Proposing an Alternative to the European Central Bank's Fiscal Convergence Criteria

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Abstract

The recent onset of the sovereign debt crisis in the Eurozone has brought the viability of the Eurozone as a currency area into question. The unsustainable debt and deficit balances accumulated by several Eurozone nations since the adoption of the common currency in 1999, and the consequent incidence of high levels of sovereign default risk in the euro-area, indicate that the fiscal convergence criteria employed by the European Central Bank to monitor the fiscal discipline and sustainability of its members have been largely ineffectual. This paper draws upon the theory of optimum currency areas, and proposes a set of business cycle convergence criteria that can be employed as an alternate means to minimize the risk of fiscal imbalances and sovereign default. Economic theory suggests that a currency union with convergent business cycles will be insulated from asymmetric shocks, removing the need for countries to rely wholly on their fiscal policies when dealing with negative shocks (as would be the case in a currency union with non-synchronous countries suffering from negative asymmetric shocks). Therefore, as the risk of fiscal imbalances is minimized, a currency union with synchronous business cycles is expected to have low incidences of sovereign default risk. This paper tests this economic intuition empirically, and employs a multivariable panel regression model to determine the relationship between business cycle convergence and sovereign default risk (proxied using sovereign yield spreads). The regressions reveal that the degree of business cycle convergence is one of the main determinants of yield differentials, and the relationship between the two is negative (as expected). The consistency of the results to numerous robustness checks provide a strong case for substituting the current fiscal convergence criteria with measures that assess the degree of business cycle convergence.

JEL Classification : E32, E43, F34, F44, F45

Keywords : Optimum Currency Area, Cycle Convergence, Sovereign Default Risk

1. Introduction

A currency area is defined as an economic union that adopts a single currency within its geographic perimeter, and maintains a flexible exchange rate regime with the rest of the world. An optimum currency area (OCA) is a currency area for which the costs of relinquishing monetary policy autonomy, and the ability to use exchange rate adjustments, are outweighed by the benefits of adopting a single currency. The Eurozone is the most readily available and widely studied example of a currency union in the modern world, and has therefore been chosen as the currency area of focus for this thesis.

At the time of its formation, critics of the Eurozone had claimed that the costs of entering the Eurozone were substantially greater than the benefits conferred by the common currency union. Participation in the Eurozone would entail an erosion of the the tools for national economic management via the loss of autonomy with respect to monetary and exchange rate policies (Cohen 1992 [7]). Since a unified monetary policy cannot meet the needs of all economies in the currency union, and is instead likely to be geared towards the requirements of the average member state, critics argued that the European Central Bank's (ECB) monetary policy stance would be far from optimal for a sizable number of Eurozone members. The loss of autonomous monetary and exchange rate policies would be most detrimental for member states whose economic structures and business cycles differed significantly from those of the rest of the currency union; this is because a unified monetary and exchange rate policy, which is designed to accommodate the needs of the average or core member states, would be least optimal for these member states given their divergence from the rest of the union. Critics argued that the Eurozone was not sufficiently structurally convergent, and that this lack of cycle convergence would lead to the divergent member states being susceptible to asymmetric shocks. They also argued that the budgetary regulations put in place by the European Monetary Union (EMU) to ensure the fiscal responsibility of its members would exacerbate and magnify the adverse

effects of such asymmetric external shocks. These fiscal regulations would prevent the member states affected by these asymmetric shocks from effectively employing the only means of adjustment left to them, i.e. fiscal policy tools. Since a substantial fiscal transfer mechanism, that redistributes resources and income from unaffected member states to affected ones, is also lacking within the Eurozone, the ability of divergent Eurozone members to effectively recover from asymmetric shocks would be further compromised. Given all of the above, the establishment of the Eurozone had been likened to a leap in the dark that could have potentially destructive implications (Eichengreen, 1990, 1992, 1993).

The onset of the sovereign debt crisis in the Eurozone has brought the optimality of the Eurozone as a currency area back into the spotlight. The lack of fiscal discipline, and the accumulation of unsustainable debts and deficits by a large number of Eurozone countries, has culminated in a sovereign debt crisis which started from Greece in autumn 2009, and gradually engulfed the whole of the European Economic and Monetary Union (EMU), and particularly the so-called periphery EMU economies. The periphery economies were running large deficits when the financial crisis struck, and the deterioration in their fiscal balances was compounded by the fiscal cost of the measures required to contain the fallout from the crisis. The worsening fiscal balances of these countries heightened the credit-risk associated with them, and caused their bond yields to soar as markets began to price a higher probability of default into their yields. To prevent the incidence of actual sovereign default in the euro-area, Greece, Ireland, and Portugal were forced in 2010-11 to resort to financial rescue schemes organised by the European Union (EU), the European Central Bank (ECB), and the International Monetary Fund (IMF) (in the context of the newly-created mechanism, the European Financial Stabilisation Facility (EFSF)). The second half of 2011 also saw Spanish and Italian government bonds come under significant market pressure. More recently, the drama surrounding the Greek negotiations with the troika, which culminated in Greece receiving its third bailout in five years, has shown that the Eurozone is still very much in the throes of its debt crisis,

and that the risk of sovereign default is a very real one in the euro-area.

Given the deterioration of fiscal balances and spike in sovereign default risk in the Eurozone periphery, the European Central Bank's ability to ensure fiscal responsibility (and thereby prevent sovereign default) amongst its members, has been called into question. A large portion of the blame has been levied on the fiscal convergence criteria that the ECB utilizes as its chief means of ensuring fiscal discipline. The criteria are outlined below:

- The country's budget deficit must not be regarded as excessive by the European Council, excessive being defined as deficits greater than 3 % of GDP for reasons other than those of a temporary or exceptional nature;
- The country's national debt must not be excessive, defined as above 60% of GDP and not declining at a satisfactory pace

The fiscal convergence criteria were meant to act as a check on the fiscal policies of member states, which are decentralized unlike the common monetary policy. They were aimed at preventing large government debts, which could pose a threat to price stability within the monetary union since they put pressure on the central bank to create surprise inflations in order to reduce the real burden of the debt (De Grauwe, 1997 [23]). The budget deficit and debt-to-GDP restrictions were also meant to prevent Eurozone interest rates from being driven up by high government debt ratios, which could act as a dampener on investment and economic growth in the union.

As recent experience has shown, the ECB's fiscal convergence criteria have by and large, failed to achieve their objectives. The lack of strict enforcement of these criteria following ascension into the Eurozone has meant that several member states have consistently breached the debt and deficit ratios after gaining entry into the union. This static nature of the fiscal convergence criteria, whereby potential entrants' qualifications for becom-

ing members of the Eurozone are assessed by their economic performance only at the point of entry, has come under heavy criticism since a dynamic measure of the economic performance of potential entrants is required to assess the medium to long-run sustainability of the Eurozone. The fiscal criteria have also come under criticism for setting arbitrary ceilings on deficit and debt levels (De Grauwe, 1994), for hampering the ability of member states to use their fiscal policies as a means of adjustment (which further accentuates the adverse consequences resulting from the loss of autonomous monetary and exchange rate policies), and for promoting an over- disinflationary and recession-biased stance (Buiter, Corsetti, and Roubini 1992). The arguments forwarded against the Maastricht convergence criteria will be covered in greater detail in the literature review section.

The increasing incidence of sovereign default risk in the Eurozone, and the ineffectiveness of the fiscal convergence criteria that have lead to it, has made it apparent that the ECB needs to devise a new means of ensuring fiscal discipline amongst its members. The theory on optimum currency areas forwards one such means, specifically the ensuring of business cycle convergence between potential entrants (and current ones) and the rest of the union. As mentioned earlier, the primary disadvantage of entering a currency union is the loss of autonomous fiscal and monetary policy. This loss exacerbates the adverse effects of the asymmetric shocks that affect the divergent member states, since these countries have to rely solely on expansionary fiscal measures to promote growth and employment during such downturns. This increased fiscal spending is likely to lead to a deterioration of fiscal balances, and increased government debt and deficit ratios. The increased debt balances, in turn, are likely to reduce the nation's credit worthiness, and lead to an increase in sovereign yields as investors begin to fear a higher risk of default. Thus, unsustainable debt balances and excessively high sovereign yields, two of the primary phenomenon the fiscal convergence criteria had been introduced to prevent, are most likely to occur in currency unions where a significant proportion of the member states have divergent business cycles. On the flip side, convergent business cycles are

likely to reduce the incidence of asymmetric shocks, and consequently the deterioration of fiscal balances that arise as a result of the lack of policy tools. Improving fiscal balances, in turn, are likely to reduce the sovereign default risk associated with Eurozone member nations. Assessing business cycle convergence as an entry criterion would also allow a more dynamic and thorough assessment of a potential entrants compatibility for the Eurozone since it assesses convergence levels that take a significant period of time to achieve (for instance, it usually takes a sustained regime of pro-trade policy measures in order to increase the economic openness of a nation), and are impossible to bring about through one-off special measures. Finally, such a convergence criterion does not impose arbitrary nominal convergence levels (as with the fiscal convergence criteria), and instead provides a sound economic basis that assesses the optimality of a currency union based upon how well the constituent member states can cope with the loss of autonomous monetary and exchange rate polices (De Grauwe, 1994).

This thesis aims to test the economic intuition highlighted above, and empirically determine the relationship between business cycle convergence and the level of sovereign default risk. Specifically, differentials in a proxy for the level of sovereign default risk (namely, differentials between the 10-year government bond yields of the countries in question) will be regressed against proxies for the degree of business cycle convergence between the countries. If the economic intuition presented above holds, we would expect to see a negative relationship between the yield differential and the level of business cycle convergence. The aim is to ultimately highlight the relevance of business cycle synchrony as a predictor of future fiscal distress, and thereby provide a more economically sound criteria to assess the suitability of potential and current members for the Eurozone such that future incidences of sovereign default risk (in the currency-area) are minimized.

Overall, business cycle convergence has been found to be a very strong predictor of yield differentials, with increases in cycle convergence leading to a reduction in yields

(as expected). Since the relationship holds up after being put through numerous robustness tests, we are relatively confident in forwarding cycle convergence as a means to vet currency-area members, and thereby prevent the incidence of fiscal irresponsibility and sovereign default risk in the currency-area.

The following section provides an overview of the current literature on EMU government bond yields. The methodology section outlines the baseline empirical model being estimated, presents the independent, dependent, and control variables being included in the model, and provides the theoretical reasoning behind the expected relationship between these variables. The results section presents the data used in the estimation models, and outlines the results of the regression estimations. Finally, the economic interpretation section presents the economic intuition behind the relationships uncovered in the results section, and empirically explores these relationships further

2. Literature Review

Since government bond yield differentials (used as a proxy for the level of sovereign default risk) are the primary variables of interest in this study, the literature focused upon here relate mostly to the existing studies on EMU government bond yields. Most studies on government bond yields model them on three main variables (see e.g. Manganelli and Wolswijk, 2009). The first of these is an international risk factor that captures the level of perceived financial risk; indexes of US stock market implied volatility, or the spread between the yields of US corporate bonds and US treasury bills, are usually used as proxies for this risk factor. The second variable is credit risk, which captures the probability of default on the part of the sovereign borrower; this is usually approximated using indicators of past fiscal performance, or projections of future fiscal performance. Ardagna (2004) and Afonso and Rault (2015) have suggested that markets attach a higher degree of credit risk at times when fiscal positions are loosening, or when there is a shift in

fiscal policy expectations (see e.g. Elmendorf and Mankiw, 1999). The third variable is the level of liquidity risk attached to the government bond; this relates to the size and depth of the sovereign bonds market, and captures the possibility of capital losses due to early liquidation. Sovereign bond liquidity is usually approximated using bid-ask spreads, transaction volumes, etc (see e.g. Favero et al., 2010, Arghyrou and Kontonikas, 2012).

Prior to the onset of the global financial crisis, the nature of the relationship between the three aforementioned variables, and European government bond yields, wasn't entirely determined conclusively. However, the consensus amongst pre-financial crisis studies was that the international risk factor was an important determinant of bond yields and spreads, as suggested by studies including Codogno et al. (2003), Geyer et al. (2004), Barrios et al. (2009), Sgherri and Zoli (2009), Manganelli and Wolswijk (2009) and Favero et al. (2010). Periods of tightening financial conditions (see e.g. Haugh et al., 2009; Barrios et al., 2009) were accompanied by a strengthening of the effect of the international risk factor on European yields; the effect was also stronger for countries with higher debt and deficit levels (see e.g. Codogno et al., 2003).

