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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"flight to quality" to the international currency. However, in the Euro crisis, that of the Sterling pound became equally low, while the other European currencies such as the Danish kroner increased its liquidity premium. By using secured rates, the following analysis examines why the Sterling pound and the Danish kroner showed asymmetric features in deviations from the covered interest parity (CIP) condition. The regression results suggest that there was a structural break in the determinants of the deviations across the European currencies in the two crises. Currency-specific money market risk was critical in explaining the deviations in the global financial crisis (GFC), while EU banks' credit risk and market risk were useful in explaining the deviations in the Euro crisis. In particular, EU banks' credit risk and market risk had asymmetric effect on the deviations. The asymmetry explains different features between the Sterling pound and the Danish kroner.

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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 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 1, 2007 to December 30, 2015, we calculated the deviations by annualized value of $(1+i^{n}_{t}) - (1+i^{us}_{t})\ (F^{n}_{t+1}/S^{n}_{t})$, where $i^{n}_{t} \equiv$ three-month currency n's OIS rate, $i^{us}_{t} \equiv$ three-month US dollar OIS rate, $S^{n}_{t} \equiv$ the spot exchange rate between the two currencies, and $F^{n}_{t+1} \equiv$ its three-month forward exchange rate. All of the data the unit of which is basis point are downloaded from Datastream. For all combinations, deviations 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 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 currencies, we can see that the Sterling pound had smaller deviations than the other non-US dollar 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. Using the Euro as the benchmark currency, Figure 2

depicts daily CIP deviations of three European currencies and the Japanese yen from January 1, 2007 to December 30, 2015. For currency k (k = the Sterling pound, the Swiss franc, the Danish kroner, and the Japanese yen), we calculated the deviations by annualized value of $(1+ i^{k}_{t}) - (1+i^{euro}_{t})(f^{k}_{t+1}/e^{k}_{t})$, where $i^{k}_{t} \equiv$ three-month currency k's OIS rate, $i^{euro}_{t} \equiv$ three-month Euro OIS rate, $e^{k}_{t} \equiv$ the Euro spot exchange rate against currency k, and $f^{k}_{t+1} \equiv$ its three-month forward exchange rate.[1] Even when we use the Euro as the benchmark currency, we can see significant positive deviations in the Danish kroner, the Swiss franc, and the Japanese yen in the figure, although the Swiss franc showed temporarily negative large deviations in September 2008. The upward deviations which became largest after the Lehman shock 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 results are essentially the same even if we calculated deviations from the CIP condition by using interest rates with shorter term-to-maturities and with longer term-to-maturities. Using the same data source and the same sample period, Figure 3 depicts daily CIP deviations of three European currencies and the Japanese yen in one-month rates and in one-year rates when we use the Euro as the benchmark currency. Except that we used a different term-to-maturity, we calculated the deviations by using the same formula as in Figure 2. Compared with the three-month rates, the one-month rates showed more temporary deviations, while the one-year rates had more persistent deviations. But even the one-month rates showed a few large spikes in the deviations. More importantly, both in one-month rates and in one-year rates, the Danish kroner, the Swiss franc, and the Japanese yen showed significant positive deviations, while the Sterling pound showed negative deviations throughout the period.

The purpose of this paper is to explore what made the CIP deviations so different between the

[1] All of the data the unit of which is basis point are downloaded from Datastream.

Sterling pound and the Danish kroner when we use the Euro as the benchmark currency. 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. 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 symmetric significant effect on the deviations of the Sterling pound and the Danish krone. In contrast, in the Euro crisis, EU banks' credit risk and market risk had asymmetric effect on the deviations of the two currencies. 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.[2] 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

[2] In July 2012, Danish central bank adopted a special monetary policy to set some of its policy rate below zero. But the following results are essentially the same even if we exclude this special period from the sample.

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, Hrung, and Sarkar (2009) show that in addition to credit risk, liquidity and market risk played important roles in explaining the deviations. Grioli and Ranaldo (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, our 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 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. Sections 5 and 6 investigate their robustness allowing alternative structural breaks and bid-ask spreads respectively. Section 7 summarizes our main results and refers to the implications.

2. Empirical Specification

The purpose of the following sections is to examine why European currencies showed asymmetric deviations from 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 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.[3] 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 demonstrate that alternative

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

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:

$$(1) \quad Dev_t(j) = constant\ term + \sum_h \alpha_h \cdot Credit_t(h) + \sum_q \beta_q \cdot Credit_t(q) + \gamma \cdot Market_t,$$

for currency j, where j = the Sterling pound and the Danish kroner.

