

**Strong Sterling Pound and Weak European Currencies in the Crises:
Evidence from Covered Interest Parity of Secured Rates ***

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Abstract

In the post Lehman period, the interest rate of the US dollar became low on the forward contract because of its role as international currency. However, in the Euro crisis, that of the Sterling pound became equally low, while the other European currencies increased its liquidity premium. By using secured rates, the following analysis examines why the Sterling pound and the Danish kroner showed asymmetric features in the two crises. The regression results suggest that there was a structural break in the determinants of deviations from covered interest parity (CIP) condition across the European currencies during the crises. Currency-specific money market risk was critical in explaining the deviations in the GFC, while EU banks' credit risk were useful in explaining the deviations in the Euro crisis. The asymmetry explains different features between the Sterling pound and the Danish kroner in the two crises.

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1. Introduction

The global financial crisis (GFC) and the following Euro crisis had enormous impacts on international markets. In particular, covered interest parity (CIP) condition, which was solidly anchored in riskless arbitrage during tranquil periods, was violated substantially during the crises. Even using secured rates such as overnight index swap (OIS) rates, the violation was substantial in the crises. In particular, when comparing interest rates across currencies, the CIP condition suggests that the US dollar had lower interest rate than any other currency in the crisis.

Figure 1 depicts daily deviations from the CIP condition between the US dollar and each of the five non-US dollar currencies: Euro, Sterling pound, Danish krone, the Swiss franc, and Japanese yen. For the sample period from January 2, 2006 to November 24, 2015, we calculated deviations from the CIP condition by the annualized value of $(1+i_t^n) - (1+i_t^{us}) (F_{t+1}^n/S_t^n)$, where i_t^n is three-month currency n 's OIS rate, i_t^{us} is three-month US dollar OIS rate, S_t^n is the spot exchange rate between the two currencies, and F_{t+1}^n is its three-month forward exchange rate. For all combinations, deviations from the CIP condition had been negligible until the beginning of August 2007. But significant upward deviations had occurred since mid-August 2007. In particular, there were very large upward deviations after the Lehman shock on September 15 in 2008. The upward deviations were temporarily stabilized in 2009. But reflecting the Euro crisis, we can still observe significant upward deviations from 2010 to 2012 and in 2015. Money that provides with liquidity has lower interest rate than any other safe asset. In the global crises, the role of the US dollar as international liquidity similarly made its interest rate lower than those of the other major currencies on the forward market.

However, when comparing interest rates across the other currencies, we can see that the Sterling pound had smaller deviations than the other major currencies after the early 2009. In particular, since the second half of 2010, the Sterling pound came to have equally low interest rate as the US dollar on the forward contract. In contrast, the other European currencies and the Japanese yen had higher interest rates in the Euro crisis. **Figure 2** depicts daily CIP deviations of the Euro from three European currencies and the Japanese yen from January 2, 2006 to November 24, 2015. For

currency k (k = the Sterling pound, the Swiss franc, the Danish kroner, and the Japanese yen), we calculated deviations of the CIP conditions by the annualized value of $(1 + i_t^k) - (1 + i_t^{\text{euro}})(f_{t+1}^k/e_t^k)$, where i_t^k is three-month currency k 's OIS rate, i_t^{euro} is three-month Euro OIS rate, e_t^k is the Euro spot exchange rate against currency k , and f_{t+1}^k is its three-month forward exchange rate. All of the data the unit of which is basis point are downloaded from [Datastream](#). Even when we use the Euro as the benchmark currency, we can see significant positive deviations in the Swiss franc, the Danish kroner, and the Japanese yen in the figure. The upward deviations which became largest after the Lehman shock still persisted in the Euro crisis. In contrast, the Sterling pound showed negative deviations throughout the period. In particular, the downward deviations were widened in the second half of 2011 when the Euro crisis became more serious. The results imply that in the Euro crisis, the Euro remained chosen as a regional liquidity among non-Euro members in Europe but that the Sterling pound was preferred more than the Euro in the international money markets.

The purpose of this paper is to explore what made the CIP deviations from the Euro so different between the Sterling pound and the Danish kroner in the twin crises. The role of the Euro as a regional liquidity in Europe might explain why the Euro's interest rate was lower than those of the Danish kroner and the Swiss franc in the crises. In contrast, the lower interest rate of the Sterling pound may be attributable not only to UK's less reliance on the Euro but also to the role of London market as a money center. In the foreign exchange transactions, London is the largest money center in the world. Based on BIS's [Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity](#), [Table 1](#) summarizes currency shares of geographical distribution of global foreign exchange market turnover in 1998, 2001, 2004, 2007, 2010, and 2013. It indicates that the UK share has been twice as large as the US share and has been much larger than the other shares. In particular, the UK share exceeded 40% in 2013. No other European countries had comparable shares to the UK. This implies that the transactions are highly thick in the London market, which might have made the Sterling pound useful in international money markets.

In the following analysis, our regression results suggest that there was a structural break in the

determinants of the deviations in the two crises. In the GFC, currency-specific money market risk had a similar effect on the deviations of the Sterling pound and the Danish krone. In contrast, EU banks' credit risk had an asymmetric effect on the deviations of the two currencies in the Euro crisis. In Europe, it was in early 2010 when fears of a sovereign debt crisis developed among investors concerning Greece's ability to meet its debt obligations. This led to a crisis of confidence, indicated by a widening of bond yield spreads and the cost of risk insurance on credit default swaps. Under the turbulence in Europe, there are asymmetric responses between the Sterling pound and the Danish krone. Our empirical results suggest that even though the Danish economy had relatively sound fundamentals, its currency faced Euro's liquidity risk in the crisis.¹ In contrast, investors increased their liquidity preference for the Sterling pound in the Euro crisis because the London market was more liquid in the foreign exchange transactions

In previous literature, several studies have explored sources of deviations from CIP condition in the global financial crisis. Baba and Packer (2009a,b) find that deviations from covered interest parity were negatively associated with the creditworthiness of European and US financial institutions. The authors such as Fong, Valente, and Fung (2010) and Coffey, Hrungr, and Sarkar (2009) show that in addition to credit risk, liquidity and market risk played important roles in explaining the deviations. Grioli and Rinaldo (2010) find that the results were essentially the same even if we used secured rates such as OIS. Fukuda (2012) finds that in the GFC, the Tokyo market had larger deviations than the London and the New York markets even though Japanese banks were more sound and healthy than EU and US banks. The following analysis confirms some of the findings in previous studies, especially those based on secured rates. However, unlike previous studies, this analysis pays a special attention to different features across several European currencies before and after the Euro crisis which has not been discussed extensively in literature.