It was also generally agreed upon that government bond yields priced in the associated sovereign credit risk, as suggested by Codogno et al. (2003), Faini (2006), Bernoth et al. (2004), Bernoth and Wolff (2008), Manganelli and Wolswijk (2009) and Schuknecht et al. (2009). However, Manganelli and Wolswijk (2009) further argued that despite the pricing in of sovereign credit risk into government bond yields, the effect wasn't strong enough to prevent unsustainable national fiscal policies. Furthermore, Hallerberg and Wolff (2008) argued that the introduction of the euro served to weaken the effect of fiscal performance on EMU sovereign bond yields. Therefore, on the whole, the evidence points towards the existence of a subdued level of sovereign default risk (as measured via the effect of fiscal performance on yields) in the Eurozone prior to the onset of the financial crisis (see e.g. Bernoth et al.,2004).

The most disputed relationship in the pre-financial crisis studies is the one between gov-

ernment bond yields and the level of liquidity risk. Codogno et al. (2003), Bernoth et al. (2004), and Pagano and Von Thadden (2004), found that Euro-government bond spreads were affected by liquidity risk to a limited extent. On the other hand, Gomez-Puig (2006), Beber et al. (2009), and Manganelli and Wolswijk (2009) found that the effect of liquidity on EMU yield spreads was strongly significant. This effect was found to be stronger when financial conditions were tight, or interest rates were higher, indicating that investors were more willing to trade lower yields for higher liquidity.

More recent, post-financial crisis studies on European government bond yields have found that the divergence in European sovereign bond spreads has been largely driven by the aforementioned increased international risk factor. The domestic banking sector has played a crucial role in this process, as determined by the studies of Candelon and Palm (2010), Gerlach et al. (2010) and Acharya et al. (2011). International banking risk has transformed to sovereign risk through two primary avenues. Firstly, declines in banking liquidity reduced the level of private investment in the economy; this, in turn, induced recessions and increasing fiscal balances. Secondly, European governments have had to be actively involved in recapitalizing banks using government funds; this process increased fiscal liabilities, and thereby increased the level of sovereign risk. Thus, as the international risk factor increased following the financial crisis, and Eurozone banks become affected by the deteriorating financial conditions abroad, this effect was transferred to the government and affected sovereign yields. The effect of the international risk factor on EMU yields, via the financial/banking sector, following the crisis has been established by the works of Attinasi et al. (2009), Sgherri and Zoli (2009), Mody (2009), Barrios et al. (2009), Gerlach et al. (2010), Schuknecht et al. (2010), Caceres et al. (2010) and Acharya et al. (2011)

Recent studies have also found that fiscal and macro-imbalances have been more heavily penalized by markets following the onset of the crisis. Arghyrou and Kontonikas (2012)

found that the post-crisis markets have been pricing several new factors, notably fiscally related, into the determination of Eurozone yield spreads. Bernoth and Erdogan (2010) also reported similar results. Markets have also been pricing the interaction of fiscal imbalances with the international risk factor to a much greater extent following the crisis (see e.g. Barrios et al., 2009; Haugh et al., 2009; Manganelli and Wolswijk, 2009; Schuknecht et al., 2010). This increased level of discrimination on the grounds of fiscal performance is one of the major factors explaining the recent observed divergence in EMU spreads (see Favero and Missale, 2011).

The post-crisis literature on have also discovered the existence of strong cross-country contagion/spill-over effects in the market for Eurozone sovereign bonds. This effect is strongest in the case of less-well rated sovereigns (see e.g. Caceres et al. 2010; Arghyrou and Kontonikas, 2012; De Santis, 2012; Favero and Missale, 2011). In contrast, and in line with the pre-crisis findings, the role of liquidity risk on Eurozone sovereign yields was found to be limited (see e.g. Attinasi et al., 2009; Sgherri and Zoli, 2009; Barrios et al., 2009; Haugh et al., 2009; Arghyrou and Kontonikas, 2012; De Santis, 2012; Favero and Missale, 2011).

From the variables outlined above, the ones that have been found to be significant determinants of yield spreads in the Eurozone have been included as explanatory variables in the regression model. Namely, measures of the international risk factor, and sovereign credit risk have been included. Other tests have also been run to test the potential relationships (such as that between yield differentials and macro-imbalances, following the following the financial crisis) presented above.

The current literature on the other primary variable of interest, namely the degree of business cycle convergence within the Eurozone, is relatively consensual. Studies such as those done by Artis and Zhang (1997,1999), and Massmann and Mitchell (2004), suggest

that since the early 1980s, the average bilateral business cycle correlation between the 12 euro area countries has increased significantly, and since the advent of the euro, business cycles have become even more closely related. Giannone, Lenza and Reichlin (2008), on the other hand, identified two groups, 'core' and 'non-core', in their paper on Eurozone business cycles; in the core group, levels of GDP per capita were found to be similar, and growth rates were highly synchronised; among countries in the periphery, however, both levels and growth rates were found to be very heterogeneous and the linkages between each of these countries and the rest of the euro area were relatively weak.

While numerous works (such as the ones cited above) have focused on determining the degree of cycle convergence, there haven't been any that have attempted to empirically establish the relationship between business cycle convergence and yield spreads within the Eurozone. Thus, this paper adds to the current economic literature on the Eurozone by bringing together two relatively disparate branches of it.

3. Methodology

This thesis employs a multivariate regression model to identify the strength and nature of the relationship between the degree of business cycle convergence and yield differentials. The aim is to determine whether business cycle convergence is positively/negatively correlated with yield differentials, and whether the degree of business cycle synchrony is statistically significant as a predictor of yield differentials. As stated earlier in the paper, the yield differential is being used as a proxy for the relative difference in the market-perceived risk of default between the two countries under consideration. Thus, the ultimate aim of this thesis is to study how relative levels of sovereign default risk are linked to the degree of business cycle convergence.

Dependent variable

The dependent variable being used in the model is the absolute value of the yield differential on 10-year sovereign bonds for the two countries under consideration. There are a number of advantages of using such a market-based approach as a proxy for the difference in sovereign default risk levels between countries. Firstly, under the assumption of market efficiency, yields are forward-looking and capture all publicly available information on the default risk of an obligor. Numerous studies on the determinants of sovereign yield spreads in the Eurozone have confirmed this, and found that sovereign credit risk, reflecting the probability of default on behalf of a sovereign borrower, is priced into government bond yields (Codogno et al. (2003), Faini (2006), Bernoth et al. (2004), Bernoth and Wolff (2008), Manganelli and Wolswijk (2009) and Schuknecht et al. (2009)). Therefore, the yield differential between two countries should, theoretically, price in the effects of all factors that influence sovereign default risk (such as fiscal balances, current account balances, etc), and accurately reflect the difference in the default probabilities (premia) the market attaches to the two countries.

Secondly, the method of determining the market implied probability of default through the use of yield spreads is well established; the spread between corporate yields and benchmarks such as the LIBOR or US 10-year Treasury yield has been shown to be a good indicator/predictor of future default risk in corporations (Gapen, 2008). It can be argued that individual nations in a currency area are similar to corporations in the sense that unlike non-currency area members, they do not have an autonomous monetary policy, and therefore have fixed reserves of currency with which to meet their debts, i.e. countries in a currency area are not capable of printing new currency in order to meet their debts. Thus, it follows from the above justifications that sovereign yields can function as a suitable proxy for the market-perceived level of sovereign default risk.

The figure below displays the 10-year government bond yields for Germany and other Eurozone members. As can be seen below, the general trend has been a convergence

in yields up until the onset of the financial crisis, following which yields have diverged considerably.

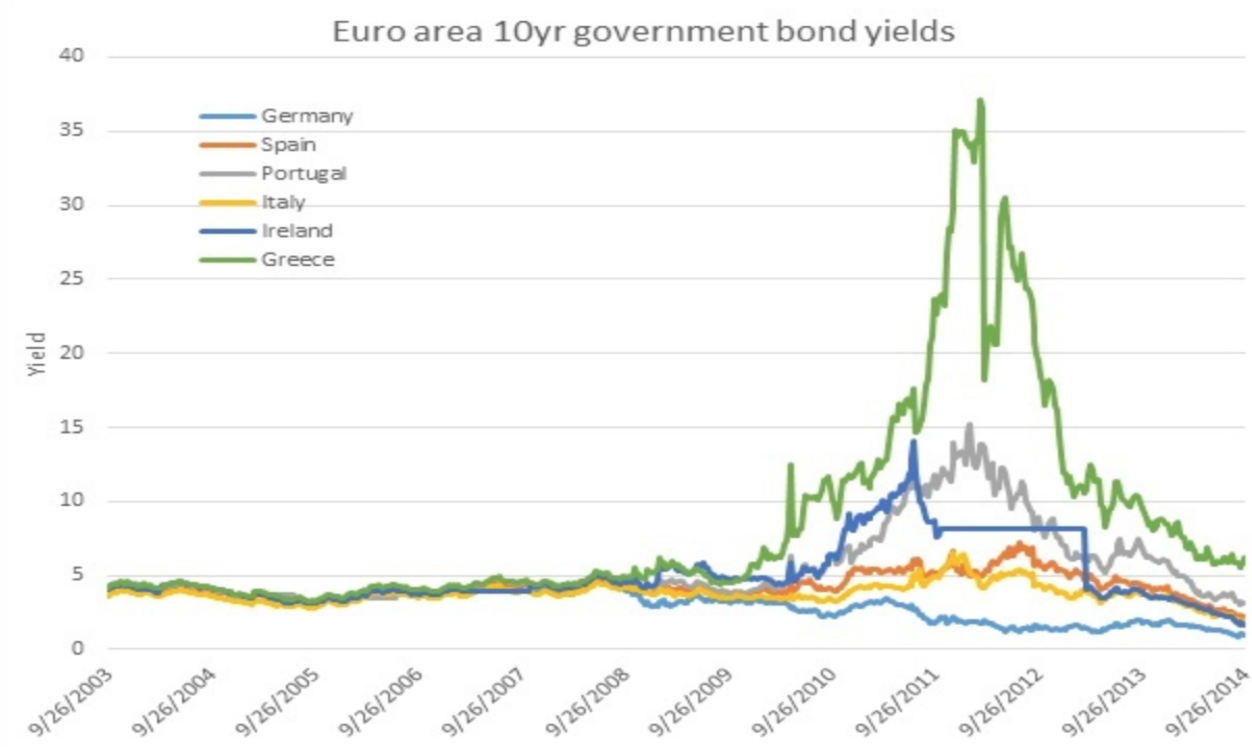


Figure 1

Independent Variables

Business Cycle Convergence : The primary independent variable of interest is the level of business cycle convergence. Since there is no obvious single measure of business cycle convergence, a number of proxies that are well established in the literature on cycle convergence are used.

The first of these proxies is the bilateral correlation between real activity in the two countries under question. The bilateral correlation method has been employed in numerous studies on European business cycle convergence, such as those by Uwe Bower and Catherine Guillemineau (ECB, 2006) and by Stphane Des and Nico Zorell (ECB, 2011). In order to compute these correlations, real GDP (after the natural log transformation),

which is a standard measure of real economic activity, is de-trended so as to extract the cyclical or business-cycle component from it. The de-trending is achieved by using the well-known Hodrick-Prescott(HP) filter (with the standard annual smoothing parameter of 6.25). After de-trending the real GDP values over the entire data sample, bilateral correlation coefficients are estimated for each country-pair. Each correlation coefficient is computed using three years' worth of de-trended real GDP data; this has been done in line with the general consensus that the average duration of business cycles tend to last between 3-5 years. Thus, for instance, one of the data points used in the analysis will be the correlation between (HP-de-trended) Austrian and Belgian real GDP over the 1995-1997 period.

The second proxy that has been used as a measure of the degree of business cycle convergence is the absolute differential of real GDP (natural-log transformed) values between the two countries under consideration. Finally, the absolute value of the differential in unemployment rates (which is another standard measure of differentials in real economic activity) between the two countries has been used as the third proxy for the degree of business cycle convergence.

Sovereign debt has been shown to become riskier during periods of economic slowdown (Alesina et al. (1992), Bernoth et al., (2004)). Therefore, it is expected that an increase in the growth rate differential between two countries will lead to an increase in the yield differential. Thus, we expect the bilateral correlation between real GDP values to be negatively correlated to the yield differential, and the absolute differentials between real GDP values and unemployment rates to be positively correlated to the yield differential. Comparing the results obtained using the above proxies will serves as an appropriate robustness check for the determined relationship between business cycle convergence and yield differentials.

The figure below plots the percentage point change in the unemployment rate (one of the measures of cycle convergence) against the number of months following the onset of the financial crisis in 2008. As can be seen, there was a significant divergence in the unemployment rate percentage changes following the crisis; this indicates an increasing level of cycle divergence, which corresponds with the higher, post-crisis, yield divergence seen in Figure 1. The two figures (1 and 2) combined display the predicted negative relationship between cycle convergence and yield differentials, with decreased cycle convergence associated with an increase in yield differentials.