We calculate deviations from the CIP condition by $Dev_t(j) \equiv (1+i^j{}_t) - (1+i^{euro}{}_t)(f^j{}_{t+1}/e^j{}_t)$, where $i^j{}_t$ is three-month currency j's OIS rate, $i^{euro}{}_t$ is three-month euro OIS rate, $e^j{}_t$ is the Euro spot exchange rate against currency j, and $f^j{}_{t+1}$ is its three-month forward exchange rate. The OIS rates are secured rates that measure market participants' expected average policy rate over the relevant term. $Dev_t(j)$ 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 contract, 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.[4] 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 when foreign exchange markets come under stress, the above three risk measures may capture 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

[4] The data was downloaded from Datastream.

currency *h*.[5] 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.[6]

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 denomination, 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

[5] 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.
[6] 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.

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 in 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, 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. Mean and median of Germany CDS index were lowest not only in the first sub-sample period but also in the second sub-sample period. The Euro crisis had 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 sovereign 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 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 took opposite sign 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 the 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 the Danish kroner, a rise of European banking crisis increased precautionary demand for the Euro and increased the 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 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. In other words, a rise of market increased precautionary demand for the Euro only in the Danish kroner. The Danish kroner was more vulnerable to the global market risk than the Sterling pound in the GFC.

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 on forward contract. 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 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. Estimation with Alternative Subsample Periods

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 will 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.[7] 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 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 coincide with the break date which 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 using different 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 were 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

[7] Bai and Perron (2003) provided theoretical and computational results.

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 in the first sub-sample essentially remained true in the Danish kroner but did not in the Sterling pound. This may suggest that the money market 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 not significant in the Pound in the first and second-sub sample periods, which is consistent with the result in the last section. 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 was significantly negative in the Sterling pound and significantly positive in 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 that the second sub-sample period is a transition period from the GFC to the Euro crisis.

6. Estimation with Bid-Ask Spreads

Until the last section, we have examined determinants of the CIP deviations by using

middle-rates, that is, average of bid and ask rates. However, bid-ask spreads, which were negligible during tranquil periods, were widened substantially on forward contract during the crises. Defining that bid-ask spread ≡ (ask rate – bid rate)/middle rate, Table 6 reports mean and maximum of the bid-ask spreads of the Euro, the Sterling pound, and the Krone against the US dollar.[8] The bid-ask spreads of the spot rates were small not only during tranquil periods but also during the crises. However, the bid-ask spreads of the forward rates, which were small during tranquil periods, were widened significantly during the crises. In particular, their maximum values became very large in 2008 and in 2009. This implies that the bid-ask spreads were temporarily widened substantially on forward contract during the crises. This feature holds true for all of the three currencies, although the bid-ask spreads in the Krone were larger than those in the Euro and the Sterling pound.

The purpose of this section is to explore whether the widened bid-ask spreads of the forward rates are crucial in explaining the essential results in the previous sections. Using bid and ask rates for the spot and forward exchange rates from January 1, 2007 to October 30, 2015, Figure 4 depicts daily CIP deviations of three European currencies and the Japanese yen when we use the Euro as the benchmark currency. Compared with Figure 2 which used the middle rates, upward deviations are larger and downward deviations are smaller when we use the bid rates, while upward deviations are smaller and downward deviations are larger when we use the ask rates. However, the essential results did not change even when we replace the middle rates either by the bid rates or by the ask rates, That is, 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 but negative deviations in the Sterling pound throughout the period.

The essential results also remained the same even when we estimate our basic equation including bid-ask spreads as additional explanatory variables. Table 7 summarizes the estimated results when we add bid-ask spreads as explanatory variables in equation (1). We estimated equation (1) without sovereign risks but with bid-ask spreads of the Euro and each local currency against the

[8] The data are downloaded from Datastream. Each forward rate is three-month rate.

US dollar. The sub-sample periods are the same as those in Table 4. The table reports the estimation results not only with forward bid-ask spreads and with both spot and forward bid-ask spreads.

In both sub-sample periods, the spot bid-ask spreads never had significant effects on the CIP deviations either in the Sterling pound or in the Danish kroner. In contrast, the effects of the forward bid-ask spreads were significant in the Danish kroner and marginally significant in the Sterling pound in the first sub-sample period. This implies that bid-ask spreads in the forward exchange rates explain part of the CIP deviations in the GFC. However, even if we include the bid-ask spreads, the estimation results of the other explanatory variables were almost the same in both sub-sample periods. That is, most of the currency-specific credit risk measures were statistically significant only in the GFC (that is, the first sub-sample period), 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 second sub-sample period). VIX was significantly positive only in the Danish kroner in the first sub-sample period, while it was significantly negative in the Sterling pound and was significantly positive in the Danish kroner in the second sub-sample period.