One important implication of this paper is that the degree of liquidity risk is not necessarily

¹ In July 2012, Danish central bank adopted a special monetary policy to set some of its policy rate below zero. But our sample does not include this special period.

related with economic fundamentals such as banking sector's soundness. Denmark and Switzerland are European countries that had relatively sound economic fundamentals in the Euro crisis. However, due to strong linkages to the Euro, they suffered from Euro's liquidity shortage in the Euro crisis. In contrast, due to the fact that London is the largest money center in the world, UK did not suffer from liquidity shortage in the Euro crisis. The result is consistent with that of Fukuda (2011) who showed that in the GFC, the Tokyo market had higher liquidity risk than the London and the New York markets because the Tokyo market is less thick than the other two markets. In literature, several studies discussed money market risk in Europe in the GFC and in the Euro crisis (see, among others, Moessner and Allen (2013)). In particular, authors such as Mindested and Risbjerg (2011) and Risbjerg and Sangill (2012) discussed the Danish money market and its liquidity in the crisis period. Our empirical results will provide with supplementary explanations for determinants of money market risk in Europe based on information obtained from CIP conditions between the Euro and other European currencies.

The rest of the paper is organized as follows. Section 2 presents a basic framework of our econometric tests. After explaining how to measure counter-party credit risk and liquidity risk in Section 3, Section 4 reports the results of our regressions. Section 5 investigates their robustness allowing alternative structural breaks. Section 6 concludes and refers to the implications.

2. Empirical Specification

The purpose of the following sections is to examine why European currencies showed asymmetric deviations from the CIP conditions in the GFC and in the Euro crisis. Since our main interest is to compare the difference between the Euro and the other European currencies, the following analysis focuses the determinants of the CIP deviations between the Euro and the two European currencies: the Sterling pound and the Danish kroner. We chose the two currencies because UK is the country that has the largest money center in the world, while Denmark is an European country that relies heavily on Euro in the ERM II. They are also exceptional non-Euro members

where relevant time-series data, especially OIS rate, is available for a long period.

The total sample period is from January 2, 2008 to March 28, 2013.² Until section 4, we split the sample before and after January 1, 2010 to allow a structural break before and after the Euro crisis. There is no definitive consensus on when the GFC ended and when the Euro crisis started. But the market turbulences after the financial crisis of 2007–2008, known as the Global Financial Crisis (GFC), were almost stabilized in late 2009. In contrast, in October 2009, the Greek government admitted that it had misreported its official economic statistics for many years. Fears of a sovereign debt crisis then developed among investors concerning Greece's ability to meet its debt obligations. In the first few weeks of 2010, there was renewed anxiety about excessive national debt, with lenders demanding ever higher interest rates from several countries with higher debt levels, deficits and current account deficits. Splitting the sample before and after January 1, 2010 would be approximately appropriate for the structural break. In section 5, we will show that alternative sample splits will not change the essential results in the paper.

Defining deviations from the CIP condition between the Euro and currency j (j = the Sterling pound and the Danish kroner) in period t by $Dev_t(j)$, the following analysis examines what factors explain $Dev_t(j)$ in the GFC and in the Euro crisis. By using daily data for the two sub-samples, we estimate the following equation:

$$(1) \quad Dev_t(j) = \text{constant term} + \sum_h \alpha_h \cdot Credit_t(h) + \sum_q \beta_q \cdot Credit_t(q) + \gamma \text{Market}_t,$$

for j = the Sterling pound and the Danish kroner.

We calculate the dependent variable by $Dev_t(j) \equiv (1+i_t^j) - (1+i_t^{\text{euro}})(f_{t+1}^j/e_t^j)$, where i_t^j is three-month currency j 's OIS rate, i_t^{euro} is three-month euro OIS rate, e_t^j is the Euro spot exchange rate against currency j , and f_{t+1}^j is its three-month forward exchange rate. The OIS rates are secured

² Our sample terminates on March 28, 2013 because daily data of LIBOR for the Danish kroner is not available after that.

rates that measure market participants' expected average policy rate over the relevant term. $Dev_i(j)$ thus reflects secured arbitrage that removes many of the counter-party credit risks. The unit is basis point. The spot exchange rates and three-month forward exchange rates used in the analysis are their interbank middle rates at 4pm in London time. The data are downloaded from [Datastream](#).

The right hand side of (1) includes three types of risk measures in addition to the constant term. The first is $Credit_t(h)$ which is a credit risk measure in currency h (h = the US dollar, the Euro, the Sterling pound, and the Danish kroner) in period t . In the crises, term premiums in the international money market became heterogeneous across currencies. In particular, due to the role of the US dollar as international liquidity, traders were especially sensitive to a liquidity shortage of the US dollar in international transactions. The first type of measure is included in (1) to capture such currency-specific risk. We explore whether local currency risk and global currency risk had different impacts in the two subsample periods.

The second is $Credit_t(q)$ which is a credit risk measure in country q (q = the United States, UK, EU, Ireland, and Denmark) in period t . In the GFC, the credit quality of European, UK, and US banks deteriorated substantially. In contrast, in the Euro crisis, soared sovereign risk hit mainly European banks. This suggests that credit risk had country-specific features in the two crises which may be captured by $Credit_t(q)$. We explore whether different country risk had different impacts in the two subsample periods.

The third is $Market_t$ which is a global market risk measure in period t . For the measure, we use the Chicago Board Options Exchange Volatility Index (VIX) which is a popular measure of the implied volatility of S&P 500 index options. A high value corresponds to a more volatile market and therefore, more costly options. Often referred to as the fear index, the VIX represents a measure of the market's expectation of volatility over the next 30-day period. We explore whether the global market risk had different impacts in the two subsample periods.

