange rate future markets. We therefore adjust our interest series by the swap rate difference

$$r_{it}^{adjusted} = i_{j,t,T} - (is_{j,t,T} - is_{g,t,T}) \quad (7)$$

and repeat the analysis. This allows to compare integration of Bunds with the German Länder to that with other EMU participants, the UK and the US.[8] However, it should be noted that this adjustment only eliminates the exchange rate changes as manifested in swap rates. It does not eliminate the risk of holding uncovered foreign bonds.

Integration levels can be different at different time horizons. For example, it is more likely that large and persistent yield innovations get incorporated into other yields at a long horizon, whereas it is possible that short-term innovations cannot immediately be reflected into yields due to transaction cost, information problems and the like. To capture the notion that yields might adjust at different speeds, we proceed in two steps (consecutively for not exchange rate adjusted yields and adjusted ones).

In a first step, we use the linear band-pass filter of Baxter and King (1999) to extract different frequencies of the data. We define three different frequencies: A high frequency equivalent to 2-3 days, a medium one of 3-10 days and

[8]A similar adjustment has been performed by Favero, Giavazzi, and Spaventa (1997) and Gómez-Puig (2006) in the context of an investigation of the determinants of sovereign bond spreads. However, it has not yet been used to adjust yields to estimate bond market integration.

a low frequency of 10-30 days. The band pass filter is an ideal filter in that it extracts only the specified frequencies.[9] Moreover, the filter delivers stationary series if the order of integration of the original series is two or less.[10] We can think of the high frequency series as a series of short-run shocks that do not determine the behavior of yields beyond 3 days. Low frequencies, in turn, capture long-run movements of yields in the course of a month.

In a second step, we use the filtered series to perform rolling windows regressions. More precisely, we estimate:

$$i_{jt}^{f} = \alpha_{jt} + \beta_{jt} i_{gt}^{f} + \varepsilon_{jt} \tag{8}$$

where i_{jt}^{f} is the filtered yield of country j at time t and i_{gt}^{f} is the filtered series of the German Bund. The regressions are performed on a backward looking window of 700 days which is shifted forward by 10 days. This results in a time series for the estimated coefficients.

If the bond markets are perfectly integrated, we would expect β to be one. Thanks to the extraction of the different frequencies, we can assess the evolution of integration levels in the short, medium and long term. Perfect high frequency integration would imply that any short run innovation to the benchmark yield is reflected in the yield of the respectively compared country on the same or subsequent day. In perfectly integrated markets, we expect any movement of the Bund yield to be also visible in the yield of country j.

High frequency integration presupposes a sufficiently high degree of information transparency and operational capacities available to market participants. Adjusting the relative prices of government bonds requires a bilateral price discovery process. Hence, the simultaneous availability of binding quotes is a crucial ingredient to high frequency integration.[11]

At a lower frequency, in turn, market participants can more easily incorporate information, resulting in a higher level of integration. Long-run movements of prices can be measured more easily on a low frequency and be priced

[9]The filter is in fact constructed by minimizing the distance of the frequency response function and the ideal frequency response function. Visual inspection of actual vs ideal showed a good fit in all cases.

[10]We tested for unit roots and could not find an order of integration higher than two.

[11]Indicative quotes or historic transaction prices can only give an orientation about the fair market price and determining the correct instantaneous price, e.g. requesting quotes from dealers by telephone, is costly and time consuming.

accordingly. Long-term convergence towards the single European currency should be reflected primarily in low frequency yields. The elimination of exchange rates through the euro should lead to an increase of the integration level. This can be achieved already years before the actual introduction of the euro, when markets formed beliefs about participants and conversion rates. Overall, we therefore expect β to be closer to one at a low frequency as compared to a high frequency. Moreover, we expect technological advances to have a strong impact on high frequency integration, while they should be of less relevance to low frequency integration.

A deviation of β from one can be due to imperfect integration but also to the fact that liquidity conditions, default rates and exchange rates are related (asymmetrically) to the yield of the benchmark bond. It can therefore be important, to control for these factors. To control for the influence of varying exchange rates, we repeat the above exercises with yields adjusted by the interest rate swap spread between the currency in question and the German swap rate, as defined in equation (7). In principle the swap adjusted data incorporate exchange rate changes as contracted in forward rate agreements. However, premia for the volatility of interest and exchange rates as well as for credit risk persist. Therefore, even swap adjusted data could show an increase in integration with the introduction of the euro. Accordingly, we estimate

$$r_{j,t}^{adjusted,f} = \alpha_{j,t} + \beta_{j,t} r_{g,t}^{f} + \varepsilon_{j,t}. \tag{9}$$

Exchange rate volatility might play a smaller role at a low frequency, compared to higher frequencies, since short-term variations are likely to cancel out over a certain period. Risk premia for time varying volatility are thus less important, especially in the European ERM system of the 1990s, which defined tolerance bands for exchange rate fluctuations. Therefore, swap rate adjustments, which do not adjust for volatility risk but capture long-run exchange rate evolutions, should lead to higher measures of low frequency integration. In turn, for high frequency integration, they are less suited since they cannot capture short term volatility variations which drive a wedge between yields.[12]

[12]Moreover, we present robustness checks to capture time-varying liquidity risks in the working paper version of this paper. To do so, we include the bid-ask spread as an additional explanatory variable in the regression. With increasing liquidity risk, we expect the yield of the respective country to go up. Unless liquidity risk is orthogonal to the benchmark yield, the estimated β coefficient could be affected.

To get a clearer picture of structural breaks in the degree of bond market integration, we perform the Quandt-Andrews breakpoint test to test for changes in the coefficient β. In principle, this is a rolling Chow (1960) breakpoint test (Andrews 1993). The basic test statistic is an F-value, which is computed as a normalized difference between the constraint residual sum of squares and the unconstraint residual sums of squares of the two sub-samples. A high F-value therefore indicates a strong structural break.

A second reason for β to deviate from one is liquidity risk, that is related to yield changes. Liquidity risk can be defined as the difficulty to buy and sell bonds in the markets. It can be particularly relevant if general risk aversion increases and investors prefer to invest in safe havens from which they can depart easily thanks to deep and liquid markets. We therefore also estimated the regression 9 with an additional control variable for liquidity, the bid-ask spread.

Finally, default risk can be re-assessed when fiscal fundamentals of a country respectively Land change relative to the German central government. We believe that such changes occur relatively rarely as fiscal and macroeconomic fundamentals change slowly and rarely. However, in times of crisis, the notions of increased default risk and reduced integration can be observationally equivalent.

Our data sample covers the period from 1992 to October 2008.[13] We use standard benchmark bond yields for EMU countries, the UK and US with approximately ten years to maturity at a daily frequency.[14] The yields are computed from daily averages of the respective benchmark bond's price. For the exchange rate adjustment, we use standard interest rate swaps for a ten year horizon. All these data are taken from Thomson Financial Datastream. To control for liquidity, we use outstanding volume and suitable bid/ask-spreads, both from Bloomberg. With respect to the German Länder, we revert to the unique data-set of Schulz and Wolff (2009), which comprises master data of all bonds issued by the Länder since 1992. The authors compute yield series based on the master data set and yield data taken from Thomson Financial Datastream. Due to the relatively low issue size of many German Länder

[13]As we lose observations applying the band pass filter, the sample effectively reaches to mid August 2008.

[14]We restrict our analysis to the EMU 12. Luxembourg does not have traded debt and is therefore excluded.

bonds, we also use single bonds' yields of all bonds exceed the threshold issue size of one billion euro.

3 Results

3.1 Main findings

Before moving to the rolling window regressions, we present in Table 1 the results of simple OLS regressions for the entire sample split into two sub-periods: 1992-1998 and 1999-2008. Several results emerge already from this first analysis. First of all, low-frequency integration is greater than high-frequency integration in all samples and periods with medium frequency integration being in between. This suggests that indeed yields co-move more strongly over extended periods of time while over shorter time horizons there can be deviations. Second, high-frequency integration is significantly greater in the second part of the sample in the euro area but also with the UK and the US. This hints to a general factor that has contributed to the increase in integration in all countries. In contrast, the increase of estimated integration parameters at a low frequency is rather small. A potential explanation for this finding is that technological possibilities have increased the ability of market participants to adjust yields more quickly. We will pinpoint this result in the next section. Third, swap adjustments of yields to adjust for exchange rate movements matter at a low frequency but do not improve estimated short-term integration. Indeed, while the measured integration coefficient β is only slightly larger at a low frequency for adjusted yields, the regressions have a much larger fit, i.e. the R^2 is roughly twice as large. This indicates that swap spreads indeed capture well different developments of nominal interest rates due to depreciating or appreciating exchange rates. In the later part of the sample, swap adjustments obviously play no role for the euro area as the exchange rate is abolished and swap spreads are zero.

In the following sub-sections, we will employ rolling windows regressions to further strengthen these results. In particular, rolling windows regression will allow us to more clearly detect time structural breaks and thereby refine our analysis.