7. 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 two 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 Euro crisis were not symmetric across European currencies. For the Danish kroner, its tight linkage to Euro is critical in the regional transactions. Consequently, increased risk in the Euro raised Danish precautionary demand for the Euro and made the Euro's interest rate lower than the Kroner's rate in the money markets. In contrast, due to less reliance on the Euro in the UK and smaller liquidity risk in the Sterling pound, increased risk in the Euro shifted precautionary demand from the Euro to the Sterling pound in the money markets. As a result, the increased EU banks' credit risk and the increased market 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	78.96	70.98	90.41	86.55	35.06	42.04
Median	72.33	63.43	79.28	69.25	30.37	40.44
Maximum	364.38	195.33	300.33	200.05	176.47	80.50
Minimum	7.44	21.19	15.11	31.80	19.23	17.94
Std. Dev.	64.71	40.02	58.59	40.40	20.79	13.87
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
Obervations	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	22.05	30.11	29.60	39.79	8.34	12.43
Median	17.10	24.08	23.82	39.08	6.90	12.40
Maximum	50.90	93.19	60.23	80.14	39.83	17.38
Minimum	5.56	1.13	9.54	−4.92	−0.58	8.63
Std. Dev.	10.88	22.99	14.97	19.73	5.60	1.96
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
Obervations	844	844	844	844	844	844

Unit is basis point.

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
Obervations	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
Obervations	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
Obervations	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
Obervations	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

Table 4. The estimated results of Equation (1) (continued)

(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.	Dependent var. (-1)	0.760	0.765	0.773	0.778
		(22.16)***	(22.32)***	(22.52)***	(22.72)***
	Dependent var. (-2)	0.143	0.141	0.122	0.124
		(4.15)***	(4.09)***	(3.57)***	(3.65)***
Measure of currency-specific credit risk	Euro LIBOR spread	−0.017	−0.016	−0.015	−0.011
		(−1.45)	(−1.48)	(−1.61)	(−1.29)
	Dollar LIBOR spread	0.030	0.010	−0.014	−0.018
		(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 country-specific bank credit risk	EU bank CDS/100	−0.012	−0.005	0.012	0.009
		(−2.69)***	(−2.07)**	(2.78)***	(2.46)**
	US bank CDS/100	0.010	−0.007	0.002	−0.006
		(1.02)	(−1.09)	(0.19)	(−0.67)
	UK bank CDS/100	0.001	0.001	−0.008	−0.004
		(0.06)	(0.11)	(−0.67)	(−0.39)
Measure of country-specific sovereign risk	Log(Ireland CDS)	0.011		0.001	
		(2.31)**		(0.20)	
	Log(Italy CDS)	−0.001		−0.009	
		(−0.09)		(−1.49)	
	Log(local CDS)	−0.004		−0.002	
		(−0.61)		(−0.36)	
Market risk	VIX	−0.001	−0.001	0.001	0.001
		(−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	0.287	0.570	−0.204	−0.006	0.035
	(−0.88)	(1.99)**	(4.88)***	(−1.70)*	(−0.20)	(1.04)
Dependent var. (-1)	0.761	0.491	0.587	0.503	0.754	0.759
	(10.69)***	(7.75)***	(9.35)***	(9.43)***	(22.84)***	(22.21)***
Dependent var. (-2)	−0.186	−0.027	0.023	0.236	0.149	0.129
	(−2.76)***	(−0.43)	(0.39)	(4.46)***	(4.48)***	(3.82)***
Euro LIBOR spread	0.234	0.282	0.049	0.256	−0.017	−0.016
	(2.36)**	(3.88)***	(0.86)	(4.58)***	(−1.50)	(−1.72)*
Dollar LIBOR spread	0.005	−0.057	−0.069	0.097	0.027	−0.013
	(0.15)	(−2.42)**	(−1.86)*	(2.79)***	(1.35)	(−0.67)
Local LIBOR spread	−0.196	−0.092	0.001	−0.220	−0.034	−0.002
	(−2.56)**	(−1.57)	(0.03)	(−6.67)***	(−1.42)	(−0.17)
EU bank CDS/100	−0.118	0.118	−0.024	−0.029	−0.012	0.013
	(−1.32)	(2.19)**	(−1.07)	(−1.11)	(−2.87)***	(2.94)***
US bank CDS/100	0.008	−0.003	0.024	0.042	0.009	0.003
	(0.68)	(−0.39)	(1.69)*	(2.58)***	(0.96)	(0.29)
UK bank CDS/100	0.059	−0.106	0.062	−0.079	0.003	−0.010
	(0.91)	(−2.32)**	(1.85)*	(−1.96)**	(0.32)	(−0.89)
Log(Ireland CDS)	0.013	0.036	−0.129	0.105	0.010	0.001
	(0.14)	(0.51)	(−3.18)***	(2.96)***	(2.32)**	(0.33)
Log(Italy CDS)	0.099	−0.141	0.036	0.002	0.010	−0.010
	(1.11)	(−1.91)*	−0.720	(0.08)	(−0.25)	(−1.57)
Log(local CDS)	−0.092	−0.007	−0.059	−0.023	−0.005	−0.002
	(−1.60)	(−0.18)	(−0.86)	(−0.63)	(−0.94)	(−0.35)
VIX	−0.001	0.008	0.002	−0.003	−0.001	0.001
	(−0.73)	(5.84)***	(1.69)*	(−2.82)***	(−3.33)***	(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.