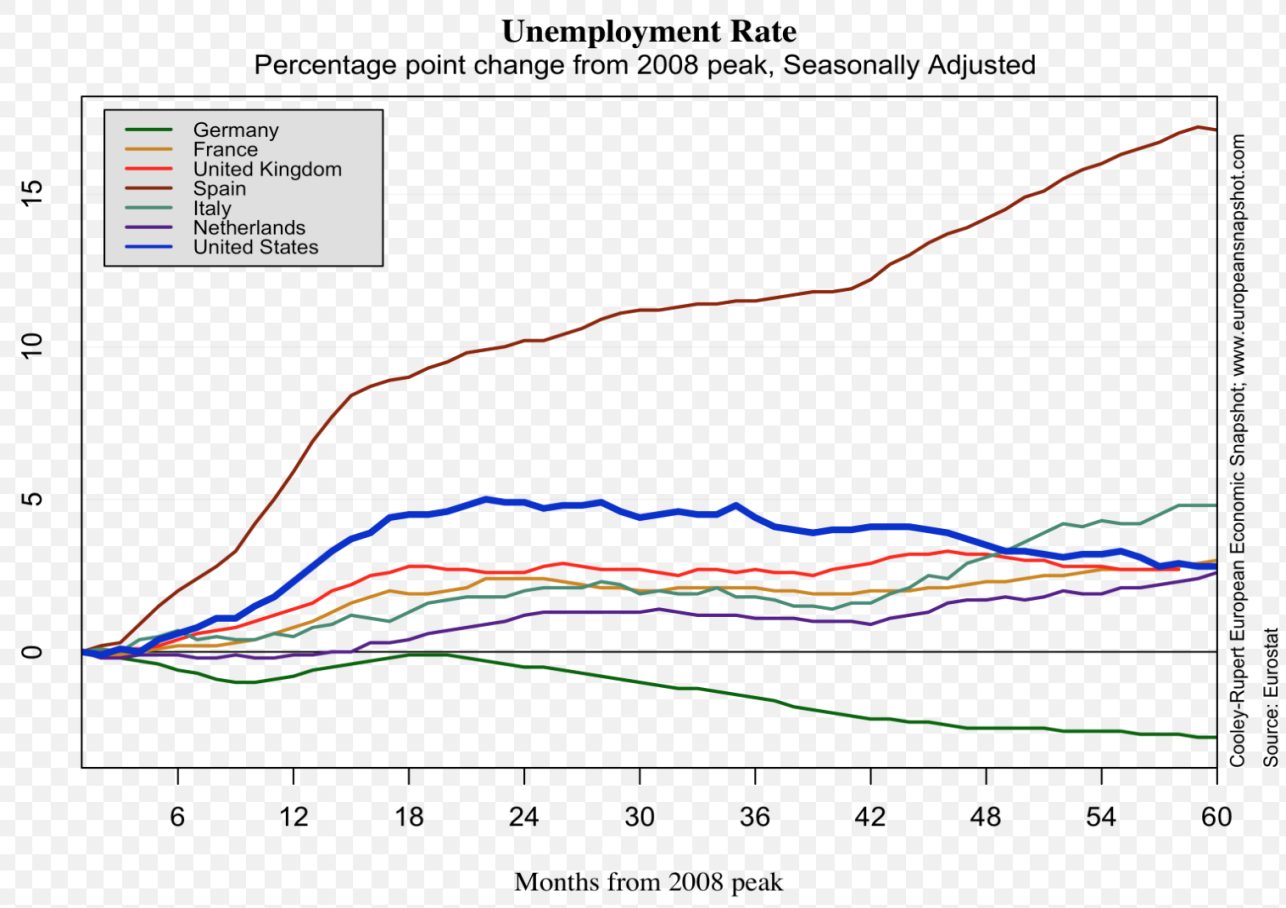


Figure 2

Differential in Fiscal Position Variables: The absolute differential between the countries' Debt-to-GDP ratios, and deficit/surplus-to-GDP ratios, have been included as explanatory variables in the regression model, following the example of a number of recent

studies on EMU government bond yield spreads (Attinasi et al. (2009), Sgherri and Zoli (2009), Gerlach et al. (2010) and Favero and Missale (2011). These variables provide a measure of the differential in credit quality between the countries under question. Since high debt-to-GDP/ deficit-to-GDP values imply increased credit risk and increased bond spreads, it is expected that an increase in the value of these differentials will be associated with an increase in the yield differential (positive correlation).

Figure 3: 10-year sovereign bond yields and government debt

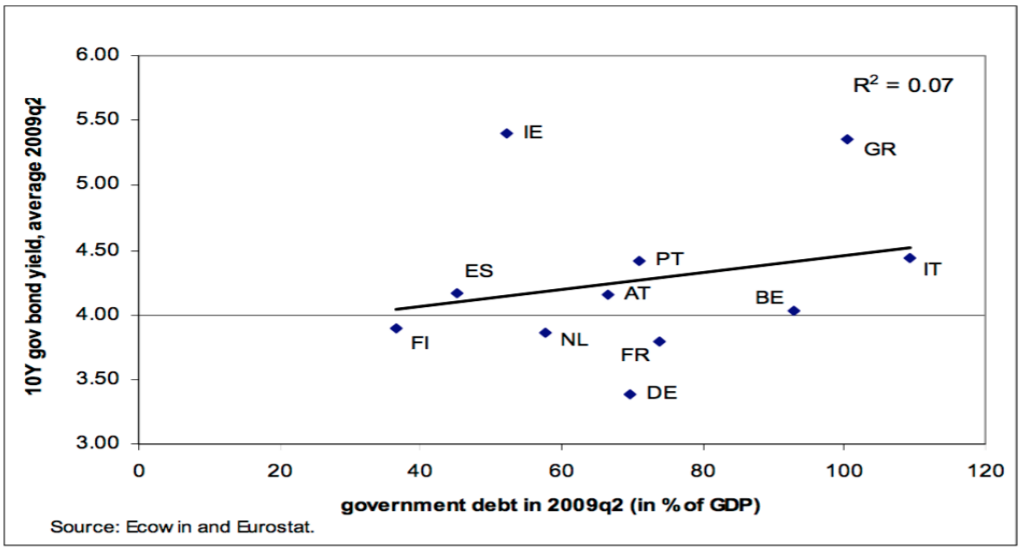


Figure 4: 10-year sovereign bond yields and expected fiscal deficit

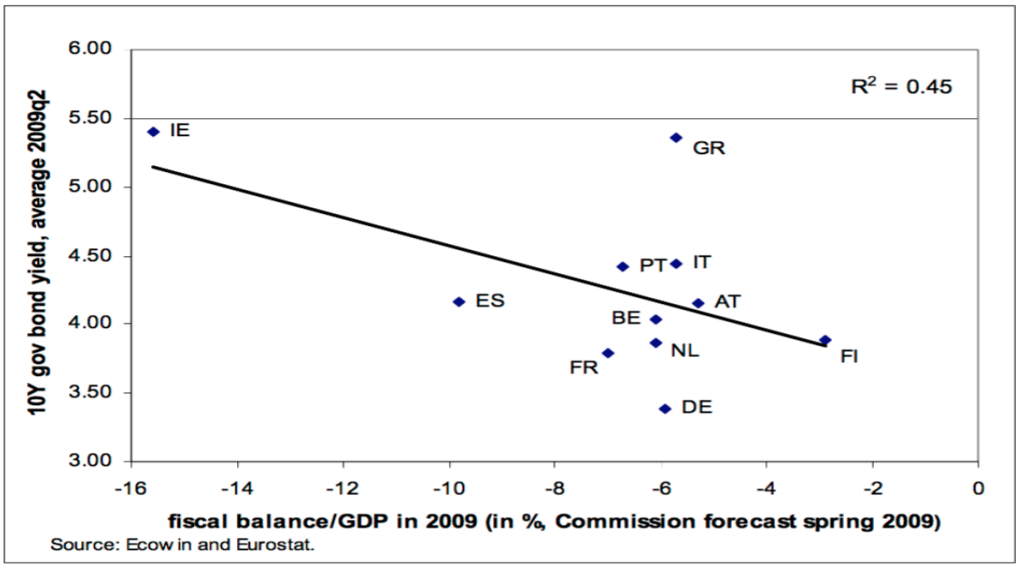


Figure 3 (shown above) plots the 10-year bond yield for Eurozone countries against the government debt-to-GDP ratio. As can be seen, the relationship is weakly positive, indicating that a one percentage point increase in the government debt ratio increases bond yields by around one basis point. Figure 4 (also shown above) plots the 10-year bond yield against the expected fiscal deficit. As can be seen in Figure 4, the relationship between yields and expected fiscal position variables is more strongly positive, with a decrease in the expected fiscal deficit/balance (from larger negative values to smaller negative values, as shown in the figure) substantially reducing the bond yield; a one percentage point rise in the expected fiscal deficit increases, ceteris paribus, government bond yields by around 10 basis points. Both figures were compiled using data from 2009.

Since expected fiscal performance (rather than current fiscal performance) appears to be more strongly correlated with bond yields, the lead operators of the fiscal position differential variables, i.e. the one-year ahead values of the fiscal position differential variables, are also used as explanatory variables in supplementary regressions as a robustness check.

Differential in Current Account Balances: The absolute differential between the countries' current-account-balance-to-GDP ratios has been included as an explanatory variable in the model. Current account deficits and surpluses mostly reflect private lending and borrowing across borders. However, the adjustment of a current account deficit may lead to a deterioration of fiscal balances (Deutsche Bank Research 2009, Goldman Sachs 2009). This can happen via a number of channels. Firstly, EMU countries with large external deficits may find it increasingly difficult to finance rising debt levels as they can no longer rely on exchange rate adjustments to restore competitiveness and promote export-led recoveries. The loss of exchange-rate adjustment means that current account deficits have to be adjusted through a period of disinflation which, with sluggish price adjustment, implies lower growth and falling tax revenues. Secondly, large current account deficits can negatively impact fiscal balances if the government is forced to take over pri-

vate debt. For instance, the current crisis has shown that once domestic banks encounter severe difficulties, nationalising banks or guaranteeing their debt may be the only option for a government. Investors may take these considerations into account when analysing a country's fiscal conditions, implying that larger current account deficits should lead to higher yields as investors price in the potential negative impact on fiscal balances. This relationship can be seen in the figure below, with countries with higher current account deficits experiencing sharper increases in bond yield spreads versus Germany (in 2009).

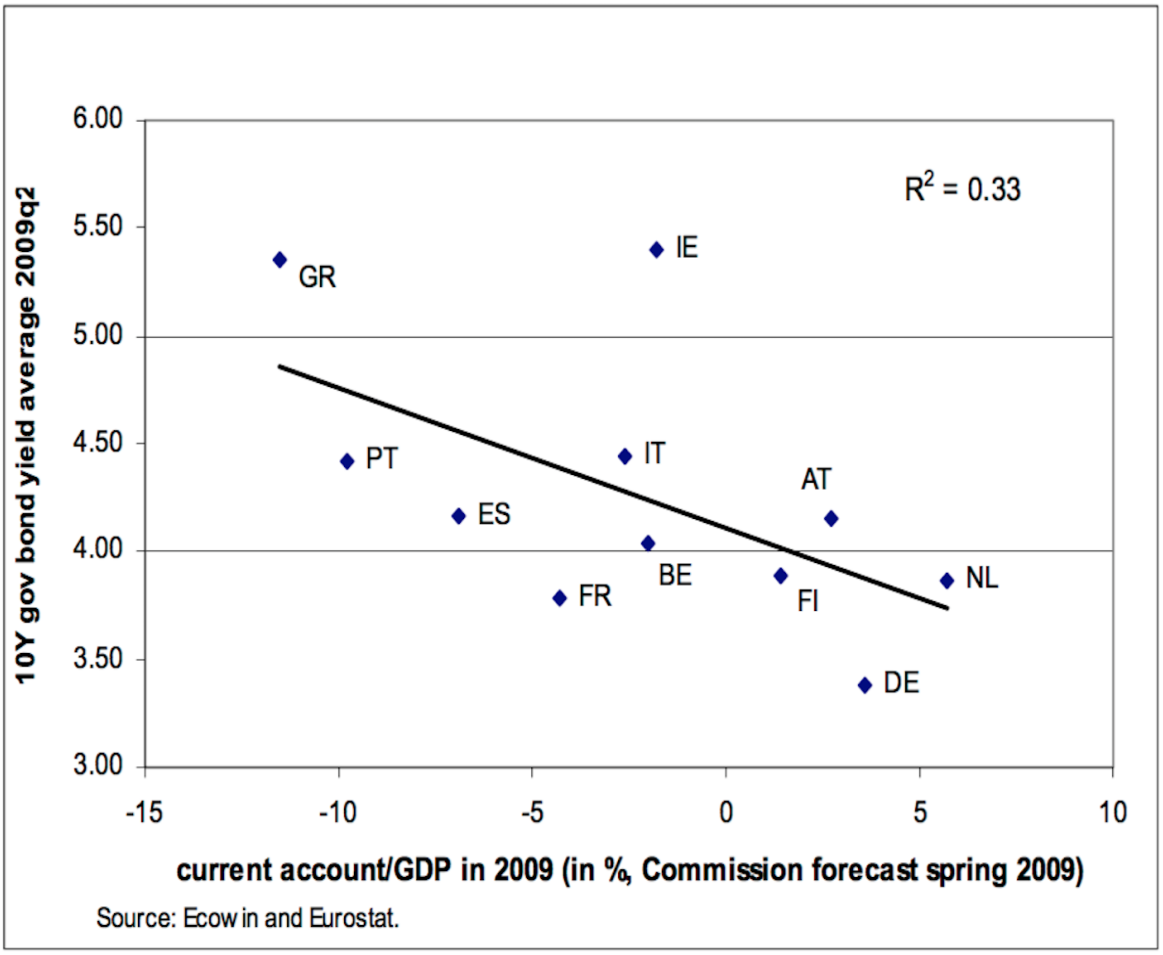


Figure 5

Thus, theoretically, the differential in current account balances is expected to be positively correlated with the yield differential.

