The Information Content of Dual-Currency Sovereign CDS for Exchange Rate Returns

Xiaoling Pu* and Jianing Zhang**

Abstract

This paper examines both the time-series and cross-sectional variation in the difference between U.S. dollar and Euro denominated sovereign CDS spreads for a group of Eurozone countries. We test several possible explanations for the widening of the difference during the European debt crisis. We find that the spread difference between dual-currency sovereign CDS significantly affects the bilateral exchange rate returns. Furthermore, the difference could predict the cumulative exchange rate returns up to ten days. The results strongly suggest that the dual-currency sovereign CDS spread difference contains important information for the exchange rate dynamics at various phases of the crisis.

JEL Classification: G12, F31

Keywords: sovereign credit default swap; exchange rate return

*Assistant Professor, Department of Finance, Kent State University, Kent, OH. Email: xpu2@kent.edu, Phone: 330-672-1200; ** Department of Finance, Penn State University, University Park, PA. Email: juz134@psu.edu.

1. Introduction

The recent Eurozone debt crisis has severely affected the sovereign debt and derivatives markets. The sovereign credit default swap (CDS) spread, representing the default risk of the underlying country, has rapidly widened since the debt woes have been messier, especially in the PIIGS (Portugal, Ireland, Italy, Greece, and Spain) countries. This paper provides an entirely new perspective to examine difference between dual-currency sovereign CDS spreads and its information content for foreign exchange rate returns. Since our sample is specifically in the Eurozone, we focus on the U.S. dollar and Euro denominated CDS on the same sovereign entity and the exchange rates between the two currencies. We examine the sovereign CDS of both PIIGS and non-PIIGS countries in the Eurozone. In many ways, the comparison in these two groups shows the distinct features across countries with poor and sound financial conditions.

Not surprisingly, pricing relationships in many capital markets broke down in the crisis. The most notable example in the corporate credit market is that CDS-bond basis, which measures the difference between CDS spread and bond credit spread of the same underlying company, becomes negative during the recent market distress, while the basis is close to zero in normal times. Bai and Collin-Dufresne (2011) test several possible explanations for the anomaly, and attribute to several factors, such as funding risk, counterparty risk, and collateral quality. In the sovereign credit derivatives market, we find the difference between the sovereign CDS spreads denominated in two currencies of the same underlying country is positive in the crisis, while there is almost no difference before 2007. The pricing violations in various markets challenge the market efficiency hypothesis and the law of one price, and several papers (e.g. Fleckenstein, Longstaff, and Lustig (2011); Coffey, Hrung, and Sarkar (2009); Buraschi, Sener, and Menguturk (2011)) identify various risk factors or impediments to arbitrage activities which could drive the price to deviate from the fundamental value.

It is common that the sovereign bonds are issued in both domestic and foreign currencies. Although the sovereign bonds denominated in different currencies has the same default risk, they may have various recovery rates since bonds denominated in multi-currencies are typically issued in different jurisdictions and governed by different

legal rules. In this respect, sovereign CDS spread is a much simpler and direct measure of credit risk. Sovereign CDS contracts are governed by the same standardized International Swap and Derivatives Association (ISDA) documentation and have consistent recovery rates, although they could be denominated in different currencies. Thus, the valuation of sovereign CDS spreads denominated in different currencies needs to incorporate the correlations among default risk, recovery risk, and currency risk. Empirically, we find the spread differential between dual-currency sovereign CDS is virtually zero, which implies that dependence across the risk factors is low. The sharply increasing spread differential in the crisis indicates that neglecting the correlations would make the valuation of sovereign CDS denominated in local and foreign currencies empirically incorrect.

The difference between U.S. dollar and Euro denominated CDS spreads is almost zero before the global financial crisis. Interestingly, the differential has a significant jump after September 2008, and then has been consistently increasing till 2010. For example, the average euro-denominated Germany CDS spread is about 16 basis points (bps), which is almost the same as the USD-denominated spread in 2008. However, the USD-denominated CDS spread soars up to 40 bps and the euro-denominated spread is only 32 bps in 2010. Such statistics are not uncommon in the eurozone. The suddenly widening difference between U.S. dollar and Euro denominated sovereign CDS spreads in the crisis triggers the large demand for quanto CDS trades, which is a new way to short European credit and currency risk. Given the market situation, it is interesting to investigate how these trading activities would take advantage of the information content in the dual-currency spread differential and what is the implication for foreign exchange markets.

Our paper is the first empirical study to investigate what are the determinant factors driving the dual-currency spread differential in the crisis. In addition, we examine whether the differences between dual-currency denominated CDS spreads contain information about the bilateral exchange rate dynamics. Market conditions are completely changed in the crisis, which might affect the correlation between sovereign

default risk and currency risk and break down the previous price relation between dual-currency denominated CDS.

We first seek to identify what were the main drivers of the dual-currency spread differential in the crisis. Market liquidity and volatility have been two candidates contributing to many arbitrage failures. Gromb and Vayanos (2002) find that the inability to cross-margin is a significant constraint on funding liquidity. Brunnermeier and Pedersen (2009) examine the importance of funding constraints in a model that links an asset's market liquidity and traders' funding liquidity. Volatility related to market uncertainty is an important proxy of investor's appetite against risky positions. Pan and Singleton (2008) and Longstaff et al. (2010) employ the VIX as the measure for tail event risk in sovereign credit market to capture the global uncertainty.

We investigate how the funding liquidity and market uncertainty explains the dual-currency spread difference, and find that funding liquidity is more important. In addition, we find the lag information of exchange rates cannot predict spread difference, while the spread difference contains predictive information for the exchange rates. In a set of causality tests for the sample, we find that the hypothesis of exchange rates are not caused by spread differential is rejected in seven out of ten countries. The results suggest significant information of the spread difference contributes to the price discovery of exchange rates between euro and dollar.

Next, we find that the time series of the difference between U.S. dollar and Euro denominated CDS spreads is closely related with the exchange rates. The larger the difference is, the cheaper the Euro is. The difference could be used to predict the contemporaneous exchange rate returns. By controlling market implied volatilities and funding liquidity, the difference still has a significant impact on the exchange rate returns. In addition, we find that the difference could predict the cumulative exchange rate returns up to ten days. The predictive power weakens with the increasing time horizon.

In a panel analysis, we find that the difference between dual-currency sovereign CDS spreads has a significant impact on the exchange rate returns by controlling the macroeconomic variables for the whole sample, PIIGS countries, and non-PIIGS countries. In particular, the magnitude of the coefficient on the spread differential is

bigger in the non-PIIGS countries than that in the PIIGS countries. The results are consistent with the fact that countries with strong economy in the Eurozone have more impact on the Euro to U.S. dollar exchange rate returns. Furthermore, we find the relation becomes stronger in 2010 when the debt crisis is worsening.