Table 6. Summary statistics of bid-ask spreads

(1) Spot rate

Unit: %

	Euro		Pound		Krone	
	Mean	Max	Mean	Max	Mean	Max
2006	0.024	0.034	0.025	0.029	0.030	0.046
2007	0.022	0.030	0.023	0.026	0.027	0.042
2008	0.022	0.032	0.024	0.049	0.028	0.047
Jan.-Aug.	0.020	0.028	0.023	0.027	0.026	0.034
Sep.-Dec.	0.025	0.032	0.028	0.049	0.032	0.047
2009	0.024	0.033	0.028	0.049	0.028	0.043
2010	0.026	0.034	0.029	0.039	0.031	0.044
2011	0.026	0.031	0.028	0.032	0.031	0.044
2012	0.029	0.033	0.029	0.033	0.033	0.040
2013	0.024	0.032	0.030	0.034	0.028	0.038
2014	0.021	0.026	0.028	0.032	0.026	0.041
2015	0.025	0.029	0.029	0.034	0.031	0.044

(2) Forward rate

Unit: %

	Euro		Pound		Krone	
	Mean	Max	Mean	Max	Mean	Max
2006	0.027	0.037	0.028	0.033	0.046	0.063
2007	0.025	0.033	0.026	0.033	0.045	0.058
2008	0.037	0.118	0.042	0.163	0.066	0.176
Jan.-Aug.	0.027	0.036	0.029	0.040	0.048	0.075
Sep.-Dec.	0.057	0.118	0.066	0.163	0.101	0.176
2009	0.030	0.072	0.034	0.088	0.069	0.129
2010	0.031	0.046	0.031	0.049	0.046	0.074
2011	0.032	0.043	0.031	0.041	0.046	0.070
2012	0.032	0.042	0.032	0.037	0.044	0.059
2013	0.026	0.042	0.032	0.039	0.038	0.055
2014	0.023	0.034	0.030	0.039	0.034	0.048
2015	0.028	0.040	0.031	0.037	0.051	0.093

Table 7. The estimated results with bid-ask spreads

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

		Sterling pound		Danish krone	
	Constant term	−0.026	−0.028	−0.008	−0.030
		(−1.07)	(−0.78)	(−0.36)	(−1.00)
Lagged dependent var.	Dependent var. (-1)	0.834	0.842	0.567	0.567
		(18.47)***	(18.34)***	(13.24)***	(13.24)***
	Dependent var. (-2)	−0.090	−0.095	0.135	0.134
		(−2.03)**	(−2.12)**	(3.25)***	(3.23)***
Measure of currency-specific credit risk	Euro LIBOR spread	0.166	0.165	0.173	0.172
		(3.59)***	(3.56)***	(4.86)***	(4.80)***
	Dollar LIBOR spread	−0.038	−0.038	0.025	0.028
		(−2.45)**	(−2.37)**	(1.64)	(1.78)*
	Local LIBOR spread	−0.096	−0.094	−0.109	−0.106
		(−3.21)***	(−3.16)***	(−4.65)***	(−4.51)***
Measure of country-specific bank credit risk	EU bank CDS/100	−0.007	−0.006	−0.019	−0.020
		(−0.40)	(−0.30)	(−1.11)	(−1.16)
	US bank CDS/100	0.002	0.001	−0.012	−0.012
		(0.31)	(0.20)	(−2.13)**	(−2.23)**
	UK bank CDS/100	0.001	0.000	0.032	0.033
		(0.06)	(−0.01)	(1.33)	(1.37)
Market risk	VIX	0.001	0.001	0.002	0.002
		(1.07)	(0.97)	(3.46)***	(3.26)***
Bid-ask spreads	Euro forward spread	−0.579	−0.712	−1.339	−1.485
		(−1.64)	(−1.87)*	(−3.76)***	(−3.90)***
	Pound forward spread	−0.126	−0.035	0.480	0.427
		(−0.47)	(−0.12)	(2.68)***	(2.33)**
	Euro spot spread		1.044		−0.862
			(0.97)		(−0.48)
	Pound spot spread		−0.688		1.832
			(−0.69)		(1.16)
	Adjusted R-squared	0.75	0.75	0.91	0.91
	Observation number	521	521	522	522