Table 1: Static Bond Market Integration

	yield (not adjusted)						swap adjusted yield					
Low frequency integration												
	Early sample			Late sample			Early sample			Late sample		
	EA	UK	US	EA	UK	US	EA	UK	US	EA	UK	US
	A	B	C	D	E	F	G	H	I	J	K	L
yield de	**0.96**	**0.98**	**0.62**	**0.96**	**0.92**	**1.02**	**0.91**	**0.93**	**0.83**	NA	**0.98**	**0.82**
	108.02	35.87	23.64	573.70	86.26	60.94	164.94	66.37	59.58		133.04	81.11
N	15,591	1,777	1,777	25,046	2,516	2,516	12,363	1,777	1,777		2,516	2,516
R2	0.43	0.42	0.24	0.93	0.75	0.60	0.69	0.71	0.67		0.88	0.72
Medium frequency integration												
	yield (not adjusted)						**swap adjusted yield**					
	Early sample			Late sample			Early sample			Late sample		
	EA	UK	US	EA	UK	US	EA	UK	US	EA	UK	US
	A	B	C	D	E	F	G	H	I	J	K	L
yield de	**0.78**	**0.66**	**0.45**	**0.92**	**0.88**	**0.85**	**0.80**	**0.73**	**0.57**	NA	**0.88**	**0.64**
	76.51	21.40	13.75	331.14	61.27	36.24	76.56	33.18	21.15		64.45	30.01
N	15,591	1,777	1,777	25,046	2,516	2,516	12,363	1,777	1,777		2,516	2,516
R2	0.27	0.21	0.10	0.81	0.60	0.34	0.32	0.38	0.20		0.62	0.26
High frequency integration												
	yield (not adjusted)						**swap adjusted yield**					
	Early sample			Late sample			Early sample			Late sample		
	EA	UK	US	EA	UK	US	EA	UK	US	EA	UK	US
	A	B	C	D	E	F	G	H	I	J	K	L
yield de	**0.44**	0.05	**-0.31**	**0.82**	**0.62**	**0.36**	**0.27**	0.04	**-0.42**	NA	**0.68**	**0.15**
	46.21	1.35	-11.52	205.80	34.93	13.21	20.03	1.22	-12.51		38.45	4.47
N	1,777	1,777	15,591	25,046	2,516	2,516	12,363	1,777	1,777		2,516	2,516
R2	0.07	0.00	0.12	0.63	0.33	0.06	0.03	0.00	0.08		0.37	0.01

Notes: Regression from equation (8). Dependent Variable is the (swap adjusted) local yield. Fixed effects panel regression for the euro area, single equation estimation for integration with the UK and US. All yields are filtered into high, medium and low frequencies. The full sample ranges from January 1992 to October 2008, the early sample covers the pre-EMU period (January 1992 to December 1998) and the late sample starts with the introduction of the euro (January 1999 to October 2008). There is no swap rate adjustment for euro area yields in the late period (column J) since as of 1999 only one swap rate prevails in the euro area. Daily observations. t-values are reported below the parameter; these are either significant on the 1% level (bold print) or insignificant.

3.2 Evolution of integration

Figure 1 depicts the evolution of the average integration coefficient β from equation (8) for the EMU countries.[15] As can be seen, at a low frequency, the

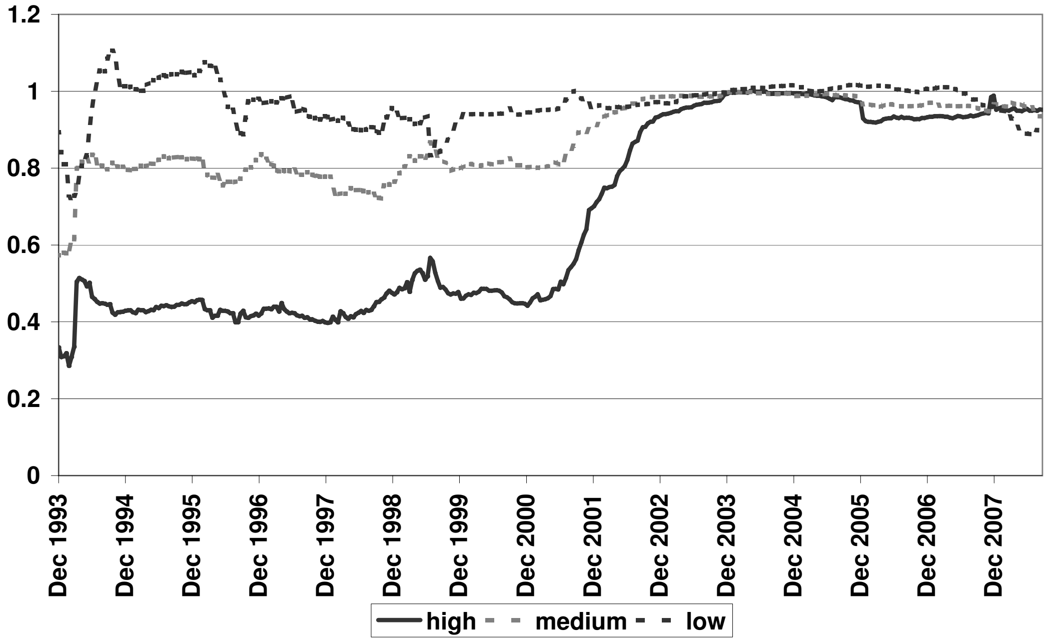

Figure 1: Evolution of average βs of EMU countries, estimated on a 700 calendar days rolling window.

average correlation of yields of EMU was hovering around the perfect integration level since the early 1990s. In contrast, for medium frequencies, the integration level is around 0.8, increasing only after 1999. The sharpest increase in the integration level can be observed for high frequency data. Here, the average integration level is around 0.5 during the 1990s but increases abruptly as soon as data from late 2000 enter the estimation window. As a consequence of the current financial crisis, EMU bond market integration at a low frequencies has declined recently, while high frequency integration remains practically unchanged.[16]

Since average EMU data might conceal a significant amount of heterogeneity across EMU countries, we also provide the variance of β coefficients at each point in time (Figure A-2). The heterogeneity across countries is higher

[15]The constant α in the regression equation is indeed practically zero in the whole sample, thus we will focus our analysis on the slope coefficient β.

[16]Parameters are estimated with great precision. Standard errors are reported in Figure A-1 in the appendix. R^2 increases with the slope coefficient β.

at the high frequency than at the low and medium frequencies. High frequency heterogeneity almost completely vanishes as of 2004. For low frequency data we observe generally a smaller variance, which is almost zero with the start of EMU. Looking at individual countries, some had significantly deviating βs in the early to mid 1990s, while as of late 1997 there appears to be complete convergence until recently.[17] At high frequencies, a strong jump for most of the countries similar to the average data can be found.

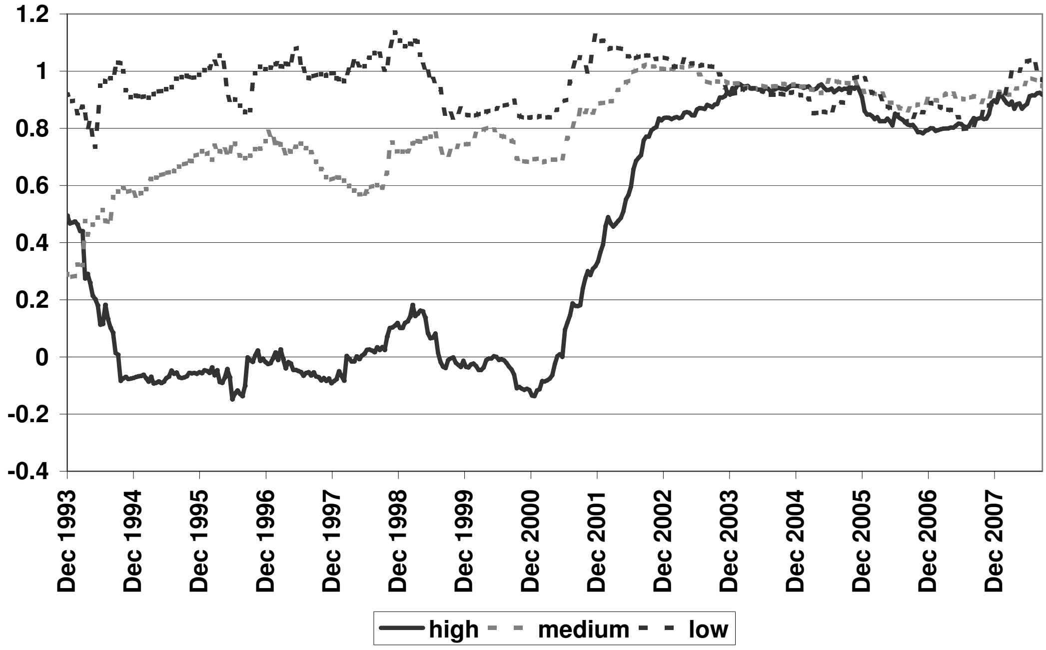

Figure 2: Evolution of β of the UK, estimated on a 700 day rolling window.