In the financial turmoil, some traders are not given as much "balance sheet" to invest, which is perceived as a shortage of liquidity to them. Under this situation, the traders are reluctant to

expose their funds during a period of time where the funds might be needed to cover their own shortfalls. Consequently, in the crisis, foreign exchange markets come under stress, and bid-ask spreads may be widened in the markets. The three risk measures may capture such financial market tightness in each currency and in each country.

3. Basic Statistics of Various Risk Measures

3.1. Currency-specific credit risk

To measure the currency-specific credit risk $Credit_t(h)$, the following analysis uses the spreads between LIBOR and OIS rate in currency h (h = the US dollar, the Euro, the Sterling pound, and the Danish kroner). LIBOR (London Interbank Offered Rate) is a daily reference rate in the London interbank market calculated for various currencies, while OIS rate is a daily secured rate that removes counter-party credit risks. Since LIBOR is based on the interest rates at which banks borrow unsecured funds from other banks in each currency, each spread reflects a counterparty credit risk in currency h .³ For example, the US dollar-denominated LIBOR–OIS spread reflects credit risk of the US dollar, while the Euro-denominated LIBOR–OIS spread reflects that of the Euro. In calculating the spreads, we use daily data of three-month LIBORs which were published by the British Bankers' Association, after 11:00 a.m. each day (Greenwich Mean Time). And that of OIS rates which were downloaded from [Datastream](#).⁴

Table 2 summarizes basic test statistics of these daily credit risk measures for the two sub-sample periods: from January 2, 2008 to December 31, 2009 and from January 2, 2010 to March 28, 2013. For comparison, it also reports basic test statistics of the same risk measures in the Swiss franc and the Japanese yen. All spreads had larger mean, median, standard deviation, and skewness in the first sub-sample period than in the second sub-sample period. Regardless of the currency

³ Taylor and Williams, (2009) use the same spreads in measuring credit risk. The spreads may have measurement errors because some panel banks acted strategically when quoting rates to the LIBOR survey during the global financial crisis (see, for example, Mollenkamp and Whitehouse [2008]). When the measurement errors exist, the estimated coefficient will be less significant in the first sub-sample period.

⁴ The daily OIS rates are quoted in different time zones depending on their currency denomination. But since their daily changes are very small, it is unlikely that the time difference affect the spreads.

denomination, the turbulence in the short-term money markets was more serious in the GFC than in the Euro crisis. In the GFC, traders who were not given as much “balance sheet” to invest faced a serious shortage of liquidity. Larger and more volatile spreads in the first sub-sample period reflect such a feature in the GFC.

The contrast between the first and the second sub-sample periods was especially conspicuous in the US dollar and the Sterling pound. The mean of the spreads in the US dollar which was close to 80 basis points for the first sub-sample dropped to about 20 basis points for the second sub-sample period. The mean in the Sterling pound which exceeded 90 basis points for the first sub-sample dropped to less than 30 basis points for the second sub-sample period. The sharply increased money market credit risk in the two currencies was relatively stabilized in the Euro crisis.

The mean of the Euro-denominated spreads also dropped significantly for the second sub-sample period. However, the spreads of the Euro, which were smaller than those of the US dollar and the Sterling pound for the first sub-sample, became larger for the second sub-sample. The Euro which was a relatively safe currency in the GFC became a relatively risky currency in the Euro crisis. Among the European currencies, the Swiss franc had the smallest spread for both of the two sub-sample periods. This was partly because the data of the Swiss franc denominated spreads is available only after November 17, 2008. But on the whole, the Swiss franc was less risky currency in the money markets during the two crises. In contrast, the Danish kroner’s spread remained high throughout the two sub-sample periods. The Danish kroner suffered from increased risk premium in the money markets during the two crises.

3.2. Country-specific credit risk

To measure the country-specific credit risk $Credit_t(q)$, the following analysis uses the credit default swap (CDS) prices for country q at 4pm in London time.. Since credit risk was conspicuous in banking sector, we use the daily time series of the five-year banks sector CDS indexes for EU, the United Kingdom, and the United States. To capture sovereign credit risk, we also use the daily time

series of the five-year sovereign CDS for Ireland, Italy, and Denmark. The data is downloaded from [Datastream](#), which is based on CMA Data Vision.

Table 3 summarizes basic test statistics for these daily banks sector and sovereign CDS for the two sub-sample periods (from January 2, 2008 to December 30, 2009 and from January 2, 2010 to March 28, 2013). For comparison, it also reports the same test statistics for sovereign CDS of US, Germany, France, Spain, and the United Kingdom. Among the three banks sector CDS indexes, US banks had larger mean, median, standard deviation, and skewness for the first sub-sample period. Although the Lehman shock damaged both European and UK banks, the credit quality US banks deteriorated most in the GFC. In contrast, European banks had larger mean, median, standard deviation, and skewness for the second sub-sample period. The mean, median, and standard deviation for EU banks sector in the second sub-sample period were more than doubled from those in the first sub-sample period and far exceeded those of US and UK banks in the same period. In the Euro crisis, the credit quality of European banks deteriorated dramatically.

Except for Ireland, sovereign CDS indexes were relatively stable for the first sub-sample period. However, reflecting their fiscal crisis, the mean, median, standard deviation of sovereign CDS indexes for Italy, Spain, and Ireland increased dramatically in the second sub-sample period. French sovereign CDS index also increased its mean, median, standard deviation substantially in the Euro crisis. In contrast, CDS indexes for the UK and Denmark increased their mean and median only modestly and reduced their standard deviation in the same period. The mean and median of Germany CDS index was lowest not only in the first sub-sample period but also in the second sub-sample period. The Euro crisis had only limited impact on the UK and Danish sovereign risk and little on Germany sovereign risk.