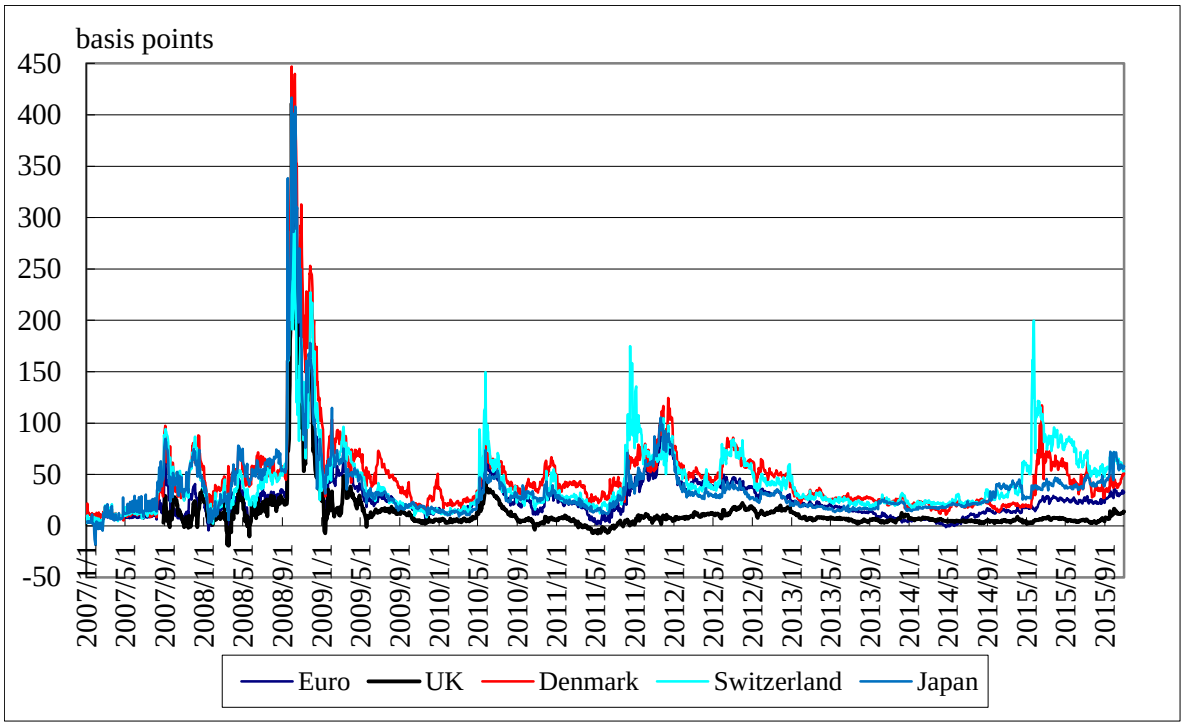
Table 7. The estimated results with bid-ask spreads (continued)

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

	Sterling pound		Danish krone	
Constant term	0.029	0.030	−0.002	0.001
	(2.42)**	(2.37)**	(−0.20)	(0.06)
Dependent var. (-1)	0.770	0.772	0.779	0.778
	(22.28)***	(22.29)***	(22.74)***	(22.69)***
Dependent var. (-2)	0.136	0.137	0.119	0.119
	(3.92)***	(3.93)***	(3.50)***	(3.48)***
Euro LIBOR spread	−0.016	−0.019	−0.010	−0.013
	(−1.52)	(−1.71)*	(−1.11)	(−1.40)
Dollar LIBOR spread	0.009	0.009	−0.014	−0.015
	(0.48)	(0.47)	(−0.75)	(−0.79)
Local LIBOR spread	0.004	0.002	−0.004	−0.003
	(0.19)	(0.12)	(−0.36)	(−0.34)
EU bank CDS/100	−0.005	−0.006	0.009	0.009
	(−2.13)**	(−2.24)**	(2.67)***	(2.64)***
US bank CDS/100	−0.007	−0.005	−0.006	−0.004
	(−1.07)	(−0.71)	(−0.72)	(−0.48)
UK bank CDS/100	0.001	0.001	−0.005	−0.006
	(0.10)	(0.14)	(−0.54)	(−0.60)
VIX	−0.001	−0.001	0.001	0.001
	(−2.28)**	(−2.19)**	(2.38)**	(2.30)**
Euro forward spread	0.120	0.662	−0.331	0.041
	(0.52)	(1.64)	(−1.31)	(0.10)
Pound forward spread	−0.367	−1.144	0.209	0.253
	(−1.25)	(−1.48)	(1.54)	(1.79)*
Euro spot spread		−0.758		−0.563
		(−1.61)		(−0.67)
Pound spot spread		0.898		−0.021
		(1.05)		(−0.03)
Adjusted R-squared	0.96	0.96	0.87	0.87
Observation number	845	845	844	844