Performing the same exercise with data from the UK relative to Germany yields a remarkably similar picture (Figure 2). Again, low to medium frequency integration levels are high throughout the sample, while high frequency integration increases steeply when data from late 2000 enter the estimation sample. Finally, we turn to the USA (Figure 3). Here, the picture is similar in the sense that there appears to be a strong increase in high frequency integration in late 2000. On balance, we also observe a gradual increase throughout the 1990s at a low and medium frequency integration level. Especially for the US, the pattern of integration is somewhat different from euro-area bond markets, which is partly due to the exchange rate, as we will discuss in section 3.4. Furthermore, the time difference leads to non-synchronous observations and

[17]With the obvious exemption of Greece, which joined the EMU only in 2001. The figure with the individual graphs is available in the working paper version of the paper (Schulz and Wolff 2008).

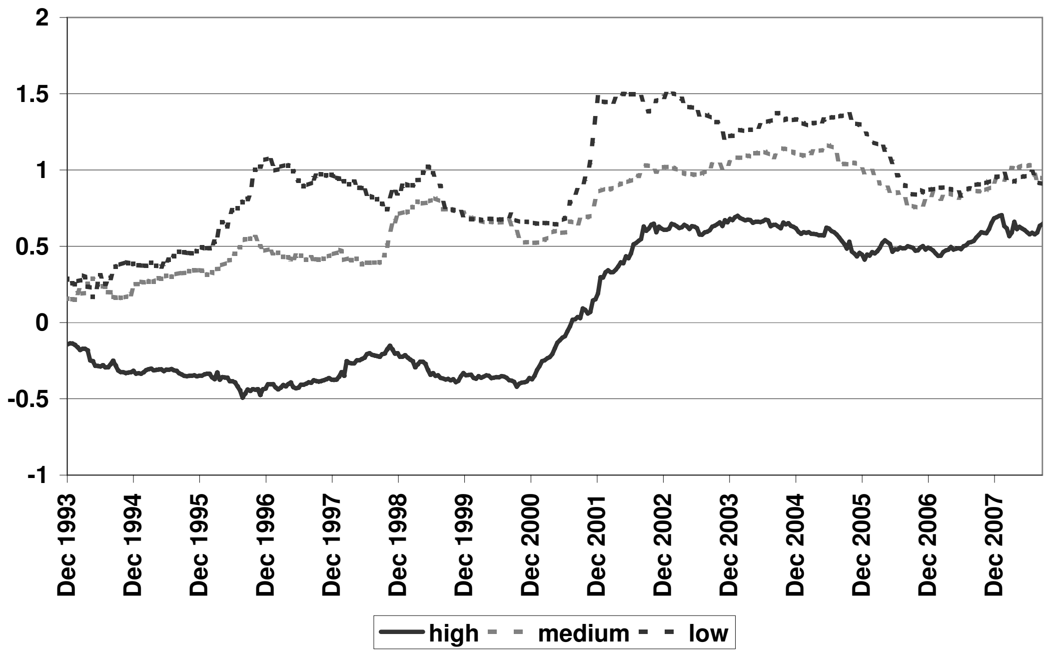

Figure 3: Evolution of β of the US, estimated on a 700 day rolling window.

moreover, the US might lead the European market. Overall, patterns of low and high frequency integration differ markedly in all regions. In the following sections we therefore discuss each separately.

3.3 Low frequency integration and financial crises

Capital markets significantly evolved in the past two decades. International capital flows soared, bond markets deepened and risk premia declined broadly. In fact, the amount of bonds and notes outstanding increased between 1992 and 1999 globally by 50% to 35 trillion US-dollar and has surged to about 80 trillion US-dollar until 2007, reflecting strong issuance activity of governments as well as financial institutions in the new millenium.[18] In a long term trend, capital markets have become more open, both in industrialized and in developing countries, which can be read as an expression of globalization, with the removal of administrative barriers being a major factor (Kaminsky and Schmukler (forthcoming), Obstfeld and Taylor (2004)). Accordingly, international capital flows have picked up remarkably from around two trillion US-dollar to more than eight trillion US-dollar in the year 2000 and around 16 trillion US-dollar 2006.[19] The share of portfolio investment among total

[18]According to the Bank for International Settlements debt securities database.

[19]Source: IMF balance of payment statistics.

global capital flows has peaked in 1999 at around 50% and has been relatively stable at roughly 40% since 2002. In addition, investors increasingly engaged in foreign securities, which might have provided further support of a more competitive and transparent bond pricing mechanism.[20] Furthermore, there has been a greater standardization of bonds, rendering these paper closer substitutes (Favero, Pagano, and von Thadden 2008). Sovereign issuers have also widely adopted issuance previews, reducing uncertainty about the upcoming supply. Other factors contribute to low frequency integration, too. On a global scale, disinflation had a dampening effect on yields (Rogoff 2004), reducing both the direct inflation component of a bond's yield and the inflation risk premium, which covers the risk of unexpected variation in inflation. Term premia have also contributed to the decline of nominal bond yields (Kim and Wright 2005). Deeper capital markets, greater bond standardization as well as larger international capital flows are also reflected in increased low frequency integration within Germany.

Notwithstanding the high degree of EMU bond market integration at low frequency, even in the early and mid 1990s, it is worthwhile to take a closer look at episodes of falling integration. Figure 4 depicts the absolute deviations of the mean EMU β parameter from one in the low frequency regressions giving an idea which events disturbed long-run integration. Most large deviations from one occurred in the wake of the major financial crises of the last 15 years. The typical pattern were abrupt changes of the low frequency co-movement. This can be due to save haven flows which primarily go into very liquid bonds (e.g. German Bunds) as well as to investors re-appreciating country-risk. While several crises interrupted low frequency integration in the 1990s, the first years of the new millenium showed constantly high levels of integration. The standard interpretation of this fact is that the EMU sovereign bond market has largely converged to a single market, though not as perfect as the money market, with remaining discrepancies being attributable mainly to - shrinking - liquidity differences (Ehrmann, Fratzscher, Gürkaynak, and Swanson (2007), Manganelli and Wolswijk (2007), European Central Bank (2008)).

However, the period from 2001 to 2007 was very benign in terms of a

[20] A major aspect of European cross border investments in the 1990s has certainly been the so called convergence trade prior to the introduction of the euro (Deutsche Bundesbank (2002)).

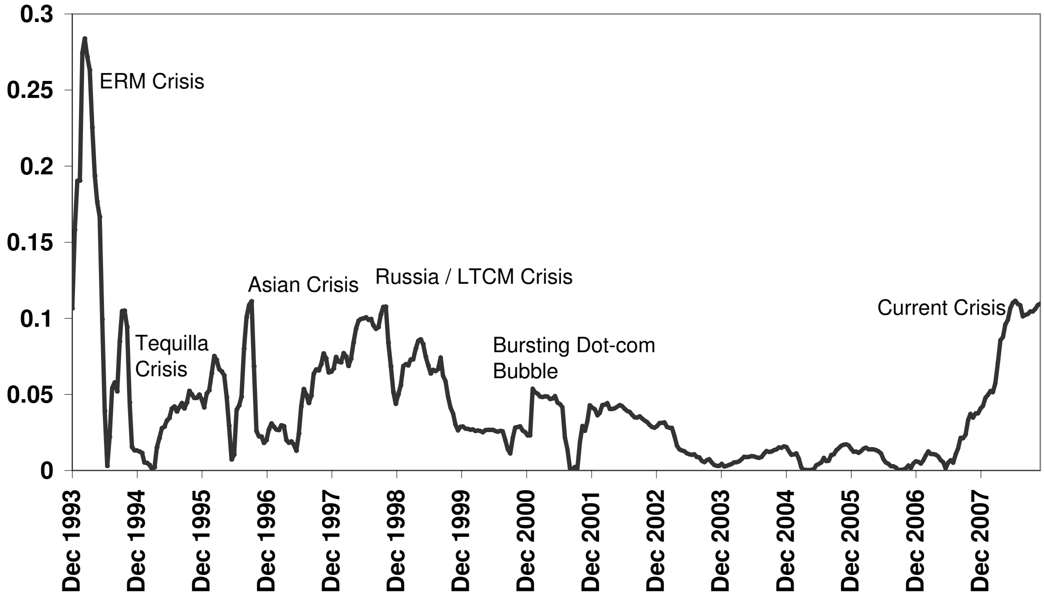

Figure 4: Absolute deviations of EMU mean β from one at low frequency.