The remainder of the paper is organized as follows. Section 2 discusses the literature and motivation. Section 3 describes the sovereign CDS, exchange rates and other related data. Section 4 presents the correlation between dual-currency spread difference and exchange rates, time series determinants in predictive regressions, and the Granger causality results. Section 5 shows the predictive ability of spread difference on exchange rate returns in time series regressions, and the impact of dual-currency spread in panel regressions with monthly and daily frequencies. Section 6 concludes.

2. Literature review and motivation

Our paper has contributed to three aspects of the asset pricing literature. First, it adds to the recent discussion of price violation in the financial crisis. For example, Buraschi, Sener, and Menguturk (2011) find that there is a severely violated relation between Treasury credit spreads denominated in dual currencies during financial distress. They construct an empirical proxy of limits to arbitrage to examine the causes of this anomaly in Turkey, Brazil, and Mexico. Bai and Collin-Dufresne (2011) examine the difference between CDS and cash-bond implied credit spreads during the 2007-2009 financial crisis, when the CDS-bond basis turned negative. Coffey, Hrung, and Sarkar (2009) provide robust evidence of deviations from the covered interest rate parity (CIP) relation in the recent crisis, and find the deviations stem partly from lack of funding and partly from heightened counterparty credit risk. Fleckenstein, Longstaff, and Lustig (2011) examine the relative mispricing of TIPS and Treasury bonds from 2004 to 2009, and find the mispricing is closely related to supply factors and other types of fixed-income arbitrages. Garleanu and Pedersen (2011) study how margin requirements affect asset prices in margin based asset pricing model, and find a funding-liquidity crisis gives rise to the price gaps between securities with identical cash-flows but different margins.

Second, our paper is related to the literature of sovereign credit risk and derivatives. With the development of sovereign CDS market, a number of studies examine the pricing of sovereign default risk. Pan and Singleton (2008) explore the default arrival and recovery implicit in the term structures of sovereign CDS spreads, and show that a single-factor model captures most of the variation in the term structures of spreads by applying the model to the sovereign CDS data of Mexico, Turkey, and Korea. Regarding the determinants of sovereign credit spreads, the literature has not yet reached the consensus. Hilscher and Nosbusch (2010) show that macroeconomic variables are significantly related with sovereign default risk, such as foreign exchange reserves, GDP growth rate, inflation, industrial production and unemployment rates. Longstaff, et al. (2010) find that the majority of sovereign credit risk can be linked to global factors. About 64 percent of the variation in sovereign CDS spreads is absorbed by a single principal component accounts. Our study contributes to the understanding of the question, that is, which economic factors drive the variations in sovereign credit spreads.

Last but not least, our paper adds to the study of the integration between currency market and sovereign credit market. Prior studies have shown that it is difficult to predict foreign exchange rate returns. For example, Meese and Rogoff (1983) and Cheung et al. (2005) have found that exchange rates between major currencies are approximated by random walks. Although sometimes exchange rates are not exactly random walks, Cheung et al. (2005) show that they are not predictable, at least at long horizons. A number of papers show that macroeconomic indicators are important for exchange rate. For example, Almeida, Goodhart, and Payne (1998) identify significant impacts of most macroeconomic announcements on the Deutsche Mark/U.S. dollar exchange rates. Groen (2005) finds that the Euro exchange rates of Canada, Japan, and the U.S. have a long-run link with monetary fundamentals. In addition, currency crash risk is proved to be linked with the macroeconomic conditions of the underlying sovereign entity. Eichengreen et al. (1996), Frankel and Rose (1996), and Kumar et al. (2003) employ macroeconomic variables to estimate the probability of currency crashes. By linking currency market with the sovereign credit market, Carr and Wu (2007) examine the relation between sovereign CDS and currency options for Mexico and Brazil, and find that CDS spreads covary with both the currency option implied volatility and the slope of the implied volatility curve in

moneyness. Chung and Hui (2011) find that the creditworthiness of countries with both weaker and sound fiscal positions are important determinants of the deep out-of-the-money Euro put option prices during the sovereign debt crisis of 2009−2010.

Previous research of credit risk in multi-currency setting is mainly focus on corporate debt securities. Warnes and Acosta (2002) extend the classical Merton (1974) structural model to incorporate debt in a foreign currency and provide a closed form valuation equation for corporate debt whose value depends on both firm value and exchange rate. Jankowitsch and Pichler (2003) present a framework of estimating credit spreads for a single corporate issuer with bonds in different currencies, and find that corporate credit spreads are correlated with exchange rates. Landschoot (2008) compares the determinants of euro and US dollar yield spreads in the corporate bond markets. Ehlers and Schönbucher (2006) find that a sudden jump in the foreign exchange rate at default may explain the observed differences between JPY and USD CDS rates for a set of large Japanese corporations. Recently, Buraschi, Sener, and Menguturk (2011) find that the arbitrage relation in Treasury credit spreads in dual currencies for Brazil, Mexico, and Turkey sovereign bond markets is severely violated during periods of financial distress. Their paper shows that the cause of this anomaly is driven both by fundamental factors and global sentiment risk related to limits to arbitrage. During the recent crisis, we notice that there is a sudden jump of difference between euro and USD denominated CDS spreads, which has not been observed before the crisis of 2008. Thus, it is interesting to examine the reason behind the market phenomenon. Our paper is the first to examine the sovereign credit risk in a multi-currency setting.

3. Data and descriptive statistics

Our sample spans the period from January 2008 to December 2010. We download the five-year U.S. dollar and Euro denominated CDS spreads from Bloomberg for ten Eurozone countries, which are Austria, Belgium, Finland, France, Germany, Portugal, Ireland, Italy, Greece, and Spain. In the sample, we could compare the features between PIIGS (Portugal, Ireland, Italy, Greece, and Spain) and non-PIIGS countries. The sovereign CDS contract is similar to a corporate CDS, in which one counterparty

agreeing to “sell” protection to another. The “protected” party pays a fee periodically in exchange for a guarantee that if a pre-specified credit event of the government bond occurs, the seller of protection will provide compensation. The underlying reference entity of a sovereign CDS is the sovereign government. In our sample, every country has sovereign CDS market, and investors trade the sovereign credit risk through sovereign CDS contracts. In addition, the denominated currency of the sovereign CDS contracts could be the domestic currency or a foreign currency. For example, if a Greek CDS contract is denominated in U.S. dollar, then the CDS protection buyer would be paid off in U.S. dollars if there is a pre-specified credit event of the underlying Greek sovereign debt. If a Greek CDS contract is denominated in Euro, then the CDS protection buyer would be paid off in Euro if there is a pre-specified credit event of the underlying Greek sovereign debt.

Before 2008, the difference between U.S. dollar and Euro denominated CDS spreads is close to zero. However, there is a sharp jump in 2008. Thus, our sample period covers the turmoil period with various phases of the crisis from 2008 to 2010. We plot the daily spread differential between USD and euro denominated CDS for each country in Figure 1. In 2008, the differential seldom deviates from zero, while it increases incrementally with the worsening of sovereign debt crisis. This pattern is most obvious in those PIIGS countries, where the euro-denominated CDS contracts become much cheaper compared with the USD-denominated counterparts in 2010.