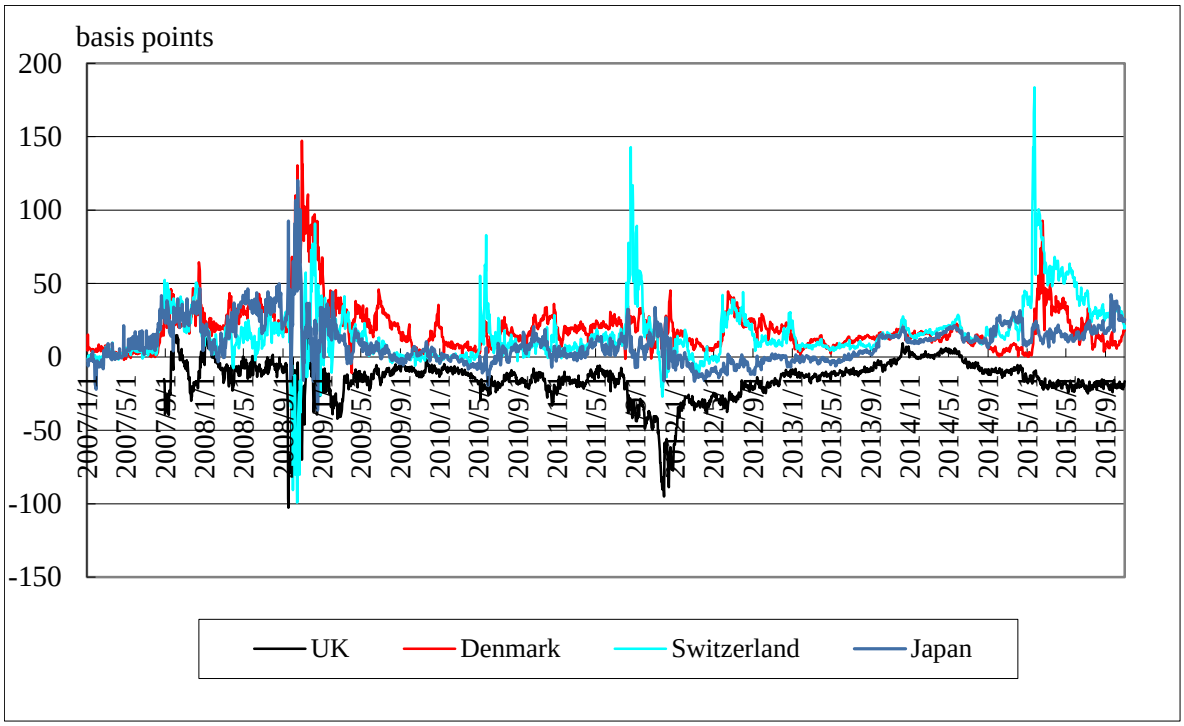
t-value is in the parentheses. *** = 1% significance level, ** = 5% significance level, * = 10% significance level.

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.

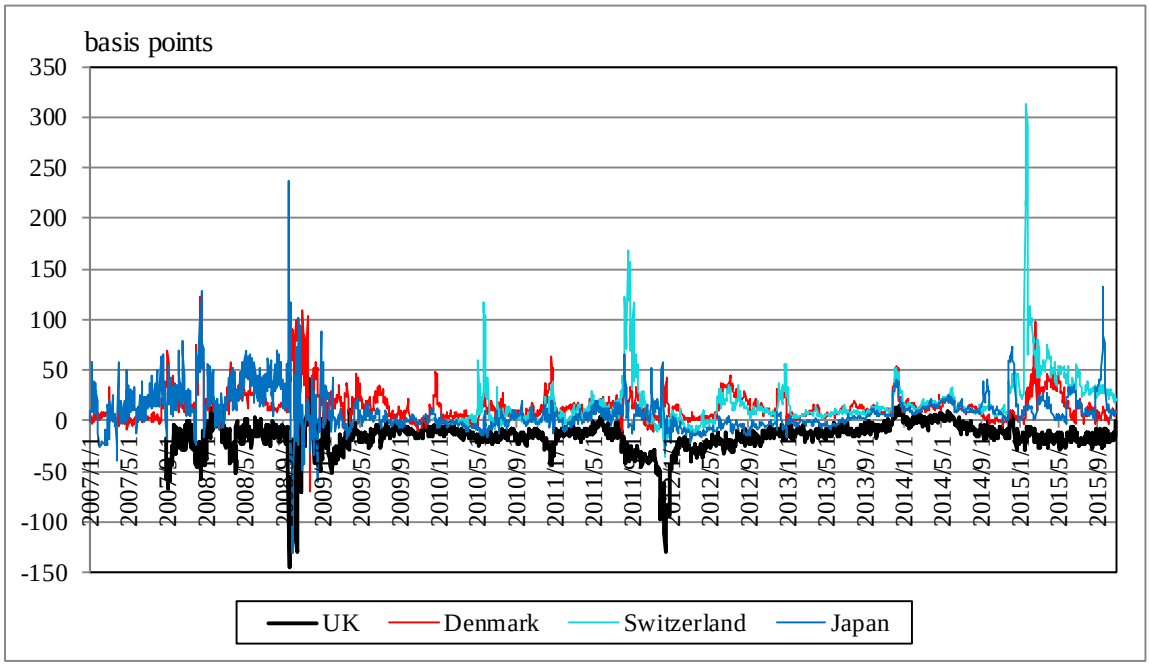
Figure 2. Deviations from the CIP condition between Euro and three currencies