macroeconomic environment with stable growth and declining inflation rates in developed as well as in many emerging economies. Financial turbulence were occurring the private sector (e.g. Worldcom, Enron or Parmalat) but did not spill over to the macroeconomic level. These favorable circumstances, often labelled great moderation, are reflected in many indicators. Especially from 2003 on, emerging and corporate bond spreads fell to historic lows, stock and bond market volatility receded. Hence, in this globally stable environment, premia for credit or liquidity risk were compressed in many asset classes. Against the backdrop of these conditions, many investors treated the EMU government bonds as close substitutes. The current financial and subsequently economic crisis, has ended the phase of propitious circumstances, clearly effecting the integration of sovereign bond markets in the EMU. With data from summer 2007 entering the estimation window, measured integration at a low frequency significantly falls in the EMU. In contrast to previous episodes, the change is building up rather steadily.[21] To pin down the timing of the decrease in low frequency integration more formally, we perform a Quandt-Andrews unknown breakpoint test. The test provides an Wald F-statistic for a structural break of the β coefficient in time. The higher the F-value, the greater is the imposed constraint of a model without a break. The mean of the Wald's F-statstics

[21] Remember, that due to applying the band pass filter, our time series ends in mid August 2008. Hence we do not capture the remarkable extension of sovereign spreads versus Germany starting in mid-September 2008.

on the sub-sample starting in 2003 evidently peaks in summer of 2007 (see Figure 5, the individual countries maxima are reported in the appendix, Table A-3). The gradual increase of the F-statistic is clearly attributable to the financial crisis as the relative weight of observations post August 2007 increases. When performing the test with a sample ending in May 2007 no increase in the likelihood of a break point is visible.[22]

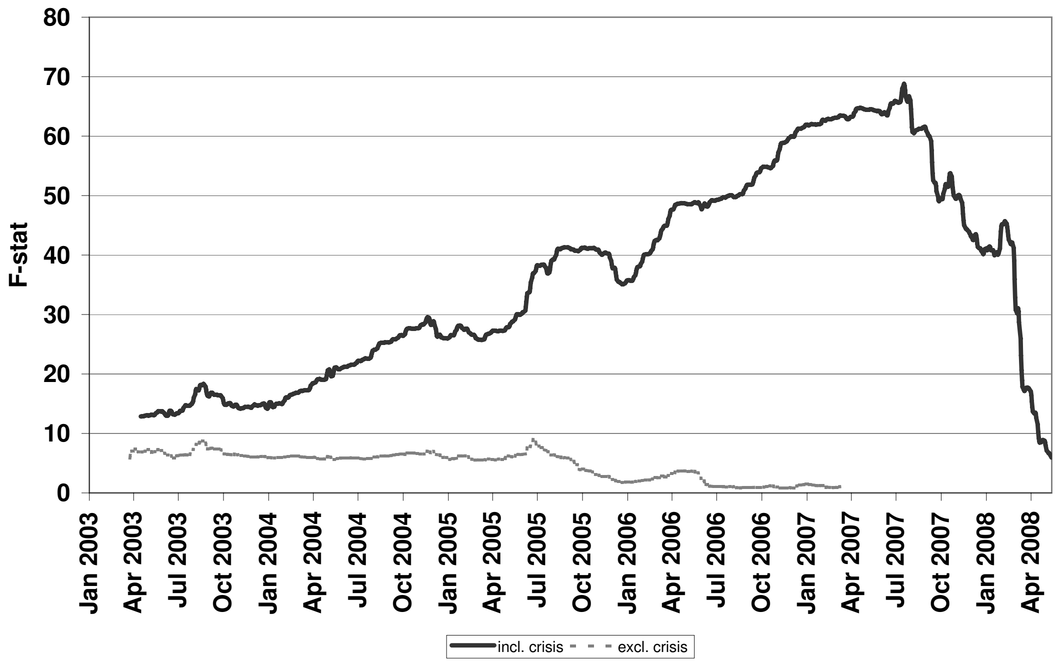

Figure 5: Mean of Wald F-statistics from Quandt-Andrews breakpoint test for EMU low frequency integration. Test is performed on a sub-sample from 2003 to August 2008. Robustness check with sub-sample excluding the current financial crisis, 2003 to May 2007.

Apparently, investors re-assess the country risk for EMU participants. The dispersion of swap spread adjusted yields (see section 3.4) for EMU sovereign bonds has recently risen to levels last observed in mid 1995. This finding is robust to the exclusion of Germany from the sample, thus it cannot solely be attributed to a special role of German Bunds as "save havens" for international capital flows. The impact of the current financial crisis on international integration is further discussed in the following section.

[22]For the complete sample starting in 1992, the largest breakpoints are found pre-EMU, indeed, when yield spreads narrowed in the run-up to the single currency (see Table A-2 in the appendix).

3.4 The role of the exchange rate

To get a deeper understanding of the importance of exchange rate fluctuations for bond market integration, in a robustness check, we adjust all yields (except for Germany) by the respective swap spread to Germany.[23] With the thus transformed yield data, we perform the frequency-filtering as for the original series and re-estimate the integration equations. For euro-area bond markets, the mean of the integration measure at a low frequency is hardly affected by incorporating exchange rates. Nevertheless, exchange rate adjustments were a major determinant of sovereign spreads to Germany pre-EMU as a lower dispersion of adjusted spreads suggests. Moreover, the variance of estimated integration coefficients βs is lower for adjusted yields. Especially at a low frequency, we find that adjustment of yields matters for the dispersion of estimated βs (see Figure 6). Here, the variability of the integration parameter is consistently lower, with the prominent exception of the early 1990s, when observation from the crises of the ERM exchange rate system are in the estimation window.

In the international dimension, swap spread corrections also tend to have a pronounced effect. Again, we focus on low frequency integration as fundamental long-run influences should be reflected primarily in that band. Estimated with adjusted data, the integration parameters at a low frequency move within a narrow corridor of 0.8 to 1.0, practically in the whole sample (see Figure 7), while the integration level without swap adjustment is far more volatile. In a swap adjusted view, international bond market integration is consistently high and does not exhibit a trend. This underlines the distinctiveness of euro-area bond market integration, which experienced a noticeable increase in integration from the mid 1990s on. The recent decline in measured euro-area integration cannot undisputable be found outside the euro area. Integration with the US tends to decline somewhat in the current financial crisis while integration with the UK only falls slightly at the end of the effective sample in mid August 2008.

All in all, exchange-rate adjustments as measured by swap-rate differences, have an effect on long-run yield convergence. For bond market integration as

[23] We use ten year swap rates. In EMU there is only one swap rate, thus no adjustment is necessary. An extend discussion of the role of the exchange rate is presented in the working paper version (Schulz and Wolff 2008).

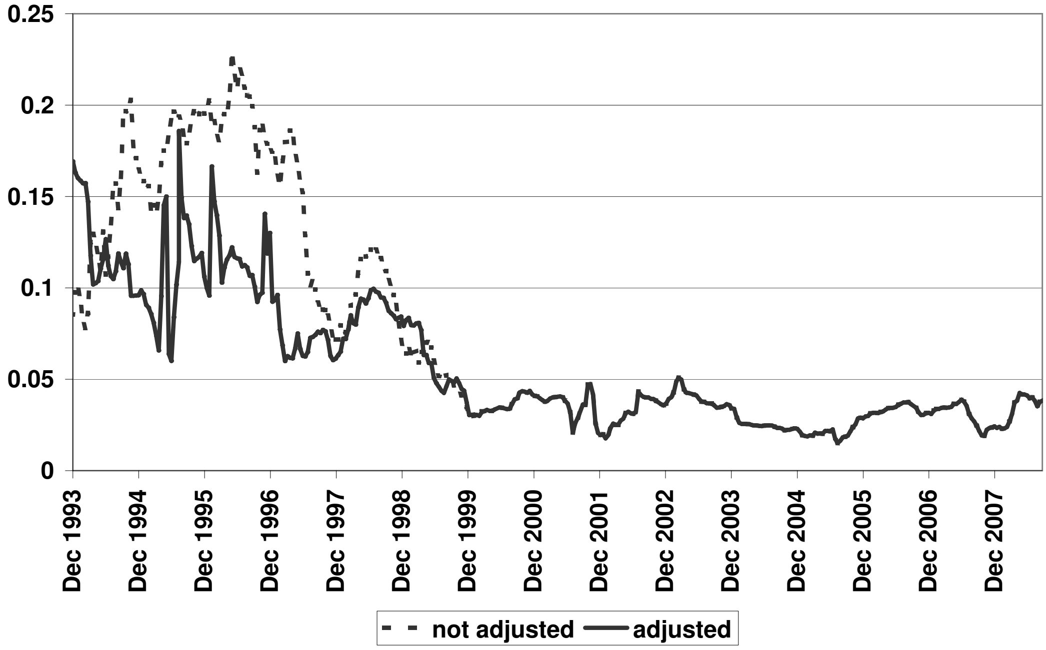

Figure 6: Standard deviation of integration parameter β for EMU countries at low frequency. Data for Greece included as of 2001. "Adjusted" stands for regressions in which the yields have been corrected by the swap rate difference between Deutsche Mark and the respective currency before applying the band-pass filter.

measured by short to medium-term yield innovations, swap adjustment plays a negligible role.