We get the Euro/dollar exchange rates, three-month and one-month Treasury bill rates, and three-month Eurodollar rates from the Federal Reserve Bank. The one-month Euro interbank offered rate (Euribor) is obtained from Bloomberg. The implied volatilities of S&P 500 options (VIX) are downloaded from Chicago Board Options Exchange (CBOE). To control the impact of macroeconomic conditions on the exchange rates, we obtain the industrial production, unemployment rate, and inflation rate (Consumer Price Index, CPI) from the International Financial Statistics database of International Monetary Fund (IMF). All the macro variables are in monthly frequency.

Table 1 presents the descriptive statistics of the whole sample, PIIGS countries, and non-PIIGS countries in Panel A, B, and C. Overall, the CDS spreads have an

increasing trend from 2008 to 2010 as European debt crisis worsens. For example, the average U.S. denominated CDS spreads is only 42 basis points (bps) in 2008 while the corresponding statistics is 211 bps in 2010. Both the U.S. dollar and Euro denominated CDS spreads have jumped about five times from 2008 to 2010. In addition, the U.S. dollar denominated CDS is more expensive than Euro denominated CDS in the sample period, which reflects the concern of Euro depreciation. In 2008, the average difference between U.S. dollar and Euro denominated CDS spreads is less than one bps, but it has substantially increased to 17 bps in 2010.

The default risk is much higher in the PIIGS countries than the non-PIIGS countries. For instance, the mean of average Euro denominated CDS spreads for the PIIGS countries is about 118 bps higher than that of the non-PIIGS countries in the whole sample period. The difference between U.S. dollar and Euro denominated CDS spreads is slightly larger for the non-PIIGS countries in 2008, but the relation has reversed in 2009 and 2010 when the debt trouble haunts the PIIGS countries. In particular, the average difference of PIIGS countries is twice more than that of the non-PIIGS countries in 2010.

The Euro has depreciated against U.S. dollar in most of the sample period. Meanwhile, the difference between U.S. dollar and Euro denominated CDS spreads has been increasing. Figure 2 shows the time series of the Euro per dollar in our sample period. Although there are up and down fluctuations in the exchange rate movements, the overall trend reflects the Euro depreciation from 2008 to 2010. The fact reveals that the protection buyer in the CDS contract expects to bear more currency risk if the residual value of the underlying debt is paid in Euro in case of default.

4. Time series determinants of the difference and its relation with exchange rates

4.1. Correlation between dual-currency CDS spread difference and exchange rates

Table 2 reports the correlation matrix among the time series variables. Panel A reports the correlation for levels. “Diff” refers to the daily average of difference between U.S. dollar and Euro denominated CDS spreads across the sample. “EU/$” is the Euro per dollar exchange rate. “VIX” is the implied volatility of S&P 500 index options.

Brunnermeier, Nagel, and Pedersen (2009) note that funding liquidity measures could predict exchange rate movements. We use "TED" as the proxy for funding liquidity, which is measured as difference between three-month U.S. Treasury rates and three-month Eurodollar rates. The "TED" spread measures the rate of return that the banks are requiring over the risk free rate to lend to other banks, thus reflecting the funding liquidity in the general market.

The correlation matrix shows that "Diff" and "VIX" has a strong positive relation with the exchange rates, respectively. Usually, the Euro depreciation is accompanied by the enlargement of the difference between U.S. dollar and Euro denominated CDS spreads. "TED" is positively related with the difference between dual-currency CDS spreads, which suggests that a severe lack of funding liquidity would result in a farther deviation between the U.S. dollar and Euro denominated CDS spreads.

Panel B reports the correlation for changes in the variables. The magnitudes are smaller, while the relation is consistent with the results in Panel A. The change in difference has a stronger relation with the market liquidity measure (change in TED), but a weaker relation with the change in market volatility. Interestingly, the change in exchange rates is more closely related with change in VIX than change in TED.

The correlation matrix suggests a close relation between dual-currency sovereign CDS spread difference and exchange rate. In addition, we find the correlation becomes smaller from 2008 to 2010. The correlation between "Diff" and "EU/$" is as high as 60 percent in 2008, but it declines to 19 percent in 2009 and 16 percent in 2010. However, we observe a skyrocketing increase in the dual-currency spread difference from 2008 to 2010. The contrast suggests that exchange rates may have a smaller impact on the widening of the spread difference than the impact of spread difference on the exchange rates.

4.2.Time series determinants of dual currency spread difference and exchange rates

In this section, we seek to identify the factors that drive the difference between dual-currency sovereign CDS spreads in the sample period. We also examine the relation between the difference and foreign exchange rates. The candidate explanatory variables are TED and VIX, which measures the funding liquidity and uncertainty of the global

market. We test the impact of contemporaneous and up to two lagged explanatory variables in the following regression:

$$Y_t = \alpha_0 X_t + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \varepsilon_t$$

When Y is dual-currency spread difference, X is exchange rate, TED, or VIX; When Y is exchange rate, X is dual-currency spread difference, TED, or VIX. The time series average difference across all countries is used in the predictive regression. We perform the regressions with Newey-West standard errors with a lag of two.[1]

We present the results in Table 3. In the first set of regressions on dual-currency spread difference, we find only the coefficient on the two lags of Ted is significant at 10%. In particular, the exchange rates do not have significant impact on the spread difference. In the second set of regressions on exchange rates, we find that the variables, two lags of spread difference and two lags of TED, are significant at % level. Specifically, the results suggest that the information content in the spread difference has predictive ability on the exchange rates. The positive coefficient shows that the wider the difference between U.S. and euro denominated CDS spreads, the cheaper the euro is.

4.3. Price discovery between two markets

Based on the previous results, we find the lag information of spread difference is significant on the exchange rates. In this section, we go further to explore the information content in the CDS and exchange rate markets and examine which market provides more timely information. We perform the Granger causality tests for each country and summarize the results in Table 4.

In the first set of tests, the null hypothesis is that, spread difference is not caused by exchange rate; in the second set of tests, the null hypothesis is that, the exchange rate is not caused by spread difference. We find the most of the p-values in the first column are greater than 10 percent, which suggests that we cannot reject the hypothesis. On the contrary, seven out of ten p-values in the second column are less than 10%, which shows that the null hypothesis is rejected in these seven countries and the information in the spread difference has contributed to the price discovery of exchange rates.

[1] We also tried different number of lags, and the results are similar.

Summarizing, the results show that the information content in the dual-currency sovereign CDS spreads has significant contribution to the exchange rates between euro and US dollars in the sample period, in which the sovereign debt crisis is worsening in the eurozone. Based on the findings, we will explore the relation between dual-currency spread difference and exchange rate returns further in the next section.