4. Estimation Results

This section reports our empirical results concerning the effects of various risk measures on the CIP deviations of the Sterling pound and the Danish kroner from the Euro. In each regression we

use daily data for each of the two sub-sample periods: from January 2, 2008 to December 30, 2009 and from January 2, 2010 to March 28, 2013. The unit of each interest rate is basis point. We run OLS regressions for equation (1) with two lagged dependent variables. To be synchronized with the dependent variable, the country-specific credit risk $Credit_t(q)$ and the currency-specific liquidity risk $Liquidity_t(k)$ are the values at 4pm in London time. But the other explanatory variables are the latest values before 4pm in London time. The estimated results with and without currency-specific liquidity risks are summarized in Table 4. It shows that several credit risk measures had significant effects on the CIP deviations of the Sterling pound and those of the Danish kroner. However, many of the risk measures had different significance levels and different signs for the two sub-sample periods, suggesting structural breaks before and after the Euro crisis. We also found some asymmetry between the Sterling pound and the Danish kroner.

4.1. Currency-specific credit risk

Regarding currency-specific credit risk measures, most of them had significant impact only in the first sub-sample period. In the first sub-sample period, the Euro-denominated spread (i.e., LIBOR–OIS spread) had a significantly positive effect on the deviations both in the Sterling pound and in the Danish kroner. The pound-denominated spread had a significantly negative effect on the Sterling pound's deviations, and so did the kroner-denominated spread on the Danish kroner's deviations. The symmetric results indicate that in the GFC, markets were very sensitive to a liquidity shortage of the Euro and that an increase in currency-specific credit risk made the currency's liquidity tighter and decreased its secured interest rate on the forward contract. The US dollar-denominated spread had a significantly negative effect only for the Sterling pound's deviations. Global liquidity shortage after the Lehman shock made not only the US dollar interest rate but also the Sterling pound interest rate lower on the forward contract, suggesting that the Sterling pound was a substitute for the US dollar in the international money markets.

In contrast, in the second sub-sample period, none of the currency-specific credit risk

measures were significant in any estimation. This may reflect the fact that the turbulence in the short-term money markets was more serious in the GFC than in the Euro crisis. Coordinated monetary policies by central banks might also have contributed to reducing liquidity risk in the international money markets in the second sub-sample period.

It is noteworthy that even the Euro-denominated spreads were significant neither in the Sterling pound nor in the Danish kroner. This implies that a rise of Euro-specific risk premium had little impact on the relative interest rate between the Euro and the other European currencies. Unlike in the GFC, markets became less sensitive to a liquidity shortage of the Euro in the Euro crisis.

4.2. Country-specific credit risk

Regarding the currency-specific measures, the US bank sector CDS had a marginally significant negative effect on the Danish kroner in the first sub-sample period. But none of the other bank sector CDS had significant effect in the first sub-sample period. The Lehman shock damaged the credit quality of both the US and European banks. As a result, country-specific banks sector CDS increased in the GFC. The increased risk might have changed the relative interest rate between the US dollar and European currencies. However, it did not lead to a significant change in the relative interest rate between the Euro and the other European currencies. In the Danish kroner, sovereign risk in Ireland had a significantly positive coefficient. This may reflect some vulnerability of the Danish kroner to the crisis. However, it had no significant impact on the Sterling pound's deviations. The results may reflect the fact that country-specific credit risk had been relatively stable in Europe except for Ireland until the end of 2009. They may also suggest that the GFC was a liquidity crisis where sovereign risk was less important than money market risk on the forward contract.

In contrast, EU banks sector CDS had a significant effect on the deviations of both the Sterling pound and the Danish kroner in the second sub-sample period. This implies that unlike in the GFC, deteriorated credit quality of European banks changed the relative interest rate among European currencies in the Euro crisis. However, it is noteworthy that the coefficient of EU banks sector CDS

had opposite signs between the Sterling pound and the Danish kroner. In the case of the Sterling pound, a rise of European banking crisis increased precautionary demand for the Sterling pound and decreased Pound's secured interest rate. This may reflect the fact that the Sterling pound substituted the role of the Euro as an international currency in the crisis. In contrast, in the case of Danish kroner, a rise of European banking crisis increased precautionary demand for the Euro and increased Kroner's secured interest rate. For Danish international transactions, the Euro is an important counterpart currency in the turnovers. In the Euro crisis, it thus became more indispensable to avoid Euro's shortage for Denmark, which decreased the secured interest of the Euro on the Danish forward contracts.

In the second sub-sample period, Irish CDS had a significant effect on the Sterling pound's deviations. From late 2009, fears of a European sovereign debt crisis developed among investors as a result of the rising government debt levels around the world together with a wave of downgrading of government debt in some European states. Concerns intensified in early 2010, particularly in April 2010 when downgrading of Greek government debt to junk bond status created alarm in financial markets. The significant coefficients of the sovereign CDS reflected the environments. Due to a strong linkage between Ireland, a rise of Irish sovereign risk decreased precautionary demand for the Sterling pound and increased the Pound's secured interest rate.

4.3. Market risk

In the first sub-sample period, the estimated coefficient of VIX was not significant in the Sterling pound but was significantly positive in the Danish kroner. This suggests that in the GFC, the market risk did not affect the Sterling pound but had a significant impact on the Danish kroner. This may imply that the Danish kroner is more vulnerable to the global market risk than the Sterling pound.

More interestingly, in the second sub-sample period, the estimated coefficient of VIX was significantly negative in the Sterling pound and was significantly positive in the Danish kroner. This

indicates that a rise of the global market risk made the Pound's secured rate lower than the Euro's secured rate but made the Danish secured interest rate higher. The increased market risk in the Euro crisis shifted demand of international transactions from the Euro to the Sterling pound, while it increased precautionary demand for the Euro in regional countries such as in Denmark. Recall that similar asymmetric effects were observed for the coefficients of EU banks sector CDS. As the global market risk increased in the Euro crisis, the Sterling pound substituted the role of the Euro as an international currency, while precautionary demand for the Euro increased in Denmark and increased the Kroner's secured interest rate.