3.5 High frequency integration and trading platforms

A different picture emerges from the analysis of high frequency filtered yields. Here, integration only starts to increase steeply when the first observations of late 2000 enter our regression window. Hence, high frequency integration only picks up almost two years after the introduction of the common European currency. Moreover, integration with respect to Germany's Bund picks up simultaneously in the UK. With respect to the US, the pattern of increasing integration is similar. In the high frequency integration, regressions clearly hint at a regime shift in the year 2000. To better capture the exact timing of the jump, we again perform the Quandt-Andrews unknown breakpoint test. Figure 8 depicts the F-statistic for the average of EMU countries, the UK and the US. For all three regions, there is a striking peak in the F-statistic around October 2000. The statistic for the EMU is the average of the single countries'

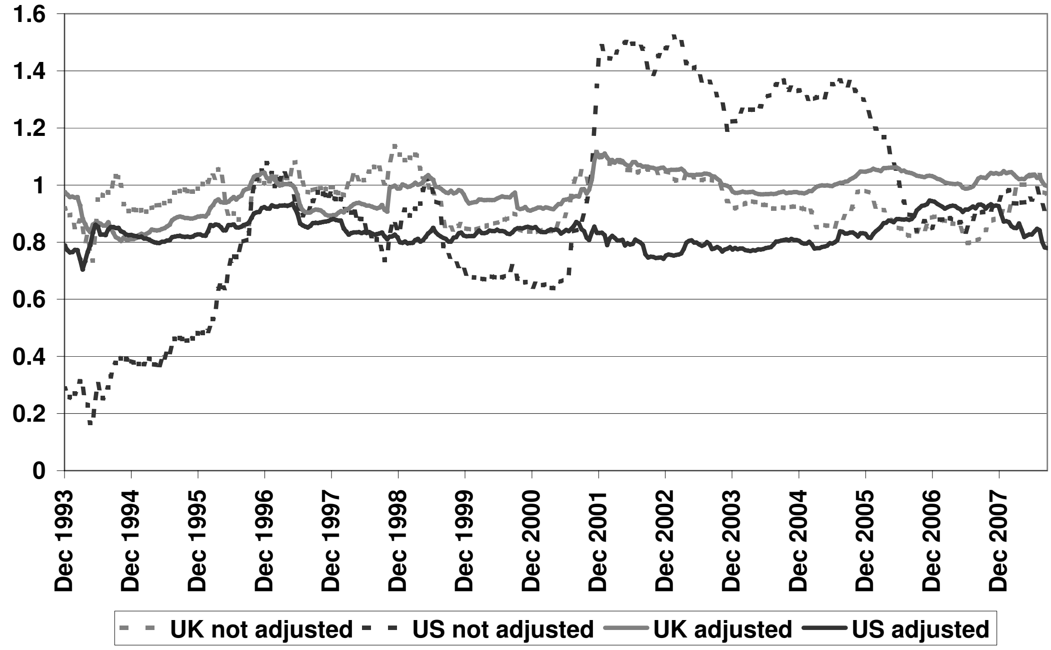

Figure 7: Low frequency integration parameter β. "Adjusted" stands for regressions in which the yields have been corrected by the swap rate difference between Deutsche Mark / the euro and the respective currency before applying the band-pass filter.

test statistics and is not driven by a single country. Thus high frequency integration jumped at that point in time to a new level. In the EMU as well as in the UK, the integration parameter subsequently is close to one.[24] This indicates full integration, i.e., Bund yield innovations are fully mirrored in other governments' bond yields. The lower level of integration with the US might be attributed to a lack of synchronization in trading hours.

The short interval at which the integration level jumps suggests a change in price discovery mechanisms around October 2000. Traditionally, bonds were traded over the counter, mainly in telephone trades. Even though prices were posted on electronic information systems like Reuters, they were mainly either indicative quotes or historic prices. Moreover, traders usually did not have access to multiple tradable quotes at one point in time. A potential reason for this jump are electronic trading platforms. In fact, already Hartmann, Maddaloni, and Manganelli (2003, p. 195) suspect that platforms seem to "...have had a significant, positive impact on the integration of government debt markets in the euro area...".

[24]The parallel shift in the average EMU integration parameter in December 2005 can be attributed solely to Spain.

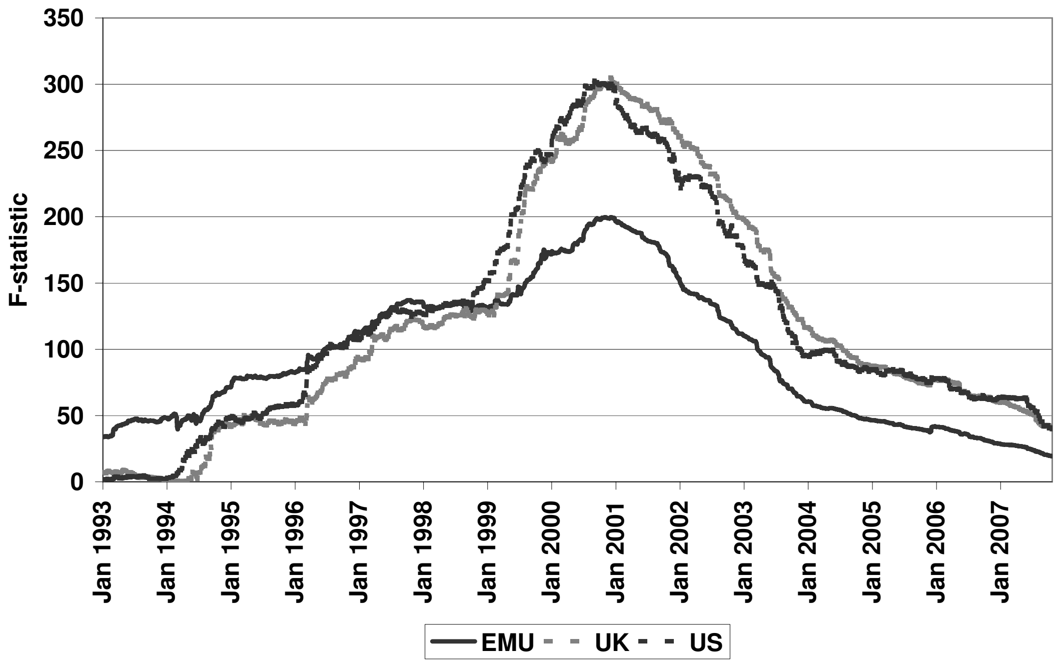

Figure 8: F-statistic from Quandt-Andrews unknown breakpoint test for EMU, US and UK (high frequency integration), sample 1992-2008.

In October 2000, Eurex-Bonds, an electronic bond trading platform in Frankfurt, became functional. It is one of the largest trading platforms for Bunds (Deutsche Bundesbank 2007) and offers real time binding quotes to its members, permitting immediate access to multiple dealers. This increases transparency and thus promotes price discovery, leading to more uniform reactions of government bond yields to innovations. In June 2000 BrokerTec went into operation, which offers a hybrid solution combining voice and electronic trading, which was able to attract trading mainly in US-Treasuries.[25]

Other electronic trading platforms also went into operation around the turn of the millennium. Most notable is the MTS platform, originally created to trade Italian government bonds, which was founded in 1988 and privatized in 1997. In the meantime, MTS has evolved into a trading network. In April 1999, Euro MTS went into operation, covering European benchmark bonds. However, the MTS system is fragmented, as only the largest and most recent bonds are traded on the Euro MTS platform.[26] To trade the full range of e.g. German

[25]For an more detailed overview of European bond market standards, see Dunne, Moore, and Portes (2006).

[26]It appears to be, that the main liquidity is with the national MTS platforms; e.g., a German ten year on the run Bund might not be traded on certain days on Euro MTS. See www.mtsdata.com/content/data/public/ebm/bulletin/.

bonds, one has to take MTS Germany (launched in April 2001) into consideration. From the perspective of price discovery, inter-dealer systems as MTS and Eurex-Bonds differ significantly from customer related trading platforms like BondVision (part of the MTS group, which started in 2001) or TradeWeb (1998), even though the latter typically record higher turnover.[27] While inter-dealer markets provide tradable quotes, systems aiming at investors offer prices only at explicit requests and therefore have only a limited impact on price discovery. In spite of the success of electronic trading platforms, the majority of trades is still arranged by telephone. In 2006 German federal paper worth more than 18,000 billion euro was traded on the telephone, while around 400 billion euro worth were exchanged on the different systems of MTS (including the platform BondVision) and the turnover on Eurex-Bonds was slightly above 200 billion euro.[28]

All in all, the strong increase in high frequency integration observable in EMU countries as well as the UK and the US around the third quarter of 2000 suggests a change in the speed at which prices are set. This has led to a greater international co-movement of yields. Based on a variety of tests, we attribute this jump to electronic trading platforms that have become functional around that time. Furthermore, the degree of high frequency integration does not fall during the current episode of financial turmoil, supporting our argument, that technological innovations rather than fundamental economic factors drive high frequency integration.