International Risk Factor : The logarithm of the SP 500 implied stock market volatility index (VIX) has been included as a proxy for the international risk factor. Since the VIX tends to spike during turmoil periods in markets (Whaley, 2000), it is expected to be a reasonable proxy for the level of international financial risk (Mody, 2009), and has been extensively used in the literature on euro area government bond spreads (Beber et al.,2009 and Gerlach et al., 2010). Increases in the value of the VIX Index are usually accompanied by the "flight-to-quality" phenomenon (with investors seeking safe haven assets). During such times of financial uncertainty, investors tend to rebalance their portfolio toward less risky securities as their risk aversion increases. In principle, this should benefit all government bonds as they are typically regarded as less risky than other asset classes such as corporate bonds or equities. However, among euro-area sovereign issuers the German Bund is perceived to be the "safest haven" both in terms of credit quality ("default-free") and liquidity. Furthermore, since the onset of the financial crisis, the high debt levels of the periphery nations have caused the bonds of these nations to be perceived as riskier assets by the market. Therefore, the "flight-to-safety" and "flight-to-liquidity" flows have benefited the bonds of the fiscally-sound Eurozone nations at the expense of the periphery ones. As a result, we would expect the VIX measure to be positively correlated with yield differentials, as increased financial uncertainty causes investors to move their capital allocations to the bonds of more credit-worthy countries.

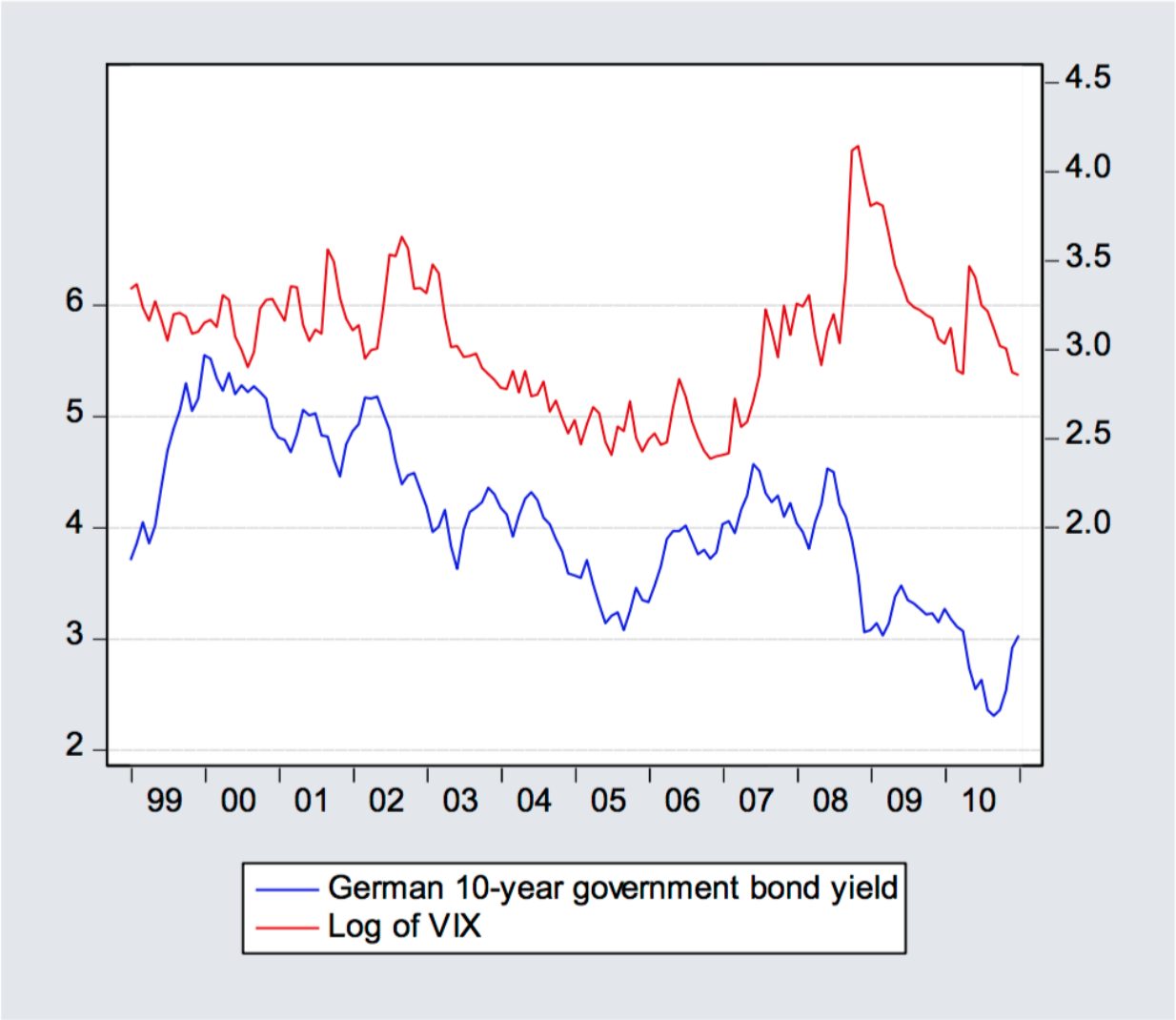


Figure 6

Control Variables

Differential in the Real Effective Exchange Rate: The absolute differential between the countries' real effective exchange rates has been included as an explanatory variable. The real effective exchange rate generally captures the credit risk originating from general macroeconomic disequilibrium; however, the inclusion of growth and fiscal fundamental differentials in our model could mean that this variable is mainly capturing the differential in external competitiveness between the two countries under consideration.

Since real exchange appreciation is expected to increase bond spreads (as theoretically justified by the analysis of Arghyrou and Tsoukalas (2011)), increases in the value of the differential are expected to be associated with increases in the yield differential.

Differential in Inflation Rates: The absolute differential between the countries' inflation rates (as measured by CPI values) has been included as an explanatory variable. In a currency union, if a country consistently inflates at a higher rate than the other currency-area members, it is likely to become less competitive in foreign markets and suffer from balance of payments imbalances (Fleming, 1971). The increased borrowing and debt issuance required to finance these balance of payments deficits is likely to increase sovereign spreads. Thus, the differential in inflation rates is expected to be positively correlated with the yield differential.

Differential in Share Prices: The absolute differential between the countries' standardized stock market indices has been used as an explanatory variable in the model. Stock market indices generally indicate the level of investor confidence in an economy, with plunging stock market prices generally associated with increasing sovereign spreads as investors anticipate fiscal responses from the government. Thus, the differential in share prices between two countries is expected to be positively correlated with the yield differential.

Financial Crisis Dummy: A dummy variable has been included to test whether the 2008-financial crisis had a significant impact on yield differentials. The dummy variable has a value of 0 for all time periods preceding 2007, and a value of 1 for all subsequent time periods.

The empirical model employed in the regressions is specified below. Each of the regressions conducted will use one of the three proxies for business cycle convergence presented

earlier in this section.

$$
\begin{aligned}
|Y_{i,t} - Y_{j,t}| = \beta &+ \alpha_o \ \rho(Cyclical_{i,t}, Cylical_{j,t}) \\
&+ \alpha_1 \ |Ln(GDP)_{i,t} - Ln(GDP)_{j,t}| \\
&+ \alpha_2 \ |U_{i,t} - U_{j,t}| \\
&+ \alpha_3 \ |debt_{i,t} - debt_{j,t}| \\
&+ \alpha_4 \ |deficit_{i,t} - deficit_{j,t}| \\
&+ \alpha_5 \ |current_{i,t} - current_{j,t}| \\
&+ \alpha_6 \ Ln(VIX)_t \\
&+ \alpha_7 \ |I_{i,t} - I_{j,t}| \\
&+ \alpha_8 \ |R_{i,t} - R_{j,t}| \\
&+ \alpha_9 \ |S_{i,t} - S_{j,t}| \\
&+ \alpha_{10} \ F_t \\
&+ \gamma_{i,j} + \epsilon_{i,j,t}
\end{aligned}
$$

- $Y_{i,t}$ represents the yield on 10 year sovereign bonds in country i in year/period t

- $\rho(Cyclical_{i,t}, Cyclical_{j,t})$ represents the correlation between the cyclical GDP components (extracted via the HP filter) of country i and j, in year/period t

- $Ln(GDP)_{i,t}$ represents the natural logarithm of country's $i's$ GDP in year/period t

- $U_{i,t}$ represents the unemployment rate in country i in year/period t

- $debt_{i,t}$ represents the debt-to-GDP ratio of country i in year/period t

- $deficit_{i,t}$ represents the deficit-to-GDP ratio of country i in year/period t

- $current_{i,t}$ represents the current-account-balance-to-GDP ratio of country i in year/period t

- $Ln(VIX)_t$ represents the natural logarithm of the VIX index in year/period t

- $I_{i,t}$ represents the rate of inflation in country i in year t

- $R_{i,t}$ represents the real effective exchange rate of country i in year/period t
- $S_{i,t}$ represents the standardized stock index of country i in year/period t
- F_t represents the value of the financial crisis dummy in year/period t
- γ_i, j represents the fixed, time-invariant factors that affect the yield differential for the i, j country pair
- ϵ_i, j, t represents the error term

Note: Measures for the level of bond market liquidity have not been included as explanatory variables in the model. This restriction arose due to the fact that liquidity-related factors influence yields at high frequencies, while credit risk evaluations are based on slow-moving macroeconomic fundamentals such as public debt and current account imbalances (Codogno et al. 2003), which are only observed at lower frequencies. Therefore, in order to keep the model consistent by using variables that affect yield differentials over roughly the same time-span, bond-market liquidity measures have been excluded.

The effect of liquidity risk on yield spreads is disputed, with Codogno et al. (2003), Bernoth et al. (2004), Pagano and Von Thadden (2004), and Jankowitsch et al. (2006) finding a limited and declining liquidity effect on EMU spreads. On the other hand, Gomez-Puig (2006), Beber et al. (2009), and Manganelli and Wolswijk (2009) have found that liquidity was an important determinant of yields spreads. Since liquidity effects are found to be stronger during periods of tightening financial conditions and higher interest rates, during which market participants are willing to trade lower yields for higher sovereign debt liquidity, we expect the financial crisis dummy to capture this effect and thereby diminish the potential omitted variable bias resulting from the exclusion of liquidity measures.

4. Results

The data used in the regression analysis has been obtained from the Federal Reserve Economic Database and the OECD database. The data-set has been restricted to the eleven European nations that initially adopted the common currency (Euro) in 1999, and Greece which adopted the Euro in 2001. The set of countries includes Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. This has been done so as to observe the relationship between business cycle convergence and yield differentials within the context of a currency union, where the member states do not have autonomous monetary and exchange rate policies. Newer adopters of the euro have been excluded due to the reduced data available on these countries (due to the reduced period over which these countries have been using the Euro).