5. Robustness test

Until the last section, we have examined what determined the CIP deviations before and after the beginning of January 2012. The separate estimation results for the two sub-sample periods showed substantial structural changes in the coefficients. For example, the Chow Breakpoint test F-statistics in each equation is 5.51 and 6.40 for the Sterling pound and 9.48 and 9.88 for the Danish kroner, all of which reject the hypothesis that there is no structural break at 1% significance level. However, since there is no consensus on when the GFC ended and when the Euro crisis began, the choice of the sub-samples was arbitrary.

The purpose of this section is to explore how the use of alternative subsample periods may change the essential results in the last section. In the analysis, we apply the Bai-Perron test which extended the Quandt-Andrews test by allowing for multiple unknown breakpoints.⁵ Assuming 15% trimming and allowing error distributions to differ across breaks, we use the Bai-Perron test to explore multiple unknown break dates and their significance in our sample. Assuming two unknown break dates at maximum, the break dates which scaled F-statistic identified are November 7, 2008 and September 18, 2009 in the Sterling pound, and November 18, 2008 and December 29, 2009 in the Danish kroner. Both in the Sterling pound and the Danish kroner, the first break date occurred in

⁵ Bai and Perron (2003) provided theoretical and computational results.

November 2008, suggesting that there was a structural break when the worst turbulence after the Lehman shock was almost stabilized. This indicates that our estimation should have allowed a structural break in the GFC. However, the second break date occurred in fall 2009 in the Sterling pound and at the end of 2009 in the Danish kroner. Both of the dates, especially the date in the Danish kroner, almost correspond to the date previous sections assumed as the end of the GFC and the beginning of the Euro crisis.

Dividing the sample period based into three sub-sample periods based on the identified break dates, we run OLS regressions for equation (1). Except for the sub-sample periods, the estimation method and the data set are exactly the same as those in the last section. [Table 5](#) reports the estimation results for the new sub-samples. Although the sub-sample periods are different, the basic messages in the previous sections hold true even in the new sub-sample periods. That is, most of the currency-specific credit risk measures are statistically significant only in the GFC (that is, the first and the second sub-sample periods), while EU banks' credit risk measures had significant but asymmetric impacts on the Sterling pound and the Danish kroner in the Euro crisis (that is, the third sub-sample period).

Regarding the country-specific credit risk measures, the coefficients of Euro-specific and local currency-specific measures had the same sign as those in the last section in the first sub-sample period. This is consistent with our view that money market risk explains the CIP deviations in the GFC. In the second sub-sample period, the result essentially held in the Danish kroner but did not hold in the Sterling pound. This may suggest that the turbulence in the GFC was stabilized earlier in the Sterling pound than in the other European currencies. In the third sub-sample period, almost all of the currency-specific credit risk measures became insignificant in both of the two currencies. As in the last section, the result supports the view that money market risk became less important in explaining the CIP deviations in the Euro crisis.

Regarding the country-specific measures, the coefficient of EU banks' credit risk was significantly positive in the Danish krone in the first sub-sample period. However, it was not

significant in the second-sub sample period, which is consistent with the result in the last section. More importantly, the coefficient of EU banks' credit risk had significant but opposite sign in the Sterling pound and the Danish kroner in the third sub-sample period. This supports our view that a rise of European banking crisis had opposite effects on the Sterling pound and on the Danish kroner in the Euro crisis. Compared with those in Table 4, the other country-specific risks had a tendency to be significant in Table 5. In particular, the effect of Irish CDS became very significant in both of the two currencies in the second sub-sample period. This may reflect the fact that the second sub-sample period is a transition period from the GFC.

6. Concluding Remarks

Financial crises increase various premiums in national and regional financial markets. But unlike medium- or long-term financial markets, liquidity shortage became vital in financial turmoil. In the post Lehman period, the interest rate of the US dollar became low on the forward contract because of its role as international currency. However, in the Euro crisis, that of the Sterling pound became equally low, while those of the other European currencies such as the Danish kroner increased their liquidity premium. In this paper, we examined why the Sterling pound and the Danish kroner had shown such asymmetric features in the two crises. The regression results suggested that there was a structural break in the determinants of deviations from covered interest parity (CIP) condition during the crises. In particular, we found that strong Sterling pound in the Euro crisis has emerged through substituting Euro's role as an international liquidity.

It was in late 2009 when fears of a sovereign debt crisis developed among investors concerning Greece's ability to meet its debt obligations due to strong increase in government debt levels. This led to a crisis of confidence, indicated by a widening of bond yield spreads and the cost of risk insurance on credit default swaps in several European countries such as Ireland, Portugal, Italy, Greece, and Spain. However, the effects of the crisis were not symmetric across European currencies. For the Danish kroner, its tight linkage to Euro is critical in the regional transactions. Consequently,

increased bid-ask spread in the Euro increased Danish precautionary demand for the Euro and made the Euro's interest rate lower than the Kroner's rate. In contrast, due to less reliance on the Euro in the UK, smaller liquidity risk in the Sterling pound in the money markets shifted precautionary demand from the Euro to the Sterling pound in the Euro crisis. As a result, the increased EU banks' credit risk enhanced the role of the Sterling pound as a substitute for the Euro in international transactions.

The Sterling pound, which had been dominant international currency before the World War I, lost its dominant role after the World War II. In a tranquil period, the US dollar is now dominant international currency in the world, while the Euro is an important international currency in Europe. Even in a turbulent period, there was a "flight to quality" to the US dollar and the Euro, which lowered their interest on forward contract. However, in a turbulent period, we could also observe a "flight to quality" to the Sterling pound. This was particularly conspicuous when the Euro crisis occurred. This may suggest that the Sterling pound is still a strong currency when the Euro becomes a weak currency.