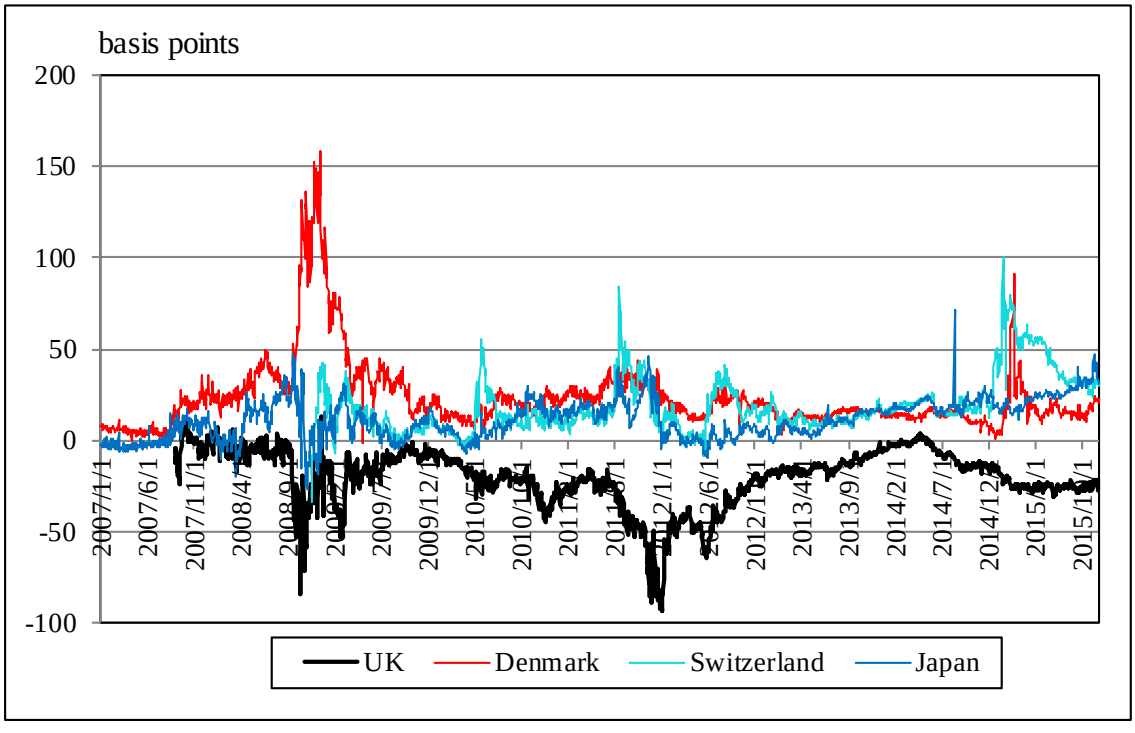
This figure depicts daily deviations from CIP condition between Euro and each of the three non-Euro currencies. The upward deviations imply that Euro had lower interest rate on the forward market.

Figure 3. Deviations from the CIP condition in one-month rates and one-year rates