All of the countries have been compared against each other in the construction of the data for the business cycle convergence and differential variables, meaning that data for 66 country-pairs have been used in the regression analysis. The data has been compiled on a yearly basis, from 1995 to 2014, for all of the variables used in the analysis. For the regression analyses that use the bilateral correlation of HP-filtered real GDP values as a measure of business cycle convergence, all the remaining variables (dependent and independent) were averaged over the relevant period before the absolute differentials were computed. Thus, for instance, the 10-year Austrian and Belgian yield values were averaged over the 1995-1999 period, and the value of the differential between them was used as the dependent variable data point that corresponds to the correlation between (HP-de-trended) Austrian and Belgian real GDP over the 1995-1999 period. This aggregation method resulted in a reduction in the number of observations in the regression analyses that use the bilateral correlation between the cyclical components of real GDP as a measure of cycle convergence.

Since the data set contains numerous observations (one corresponding to each country-pair) for each time variable (single year or 5-year period), a longitudinal (cross-sectional) analysis of the data has been conducted. The summary statistics for the variables used in the regression with the averaged values (over 5-year periods) are displayed below:

Table 1: Summary Statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Yield Differential	1.152	2.026	0.003	10.948	264
Correlation of Cyclical GDP Component	0.498	0.47	-0.886	0.998	264
Unemployment Rate Differential	4.328	3.906	0.063	18.27	253
Debt-to-GDP Ratio Differential	36.365	26.074	0.187	124.026	253
Deficit Ratio Differential	3.521	2.65	0.034	12.928	264
Inflation Rate Differential	0.817	0.891	0.004	4.979	264
SharePriceDifferential	31.402	27.532	0.178	117.002	253
Real Effective Exchange Rate Differential	0.04	0.039	0	0.212	264
Debt-to-GDP Squared Differential	5988.962	4724.82	253		
Current Account Balance Differenential	6.608	5.103	0.016	25.328	192
Ln VIX Value	3.004	0.106	2.837	3.098	301
Financial Crisis Dummy	0.25	0.434	0	1	264

The summary statistics for the variables used in the regression with the non-averaged values are displayed below:

Table 2: Summary statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Yield Differential	1.183	2.481	0	21.002	1254
Ln GDP Differential	1.506	1.043	0	4.722	1320
Unemployment Rate Differential	4.478	4.142	0	22.25	1276
Debt-to-GDP Ratio Differential	36.459	26.519	0.041	151.748	1213
Deficit Ratio Differential	3.879	3.439	0.005	31.766	1320
Inflation Rate Differential	1.121	1.146	0	8.143	1320
Share Price Differential	33.244	35.264	0	218.82	1276
Real Effective Exchange Rate Differential	0.042	0.042	0	0.238	1320
Debt-to-GDP Squared Differential	6077.268	5058.328	5.571	32124.647	1213
Current Account Balance Differential	6.543	4.922	0.007	25.076	944
Ln VIX Value	3.004	0.283	2.55	3.487	1320
Financial Crisis Dummy	0.35	0.477	0	1	1320

The correlation matrices for the data set is included in the appendix. The correlation between the measures of business cycle convergence and the yield differential are as

expected. Specifically, the bilateral correlation between HP-filtered real GDP values is negatively correlated with the yield differential (with a correlation coefficient of -0.6730), and the absolute differential of unemployment rates is positively correlated with the yield differential (with a correlation coefficient of +0.6277).

In order to estimate the relationship between business cycle convergence and yield differentials, we first run a series of OLS regressions. The first set of regressions, labelled (1) and (2), are run on Data-Set 1 which contains the averaged (over 5-year periods) values for the variables. (1) uses the bilateral correlation coefficient between HP-filtered real GDP values as the measure of business cycle convergence, and (2) uses the absolute differential of unemployment rates as the measure of cycle convergence. The second set of regressions, labelled (3) and (4), are run on Data-Set 2 which contains the non-averaged (yearly) values for the variables. (3) uses the absolute differential of real GDP values as the measure of cycle convergence, and (4) uses the absolute difference of unemployment rates as the measure of cycle convergence. The results from the regression are shown below.

Table 3: **OLS Regression on Data-Set 1**

	(1) Yield Differential	(2) Yield Differential
Correlation of Cyclical GDP Component	-1.924***	
	(-6.64)	
Unemployment Rate Differential		0.207***
		(7.07)
Debt to GDP Ratio Differential	-0.0613***	-0.0736***
	(-5.81)	(-7.44)
Deficit Ratio Differential	0.0910*	0.0690
	(2.10)	(1.59)
Debt to GDP Squared Differential	0.000471***	0.000544***
	(7.84)	(9.72)
Inflation Rate Differential	-0.391	-0.514*
	(-1.49)	(-1.99)
Share Price Differential	-0.00344	0.000890
	(-0.87)	(0.23)
Real Effective Exchange Rate Differential	14.07*	17.36**
	(2.10)	(2.64)
Current Account Balance Differential	0.0484*	0.0487*
	(2.23)	(2.27)
Ln VIX Value	5.733	4.948
	(1.84)	(1.62)
Financial Crisis Dummy	2.057**	1.893**
	(2.80)	(2.61)
Constant	-16.75	-16.38
	(-1.76)	(-1.74)
Observations	177	177

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: **OLS Regression on Data-Set 2**

	(3) 10 Yr Yield Differential	(4) 10 Yr Yield Differential
Ln GDP Differential	0.160	
	(1.93)	
Unemployment Rate Differential		0.204***
		(11.05)
Debt to GDP ratio Differential	-0.0745***	-0.0486***
	(-9.40)	(-6.81)
Deficit ratio Differential	0.125***	0.0726***
	(5.66)	(3.41)
Debt to GDP Squared Differential	0.000512***	0.000357***
	(12.33)	(9.30)
Inflation Rate Differential	0.0127	0.0522
	(0.14)	(0.60)
Share Price Differential	-0.00137	-0.00139
	(-0.55)	(-0.59)
Real Effective Exchange Rate Differential	9.434***	3.609
	(3.40)	(1.36)
Current Account Balance Differential	0.0545**	0.0519**
	(3.21)	(3.25)
Ln VIX Value	-1.605***	-1.178***
	(-6.17)	(-4.76)
Financial Crisis Dummy	1.284***	0.900***
	(6.74)	(4.93)
Constant	3.756***	2.343**
	(4.73)	(3.13)
Observations	897	897

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The results above largely support the expected relationship between the measures of business cycle convergence, and yield differentials. In (1), the correlation between the cyclical component of real GDP values was found to be negatively correlated with the yield differential as expected. In (2) and (4), the absolute differential between unemployment rates was found to be positively correlated with the yield differential. The aforementioned variables were all found to be statistically significant predictors of yield differentials at the 0.001 level, indicating a high degree of explanatory power. In (3), the measure of business cycle convergence (the absolute differential between real GDP values)

was found to be statistically insignificant at the 5% level, but statistically significant at the 10% level.

The negative coefficient on the correlation between cyclical GDP components in (1) indicates that an increase in the correlation between the cyclical components of two countries' real GDP values, i.e. an increase in the level of cycle convergence between the two countries, causes a decrease in the yield differential between the two countries. The size of the coefficient is equal to 1.924, indicating that an increase in the correlation coefficient by 0.1 is expected to decrease the yield differential by 19.24 percent (all else equal). For the differential variables, a positive coefficient indicates that as the differential for that variable increases, the yield differential also increases. Similarly, a negative coefficient indicates that the differential for the variable and the yield differential move in opposite directions. Numerically, the coefficient on the differential variables can be interpreted as representing the percentage change in the yield differential brought about a unit percentage change in the relevant variable. For instance, the coefficient on the unemployment rate differential in (2) indicates that a 1 percent increase in the differential would be expected to increase the yield differential by 20.7 percent, and in (3) it indicates that a 1 percent increase in the differential is expected to increase the yield differential by 20.4 percent. The adjusted R-squared values for (1) and (2) are 0.70 and 0.71 respectively. For (3) and (4), the adjusted R squared values are 0.36 and 0.44 respectively. Thus, the regressions using the data-set with the averaged values produce higher R-squared values when computing OLS regressions.

Since we are working with cross-sectional data with distinct groups (66 distinct groups for the 66 country pairs present in the data-set), fixed effects regressions has been conducted to account for pair-specific, "within" fixed effects that do not vary over the estimation period. First, a Hausman test (with the results from the test included in the appendix) was conducted on both data sets to determine the choice between the fixed effects model

and the random effects model (which should be used instead of the fixed effects model if the variation across the country-pairs is assumed to be random and uncorrelated with the predictor or independent variables included in the model). The results from the Hausman test indicate that the use of fixed effects models would be appropriate for both data-sets. The aim in conducting a fixed-effects regression is to remove any omitted variable bias (which is likely to be present since there are potentially many other variables affecting the yield differential between countries that haven't been included in the model as controls). The fixed effects model will account for any unobserved factors that are specific and time-invariant for a country-pair, and that affect the yield differential. A lag of the yield differential, i.e. the yield differential between the two countries in the prior year/5-year-period, has also been included as an explanatory variable in the model to test for the presence of yield persistence.

The output from the fixed effects regression for Data-Set 1 ((5) and (6)) and Data-Set 2 ((7) and (8)) is included below.

Table 5: **Fixed Effects Regression on Data-Set 1**

	(5) Yield Differential	(6) Yield Differential
Correlation of Cyclical GDP Component	-1.405***	
	(-4.21)	
Unemployment Rate Differential		0.217***
		(5.37)
L(1).Yield Differential	-0.287	-0.125
	(-1.03)	(-0.46)
Debt to GDP Ratio Differential	-0.146***	-0.143***
	(-6.10)	(-6.22)
Deficit Ratio Differential	-0.0480	-0.134**
	(-1.04)	(-2.86)
Debt to GDP Squared Differential	0.000962***	0.000883***
	(7.09)	(6.75)
Inflation Rate Differential	-0.808**	-0.621*
	(-3.04)	(-2.38)
Share Price Differential	-0.0205***	-0.0163**
	(-3.70)	(-3.08)
Real Effective Exchange Rate Differential	-3.335	1.771
	(-0.51)	(0.28)
Current Account Balance Differential	-0.0588	-0.0494
	(-1.69)	(-1.49)
Ln VIX Value	-5.990	-3.520
	(-1.80)	(-1.07)
Financial Crisis Dummy	-2.134**	-1.371
	(-2.81)	(-1.80)
Constant	22.27*	13.09
	(2.14)	(1.26)
Observations	177	177

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: **Fixed Effects Regression using Data-Set 2**

	(7) Yield Differential	(8) Yield Differential
Ln GDP Differential	2.186**	
	(2.61)	
Unemployment Rate Differential		0.129***
		(5.37)
L(1).Yield Differential	0.685***	0.630***
	(17.34)	(15.54)
Debt to GDP Ratio Differential	0.0268*	0.0349**
	(2.19)	(2.89)
Deficit Ratio Differential	-0.0298	-0.0492*
	(-1.44)	(-2.39)
Debt to GDP Squared Differential	-0.000258***	-0.000307***
	(-3.99)	(-4.82)
Inflation Rate Differential	-0.265**	-0.211**
	(-3.28)	(-2.63)
Share Price Differential	-0.0101***	-0.0124***
	(-3.75)	(-4.65)
Real Effective Exchange Rate Differential	-12.61***	-11.43***
	(-4.57)	(-4.19)
Current Account Balance Differential	-0.0746***	-0.0330
	(-3.31)	(-1.41)
Ln VIX Value	-0.139	-0.113
	(-0.63)	(-0.52)
Financial Crisis Dummy	0.772***	0.546**
	(4.37)	(3.14)
Constant	-0.481	1.945**
	(-0.36)	(2.98)
Observations	871	871

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As can be seen above, all the measures of business cycle convergence, i.e the correlation between cyclical GDP components in (1), the absolute differential between unemployment rates in (2) and (4), and the absolute differential between real GDP values in (3), were found to be statistically significant predictors of yield differentials. The correlation between cyclical GDP components, and the absolute differential between unemployment rates, are statistically significant at the 0.001 level again, further affirming the strong explanatory power of these variables, and acting as a robustness check. The absolute

differential between real GDP values is now significant at the 0.01 level, whereas with the OLS regression it was only significant at the 0.10 level.

The signs on the coefficients of variables measuring business cycle convergence are as expected, and have not changed from the OLS regression. The unemployment differential and real GDP differential are positively correlated with the yield differential, whereas the correlation between cyclical GDP components is negatively correlated with the yield differential. With regard to the values, the coefficient on the correlation between cyclical GDP components has decreased from 1.924 to 1.405; the coefficient on the absolute differential between unemployment rates has increased from 0.207 to 0.217 (between (2) and (6)), and decreased from 0.204 to 0.129 (between (4) and (8)); the coefficient on the absolute differential between real GDP values has increased considerably from 0.160 to 2.186, resulting in the new significance of the variable. The "within" R squared values for the regressions computed on Data-Set 1, i.e. (5) and (6), are 0.83 and 0.84, respectively. The "within" R-squared values for the regressions computed on Data-Set 2, i.e. (7) and (8), are 0.55 and 0.56, respectively. Thus, the trend of higher R-squared values seen for the OLS regressions computed using Data-Set 1 continues when fixed-effects regressions are used instead.