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Table 1. Currency Shares of Geographical Distribution of Foreign Exchange Market Turnover

Country							
	1995	1998	2001	2004	2007	2010	2013
Australia	2.5	2.3	3.2	4.1	4.1	3.8	2.7
Denmark	1.9	1.3	1.4	1.6	2.1	2.4	1.5
France	3.8	3.7	2.9	2.6	3.0	3.0	2.8
Germany	4.8	4.7	5.4	4.6	2.4	2.1	1.7
Hong Kong SAR	5.6	3.8	4.0	4.1	4.2	4.7	4.1
Japan	10.3	7.0	9.0	8.0	5.8	6.2	5.6
Singapore	6.6	6.9	6.1	5.1	5.6	5.3	5.7
Switzerland	5.4	4.4	4.5	3.3	5.9	5.2	3.2
United Kingdom	29.3	32.6	32.0	32.0	34.6	36.7	40.9
United States	16.3	18.3	16.1	19.1	17.4	17.9	18.9
others	13.5	15.0	15.2	15.6	14.8	12.8	12.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note) Daily averages in April, in billions of US dollars and percentages.

Table 2. Basic Test Statistics for Daily Credit Risk Measures for the Two Sub-sample Periods

(1) First Sample (from Jan 2, 2008 to Dec. 31, 2009)

	US Dollar	Euro	Sterling pound	Danish kroner	Swiss franc	Japanese yen
Mean	0.79	0.71	0.90	0.87	0.35	0.42
Median	0.72	0.63	0.79	0.69	0.30	0.40
Maximum	3.64	1.95	3.00	2.00	1.76	0.81
Minimum	0.07	0.21	0.15	0.32	0.19	0.18
Std. Dev.	0.65	0.40	0.59	0.40	0.21	0.14
Skewness	1.85	1.22	0.83	0.98	3.38	0.36
Kurtosis	7.26	4.02	3.07	2.96	16.85	2.94
Observations	522	522	522	522	294	522

(2) Second Sample (from Jan 2, 2010 to March 28, 2013)

	US Dollar	Euro	Sterling pound	Danish kroner	Swiss franc	Japanese yen
Mean	0.22	0.30	0.30	0.40	0.08	0.12
Median	0.17	0.24	0.24	0.39	0.07	0.12
Maximum	0.51	0.93	0.60	0.80	0.40	0.17
Minimum	0.06	0.01	0.10	-0.05	-0.01	0.09
Std. Dev.	0.11	0.23	0.15	0.20	0.06	0.02
Skewness	0.73	1.26	0.69	-0.09	1.58	0.13
Kurtosis	2.63	3.69	2.20	1.85	6.11	2.41
Observations	844	844	844	844	844	844

Table 3. Basic Test Statistics for Daily Banks Sector and Sovereign CDS

(1) First Sample (from Jan 2, 2008 to Dec. 31, 2009)

	US bank	EU bank	UK bank
Mean	191.9	143.3	141.6
Median	170.6	126.4	137.7
Maximum	596.0	319.5	235.2
Minimum	86.5	49.8	70.7
Std. Dev.	78.7	57.1	34.8
Skewness	1.3	1.1	0.4
Kurtosis	5.4	3.9	2.6
Observations	522	522	522

sovereign	USA	Germany	UK	France	Italy	Spain	Ireland	Denmark
Mean	31.1	25.7	56.9	30.2	78.8	67.2	127.7	43.1
Median	25.9	22.5	52.1	25.2	63.2	61.0	139.8	27.0
Maximum	95.0	92.5	165.0	96.5	190.0	163.5	390.0	150.0
Minimum	6.0	5.2	7.4	6.7	21.1	19.8	12.8	5.4
Std. Dev.	23.0	20.0	41.8	21.2	46.8	33.9	95.2	40.2
Skewness	1.0	1.2	0.7	1.1	0.9	0.7	0.5	1.1
Kurtosis	3.2	4.3	2.5	3.7	2.7	2.7	2.5	2.9
Observations	522	522	522	522	522	522	522	522

(2) Second Sample (from Jan 2, 2010 to March 28, 2013)

	US bank	EU bank	UK bank
Mean	143.7	319.7	165.0
Median	127.2	313.1	155.3
Maximum	264.9	606.4	295.4
Minimum	82.9	97.0	94.2
Std. Dev.	43.7	111.0	43.7
Skewness	0.8	0.1	0.7
Kurtosis	2.4	2.3	2.7
Observations	844	844	844

sovereign	USA	Germany	UK	France	Italy	Spain	Ireland	Denmark
Mean	42.6	35.3	59.7	77.7	232.5	246.2	479.6	54.9
Median	41.8	32.2	59.9	65.8	202.4	231.9	544.7	34.1
Maximum	65.0	79.3	95.0	171.6	498.7	492.1	1249.3	147.1
Minimum	27.6	12.4	24.2	29.5	72.0	73.5	114.9	18.0
Std. Dev.	6.4	13.7	15.9	32.5	116.2	90.0	244.7	37.6
Skewness	0.2	0.8	-0.1	0.8	0.6	0.5	0.1	0.8
Kurtosis	2.7	2.9	2.5	2.7	2.0	2.6	2.0	2.0
Observations	844	844	844	844	844	844	844	844

Table 4. The estimated results of Equation (1)

(1) First Sample (from Jan 2, 2008 to Dec. 31, 2009)

		Sterling pound		Danish krone	
	Constant term	-0.001	-0.034	-0.021	-0.017
		(-0.01)	(-1.44)	(-0.33)	(-0.74)
Lagged	Dependent var. (-1)	0.573	0.830	0.573	0.592
dependent		(18.77)***	(18.84)***	(13.31)***	(13.70)***
var.	Dependent var. (-2)	-0.083	-0.079	0.101	0.108
		(-1.88)*	(-1.80)*	(2.43)**	(2.60)***
Measure of	Euro LIBOR spread	0.160	0.162	0.257	0.189
currency-		(3.47)***	(3.52)***	(6.29)***	(5.25)***
specific	Dollar LIBOR spread	-0.055	-0.046	0.000	-0.001
credit risk		(-3.30)***	(-3.16)***	(0.03)	(-0.05)
	Local LIBOR spread	-0.095	-0.096	-0.171	-0.109
		(-3.19)***	(-3.26)***	(-5.71)***	(-4.96)***
Measure of	EU bank CDS/100	0.015	-0.096	-0.014	-0.002
country-		(0.77)	(-0.11)	(-0.80)	(-0.14)
specific	US bank CDS/100	0.000	0.004	0.000	-0.011
bank credit		(-0.04)	(0.70)	(0.02)	(-1.98)**
risk	UK bank CDS/100	-0.009	-0.005	-0.002	0.016
		(-0.37)	(-0.21)	(-0.10)	(0.68)
Measure of	Log(Ireland CDS)	0.008		0.032	
country-		(0.35)		(2.02)**	
specific	Log(Italy CDS)	-0.002		-0.031	
sovereign risk		(-0.10)		(-1.40)	
	Log(local CDS)	-0.024		0.012	
		(-0.73)		(0.51)	
Market	VIX	0.001	0.000	0.002	0.002
risk		(1.52)	(0.70)	(2.63)***	(3.60)***
	Adjusted R-squared	0.75	0.75	0.91	0.91
	Observation number	521	521	522	522