5. Relation between dual-currency spread difference and exchange rate returns

We investigate the time series relation between dual-currency sovereign CDS spread difference and exchange rate returns, and examine whether the dual-currency sovereign CDS spread difference could predict the exchange rate return. We also examine the impact of the spread difference on exchange rate return across countries by controlling the macroeconomic conditions.

5.1. Time series regressions of predictive ability

We first examine the time series relationships between the dual-currency sovereign CDS spread difference and exchange rate return. We compute the daily difference between U.S. dollar and Euro denominated CDS spreads for each country. Then we calculate the daily average of the difference across the sample. Figure 3 depicts the time series of the daily average difference between U.S. dollar and Euro denominated CDS spreads, which has an up-trend over the entire period. In the first half year of 2008, the difference is small and close to zero.[2] With the global financial debut in September 2008 and debt worries in Europe, the difference starts to escalate. When the Euro debt crisis is worsening, the Euro-denominated sovereign CDS is priced much cheaper than the U.S. dollar denominated CDS. We calculate the daily exchange rate return on Euro by following Ang and Chen (2010) as:

$$R^e_{t+1} = S^e_{t+1} / S^e_t (1 + r^e_t) - (1 + r_t) \tag{1}$$

[2] The average difference between U.S. dollar and Euro denominated CDS spreads is usually close to zero before 2008. Surprisingly, this equality approximation before the crisis was severely violated since 2008.

where S_t^e is the exchange rate in terms of dollar price of one unit of Euro, r_t^e is the short rate in Euro, and r_t is the U.S. short rate.

Table 5 examines the impact of daily average difference between the U.S. dollar and Euro denominated CDS spreads ("Diff") on the daily exchange rate returns in time series regressions. Consistent with the positive correlation found in Table 2, the daily Euro exchange rate return is positively affected by the difference between U.S. dollar and Euro denominated CDS spreads at 1% significant level. The standard errors are estimated from Newey West (1987) procedure with three lags.[3] In addition, the difference spread has positive impact on the exchange rate return with the control of VIX and TED at 1% significance level. The market volatility (VIX) and funding liquidity risk (TED) are also positively related with the exchange rate return.

5.2. Can difference between dual-currency sovereign CDS predict exchange rate returns?

In the previous analysis, we find that exchange rate return is significantly affected by the difference between U.S. dollar and Euro denominated sovereign CDS spreads. Next, we examine time series behavior of the dual-currency spread difference, and the persistence of its predictability on the exchange rate returns.

Following Ang and Chen (2010), we compute the *k*-day cumulative excess exchange rate returns as:

$$R_{t,k}^e = \exp\left[\frac{1}{k}\sum_{j=1}^{k}\log(1+R_{t+j}^e)\right]-1 \quad (2)$$

where R_{t+j}^e is the excess Euro exchange rate return over the next *j* days. Table 6 presents the time series regression of the dual-currency sovereign CDS spread difference on cumulative excess exchange rate returns over one to ten days. The standard errors are adjusted by Newey West (1987) method.[4]

The results show that the difference between U.S. dollar and Euro denominated CDS spreads could predict the cumulative Euro exchange rate returns up to ten days.

[3] We tried different number of lags, and the results are similar.

[4] The results with different lag numbers are similar. When the lag number increases, the predictive power decreases. We report the conservative results in the paper. With up to 30 lags, the difference between U.S. dollar and Euro denominated CDS spreads still can predict cumulative exchange rate returns up to ten days.

However, the predictive power disappears in a longer time horizon, which is consistent with the difficulty of predicting exchange rate returns documented in the literature. The significance level of the "Diff" coefficients has a decreasing trend over the horizon. The coefficient is at 1% significant level for one-day cumulative return, 5% significant level for the coefficients up to four days, and 10% significant level for the remaining coefficients. When we test the impact on the cumulative excess exchange rate return over 11 or more days, the t-statistics are insignificant. Again, we find the dual-currency CDS spread difference has a positive relation with the cumulative excess exchange rate returns. When the Euro-denominated CDS is cheaper than the U.S. dollar denominated CDS, it usually reflects the expectation of Euro depreciation.

5.3. Impact on exchange rate returns with macroeconomic variables at monthly frequency

We employ a monthly panel regression framework to examine whether the dual-currency sovereign CDS spread difference has strong impact on the excess exchange rate returns by controlling the monthly macroeconomic factors, such as industrial production, unemployment rate, and inflation rate. The month-end difference between U.S. dollar and Euro denominated CDS spreads and monthly exchange rate returns are used in the regressions.[5]

Table 7 reports the regression results at monthly frequency for the whole sample, PIIGS countries, and non-PIIGS countries from 2008 to 2010.[6] Clearly, the difference between U.S. dollar and Euro denominated CDS spreads ("Diff") has a significant impact on the exchange rate return. Both the coefficients are significant at a 5% level with control variables for all three samples. The magnitude of the coefficient of "Diff" is about two times larger in the non-PIIGS sample than that in the PIIGS sample, which suggests

[5] We tried other macro variables, such as change in GDP volume and GDP deflator, and the results are similar. They are available upon request. However, we do not include them in the paper, since these variables are not in monthly frequency, which requires data interpolation in the regressions.
We also tried the monthly average dual-currency CDS spread difference for each country based on the daily data, and the regression results are consistent with those reported in the paper.

[6] There are several outliers shown in Figure 3. For robustness check, we also run the regressions by removing the outliers and the results are similar, which are available upon request.

that the dual-currency CDS spread differential of countries with strong economy contains more information about the Euro-dollar exchange rate dynamics.

Among the macroeconomic variables, the coefficient of the change in industrial production is positively significant for the exchange rate returns in the PIIGS sample. Both the change in unemployment and inflation rate have negative impact on the exchange rate returns, which suggests that a country's higher unemployment and inflation rates would hamper the exchange rate return of its currency.

We conduct Chow tests for each country between any two consecutive years to examine whether there is significant structural change in our sample period. Between the year 2008 and 2009, all the p-values are greater than 10% except the one of Belgium. Between the year 2009 and 2010, all the p-values are greater than 10%. The results suggest that the null hypothesis cannot be rejected, and there is no significant structural change in the sample period. Thus, it is appropriate to conduct the pooled panel regressions in our sample period.

5.4. Impact on exchange rate returns with macroeconomic variables at daily frequency

For robustness, we run the daily regressions for each year by using the same macro variables each day in a month, daily dual-currency sovereign CDS spread difference, and daily exchange rate returns. The results are presented in Table 8. We find the impact of differential spread between dual-currency sovereign CDS is highly significant in 2010. However, the results are weaker in 2008. This is consistent with the observations in Figure 3, in which the spread differential is in small magnitudes in 2008 while the curves jump up in 2010.

Table 9 presents the results for PIIGS and non-PIIGS samples. Although the magnitude of spread differential is smaller in the non-PIIGS sample, we find the impact of spread differential on exchange rate return is stronger in this group of countries. The finding is consistent with the fact that non-PIIGS countries, especially Germany and France, play a more important role in determining the value of euro. The sub-sample

results are in line with those in Table 8, that is, the spread differential between dual-currency CDS has more information content when the debt crisis is worsening in 2010.