In order to obtain more robust results that hold up in the presence of non-normal errors (as are likely to be present in the varied macroeconomic data being used), robust estimations of the fixed-effects regression model were conducted using both data-sets. This was done by running the fixed effects regression using a clustering technique that allows the error terms within each country-pair to be correlated. The results from these regressions are displayed below; (9) and (10) were computed using Data-Set 1, and (11) and (12) were computed using Data-Set 2.

Table 7: **Fixed Effects Regression (Using Clustered Errors) on Data-Set 1**

	(9) Yield Differential	(10) Yield Differential
Correlation of Cyclical GDP Component	-1.405***	
	(-3.67)	
Unemployment Rate Differential		0.217***
		(5.31)
L(1).Yr Yield Differential	-0.287	-0.125
	(-1.32)	(-0.61)
Debt to GDP Ratio Differential	-0.146***	-0.143***
	(-4.90)	(-5.33)
Deficit Ratio Differential	-0.0480	-0.134**
	(-1.27)	(-3.22)
Debt to GDP Squared Differential	0.000962***	0.000883***
	(5.89)	(5.43)
Inflation Rate Differential	-0.808**	-0.621**
	(-2.78)	(-2.83)
Share Price Differential	-0.0205**	-0.0163**
	(-2.94)	(-2.77)
Real Effective Exchange Rate Differential	-3.335	1.771
	(-0.50)	(0.31)
Current Account Balance Differential	-0.0588*	-0.0494
	(-2.42)	(-1.57)
Ln VIX Value	-5.990	-3.520
	(-1.86)	(-1.41)
Financial Crisis Dummy	-2.134**	-1.371*
	(-2.80)	(-2.47)
Constant	22.27*	13.09
	(2.22)	(1.63)
Observations	177	177

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: **Fixed Effects Regression (Using Clustered Errors) on Data-Set 2**

	(11) Yield Differential	(12) Yield Differential
Ln GDP Differential	2.186	
	(1.57)	
Unemployment Rate Differential		0.129**
		(3.28)
L(1).Yield Differential	0.685***	0.630***
	(21.80)	(15.74)
Debt to GDP Ratio Differential	0.0268	0.0349*
	(1.95)	(2.38)
Deficit Ratio Differential	-0.0298	-0.0492
	(-1.05)	(-1.69)
Debt to GDP Squared Differential	-0.000258***	-0.000307***
	(-3.73)	(-3.98)
Inflation Rate Differential	-0.265**	-0.211**
	(-3.11)	(-2.81)
Share Price Differential	-0.0101**	-0.0124***
	(-3.44)	(-4.26)
Real Effective Exchange Rate Differential	-12.61**	-11.43**
	(-3.31)	(-3.09)
Current Account Balance Differential	-0.0746**	-0.0330
	(-3.11)	(-1.36)
Ln VIX Value	-0.139	-0.113
	(-1.15)	(-1.03)
Financial Crisis Dummy	0.772***	0.546***
	(5.13)	(4.21)
Constant	-0.481	1.945***
	(-0.25)	(4.07)
Observations	871	871

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As is expected, taking heteroskedastic errors into account causes the standard errors of the coefficient estimates to increase. However, the measures of business cycle convergence in (9), (10), and (12), remain strongly significant (and retain the expected signs on their coefficients) when the regression is run allowing for clustered results as shown above. However, the absolute differential between real GDP values becomes insignificant as a predictor of yield differentials at the 5% level in (11).

Finally, fixed-effects regressions were run taking into account time-fixed effects. Time-fixed effects, i.e. dummy variables for every year in the data-set, were included as explanatory variables in the model after running a test (the results from which are included in the appendix) that rejected the null hypothesis of the coefficients on all the years being jointly equal to zero. This indicates that some of the variation in yield differentials can be explained by the year (time) variable; these variables have thus been included in the regressions to prevent omitted variable bias, and test whether the measures of business cycle convergence remain significant after their inclusion. Regressions (13) and (14) (shown below) were computed using Data-Set 2; time-fixed effects regressions were not computed on Data-Set 1 since it includes only four time periods (as a result of the 5-year aggregation), two of which are dropped due to multi-collinearity when attempting to estimate a time-fixed effects model. The coefficients on the individual year variables have not been shown due to space constraints (an F-test indicates they are jointly significant, however).

As can be seen below, the measures of business cycle convergence, namely the absolute differential between real GDP values, and the absolute differential between unemployment rates, remain statistically significant predictors of yield differentials when time-fixed effects are taken into account. The coefficients on the measures of cycle convergence have decreased significantly from the prior regressions however; the coefficient on the absolute differential of (log-transformed) real GDP values is 1.686, as opposed to 2.186 in the prior fixed effects regression (run on Data-Set 2); similarly, the coefficient on the absolute differential of unemployment rates is 0.0887, as opposed to 0.129 in the prior fixed effects regression. This is indicative of the some of explanatory power having been moved from the measures of cycle convergence to the individual year variables.

Table 9: **Time-Fixed Effects Regression on Data-Set 2**

	(13) Yield Differential	(14) Yield Differential
Ln GDP Differential	1.686*	
	(2.27)	
Unemployment Rate Differential		0.0887***
		(4.12)
L(1).Yield Differential	0.645***	0.611***
	(16.05)	(14.97)
Debt to GDP Ratio Differential	0.0232	0.0257*
	(1.87)	(2.09)
Deficit Ratio Differential	-0.0416*	-0.0558**
	(-2.28)	(-3.05)
Debt to GDP Squared Differential	-0.000173*	-0.000192**
	(-2.54)	(-2.86)
Inflation Rate Differential	-0.0906	-0.0614
	(-1.24)	(-0.85)
Share Price Differential	-0.00666*	-0.00825**
	(-2.56)	(-3.17)
Real Effective Exchange Rate Differential	-13.81***	-12.10***
	(-4.91)	(-4.27)
Current Account Balance Differential	-0.0592**	-0.0312
	(-3.02)	(-1.54)
Ln VIX Value	7.388***	6.968***
	(4.08)	(3.87)
Financial Crisis Dummy	2.024*	1.789*
	(2.41)	(2.14)
Constant	-23.41***	-20.26***
	(-4.15)	(-3.61)
Observations	871	871

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5. Economic Interpretation

The results from the OLS, fixed effects, fixed effects with clustered errors, and time-fixed effects regressions all indicate that the measures of business cycle convergence are statistically significant predictors of yield differentials, and that the nature of this relationship is as expected, with increases in the degree of cycle convergence causing decreases in yield differentials.

The regressions conducted in the previous section use proxies to measure the level of business cycle convergence between the Eurozone countries. The countries that had real GDP growth rates or unemployment rates that were significantly different from the rest of the union (as measured by the size of the correlation between the cyclical GDP components, and the differentials in real GDP values and unemployment rates) are likely to have business cycles that are asynchronous relative to the rest of the union. This asynchrony in the business cycle (relative to the other Eurozone countries) can be used to explain the observed inverse relationship between business cycle convergence and yield differentials.

Optimum currency area theory forwards that if a currency area has member states whose business cycles diverge significantly from each others', the uniform monetary policy that is implemented for the entirety of the currency area will not be optimal for the divergent member states. In the event of negative asymmetric shocks or a cyclical recession, these nations will have to wholly rely on fiscal policy measures in order to promote growth; expansionary monetary policy measures such as interest rate cuts and open market operations will not be available (or not available to the extent required) to these countries as the rest of the union is in a different phase of the business cycle. The divergent member state will also be unable to use devaluation as an engine of export-led growth since it no longer has an autonomous exchange rate policy. Thus, expansionary fiscal measures are the only tools available to the government in the event of a downturn. Expansion-

ary fiscal policy has to be funded either via reduced taxation or increased government spending (or a combination of the two). In either case, the government's fiscal balances worsen as revenues fall and expenditures increase. Increases in government debt balances and liabilities are likely to cause the market to charge a higher risk premium for any debt issued by the government. In other words, the risk of sovereign default is perceived to be higher as government debt and deficit ratios increase. Thus, business cycle divergence is likely to lead to deteriorating fiscal balances in the future, which in turn is expected to lead to increasing yields relative to the rest of the currency union members.

As mentioned earlier, the results from the regressions confirm the theoretical relationship outlined in the last paragraph; furthermore, the strong significance of the business cycle convergence measures as predictors of yield differentials, and the manner in which the results remain strongly significant throughout numerous robustness tests, indicate that business cycle convergence is very relevant for determining yield differentials. As mentioned earlier, sovereign debt generally tends to become riskier when a country is going through a downturn, and sovereign spreads relative to other, economically better performing, countries increases. This effect is likely to be magnified within the context of a currency union since individual member states do not have autonomous monetary and exchange rate policies, and therefore it is all the more important to ensure cycle convergence within a currency union.

As a final robustness check on the relationship between business cycle convergence and yield differentials, a further set of regressions were computed to determine whether the nature of this relationship changed significantly following the financial crisis. In order to empirically determine this, an interaction term was created by interacting the measures of business cycle convergence with the financial crisis dummy variable. The results from the fixed effects regressions incorporating this interaction term are shown below; regressions (15) and (16) were computed on Data-Set 1, and regressions (17) and (18) were computed

on Data-Set 2. The D$\times$ terms represent the interactions between the measures of cycle convergence and the financial crisis dummy.

Regressions (16), (17), and (18) indicate that there hasn't been a significant change in the relationship between business cycle convergence and yield differentials following the financial crisis; this is indicated by the insignificance of the interaction terms between the measures of cycle synchrony (the absolute value of the differentials between unemployment rates, and the absolute value of the differentials between real GDP values) and the financial crisis dummy. Therefore, these regressions indicate that the negative relationship between cycle convergence and yield differentials observed in the previous section was present from before the onset of the financial crisis. However, in regression (15), the interaction term between the measure of cycle convergence (the correlation between cyclical GDP components) and the financial crisis dummy is strongly significant; in fact, the regression shows a positive relationship between the correlation of cyclical GDP components and the yield differential prior to the financial crisis; the large negative coefficient on the interaction term indicates that the overall negative relationship (between the correlation of cyclical GDP components and the yield differential) observed in the regressions in the prior section were driven primarily by the strong negative relationship that came into effect following the financial crisis. One possible explanation for this is that the market became more discriminating following the financial crisis, and began to price in differences in macroeconomic fundamentals to a much greater extent when determining yield spreads. However, since the other regressions do not show the same significance for the interaction term, this hypothesis remains disputed.

Table 10: **Fixed Effects Regression on Data-Set 1 with Cycle Convergence Interaction Terms**

	(15) Yield Differential	(16) Yield Differential
Correlation of Cyclical GDP Component	0.800*	
	(2.49)	
Unemployment Rate Differential		0.144*
		(2.34)
D × Correlation of Cyclical GDP Component	-3.078***	
	(-7.17)	
D × Unemployment Rate Differential		0.0611
		(0.95)
Debt to GDP Ratio Differential	-0.128***	-0.134***
	(-6.50)	(-5.25)
Deficit Ratio Differential	-0.0497	-0.124**
	(-1.39)	(-3.13)
Debt to GDP Squared Differential	0.000840***	0.000842***
	(7.76)	(5.31)
Inflation Rate Differential	-0.616**	-0.514*
	(-2.77)	(-2.56)
Share Price Differential	-0.0149*	-0.0164**
	(-2.58)	(-2.73)
Real Effective Exchange Rate Differential	10.95***	1.780
	(3.74)	(0.47)
Current Account Balance Differential	-0.0147	-0.0566
	(-0.63)	(-1.84)
Ln VIX Value	-2.605	-3.211
	(-1.43)	(-1.77)
Financial Crisis Dummy	1.145*	-1.327**
Constant	8.978	12.03*
	(1.54)	(2.03)
Observations	192	192

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11: **Fixed Effects Regression on Data-Set 2 with Cycle Convergence Interaction Terms**

	(17) Yield Differential	(18) Yield Differential
Ln GDP Differential	5.579*	
	(2.32)	
Unemployment Rate Differential		0.208**
		(3.42)
D × Ln GDP Differential	-0.217	
	(-1.06)	
D × Unemployment Rate Differential		0.0811
		(1.10)
Debt to GDP Ratio Differential	-0.0691***	-0.0323
	(-3.46)	(-1.48)
Deficit Ratio Differential	0.0128	-0.0415
	(0.55)	(-1.80)
Debt to GDP Squared Differential	0.000389***	0.000154
	(4.95)	(1.44)
Inflation Rate Differential	-0.226*	-0.115
	(-2.21)	(-1.39)
Share Price Differential	-0.0105**	-0.0159***
	(-2.78)	(-4.62)
Real Effective Exchange Rate Differential	-6.110	-2.628
	(-1.30)	(-0.56)
Current Account Balance Differential	-0.163***	-0.0564
	(-4.82)	(-1.79)
Ln VIX Value	-0.738***	-0.550***
	(-4.54)	(-3.92)
Financial Crisis Dummy	1.155***	0.128
	(4.14)	(0.57)
Constant	-3.039	3.169***
	(-0.88)	(5.35)
Observations	897	897

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Given that the interaction term (between the measure of cycle convergence, and the financial crisis dummy) was insignificant in 3 of the 4 regressions shown above, we can be reasonably confident in claiming that there hasn't been a significant change in the determined relationship between cycle convergence and yield divergence, i.e. increases in cycle convergence were correlated with lower yield divergence even before the financial

crisis. Since our results are robust to limiting the data to just the pre-crisis period, we can claim that the model presented here would have been valid had it been employed prior to the financial crisis, and the same conclusions would have been drawn. Furthermore, regression (15) highlights that the negative relationship between cycle convergence and yield differentials might be even stronger, and more conclusive, in the current macroeconomic climate. Thus, the recommendation for the ECB to focus on cycle convergence as a means of preventing the incidence of excessively high yields and sovereign defaults remains very relevant.