(2) Second Sample (from Jan 4, 2010 to March 28, 2013)

		Sterling pound		Danish krone	
	Constant term	-0.017	0.021	0.035	-0.001
		(-0.39)	(3.52)***	(1.06)	(-0.22)
Lagged	Dependent var. (-1)	0.760	0.765	0.773	0.778
dependent		(22.16)***	(22.32)***	(22.52)***	(22.72)***
var.	Dependent var. (-2)	0.143	0.141	0.122	0.124
		(4.15)***	(4.09)***	(3.57)***	(3.65)***
Measure of	Euro LIBOR spread	-0.017	-0.016	-0.015	-0.011
currency-		(-1.45)	(-1.48)	(-1.61)	(-1.29)
specific	Dollar LIBOR spread	0.030	0.010	-0.014	-0.018
credit risk		(1.39)	(0.52)	(-0.78)	(-1.01)
	Local LIBOR spread	-0.037	0.003	-0.001	-0.004
		(-1.45)	(0.18)	(-0.11)	(-0.44)
Measure of	EU bank CDS/100	-0.012	-0.005	0.012	0.009
country-		(-2.69)***	(-2.07)**	(2.78)***	(2.46)**
specific	US bank CDS/100	0.010	-0.007	0.002	-0.006
bank credit		(1.02)	(-1.09)	(0.19)	(-0.67)
risk	UK bank CDS/100	0.001	0.001	-0.008	-0.004
		(0.06)	(0.11)	(-0.67)	(-0.39)
Measure of	Log(Ireland CDS)	0.011		0.001	
country-		(2.31)**		(0.20)	
specific	Log(Italy CDS)	-0.001		-0.009	
sovereign risk		(-0.09)		(-1.49)	
	Log(local CDS)	-0.004		-0.002	
		(-0.61)		(-0.36)	
Market	VIX	-0.001	-0.001	0.001	0.001
risk		(-3.00)***	(-2.30)**	(2.40)**	(2.30)**
	Adjusted R-squared	0.956	0.956	0.870	0.870
	Observation number	845	845	844	844

Notes: 1) In the table, “local” means either the Sterling pound or UK for the Sterling pound and either the Danish krone or Denmark for the Danish krone.

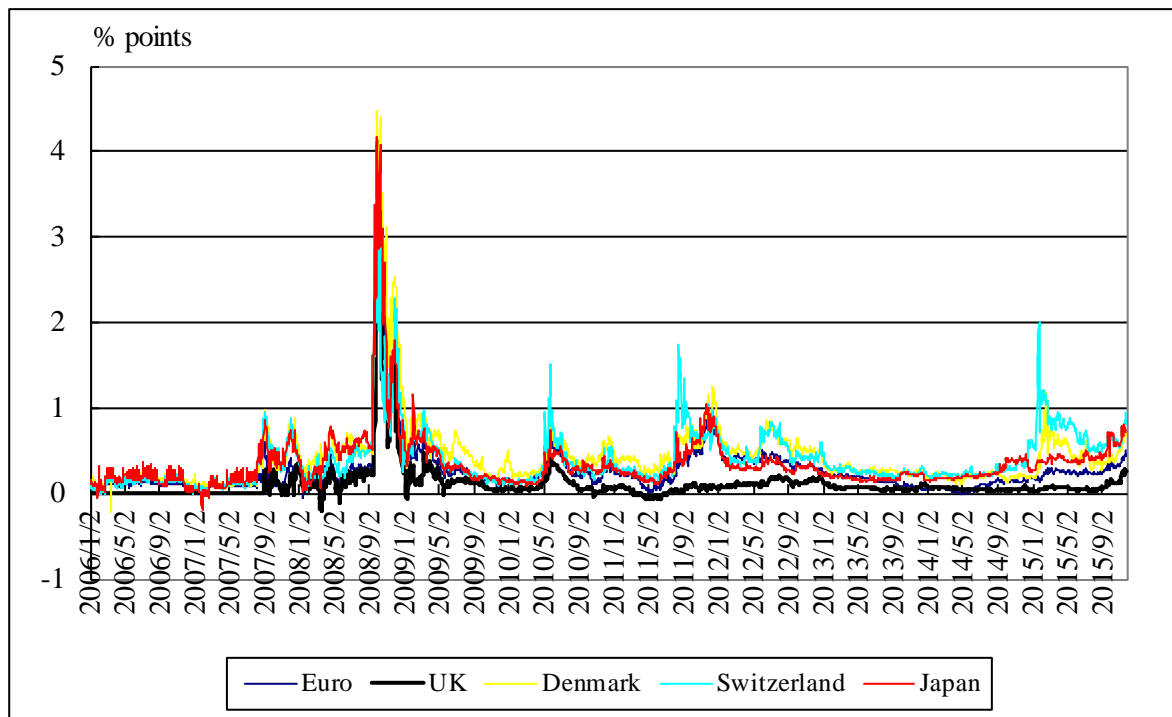
2) t-value is in the parentheses. *** = 1% significance level, ** = 5% significance level, * = 10% significance level.