3.6 German Länder

As an additional control group to the EMU countries, we investigate closely the German Länder. The German Länder faced a common framework already as of the beginning of our sample in the early 1990s (and also before, of course). Studying them therefore helps to disentangle harmonization in EMU countries from other trends. Moreover, the bonds considered were all issued in the same currency at a time, the Deutsche Mark and subsequently the euro.

Figure 9 plots the estimated integration coefficients for the German Länder.

[27] Recently, investors have pressed to gain a direct access to the inter-dealer MTS systems. For an analysis of inter-dealer vs. customer markets see Dunne, Hau, and Moore (2008).

[28] In 2006, less than 2% of trades were executed on stock exchanges (Deutsche Bundesbank (2007), principle of double-counting).

High frequency integration levels remain at very low levels throughout the

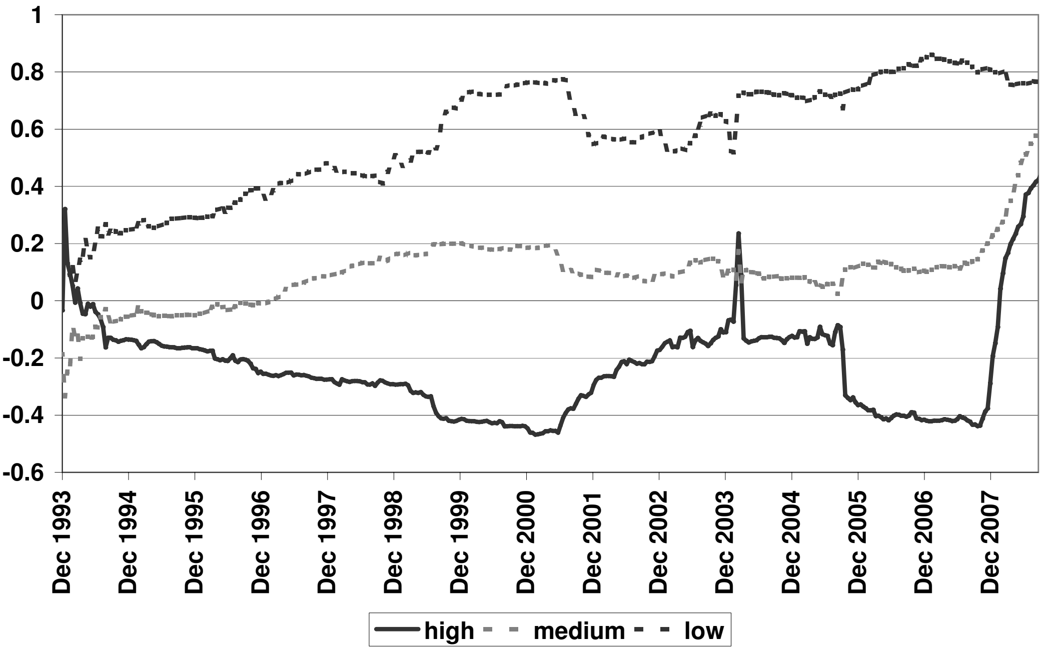

Figure 9: Evolution of average βs of German Länder.

sample, picking up only somewhat as of late 2007. We attribute this low level to the fact that most Länder bonds are quite small in size. This lack of liquidity reduces the incentives to adjust prices relative to the Bund by selling or buying. At a lower frequency, however, we observe a continuous increase in integration levels. This suggests that larger movements of Bund yields are increasingly reflected in Länder yields. This is consistent with the changed debt strategy of the Länder, who tend to issue larger bonds (Schulz and Wolff 2009).

The increase in low frequency integration mirrors the one for EMU countries. This suggests, as did the increase of the UK integration, that the role of the exchange rate for bond market integration is at best an indirect one. The absence of exchange rates in Germany precludes exchange rate risk as a prime determinant of missing integration. However, it is possible that through the elimination of the exchange rate of Germany towards the other EMU countries, international investors increased their engagement in the German Länder bond market thereby leading to greater price convergence.

If we look more closely at large bonds, that have the potential to be traded on electronic trading platforms, we find a sample of roughly 40 bonds that exceed the threshold of 1 billion euro, which is required by Eurex-Bonds, only

6 exceed the value of 2 billion euro required by EuroMTS. We compare the yield of each individual large bond with a comparable benchmark bond of the Bund. Yield differentials of one, ten and 30 days approximate high, medium and low frequency. Figure 10 plots the evolution of the average β for the two groups. At low and medium frequency, large bonds are slightly closer connected

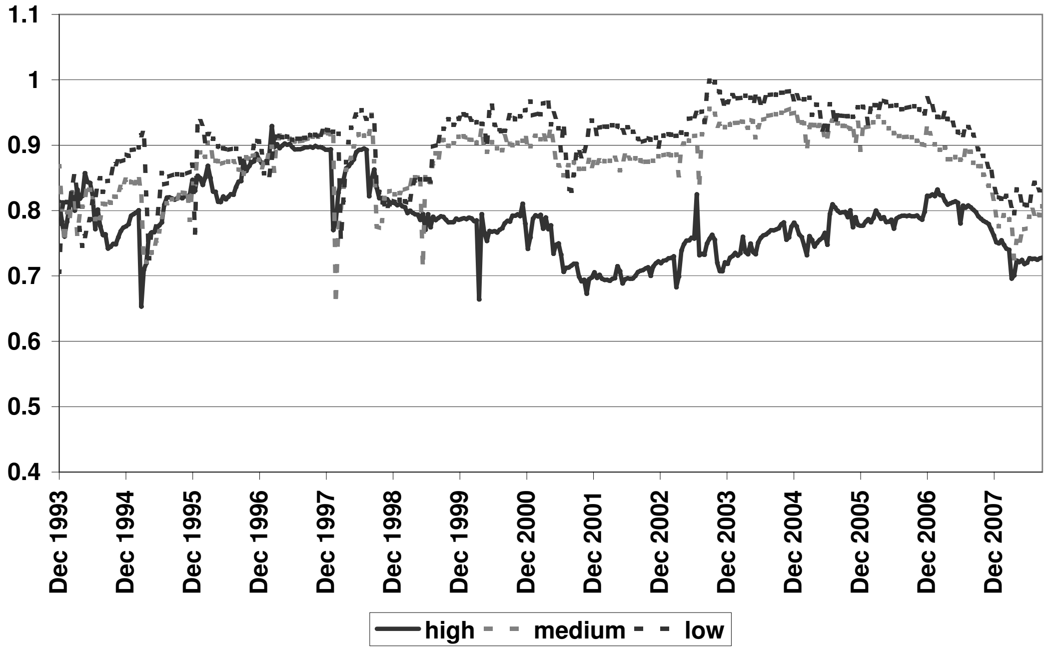

Figure 10: Evolution of average βs of large German Länder bonds. Average of pairwise comparison to suitable Bunds. Yield differences of one, ten and 30 days approximate high, medium and low frequency.

to Bunds than average Länder bonds, reflecting their higher liquidity. At a high frequency, Länder bond integration is rather weak and the sharp increase observed for central government bonds is missing. Apparently, even large Länder bonds are hardly traded on electronic platforms. Integration is falling by all measures as soon as data from the current financial crisis is entering the estimation window. This is consistent with evidence, that brokers at times suspended binding quotes for Länder bonds in the inter-dealer market.[29]

All in all, the German Länder bond market still has seen a remarkable increase in integration with the Bund in the course of the last 15 years at a low frequency. At higher frequencies, however, integration levels remain very low. The vast majority of German Länder bonds are, however, too small to

[29] Technically, Länder bonds are traded at the covered bond desks at several market places. Indeed, a sample of trades on MTS between September 2007 and May 2008 records practically no trades.

be traded on electronic platforms; their price discovery process is therefore too slow to show high frequency integration.

3.7 Robustness

We performed a number of robustness checks. To make our results more easily comparable with the bulk of the literature on bond market integration, we regressed the difference of yields of country j on the difference of the German Bund's yield.[30] We use the first difference of yields (i.e., the day-to-day change) to capture fast adjustment of yields. Medium and low adjustment speeds are captured with 5 and 10 business days differences. Baele, Ferrando, Hördahl, Krylova, and Monnet (2004) use one month differences and thus capture very slow and long-run adjustments.[31] The results of this exercise are presented and discussed in depth in the appendix of the working paper version of this paper. The resulting picture is virtually identical to the frequency filtered data. We again observe a sharp increase of integration levels in the one day difference estimation around the time of the introduction of trading platforms. For lower frequencies, i.e., five and ten days differences, integration seems to increase gradually in the course of the 1990s.