The relative statistical insignificance of the proxy for the level of international risk, i.e. the natural logarithm of the VIX Index, is interesting to note. The Ln VIX variable was a significant predictor of yield differentials only in regressions (3), (4), (13), and (14). Moreover, a negative relationship between the Ln VIX variable and the yield differential was found in regressions (3) and (4). This result is contrary to the expected relationship, and that which was uncovered by prior studies that have been done on the determinants of Eurozone yield spreads. The fact that the variable becomes strongly significant, with the expected positive sign on the coefficient, when time-fixed effects are introduced in the model (in regressions (13) and (14)) indicates that the unexpected results might have been caused due to the incidence of omitted variable bias (since time fixed effects have been shown to jointly be a significant predictor of yield differentials). Another possible explanation for the relative insignificance of the international risk factor proxy is that the effect of the risk factor is homogeneous across most of the countries included in the sample, and it has thus affected sovereign yields across the Eurozone in a similar fashion. If the risk factor has a similar effect on yields, its effect on the yield differential will be negligible.

As a robustness check, another set of regressions were run using the spread between Moody's Seasoned BAA corporate bond yield, and the US 10-year Treasury yield, as

the proxy for the international risk factor. The results from the regressions are included below. Regressions (19) and (20) were run on Data-Set 1, while regressions (21) and (22) were run on Data-Set 2.

Table 12: **Fixed Effects Regression on Data-Set 1 Using The Treasury-Corporate Spread**

	(19) Yield Differential	(20) Yield Differential
Correlation of Cyclical GDP Component	-1.232***	
	(-4.37)	
Unemployment Rate Differential		0.217***
		(6.02)
Debt to GDP Ratio Differential	-0.156***	-0.147***
	(-6.83)	(-6.80)
Deficit Ratio Differential	-0.0330	-0.109*
	(-0.74)	(-2.47)
Debt to GDP Squared Differential	0.00101***	0.000928***
	(7.93)	(7.60)
Inflation Rate Differential	-0.545*	-0.314
	(-2.49)	(-1.47)
Share Price Differential	-0.0163**	-0.0125*
	(-3.17)	(-2.59)
Real Effective Exchange Rate Differential	1.222	4.193
	(0.22)	(0.81)
Current Account Balance Differential	-0.0588	-0.0448
	(-1.92)	(-1.55)
Corporate Treasury Spread	0.111	0.737
	(0.19)	(1.28)
Financial Crisis Dummy	-0.662*	-0.560
	(-2.10)	(-1.95)
Constant	2.916	-0.410
	(1.70)	(-0.23)
Observations	192	192

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 13: **Fixed Effects Regression on Data-Set 2 Using The Treasury-Corporate Spread**

	(21) Yield Differential	(22) Yield Differential
Ln GDP Differential	2.212**	
	(2.65)	
Unemployment Rate Differential		0.132***
		(5.51)
L(1). Yield Differential	0.691***	0.635***
	(17.59)	(15.74)
Debt to GDP Ratio Differential	0.0228	0.0309*
	(1.87)	(2.57)
Deficit Ratio Differential	-0.0336	-0.0534**
	(-1.64)	(-2.61)
Debt to GDP Squared Differential	-0.000236***	-0.000286***
	(-3.66)	(-4.51)
Inflation Rate Differential	-0.275***	-0.218**
	(-3.44)	(-2.76)
Share Price Differential	-0.0110***	-0.0135***
	(-4.08)	(-5.02)
Real Effective Exchange Rate Differential	-13.41***	-12.18***
	(-4.96)	(-4.56)
Current Account Balance Differential	-0.0831***	-0.0407
	(-3.70)	(-1.76)
Corporate Treasury Spread	0.221*	0.245*
	(2.12)	(2.38)
Financial Crisis Dummy	0.526**	0.278
	(2.65)	(1.41)
Constant	-1.254	1.220**
	(-1.01)	(3.18)
Observations	871	871

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As can be seen from the regression results above, while the coefficient on the corporate treasury yield is positive for all the regressions (as expected), it is only significant for regressions (21) and (22). This could be due to the fact that averaging the values (as was done with Data-Set 1) reduces the explanatory power of the corporate-treasury yield measure. The sizes of the significant coefficients on the Corporate Treasury Spread (in regressions (21) and (22)) are relatively large; (21) indicates that a 1% increase in

the corporate treasury spread is expected to increase yield differentials by 22%, whereas (22) indicates a similar-sized increase of 24.5%. All in all, while the international risk factor has been found to be an important determinant of Eurozone yields (refer to the Literature Review section), it appears to be difficult to establish the differential effect it has on sovereign yields between country-pairs. We expect this differential effect to become significantly more pronounced if regressions are restricted to comparing just the core Eurozone nations against the periphery ones; this is because of the capital flight from riskier to safer sovereign debt (and the consequent yield divergence) that coincided with the increase in the international risk factor

The relationship between the fiscal position differential variables (differential between debt-to-GDP ratios, and deficit-to-GDP ratios) and the yield differential (as determined by the regressions) appears to be inconclusive. While both fiscal differentials have been found to be statistically significant predictors of yield differentials in a size-able number of the regressions that were run in the prior section, the signs on their coefficients alternate between positive and negative instead of remaining positive throughout (as theory would suggest).

This disparity can perhaps be explained by the hypothesis that markets price in future or expected fiscal balances, rather than current ones, when determining sovereign yields. This hypothesis is supported by the figures (Figure 3 and 4) provided in the Methodology section, which showed that the relationship between sovereign yields and expected fiscal balances is significantly stronger than that between sovereign yields and current fiscal balances. Similar conclusions were drawn in the following recent studies on EMU government bond yield spreads - Attinasi et al. (2009), Sgherri and Zoli (2009), Ger-lach et al. (2010) and Favero and Missale (2011). To test this hypothesis and determine the relationship between future/expected fiscal position differential variables, and the yield differential, regressions (23) and (24) were run using lead (one-year-ahead) values of the

debt-to-GDP and deficit-to-GDP differentials as the model's explanatory variables (as opposed to the current values of these differentials). The regressions were restricted to Data-Set 2 since employing lead-operators over a 5-year period (as would be the case with the averaged data in Data-Set 1) is likely to erode the potential explanatory power of the fiscal variables. The results from the regressions are shown below; the F(1) operators indicate the one-year ahead values of the fiscal differential variables.

Table 14: **Fixed Effects Regression Using Lead Operators of Fiscal Differentials**

	(23) Yield Differential	(24) Yield Differential
Ln GDP Differential	3.207	
	(1.75)	
Unemployment Rate Differential		0.145***
		(3.50)
F(1).Debt to GDP Ratio Differential	0.0202*	0.0203*
	(2.47)	(2.39)
F(1). Deficit Ratio Differential	0.0831**	0.0630**
	(3.10)	(2.76)
Inflation Rate Differential	-0.341***	-0.254**
	(-3.87)	(-3.34)
L(1).Yield Differential	0.509***	0.427***
	(16.72)	(8.56)
Share Price Differential	-0.0107**	-0.0128***
	(-3.29)	(-3.83)
Real Effective Exchange Rate Differential	-6.951	-5.624
	(-1.85)	(-1.59)
Current Account Balance Differential	-0.0763**	-0.0322
	(-2.95)	(-1.20)
Ln VIX Value	-0.190	-0.127
	(-1.65)	(-1.30)
Financial Crisis Dummy	0.696***	0.392**
	(5.39)	(3.02)
Constant	-3.305	0.441
	(-1.24)	(0.80)
Observations	812	812

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As can be seen above, the lead operators of the fiscal differential variables are all statistically significant predictors of the yield differential. Furthermore, the coefficients are all positive, reflecting the expected positive relationship between yield differentials and fiscal position differentials. The sizes of the coefficients indicate that a 1 percentage point increase in the debt-to-GDP ratio differential increases the yield differential by roughly 2 percent, whereas a 1 percentage point increase in the deficit-to-GDP ratio differential increases the yield differential by approximately 6.3 - 8.3 percent.

As was the case with the fiscal position differentials, the relationship between the current account balance differential and the yield differential could not be established conclusively in the prior section. As explained in the methodology section, the current account balance is one of the factors that drives the market's perception of credit risk, and is therefore expected to be a significant predictor of sovereign yields; the nature of the relationship is expected to be positive, with an increase in the current account differential correlated with an increase in the yield differential. One potential explanation for the inconclusiveness of the regression results is that the relationship between the current account balance and sovereign yields became prominent and significant following the onset of the financial crisis, following which markets became more discerning of differences in macroeconomic fundamentals between countries, and began pricing in these differences to a greater extent when determining yield spreads. The shift of private sector debt (which is the primary constituent of current account deficits) to the public sector (through bank bailouts, etc) also suggest an increase in the significance of the current account balance differential as a predictor of yield differentials. In order to test this hypothesis, fixed-effects regressions were run including an interaction term between the current account balance differential, and the financial crisis dummy; this interaction term is meant to capture any significant changes in the relationship between current account balance differentials, and yield differentials, following the financial crisis. Regressions (25) and (26) were computed using Data-Set 1, and regressions (27) and (28) were computed using Data-Set 2. The variable

beginning with D × indicates the interaction term between the current account balance differential, and the yield differential.

Table 15: **Fixed Effects Regression on Data-Set 1 with Current Account Balance Differential Interaction Term**

	(25) Yield Differential	(26) Yield Differential
Correlation of Cyclical GDP Component	-1.242***	
	(-4.13)	
Unemployment Rate Differential		0.214***
		(5.84)
Debt to GDP Ratio Differential	0.000274	-0.00238
	(0.04)	(-0.33)
Deficit Ratio Differential	-0.139**	-0.198***
	(-2.89)	(-4.29)
Inflation Rate Differential	-0.940***	-0.727**
	(-3.72)	(-2.97)
Share Price Differential	-0.0358***	-0.0305***
	(-6.58)	(-5.89)
Real Effective Exchange Rate Differential	-0.270	-0.696
	(-0.06)	(-0.15)
Current Account Balance Differential	-0.165***	-0.140***
	(-4.77)	(-4.21)
Ln VIX Value	-6.593**	-6.171**
	(-2.72)	(-2.72)
Financial Crisis Dummy	-2.145**	-1.788**
	(-3.23)	(-2.83)
D × Current Account Balance Differential	0.279***	0.228***
	(5.14)	(4.34)
Constant	25.15**	22.09**
	(3.31)	(3.08)
Observations	192	192

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 16: **Fixed Effects Regression on Data-Set 2 with Current Account Balance Differential Interaction Term**

	(27) Yield Differential	(28) Yield Differential
Ln GDP Differential	2.468**	
	(2.98)	
Unemployment Rate Differential		0.109***
		(4.52)
L(1).Yield Differential	0.600***	0.544***
	(19.17)	(15.64)
Debt to GDP Ratio Differential	-0.0221***	-0.0224***
	(-4.81)	(-4.93)
Deficit Ratio Differential	-0.0287	-0.0437*
	(-1.40)	(-2.12)
Inflation Rate Differential	-0.287***	-0.247**
	(-3.59)	(-3.11)
Share Price Differential	-0.00836**	-0.0105***
	(-3.10)	(-3.92)
Real Effective Exchange Rate Differential	-14.35***	-13.53***
	(-5.26)	(-4.98)
Current Account Balance Differential	-0.125***	-0.0837**
	(-4.94)	(-3.16)
Ln VIX Value	-0.149	-0.0899
	(-0.68)	(-0.41)
Financial Crisis Dummy	-0.299	-0.506*
	(-1.30)	(-2.23)
D × Current Account Balance Differential	0.133***	0.123***
	(4.82)	(4.47)
Constant	-0.0732	2.779***
	(-0.05)	(4.09)
Observations	871	871

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As can be seen in the regression tables above, the interaction term between the current account balance differential and the financial crisis dummy is strongly significant in all four of the regressions. The sign on the interaction term is positive throughout (as expected), indicating that current account balance differentials were positively correlated with yield differentials following the onset of the financial crisis. It is interesting to note that the current account balance differential (by itself) was also strongly significant as a

predictor of yield differentials prior to the financial crisis; however, the negative sign on these coefficients indicate that the pre-crisis relationship was the inverse of the post-crisis one. However, the coefficient on each of the interaction terms is significantly larger than the coefficient on the corresponding differential variable (by itself), indicating that the overall relationship between current account balance differentials, and yield differentials, was negative following the financial crisis.