6. Conclusions

Focusing on the spread difference between dual-currency sovereign CDS is interesting as it provides more general insights into the foreign exchange rates literature. Our analysis is a preliminary step in testing the relation between spread difference and exchange rate returns. The study reveals that the difference between U.S. dollar and Euro denominated CDS spreads is enlarged in the sovereign debt crisis. With the worsening of the debt crisis, the difference would have a larger impact on the excess exchange rate returns. Additionally, the difference has predictive power on the cumulative excess exchange rate returns up to ten days. With the macroeconomic variables controlled in the panel regression, we find the strong impact of the difference on the exchange rate returns. The impact is especially strong in the year of deep debt crisis. Our findings shed lights on the relation between sovereign CDS markets and currency exchange rate returns, which is helpful to understand the credit market and foreign exchange market integration.

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Table 1 Summary statistics

The sovereign CDS data are obtained from Bloomberg. The exchange rates are obtained from the Federal Reserve Bank. Our sample period is from 2008 to 2010. Panel A reports the statistics for the whole sample. Panel B reports the statistics for the PIIGS countries. Panel C reports the statistics for the non-PIIGS countries. The "US CDS" refers to the U.S. dollar denominated CDS; the "EU CDS" refers to the Euro denominated CDS; and the "Diff" refers to the spread difference between the "US CDS" and "EU CDS". We compute the time series average of "US CDS", "EU CDS", and "Diff" for each country. Then we report the cross-sectional statistics. The "EU/$" is the exchange rate of Euro per dollar.

Panel A: Whole sample

Year	2008−2010				
	Mean	Median	Min	Max	Std.Dev
US CDS (bps)	125.01	99.83	32.59	307.70	92.38
EU CDS (bps)	116.98	97.38	29.05	293.93	88.98
Diff (bps)	8.03	6.86	2.45	13.77	4.21
EU/$	0.72	0.72	0.62	0.84	0.05
Year	2008				
US CDS (bps)	42.30	42.02	17.38	73.92	19.50
EU CDS (bps)	41.33	41.19	16.73	72.88	19.65
Diff (bps)	0.97	0.82	0.11	2.71	0.75
EU/$	0.68	0.67	0.62	0.80	0.05
Year	2009				

US CDS (bps)	98.89	91.70	36.12	190.12	53.45
EU CDS (bps)	94.79	86.98	34.14	188.46	52.90
Diff (bps)	4.09	4.12	1.66	7.42	2.13
EU/$	0.72	0.71	0.66	0.80	0.04
Year			2010		
US CDS (bps)	211.00	143.78	40.03	682.98	198.94
EU CDS (bps)	193.54	138.16	32.83	649.84	190.40
Diff (bps)	17.46	12.92	5.63	33.13	10.77
EU/$	0.76	0.75	0.69	0.84	0.03

Table 1 Summary statistics (continued)

The sovereign CDS data are obtained from Bloomberg. The exchange rates are obtained from the Federal Reserve Bank. Our sample period is from 2008 to 2010. Panel A reports the statistics for the whole sample. Panel B reports the statistics for the PIIGS countries. Panel C reports the statistics for the non-PIIGS countries. The "US CDS" refers to the U.S. dollar denominated CDS; the "EU CDS" refers to the Euro denominated CDS; and the "Diff" refers to the spread difference between the "US CDS" and "EU CDS". We compute the time series average of "US CDS", "EU CDS", and "Diff" for each country. Then we report the cross-sectional statistics. The "EU/$" is the exchange rate of Euro per dollar.

Panel B: PIIGS countries

Year			2008−2010		
	Mean	Median	Min	Max	Std
US CDS (bps)	179.88	136.48	99.83	307.70	90.86
EU CDS (bps)	169.64	125.06	97.38	293.93	87.95
Diff (bps)	10.24	11.42	2.45	13.77	4.47
			2008		
US CDS (bps)	57.57	55.02	46.32	73.92	13.01
EU CDS (bps)	56.87	54.53	45.53	72.88	13.02
Diff (bps)	0.70	0.83	0.11	1.04	0.41
			2009		
US CDS (bps)	128.50	110.64	78.64	190.12	49.48
EU CDS (bps)	124.28	107.79	74.22	188.46	49.65

Diff (bps)	4.21	4.42	1.66	7.42	2.18
			2010		
US CDS (bps)	320.75	285.46	143.78	682.98	211.41
EU CDS (bps)	297.06	256.20	138.16	649.84	204.61
Diff (bps)	23.68	28.64	5.63	33.13	10.89

Table 1 Summary statistics (continued)

The sovereign CDS data are obtained from Bloomberg. The exchange rates are obtained from the Federal Reserve Bank. Our sample period is from 2008 to 2010. Panel A reports the statistics for the whole sample. Panel B reports the statistics for the PIIGS countries. Panel C reports the statistics for the non-PIIGS countries. The "US CDS" refers to the U.S. dollar denominated CDS; the "EU CDS" refers to the Euro denominated CDS; and the "Diff" refers to the spread difference between the "US CDS" and "EU CDS". We compute the time series average of "US CDS", "EU CDS", and "Diff" for each country. Then we report the cross-sectional statistics. The "EU/$" is the exchange rate of Euro per dollar.

Panel C: non-PIIGS countries

Year			2008−2010		
	Mean	Median	Min	Max	Std
US CDS (bps)	56.42	57.80	32.59	77.48	21.43
EU CDS (bps)	51.16	52.09	29.05	71.41	20.03
Diff (bps)	5.26	5.31	3.55	6.86	1.49
			2008		
US CDS (bps)	27.03	26.52	17.38	37.72	9.80
EU CDS (bps)	25.80	24.81	16.73	36.86	9.37
Diff (bps)	1.23	0.79	0.65	2.71	0.99
			2009		
US CDS (bps)	61.88	52.25	36.12	106.90	32.64
EU CDS (bps)	57.94	48.98	34.14	99.65	30.25

Diff (bps)	3.94	3.27	1.98	7.25	2.39
			2010		
US CDS (bps)	73.83	73.52	40.03	108.23	28.04
EU CDS (bps)	64.15	64.22	32.83	95.31	25.79
Diff (bps)	9.68	9.30	7.20	12.92	2.43

Table 2 Correlation statistics

The table reports the correlation among "Diff", "EU/$", "VIX", and "TED" in the sample period. The "Diff" is the time series of cross-sectional average spread difference between U.S. dollar denominated CDS and Euro denominated CDS. "EU/$" is the exchange rate of Euro per dollar. "VIX" is the implied volatility index of S&P 500 options. "TED" is the rate difference between three-month Euro dollar and three-month U.S. Treasury bills.