Table 5. The estimated results under Alternative Sample Split

	First sub-sample		Second sub-sample		Third sub-sample	
	S. pound	Danish krone	S. pound	Danish krone	S. pound	Danish krone
estimation period	1/02/2008 - 11/06/2008	1/02/2008 - 11/17/2008	11/07/2008 - 9/17/2009	11/18/2008 - 12/28/2009	9/18/2009 - 3/29/2013	12/29/2009 - 3/28/2013
Constant term	-0.131 (-0.88)	0.287 (1.99)**	0.570 (4.88)***	-0.204 (-1.70)*	-0.006 (-0.20)	0.035 (1.04)
Dependent var. (-1)	0.761 (10.69)***	0.491 (7.75)***	0.587 (9.35)***	0.503 (9.43)***	0.754 (22.84)***	0.759 (22.21)***
Dependent var. (-2)	-0.186 (-2.76)***	-0.027 (-0.43)	0.023 (0.39)	0.236 (4.46)***	0.149 (4.48)***	0.129 (3.82)***
Euro LIBOR spread	0.234 (2.36)**	0.282 (3.88)***	0.049 (0.86)	0.256 (4.58)***	-0.017 (-1.50)	-0.016 (-1.72)*
Dollar LIBOR spread	0.005 (0.15)	-0.057 (-2.42)**	-0.069 (-1.86)*	0.097 (2.79)***	0.027 (1.35)	-0.013 (-0.67)
Local LIBOR spread	-0.196 (-2.56)**	-0.092 (-1.57)	0.001 (0.03)	-0.220 (-6.67)***	-0.034 (-1.42)	-0.002 (-0.17)
EU bank CDS/100	-0.118 (-1.32)	0.118 (2.19)**	-0.024 (-1.07)	-0.029 (-1.11)	-0.012 (-2.87)***	0.013 (2.94)***
US bank CDS/100	0.008 (0.68)	-0.003 (-0.39)	0.024 (1.69)*	0.042 (2.58)***	0.009 (0.96)	0.003 (0.29)
UK bank CDS/100	0.059 (0.91)	-0.106 (-2.32)**	0.062 (1.85)*	-0.079 (-1.96)**	0.003 (0.32)	-0.010 (-0.89)
Log(Ireland CDS)	0.013 (0.14)	0.036 (0.51)	-0.129 (-3.18)***	0.105 (2.96)***	0.010 (2.32)**	0.001 (0.33)
Log(Italy CDS)	0.099 (1.11)	-0.141 (-1.91)*	0.036 (0.72)	0.002 (0.08)	0.010 (-0.25)	-0.010 (-1.57)
Log(local CDS)	-0.092 (-1.60)	-0.007 (-0.18)	-0.059 (-0.86)	-0.023 (-0.63)	-0.005 (-0.94)	-0.002 (-0.35)
VIX	-0.001 (-0.73)	0.008 (5.84)***	0.002 (1.69)*	-0.003 (-2.82)***	-0.001 (-3.33)***	0.001 (2.60)***
Observation number	222	229	225	290	921	848

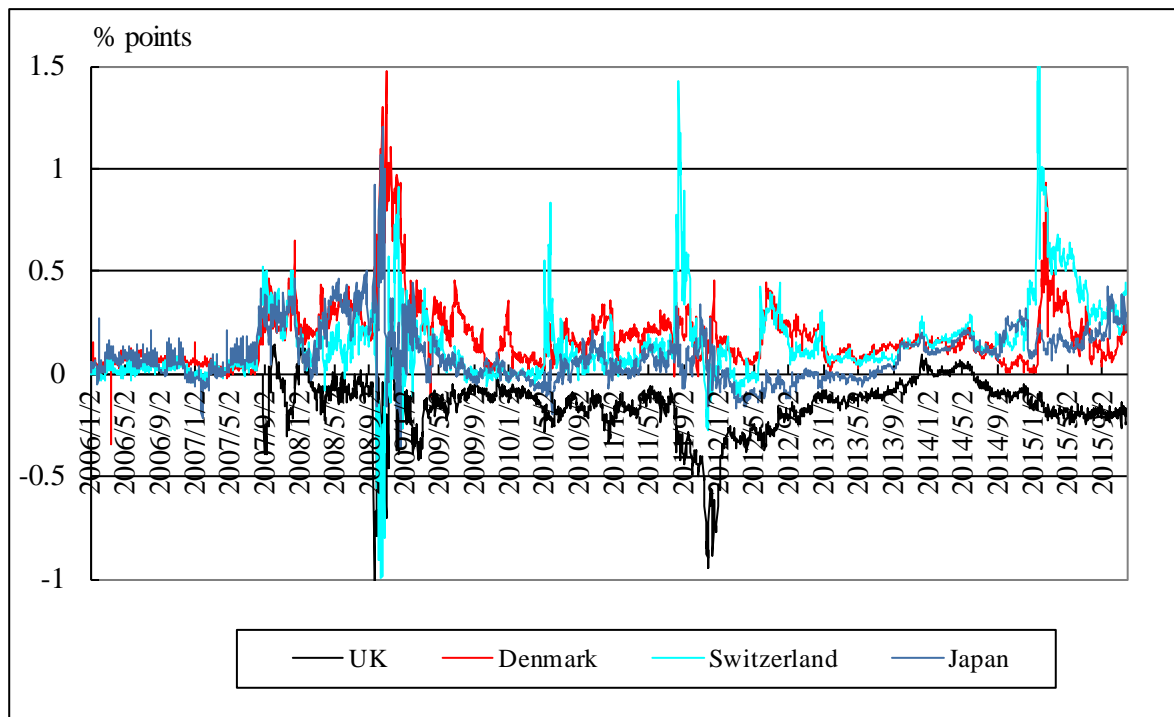
t-value is in the parentheses. *** = 1% significance level, ** = 5% significance level, * = 10% significance level.

Figure 1. Deviations from the CIP condition between US dollar and five currencies



This figure depicts daily deviations from CIP condition between the US dollar and each of the five currencies. The upward deviations imply that the US dollar had lower interest rate on the forward market.

Figure 2. Deviations from the CIP condition between Euro and three currencies



This figure depicts daily deviations from CIP condition between Euro and each of the three non-Euro currencies. The upward deviations imply that Euro had lower interest rate on the forward market.