6. Conclusion

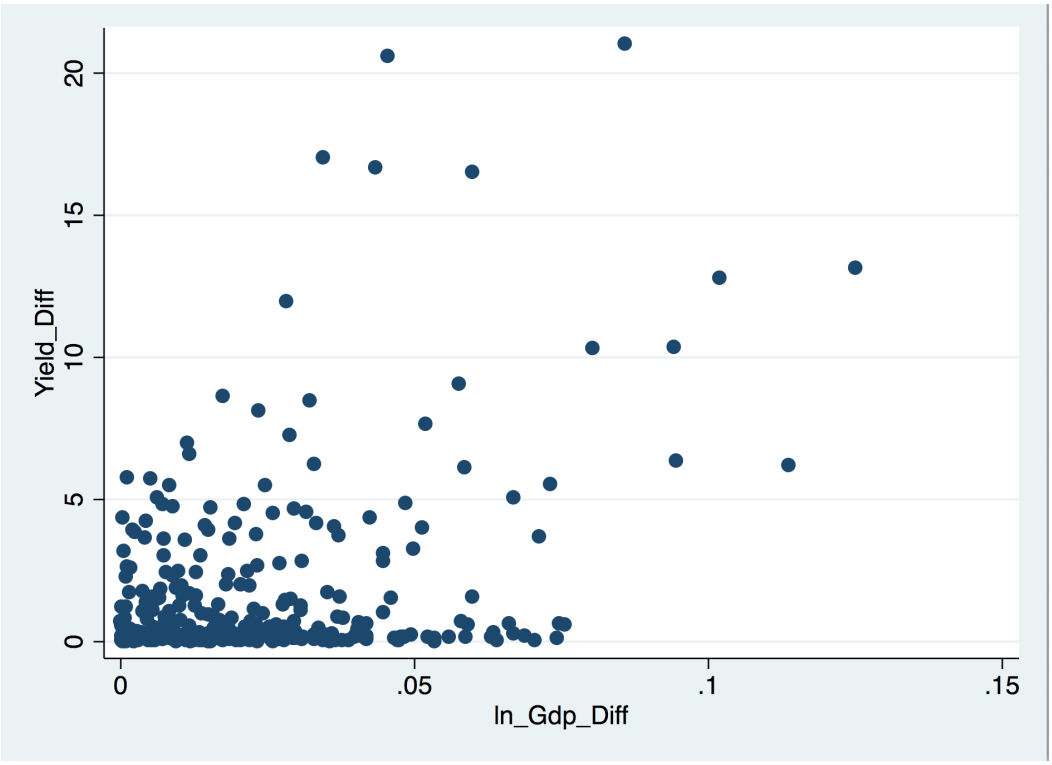
The recent sovereign debt crisis in the Eurozone has brought the viability of the Eurozone as a currency area into question. The unsustainable debt and deficit balances accumulated by several Eurozone nations since the adoption of the common currency in 1999, and the consequent incidence of high levels of sovereign default risk in the euro-area, indicate that the rules employed by the European Central Bank to monitor the fiscal discipline and sustainability of its members have been largely ineffectual. The primary means employed by the ECB to ensure fiscal discipline within the union are the fiscal criteria in the Maastricht Treaty. As mentioned earlier, numerous critics have voiced their concerns regarding these fiscal criteria, stating that they are deflationary and recession-inducing in nature, and by and large set entirely arbitrary ceilings on debt and deficit ratios. Furthermore, since adherence to the criteria is only strictly enforced at the point of entry into the currency union, member states are relatively free to breach the debt and deficit ratios following entry (as has been the case with numerous Eurozone nations). Member states (e.g. Italy) have also been known to take one-off measures to bring their debt and deficit ratios in line so that they could gain ascension to the Eurozone, following which they revert to breaching the ratios. Thus, it has become clear that the ECB needs some other means to enforce the fiscal discipline of its members, and thereby prevent the incidence of high levels of sovereign default risk within its boundaries.

The theory of optimum currency areas forwards one such means, specifically the ensuring of business cycle convergence between a potential entrant (or current member) and the rest of the countries in the union. The economic rationale behind such a means, as has been discussed earlier in the paper, is sound; if countries with significantly asynchronous business cycles are admitted to the union, they are likely to have to resort to depleting their fiscal balances in response to any asymmetric shocks that they suffer; this in turn would result in increases in sovereign yields (as the market perceived risk of default increases), further increasing future interest payments and deteriorating the fiscal positions of such countries. On the other hand, countries that have convergent business cycles are generally affected by the same shocks, i.e. they are less susceptible to asymmetric ones, and thus it isn't likely that they will have to rely wholly on fiscal policy tools (as countries with asynchronous business cycles would) in the event of negative shocks; since the shock will affect the entirety of the currency-area (under the assumption of convergent business cycles), monetary and exchange rate policies can be implemented by the central bank to act as adjustment mechanisms, thereby easing the burden on the member-states' fiscal balances. This, in turn, would mean that sovereign yields, and the level of sovereign default risk, would be kept in check. Thus, if the ECB aims to promote fiscal responsibility and reduce the risk of sovereign default amongst its members, it should assess potential and current members based on how synchronous their business cycles are with those of the rest of the union. The results of the regressions conducted in this paper back this claim, and show that the degree of business cycle convergence is one of the most important determinants of yield differentials (and thus the relative level of sovereign default risk). The consistent negative relationship between cycle convergence and yield differentials (as uncovered by the regressions) provide empirical justification for attempting to lower yields and the risk of sovereign default through cycle convergence.

Furthermore, convergence in business cycles represents real convergence, as opposed to the nominal convergence that is required by the Maastricht criteria, and cannot be achieved

through one-off measures. Finally, as the results from the regressions in this paper indicate, a currency union with convergent business cycles is less likely to suffer from one or two divergent states having high risks of default, and burdening the remainder of the member states with potential bail-out payments and debt-rescheduling agreements. Therefore, the case for substituting the fiscal criteria in the Maastricht Treaty with measures that assess the degree of business cycle convergence is a strong one.

Appendix



Scatter plot showing the positive correlation between a proxy for the degree of business cycle convergence (the absolute differential of real GDP values) and the yield differential

	YrYiel~l	Cyclic~t	Unempl~l	Debtto..	Defici~l	D~Squa~l	Inflat~l	ShareP~l	RealEf~f	Curren~n	VixValue	Financ~y
YrYieldDif~l	1.0000											
CyclicalGD~t	-0.6730	1.0000										
Unemployme~l	0.6277	-0.5474	1.0000									
DebttoGDPr~l	0.2652	-0.0683	0.0705	1.0000								
Deficitrat~l	0.3353	-0.2495	0.3100	0.2862	1.0000							
DebttoGDPS~l	0.5183	-0.2776	0.2117	0.8996	0.2568	1.0000						
InflationR~l	-0.1013	0.0427	-0.0528	-0.0669	0.1030	-0.1027	1.0000					
SharePrice~l	-0.0695	0.0125	-0.1419	0.0977	0.1089	0.0671	0.2717	1.0000				
RealEffect~f	-0.0240	-0.0559	0.0365	-0.0609	-0.0285	-0.0963	0.6063	0.1826	1.0000			
CurrentAcc~n	0.0261	0.0260	0.0202	0.2080	0.3046	0.0806	0.0637	0.1207	-0.0537	1.0000		
VixValue	-0.5007	0.4341	-0.4132	-0.0807	-0.2260	-0.2547	0.1312	0.2432	0.2080	0.2196	1.0000	
FinancialC~y	0.5630	-0.4567	0.4453	0.0740	0.2243	0.2766	-0.2448	-0.3024	-0.2583	-0.2308	-0.9281	1.0000

Correlation Matrix for Data-Set 1

	Coefficients			
	(b) fixed	(B) random	(b−B) Difference	sqrt(diag(V_b−V_B)) S.E.
CyclicalGD~t	**−1.182423**	**−1.376477**	**.194054**	**.0904829**
Unemployme~l	**.1956915**	**.156062**	**.0396295**	**.0244653**
YrYieldDif~l				
L1.	**.0647771**	**.3912259**	**−.3264489**	**.0910293**
DebttoGDPr~l	**−.1391302**	**−.0589267**	**−.0802035**	**.0191015**
Deficitrat~l	**−.1234823**	**.042299**	**−.1657813**	**.0147147**
DebttoGDPS~l	**.0008828**	**.0004545**	**.0004283**	**.0001089**
InflationR~l	**−.4206353**	**−.3898825**	**−.0307528**	**.0525902**
SharePrice~l	**−.0181511**	**−.0016992**	**−.0164519**	**.0033487**
RealEffect~f	**−.165036**	**15.11075**	**−15.27579**	**.**
CurrentAcc~n	**−.0037311**	**.0394899**	**−.043221**	**.0260528**
VixValue	**.2841932**	**6.707219**	**−6.423026**	**1.405202**
FinancialC~y	**−.8699229**	**1.974536**	**−2.844459**	**.2403964**

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(**11**) = (b−B)'[(V_b−V_B)^(−1)](b−B)
= **94.13**
Prob>chi2 = **0.0000**
(V_b−V_B is not positive definite)

Results of Hausman Test for Data-Set 1

	Coefficients			
	(b) fixed	(B) random	(b−B) Difference	sqrt(diag(V_b−V_B)) S.E.
LnGDPDiffe~l	**1.814512**	**−.0528655**	**1.867378**	**.8235492**
Unemployme~l	**.1245216**	**.0660358**	**.0584858**	**.0161369**
YrYieldDif~l				
L1.	**.6118959**	**.6783984**	**−.0665025**	**.0183481**
DebttoGDPr~l	**.0326982**	**.0061306**	**.0265675**	**.0095517**
Deficitrat~l	**−.046293**	**.0365006**	**−.0827936**	**.0084411**
DebttoGDPS~l	**−.0002924**	**−.0000514**	**−.000241**	**.0000478**
InflationR~l	**−.2219341**	**−.1020223**	**−.1199118**	**.0240768**
SharePrice~l	**−.011823**	**−.0000546**	**−.0117684**	**.0017389**
RealEffect~f	**−11.57412**	**−6.224181**	**−5.349939**	**1.241789**
CurrentAcc~n	**−.037335**	**.049328**	**−.086663**	**.0188873**
VixValue	**−.1287423**	**−.2055604**	**.0768181**	**.0132365**
FinancialC~y	**.6170288**	**.6977879**	**−.0807592**	**.0794996**

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(**11**) = (b−B)'[(V_b−V_B)^(−1)](b−B)
= **127.21**
Prob>chi2 = **0.0000**
(V_b−V_B is not positive definite)

Results of Hausman Test for Data-Set 2

```
. testparm i.Year

 ( 1)  1997.Year = 0
 ( 2)  1998.Year = 0
 ( 3)  1999.Year = 0
 ( 4)  2000.Year = 0
 ( 5)  2001.Year = 0
 ( 6)  2002.Year = 0
 ( 7)  2003.Year = 0
 ( 8)  2004.Year = 0
 ( 9)  2005.Year = 0
 (10)  2006.Year = 0
 (11)  2007.Year = 0
 (12)  2008.Year = 0
 (13)  2009.Year = 0
 (14)  2010.Year = 0
 (15)  2011.Year = 0
 (16)  2012.Year = 0

       F( 16,   778) =   19.96
            Prob > F =    0.0000
```

Results of Testing for Time Fixed Effects

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