We use the approach of simple rolling windows OLS regression to control for a variety of other factors that might influence integration. Most importantly, we include the difference of the bid-ask spread in the regressions as a control for time varying liquidity premia. However, the inclusion of the bid-ask spread as a control variable does not alter the main results. Moreover, the effect of bid-ask spreads themselves becomes virtually absent in the mid-late 1990s. This is in line with previous findings in the literature that the role of liquidity measures has become smaller in EMU. Overall, the increase in integration levels with data from late 2000 entering the sample appears to be be very robust.

[30]In doing so, we abstract from any possible co-integration relationship as do the mentioned authors.

[31]The results for 10 days and 22 business days differences look practically identical. We therefore do not present 1 month differences.

4 Conclusions

This paper presents a versatile approach to capture different dimensions of sovereign bond market integration. We document a gradual and often substantial increase in low frequency sovereign bond market integration, equivalent to a range between 10 and 30 days, among markets not directly affected by the creation of the euro, i.e. the integration of the German Bund market with the UK, the US and the market for German Länder bonds. In contrast, integration between EMU participants was on average already at a rather high level in the early 1990s. However, heterogeneity was still considerable at that time and declined with expectations about the introduction of the euro getting firmer. Apart from the common currency, tightening of integration can be fundamentally attributed to increased international capital flows, deeper capital markets and greater standardization of bonds. Controlling for exchange rates, as expressed in the swap spread, increases low frequency integration internationally and abates dispersion of the integration measure for EMU countries. The current financial crisis has markedly reduced the measure level od integration within the EMU at a low frequency. Apparently, investors re-assess country risk which, in combination with significantly varying market liquidity, lowers the measure of integration. At higher frequencies, especially at frequencies capturing day-to-day changes, integration levels were comparatively low during the 1990s and increased abruptly at around October 2000 for EMU countries, as well as with the US and the UK. We argue that this sudden increase can be best explained by electronic trading platforms, which were introduced at that time and changed the price discovery process. In contrast, exchange rates seem to play a negligible role for short-term integration measures. Furthermore, the current financial crisis has no effects on the level of high frequency integration as trading technology remains unchanged.

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Appendix

A Main appendix

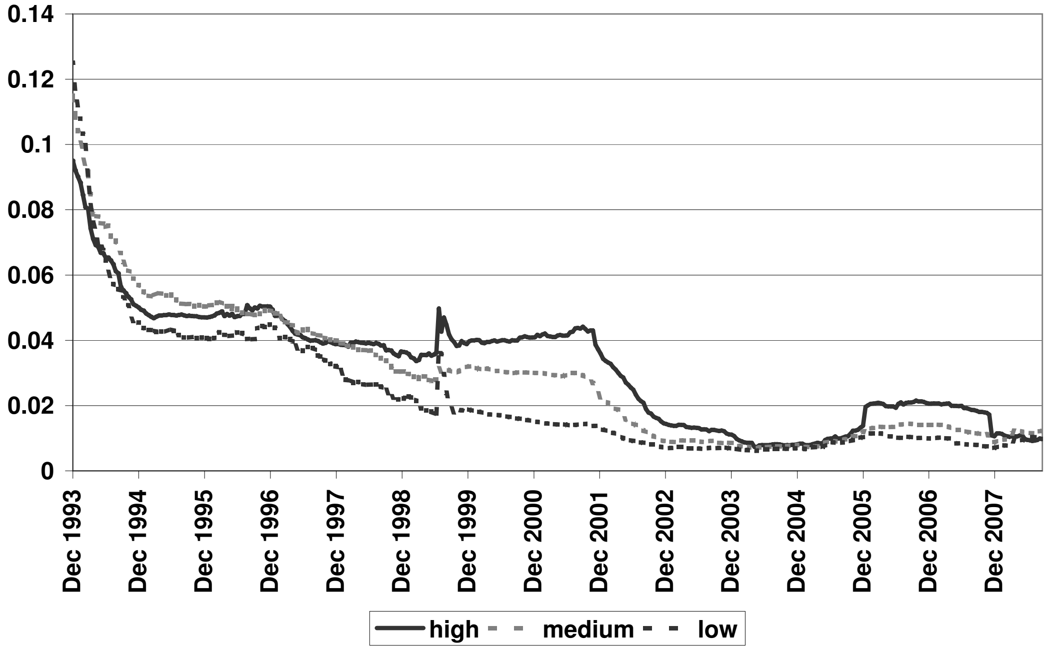

Figure A-1: Evolution of mean standard errors of βs of EMU countries.

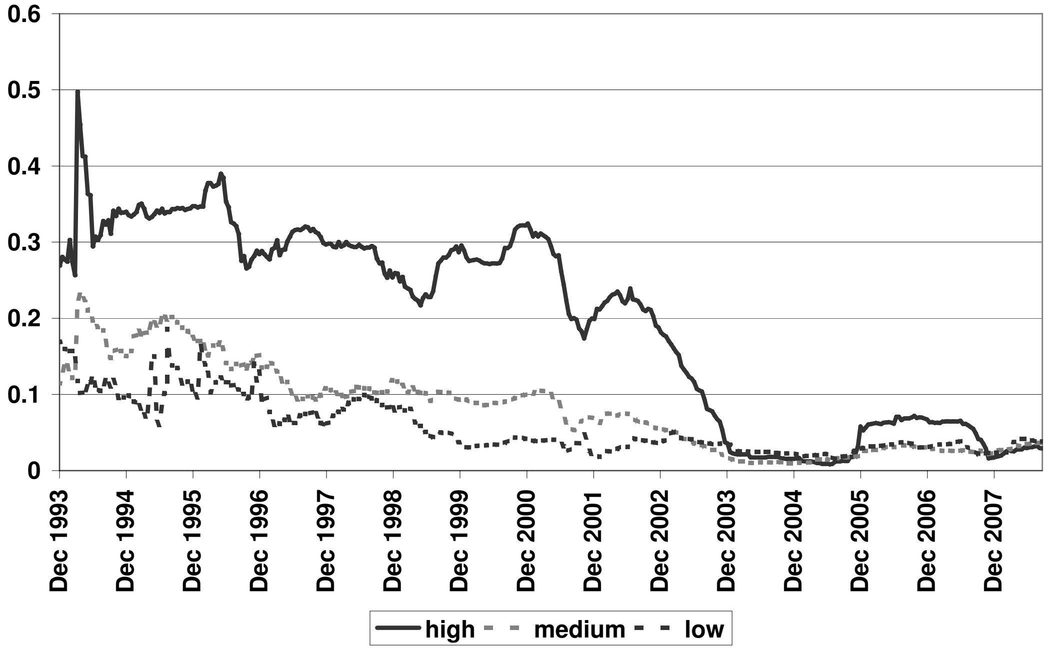

Figure A-2: Evolution of standard deviation of βs of EMU countries. Data for Greece included as of 2001. Yield data are **not** swap adjusted.

Table A-1: Maximum Wald F-statistic with high frequency data, 1992-2007

	date	F
aus	5/16/1996	327.9826
bel	9/19/2000	312.6054
esp	11/23/1998	524.2919
fin	9/18/2000	164.1811
fra	10/31/2000	514.4295
grc	3/20/2001	368.1359
irl	12/7/2000	853.7301
ita	4/4/1997	44.67071
nld	9/18/2000	1134.715
prt	12/7/1999	450.4578
uk	12/11/2000	532.8975
us	7/18/2000	455.1495

Notes: Maximal F-value for Quandt-Andrews unknown breakpoint test. Data are not swap adjusted.

Table A-2: Maximum Wald F-statistic with low frequency data, 1992-2007

	date	F
aus	9/22/1998	442.40
bel	12/9/1996	24.32
esp	5/2/1996	44.75
fin	6/28/1995	30.49
fra	8/26/1999	26.13
grc	12/10/2001	203.01
irl	3/16/1995	16.81
ita	3/14/1996	82.76
nld	8/2/1999	75.38
prt	9/29/1998	34.60
uk	7/21/2003	10.69
us	1/15/2001	360.01

Notes: Maximal F-value for Quandt-Andrews unknown breakpoint test. Data are not swap adjusted.

Table A-3: Maximum Wald F-statistic with low frequency data, 2003-2008

	date	F
aus	8/28/2007	52.33
bel	7/17/2007	49.01
esp	6/23/2005	74.32
fin	4/24/2003	58.19
fra	7/17/2007	69.68
grc	7/17/2007	109.70
irl	12/3/2007	63.15
ita	7/18/2007	116.5
nld	7/12/2007	62.23
prt	6/22/2007	113.60
uk	4/15/2003	15.19
us	12/06/2004	72.04

Notes: Maximal F-value for Quandt-Andrews unknown breakpoint test. Data are not swap adjusted.