Panel A: Level

	EU/$	Diff	TED
EU/$	1		
Diff	0.493	1	
TED	0.016	0.393	1
VIX	0.447	-0.213	-0.724

Panel B: Change

	ΔEU/$	ΔDiff	ΔTED
ΔEU/$	1		
ΔDiff	0.018	1	
ΔTED	0.040	0.237	1
ΔVIX	0.149	0.002	-0.005

Table 3 Time series determinants of dual-currency spread difference / exchange rates

This table reports the predictive regressions on the "Diff" or "EU/$" at the daily frequency. "Diff" is the time series average of spread difference all the sample. "EU/$" is the euro/dollar exchange rates. TED is measured as the difference as three-month Eurodollar rates and three-month Treasury bill rates. VIX is the implied volatility of the S&P 500 index options.

The regression takes the format as: $Y_t = \alpha_0 X_t + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \varepsilon_t$. When Y is "Diff", X is "EU/$", "TED", or "VIX"; when Y is "EU/$", X is "Diff", "TED", or "VIX". The t-statistics are reported in the parentheses using the Newey-West standard errors with a lag of two. The sample period is from January 2008 to December 2010.

	Diff			EU/$		
	EU/$	TED	VIX	Diff	TED	VIX
t	3.283	2.395	-0.146	0.001	0.002	0.001
	(0.05)	(1.35)	(-1.14)	(0.97)	(0.12)	(0.16)
t-1	87.909	-2.373	0.112	0.001	0.031	0.001
	(1.23)	(-0.92)	(0.84)	(1.41)	(1.58)	(1.51)
t-2	1.613	3.533*	-0.106	0.001**	-0.032**	0.001
	(0.02)	(1.81)	(-0.88)	(2.12)	(-2.01)	(0.64)
Adj. R-squared	27%	14%	3%	27%	0%	20%

Table 4 Contributions to price discovery

This table presents the Chi-square and p-value of the Granger causality test in each country. The null hypothesis for the first set of tests is "spread difference is not caused by exchange rate", and the null hypothesis for the second set of tests is "exchange rate is not caused by spread difference". If the p-value is greater than 5%, then we cannot reject the null hypothesis.

	H0: Diff not caused by EX		H0:EX not caused by Diff	
country	Chi-square	p-value	Chi-square	p-value
Austria	5.48	0.06	16.35	0.00
Belgium	3.57	0.17	7.73	0.02
Finland	0.16	0.92	2.44	0.30
France	4.02	0.13	21.51	0.00
Germany	2.50	0.29	12.01	0.00
Greece	5.30	0.07	11.72	0.00
Ireland	0.90	0.64	0.26	0.88
Italy	0.35	0.84	0.75	0.69
Portugal	1.04	0.59	5.78	0.06
Spain	0.81	0.67	5.58	0.06

Table 5 Time series regression between spread difference and exchange rate returns

This table reports the time series regression of daily spread difference between dual-currency CDS on daily exchange rate returns with Newey-West standard errors. The "Diff" is the time series of cross-sectional average spread difference between U.S. dollar denominated CDS and Euro denominated CDS. "EU/$" is the exchange rate of Euro per dollar. "VIX" is the implied volatility index of S&P 500 options. "TED" is the rate difference between three-month Euro dollar and three-month U.S. Treasury bills. The t-statistics are in the parenthesis. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

Diff	0.110***	0.072**	0.061***
	(3.63)	(2.42)	(2.65)
TED		0.971***	1.948***
		(4.75)	(3.80)
VIX			0.105***
			(3.55)
Intercept	-3.184***	-1.889***	-3.825***
	(-6.68)	(-3.23)	(-5.14)
Obs. Number	718	715	715
adj. R-squared	21%	34%	46%

Table 6 Predictability of spread difference on exchange rate returns

This table reports the time series regression of spread difference between dual-currency CDS on cumulative one- to ten-day exchange rate returns with Newey-West standard errors. "Diff" is the time series of cross-sectional average spread difference between U.S. dollar denominated CDS and Euro denominated CDS. The t-statistics are in the parenthesis. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

	CRET1	CRET2	CRET3	CRET4	CRET5	CRET6	CRET7	CRET8	CRET9	CRET10
Diff	0.011***	0.012**	0.014**	0.017**	0.019*	0.022*	0.024*	0.026*	0.029*	0.031*
	(2.66)	(2.28)	(2.09)	(1.99)	(1.93)	(1.88)	(1.85)	(1.82)	(1.79)	(1.68)
Intercept	-0.003***	-0.003***	-0.003***	-0.003***	-0.003**	-0.003**	-0.004**	-0.004*	-0.004*	-0.004*
	(-4.79)	(-3.80)	(-3.18)	(-2.81)	(-2.44)	(-2.20)	(-2.08)	(-1.94)	(-1.85)	(-1.78)
Obs. Number	717	688	659	631	605	579	553	527	501	476
adj. R-squared	1.70%	1.59%	1.68%	1.86%	2.03%	2.22%	2.32%	2.42%	2.58%	2.53%

Table 7 Monthly regressions on exchange rate return with macro variables

This table reports the panel regression results at the monthly frequency for the whole sample, PIIGS, and non-PIIGS countries in the whole sample period. The dependent variable is the monthly Euro exchange rate return. "Diff" is the month-end difference between U.S. dollar and Euro denominated CDS spreads. We use the change in industrial production, change in unemployment rate, and inflation rate as the control variables. The t-statistics are in the parenthesis. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

	Whole		PIIGS		Non-PIIGS	
Diff	0.050***	0.069**	0.024*	0.052***	0.091*	0.099**
	(3.83)	(3.24)	(3.04)	(5.57)	(2.44)	(2.92)
Chg. in industrial production		-11.627		30.871***		-15.229
		(-0.96)		(3.16)		(-1.04)
Chg. in unemployment rate		-10.027***		-3.188*		-12.268***
		(-4.13)		(-1.86)		(-4.67)
Inflation rate		-0.721***		-0.306**		-0.753***
		(-7.27)		(-2.45)		(-6.28)
Intercept	-0.487***	0.454**	-0.337	33.182**	-0.666***	0.300*
	(-4.98)	(2.99)	(-1.59)	(2.36)	(-4.87)	(2.19)
Obs. Number	283	225	112	59	171	166
R-squared	1.07%	9.99%	0.37%	4.00%	2.24%	11.40%

Table 8 Daily regressions on exchange rate return with macro variables

This table reports the panel regression results at the daily frequency for the whole sample. The dependent variable is the daily Euro exchange rate return. "Diff" is the daily differential between U.S. dollar and Euro denominated CDS spreads. We use the change in industrial production, change in unemployment rate, and inflation rate as the control variables. The t-statistics are in the parenthesis. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