(1) One-month rates



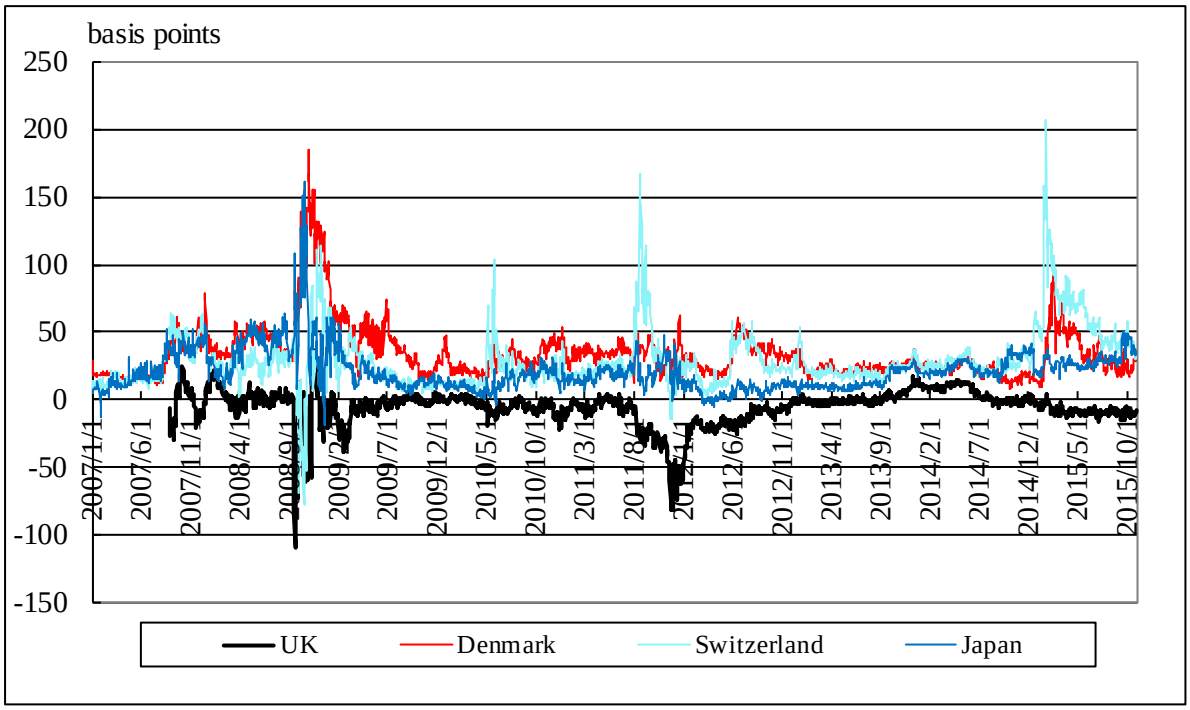
(2) One-year rates



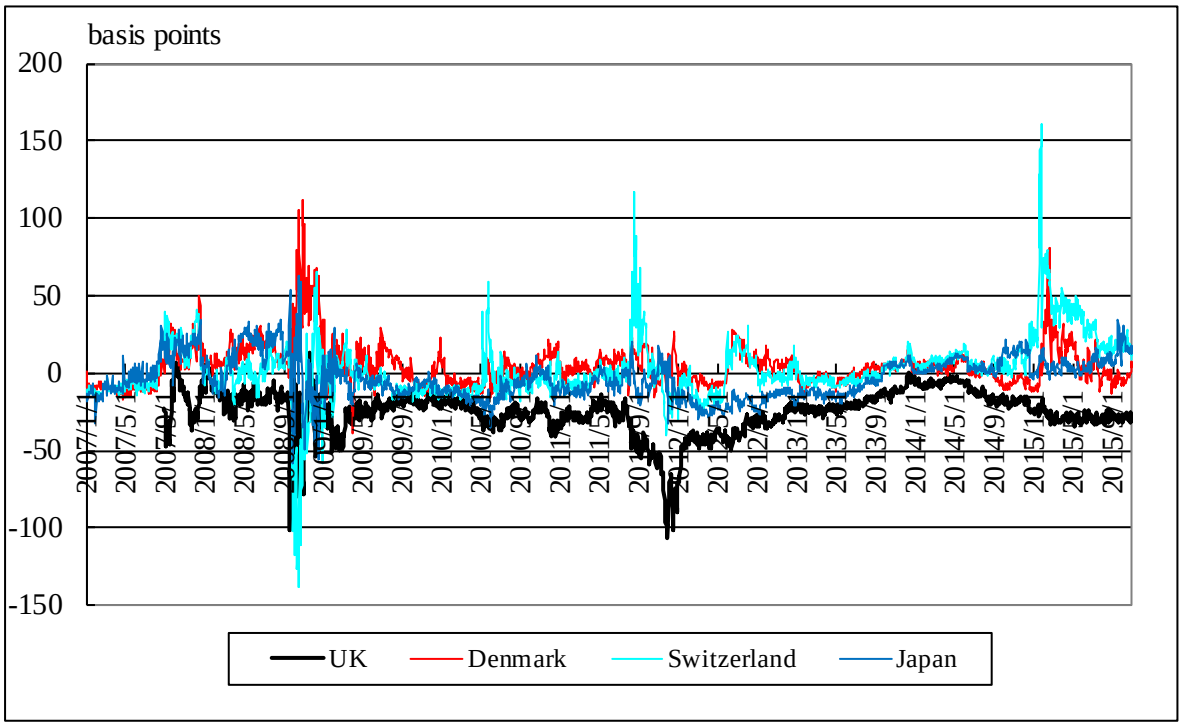
This figure depicts daily deviations from CIP condition between Euro and each of the three non-Euro currencies. The upward deviations imply that Euro had lower interest rate on the forward market.

Figure 4. Deviations from the CIP condition in bid and ask rates

(1) Bid rates



(2) Ask rates



Using bid rates and ask rates respectively, this figure depicts daily deviations from CIP condition. The upward deviations imply that Euro had lower interest rate on the forward market.