B Tables

Table B-1: Static Bond Market Integration: Full sample

Low frequency integration						
	yield (not adjusted)			**swap adjusted yield**		
	EA	UK	US	EA	UK	US
	A	B	C	D	E	F
yield de	**0.96**	**0.95**	**0.83**	**0.94**	**0.96**	**0.82**
	256.29	71.13	55.33	428.47	129.58	99.1
N	40,637	4,293	4,293	37,409	4,293	4,293
R2	0.62	0.54	0.42	0.83	0.80	0.70
Medium frequency integration						
	yield (not adjusted)			**swap adjusted yield**		
	EA	UK	US	EA	UK	US
	A	B	C	D	E	F
yield de	**0.86**	**0.78**	**0.67**	**0.88**	**0.81**	**0.61**
	195.06	49.94	34.28	216.17	66.18	36.26
N	40,637	4,293	4,293	37,409	4,293	4,293
R2	0.48	0.37	0.22	0.56	0.51	0.23
High frequency integration						
	yield (not adjusted)			**swap adjusted yield**		
	EA	UK	US	EA	UK	US
	A	B	C	D	E	F
yield de	**0.65**	**0.34**	**0.03**	**0.61**	**0.37**	**-0.13**
	138.22	18.50	1.59	107.54	21.47	-5.44
N	40,637	4,293	4,293	37,409	4,293	4,293
R2	0.32	0.07	0.00	0.24	0.10	0.01

Notes: Regression from equation (8). Full sample from January 1992 to October 2008. Dependent Variable is the (swap adjusted) local yield. Fixed effects panel regression for the euro area, single equation estimation for integration with the UK and US. All yields are filtered into high, medium and low frequencies. Daily observations. t-values are reported below the parameter; all are significant on the 1% level (bold print).

Table B-2: Static Bond Market Integration: EMU member states

Low frequency integration, yields not adjusted	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.92**	**0.96**	**1.01**	**0.98**	**0.95**	**0.87**	**0.96**	**1.04**	**0.95**	**0.93**
	186.19	138.03	57.59	63.73	125.13	88.84	101.11	58.16	199.58	78.58
N	4,293	4,293	4,293	4,293	4,293	2,402	4,293	4,293	4,293	3,891
R2	0.89	0.82	0.44	0.49	0.78	0.77	0.70	0.44	0.90	0.61
Medium frequency integration, yields not adjusted	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.89**	**0.89**	**0.89**	**0.92**	**0.85**	**0.91**	**0.77**	**0.94**	**0.82**	**0.78**
	143.48	98.93	49.78	53.79	70.83	96.93	60.21	44.99	96.20	53.65
N	4,293	4,293	4,293	4,293	4,293	2,402	4,293	4,293	4,293	3,891
R2	0.83	0.70	0.37	0.40	0.54	0.80	0.46	0.32	0.68	0.43
High frequency integration, yields not adjusted	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.81**	**0.73**	**0.58**	**0.73**	**0.53**	**0.87**	**0.41**	**0.86**	**0.48**	**0.58**
	108.22	71.11	42.99	44.17	33.72	88.06	26.51	47.34	39.04	31.16
N	4,293	4,293	4,293	4,293	4,293	2,402	4,293	4,293	4,293	3,891
R2	0.73	0.54	0.30	0.31	0.21	0.76	0.14	0.34	0.26	0.20

Notes: Regression from equation (8). Full sample from January 1992 to October 2008. Dependent Variable is the local yield. All yields are filtered into high, medium and low frequencies. Daily observations. t-values are reported below the parameter; all are significant on the 1% level (bold print).

Table B-3: Static Bond Market Integration: EMU member states (2)

Low frequency integration, swap adjusted yields										
	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.99**	**0.97**	**0.92**	**0.98**	**0.92**	**0.83**	**0.98**	**0.90**	**0.95**	**0.97**
	271.08	177.86	112.94	161.74	159.91	87.21	155.89	102.01	190.31	114.80
N	3,505	4,293	4,293	3,399	4,293	2,402	3,094	4,293	4,293	3,544
R2	0.95	0.88	0.75	0.89	0.86	0.76	0.89	0.71	0.89	0.79
Medium frequency integration, swap adjusted yields										
	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.93**	**0.88**	**0.90**	**0.90**	**0.87**	**0.87**	**0.83**	**0.90**	**0.81**	**0.88**
	158.62	100.24	50.28	79.84	77.43	80.96	61.96	58.42	87.29	57.18
N	3,505	4,293	4,293	3,399	4,293	2,402	3,094	4,293	4,293	3,544
R2	0.88	0.70	0.37	0.65	0.58	0.73	0.55	0.44	0.64	0.48
High frequency integration, swap adjusted yields										
	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.86**	**0.63**	**0.50**	**0.63**	**0.50**	**0.82**	**0.52**	**0.76**	**0.42**	**0.53**
	93.25	52.24	22.69	37.74	30.57	66.47	27.91	35.25	30.40	24.78
N	3,505	4,293	4,293	3,399	4,293	2,402	3,094	4,293	4,293	3,544
R2	0.71	0.39	0.11	0.30	0.18	0.65	0.20	0.22	0.18	0.15

Notes: Regression from equation (8). Full sample from January 1992 to October 2008. Dependent Variable is the swap adjusted local yield. All yields are filtered into high, medium and low frequencies. Daily observations. t-values are reported below the parameter; all are significant on the 1% level (bold print).

Table B-4: Static Bond Market Integration: EMU member states (3)

Low frequency integration, yields not adjusted, early sample										
	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.82**	**0.95**	**1.07**	**0.96**	**0.96**	NA	**0.96**	**1.14**	**0.92**	**0.88**
	81.62	62.90	26.65	27.52	60.83		45.90	28.16	93.63	30.27
N	1,777	1,777	1,777	1,777	1,777		1,777	1,777	1,777	1,375
R2	0.79	0.69	0.29	0.30	0.68		0.54	0.31	0.83	0.40
Medium frequency integration, yields not adjusted, early sample										
	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.79**	**0.85**	**0.82**	**0.87**	**0.75**	NA	**0.65**	**0.97**	**0.71**	**0.60**
	64.18	44.79	20.21	22.59	32.68		24.24	20.29	45.36	19.40
N	1,777	1,777	1,777	1,777	1,777		1,777	1,777	1,777	1,375
R2	0.70	0.53	0.19	0.22	0.38		0.25	0.19	0.54	0.22
High frequency integration, yields not adjusted, early sample										
	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.67**	**0.57**	**0.26**	**0.56**	**0.27**	NA	**0.10**	**0.94**	**0.18**	**0.35**
	52.16	29.72	9.88	16.70	9.76		3.73	24.41	8.94	10.09
N	1,777	1,777	1,777	1,777	1,777		1,777	1,777	1,777	1,375
R2	0.61	0.33	0.05	0.14	0.05		0.01	0.25	0.04	0.07

Notes: Regression from equation (8). Dependent Variable is the local yield. Early sample from January 1992 to December 1998. All yields are filtered into high, medium and low frequencies. Daily observations. t-values are reported below the parameter; all are significant on the 1% level (bold print).

Table B-5: Static Bond Market Integration: EMU member states (4)

Low frequency integration, yields not adjusted, late sample										
	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**1.01**	**0.97**	**0.97**	**1.00**	**0.95**	**0.87**	**0.96**	**0.96**	**0.98**	**0.96**
	313.08	250.55	249.81	246.50	159.68	88.84	202.65	199.08	266.72	160.00
N	2,516	2,516	2,516	2,516	2,516	2,402	2,516	2,516	2,516	2,516
R2	0.97	0.96	0.96	0.96	0.91	0.77	0.94	0.94	0.97	0.91

Medium frequency integration, yields not adjusted, late sample										
	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.97**	**0.93**	**0.94**	**0.96**	**0.93**	**0.91**	**0.88**	**0.91**	**0.91**	**0.90**
	187.62	135.75	146.76	135.40	78.63	96.93	90.44	133.94	103.60	69.81
N	2,516	2,516	2,516	2,516	2,516	2,402	2,516	2,516	2,516	2,516
R2	0.93	0.88	0.90	0.88	0.71	0.80	0.76	0.88	0.81	0.66

High frequency integration, yields not adjusted, late sample										
	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
	A	B	C	D	E	F	G	H	I	J
yield de	**0.95**	**0.88**	**0.88**	**0.88**	**0.77**	**0.87**	**0.70**	**0.79**	**0.76**	**0.77**
	119.91	95.33	101.68	81.68	48.60	88.06	47.70	78.07	60.01	37.97
N	2,516	2,516	2,516	2,516	2,516	2,402	2,516	2,516	2,516	2,516
R2	0.85	0.78	0.80	0.73	0.48	0.76	0.48	0.71	0.59	0.36

Notes: Regression from equation (8). Late sample from January 1999 to October 2008. Dependent Variable is the local yield. All yields are filtered into high, medium and low frequencies. Daily observations. t-values are reported below the parameter; all are significant on the 1% level (bold print).