	2008-2010		2008		2009		2010	
Diff	0.007***	0.009***	0.017	-0.002	-0.002	0.005*	0.004***	0.002*
	(6.94)	(6.78)	(1.54)	(-0.13)	(-1.05)	(2.28)	(3.53)	(2.04)
Chg. in Industrial Production		-0.312		-1.799**		0.573		-0.023
		(-1.77)		(-3.09)		(1.17)		(-0.06)
Chg. in Unemployment		-0.949		0.453		-5.658**		1.192
		(-1.03)		(0.37)		(-3.08)		(0.65)
Inflation rate		-0.119***		-0.240***		-0.129***		0.063**
		(-8.88)		(-4.36)		(-8.97)		(2.93)
Intercept	-0.230***	-0.068**	-0.501***	0.306	-0.046***	-0.069***	-0.136***	-0.206***
	(-30.44)	(-3.35)	(-46.07)	(1.55)	(-6.53)	(-8.90)	(-7.85)	(-8.75)
Obs. Number	6,098	4,947	1,645	1,407	2,211	1,765	2,242	1,775
R-squared	1.30%	6.00%	0.50%	4.50%	0.10%	1.90%	0.50%	0.80%

Table 9 Daily regressions on exchange rate return with macro variables for sub-samples

This table reports the panel regression results at the daily frequency for the PIIGS and non-PIIGS samples. The dependent variable is the daily Euro exchange rate return. "Diff" is the daily differential between U.S. dollar and Euro denominated CDS spreads. We use the change in industrial production, change in unemployment rate, and inflation rate as the control variables. The t-statistics are in the parenthesis. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

Panel A: PIIGS sample

	2008-2010		2008		2009		2010	
Diff	0.023*	0.015	-0.034	-0.043	-0.066	-0.126	0.033*	0.206
	(2.52)	(0.61)	(-0.58)	(-0.35)	(-1.26)	(-4.02)	(2.53)	(1.58)
Chg. in Industrial Production		-3.370		-4.933**		0.323		1.500
		(-6.07)		(-26.20)		(0.23)		(0.16)
Chg. in Unemployment		1.671**		1.914		-4.318		-50.309
		(25.07)		(0.20)		(-0.71)		(-2.43)
Inflation rate		-0.657		-1.397		-0.186		-5.508
		(-3.70)		(-1.96)		(-0.62)		(-2.64)
Intercept	-0.414***	0.739	-1.626***	3.548	0.822**	1.048**	-0.424	5.491
	(-5.99)	(1.57)	(-42.62)	(1.36)	(3.64)	(13.71)	(-1.59)	(5.06)
Obs. Number	2,331	1,249	749	489	965	486	617	274
R-squared	1.0%	8.1%	0.1%	5.4%	2.7%	6.5%	1.0%	24.2%

Table 9 Daily regressions on exchange rate return with macro variables for sub-samples (continued)

This table reports the panel regression results at the daily frequency for the PIIGS and non-PIIGS samples. The dependent variable is the daily Euro exchange rate return. "Diff" is the daily differential between U.S. dollar and Euro denominated CDS spreads. We use the change in industrial production, change in unemployment rate, and inflation rate as the control variables. The t-statistics are in the parenthesis. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

Panel B: non-PIIGS sample

	2008-2010		2008		2009		2010	
Diff	0.068***	0.070***	0.039	-0.108	0.022	0.020*	0.113*	0.232**
	(4.22)	(5.13)	(0.44)	(-0.68)	(1.65)	(2.25)	(2.08)	(3.02)
Chg. in Industrial Production		-6.451***		-15.072***		-2.662**		-0.283
		(-4.70)		(-5.41)		(-2.59)		(-0.06)
Chg. in Unemployment		-12.793***		-22.344*		-8.824*		-15.077***
		(-6.47)		(-2.40)		(-2.06)		(-4.93)
Inflation rate		-0.667***		-1.971**		0.050		-1.949**
		(-8.70)		(-2.90)		(0.13)		(-3.21)
Intercept	-0.564***	0.307**	-1.750***	4.416	0.425***	0.438***	-0.890	0.606
	(-6.75)	(2.83)	(-17.05)	(1.96)	(7.76)	(11.61)	(-1.56)	(0.64)
Obs. Number	3,488	3,482	1,042	1,037	1,415	1,414	1,031	1,031
R-squared	1.8%	7.2%	0.1%	7.8%	0.4%	0.6%	3.4%	7.4%

Figure 1 Time series of dual-currency spread difference for each country

The graphs describe the time series of spread difference between U.S. denominated and Euro denominated CDS for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Portugal, and Spain. Data period is from January 2008 to December 2010.

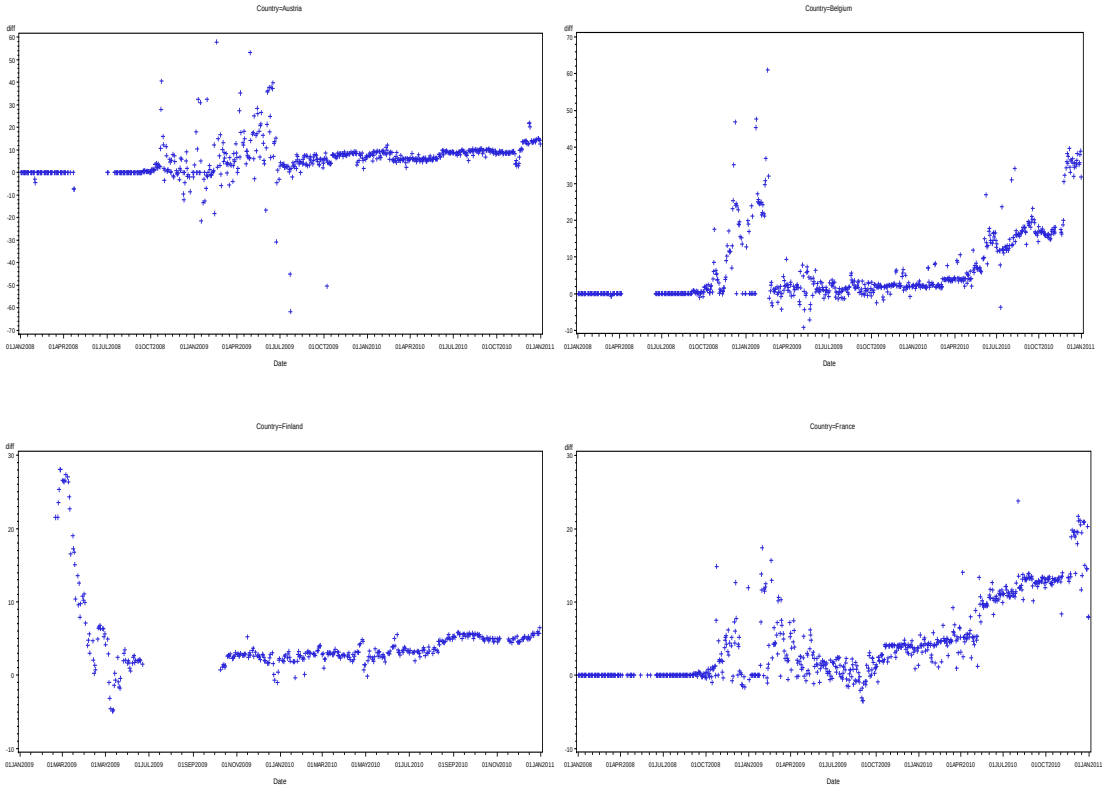

Figure 1 Time series of dual-currency spread difference for each country (continued)

The graphs describe the time series of spread difference between U.S. denominated and Euro denominated CDS for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Portugal, and Spain. Data period is from January 2008 to December 2010.

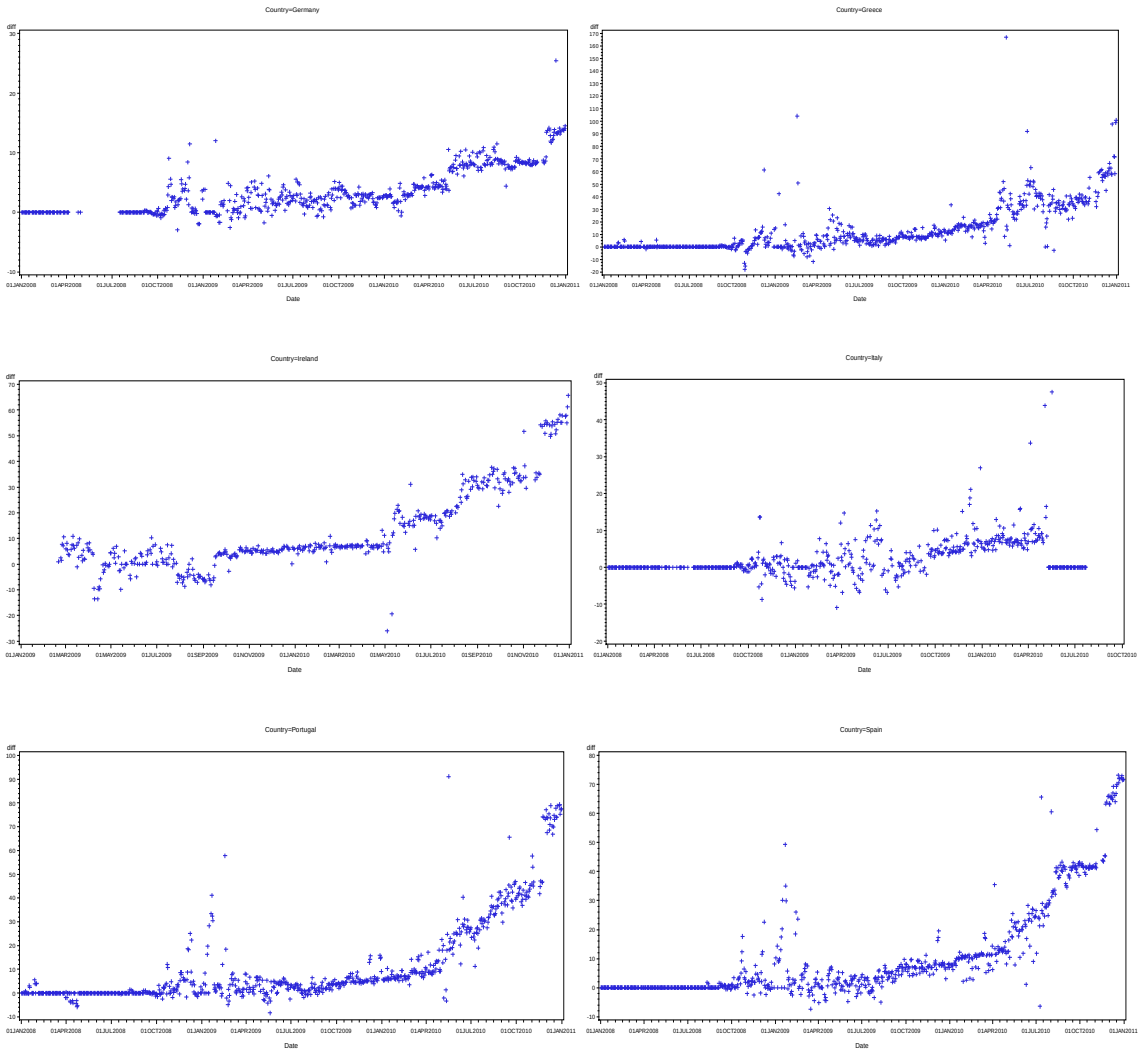

Figure 2 Time series of exchange rates (Euro/dollar)

The graph presents the time series of exchange rates (Euro per dollar) in the period from January 2008 to December 2010.

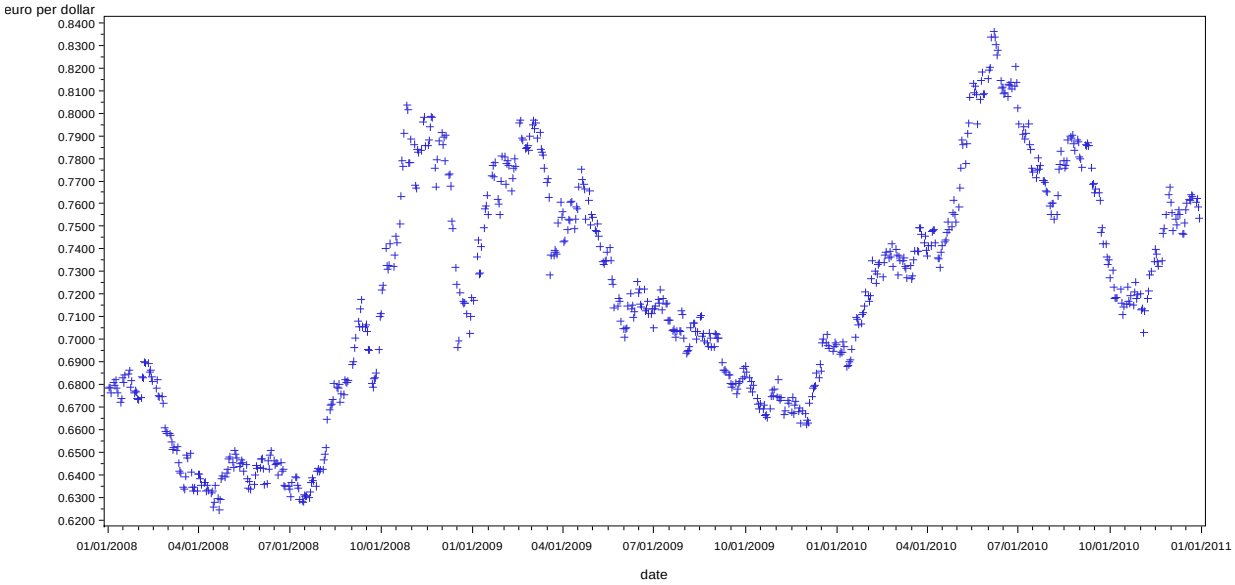

Figure 3 Time series of average spread difference between U.S. denominated and Euro denominated CDS

The graph describes the time series of average spread difference between U.S. denominated and Euro denominated CDS across the sample. Data period is from January 2008 to December 2010.